Optimization of the charcoal chain in Tanzania

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Abstract

The high reliance on charcoal makes Tanzanian producers, traders and consumers vulnerable for environmental problems such as deforestation. Increasing the sustainability of the charcoal chain in Tanzania calls for a comprehensive approach that accounts for a multitude of aspects (e.g technological, economic, social and environmental issues). At present, the development of such a comprehensive policy is hampered by lack of information about the charcoal chain as well as the limited recognition of policy makers in Tanzania of the interdependencies between the segments within the charcoal chain. This paper aims to provide a comprehensive analytical overview of all three components of the charcoal sector: production, trade and consumption. This overview contributes to the development of a comprehensive policy regarding the role of charcoal in Tanzania's energy strategy.

Preliminary lessons drawn from the available sources of information include the following: (1) The vast magnitude of the industry implies that changes in the sector can only be realized gradually with a comprehensive approach as a basis. Sudden interventions such as the ban on charcoal production and trade are counter-effective; (2) Despite the high environmental awareness among the charcoal producers, their poverty leaves no alternative but to continue the profession of charcoal making. Lack of alternative livelihood options, prevent them from shifting to more sustainable income sources; (3) Kiln efficiency is extremely low, thereby enhancing the rate of deforestation. Projects supporting the improvement of kiln efficiency would greatly support local communities as well as the environment. (4) Charcoal induced deforestation causes ample externalities, such as downstream water shortages. Because of these relationships, innovative economic instruments such as Payments for Environmental Services (PES) could be considered. (5) Current policies directed at the charcoal chain are inefficient in many ways. The command and control policies dominating the approach of the current Tanzanian government need to be supplemented by market-based approaches.

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Poverty Reduction and Environmental Management (PREM)

PREM aims to deepen and broaden the exposure of economic researchers and policy advisors in developing countries to the theory and methods of natural resource management and environmental economics. It is envisaged that this will encourage effective policy change in developing countries with the joint goals of poverty reduction and sustainable environmental management.

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1. Introduction

With an estimated population of 34 million people and an extremely high reliance on charcoal, Tanzania is a classic example of the social and environmental risks faced by many developing countries. About 85% of the total urban population depends on charcoal for household cooking and energy for small and medium enterprises (Sawe, 2004). In 1992, the total amount of charcoal consumed nationwide was estimated to be about 1.2 million tons[2]. In 2002, it was estimated that the charcoal business generated revenues of more than 200 billion Tshs ($200 million) and that more than 70,000 people from rural and urban areas where employed in the charcoal industry (TaTEDO, 2002). Dar es Salaam, Tanzania's largest city, accounts for more than 50% of all charcoal consumed in the country.

The charcoal sector is far from sustainable. The forest resources that the industry is relying on are disappearing rapidly and the productivity of the sector has not seen any improvement. In many ways, – economically, socially and environmentally – the charcoal sector in Tanzania is operating in a suboptimal manner. Yet, solutions that safeguard the charcoal sector's future are not straightforward.

The complexity of the charcoal industry is enormous, involving a multitude of aspects to be taken into account. The recent attempt of the Tanzanian government to stop deforestation by introducing a sudden ban on charcoal production is a typical example of a one-dimensional intervention that is bound to fail because it ignores the complexity of the charcoal chain. For policies to be effective, a comprehensive approach is needed that recognises the interdependencies between the different segments in the charcoal chain (i.e. production, trade, consumption) as well as the multitude of dimensions to be taken into account (e.g. technologies, economics, social, etc.).

This paper aims to provide a comprehensive analytical overview of all three components of the charcoal sector: production, trade and consumption. This overview should contribute to the development of a comprehensive policy with regard to the role charcoal has in Tanzania's energy strategy. It is expected to prepare the ground for a reform of the charcoal sector with the goal to:

1. Regulate charcoal production and trade, and
2. Provide feasible options for sustainable production and marketing.

The outline of the report is based on the chain approach, following the physical flow of charcoal moving from producers to consumers while simultaneously monitoring the monetary flows that move in the opposite direction (Figure 1.1). To increase our understanding of the developments in the charcoal chain in Tanzania, we systematically address a number of dimensions in each segment of the chain. These dimensions either represent *drivers* that influence the course of the charcoal flows, or denote indicators that reveal the *impact* of certain developments within the chain.

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[2] The estimate was based on several studies conducted on charcoal consumption in urban areas of Tanzania (World Bank 1998, Sawe and Kaale2002).

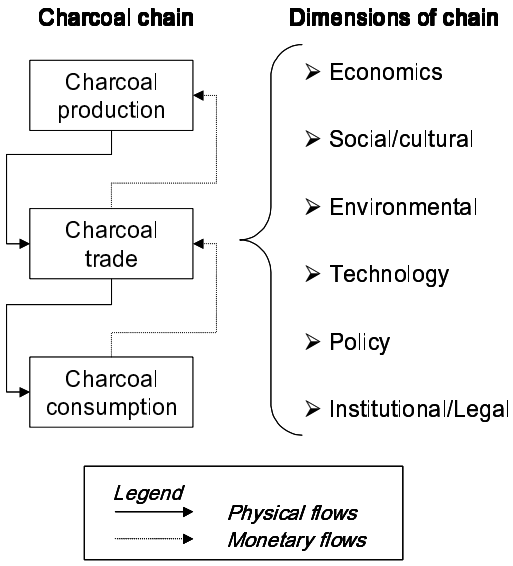


Figure 1.1 Analytical framework for the charcoal chain.

While this report deals with the issue of charcoal in Tanzania in general, much of the data presented comes from our work in the Coastal Forests surrounding Dar es Salaam, specifically the Pugu and Kazimzumbwi forests. Data collected consisted of both primary and secondary data. A broad range of methods was employed for primary data collection: semi-structured interviews, questionnaire surveys, choice experiments, contingent valuation and GIS.

The report is structured around the charcoal chain in Tanzania. Chapter 2 describes the various dimensions in the context of the production of charcoal. Chapter 3 concentrates on the trade of charcoal, connecting the production and consumption segment. The consumption segment of charcoal in Tanzania is elaborated upon in Chapter 4. Conclusions and policy recommendations are presented in Chapter 5.

2. Charcoal production

2.1 General background

Traditional charcoal making is a very tedious operation and requires an intimate practical knowledge of the principles of combustion. Charcoal can be produced from wood, coconut shell or crop residue in a process called carbonization. Carbonization is the method of burning wood or biomass in the absence of air after which it breaks down into liquids, gases and charcoal. During the charcoal production process in the kiln, water, combustible gases, methanol, acetic acids and tars are driven off, and when the temperature is high enough pyrolysis begins (the breaking down of wood under high temperature in the absence of air). At the end of pyrolysis what remains is the carbonized wood or charcoal.

Source of raw materials

Almost all charcoal in the country is produced in the rural areas, with the largest shares of raw materials extracted from (World Bank 1988; CHAPOSA, 2001; MNRT, 2002C):

- Open Miombo woodlands (owned by local governments);

- Reserved forests;
- Bushland forests (publicly owned);
- Mangrove forests, and
- Farm lands.

The radius of the area from which these raw materials are collected is steadily increasing, with charcoal makers needing to travel progressively further to obtain the resources needed. Most of the resources needed for the production of charcoal are found in the forested areas surrounding the urban centres. However, travel distances to these sources vary significantly between regions and locations.

Preference and suitability of trees used for charcoal burning varies with the type, 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 (Monela et al 1993). If not easily available or accessible, other tree species like *Mangifera indica* with low calorific values can be used as well. The Annex of this report lists some tree species used for charcoal production. Reserved trees such as *Melicia excelsa, Ptrocarpus angolensis* and *Dalbegia melanoxylon,* although they have high calorific values, cannot be harvested as they are nationally protected tree species.

Harvesting trees

Two types of wood harvesting dominate: clear felling of forestland for agriculture purposes and subsequent carbonization of the felled trees; and selective cutting done by the charcoal makers who aim at generating income from charcoal business only. Selective harvesting is in principle the least destructive form as it allows young trees to grow. However, due to inadequate management skills young trees are also chopped down and used to cover the charcoal kilns, resulting in unnecessary forest destruction.

Field experience in Rufiji and Shinyanga shows that, due to inadequate harvesting skills most charcoal burners either cut trees at a height of one meter above the ground (breast height) or fell in any direction regardless of presence of young trees. Moreover, branches are rarely used for charcoal burning (Sago pers.com). This results in large amount of wasted wood, which could well be used for charcoal production.

Charcoal production process

The entire production cycle takes almost two months, but the charcoal burning itself, using the traditional earth mound kiln, takes around 18 days. The efficiency of the process depends on the construction of the kiln (i.e. arrangement of the billets), moisture content of wood, the monitoring of the carbonization process and perhaps for the largest part on the skills of the producers. Between three and ten people are usually involved in the production. They are responsible for felling the trees, assembling them in the kiln, guarding the kiln and packing the charcoal for transport. With regard to the last point; producers tend to overpack the bags for tax related reasons. A more detailed explanation of these reasons will be provided in the following section about the charcoal trade. For the steps involved in charcoal making see Table 2.1.

Table 2.1 Steps in the Charcoal Production Process.

Steps	Activities
Material preparation	Felling of trees Cross-cutting into short logs Wood drying
Kiln manufacture	Kiln base/structure Piling of the logs into a clamp Covering the clamp with grass/sand or grass/stones
Carbonization	Initiate the fire Carbonization control Cooling period
Packing & selling	Packing into bags Transport to road side

2.2 Social and cultural domain

Population growth

It is evident that the increased population in areas adjacent to the Coastal Forests and the nearby urban centres puts heavier pressure on protected forests. This is because as the population increases, more charcoal is needed for cooking, more fodder is needed for animals, more of the forest is used as pasture, and more forest is cleared for crops. Charcoal is also used in Dar es Salaam's commercial sectors. Thus, excessive deforestation, in response to the rapid expanding population, can increase stress on the poorer sections of the society and on women, as they have been primarily involved in gathering fuel wood, fodder and water in the traditional village economies. The trend in population of the study area is shown in Table 2.2.

Table 2.2 Population growth around Pugu and Kazimzumbwi from 1978-2004.

Region	Village	Population 1978	Population 2004
Coast	Kazimzumbwi	932	1,757
	Kifuru	497	937
	Maguruwe	675	1,272
	Kisanga	870	1,640
	Kola	287	541
Dar	Buyuni	1,527	2,878
	Pugu	9,594	18,085

Notes: The population growth rates are based on official estimates of population growth rates as reported in the national census for the 1978, 1988, 1998 and 2002.

Motives to produce charcoal

The production of charcoal is the most remunerative among the forest related activities. Besides constituting the major source of income and employment for many rural people, it generates revenues for the government. A major reason for the widespread involvement of rural people in charcoal production is related to the labour- intensive nature of the business with a very low input of capital. Charcoal making is more or less a zero-cost activity. Most producers collect the wood free of charge, use their own labour and make

a negligible initial investment to buy the basic tools required to set up the activity (i.e. axe, machete, hoe, shovel, fork and wooden levers). Since alternatives to earn cash income are currently few, opportunity costs are also low. The most important factor encouraging people to start producing charcoal is the lack of alternative income-generating activities and the fact that charcoal is a cash product, with a large market ready to absorb the entire production.

Producers are generally organized in informal groups and tend to cluster into geographical areas that are particularly suitable for the production. The choice of the sites depends primarily on the quantity and quality of the trees but also on the level of monitoring by the forest authorities. Two distinct groups of charcoal producers are noticeable. First, there are *farmers* who produce charcoal as part of secondary activities. The second group comprises of charcoal making *specialists* for whom charcoal making forms their primary activity.

The economic similarity between the two groups is that the production of charcoal is the most important forest related activity for both groups. Our field survey, conducted among the rural communities settled in the proximity of the studied forests, revealed that almost 50% of the households are involved in charcoal making. It must be noted that because charcoal production does take place in protected forests, and is considered illegal, many people are reluctant to discuss their charcoal making activities. We believe not all respondents have answered truthfully when asked whether they produced charcoal. Only 278 households out of the 360 interviewed confirmed being involved and for just those households charcoal production data could be collected.

The production of charcoal takes up most of the time of the people involved. Both categories of respondents spend around 220 days a year in the forest making charcoal. The specialists, however, are a lot more efficient. On average, they produce 267 bags a year, while the farmers do not produce more than 171 bags. The kilns used by charcoal makers are also almost twice as large.

All identified charcoal makers claimed to be producing independently and not to have been hired by someone else. We are suspicious about these responses, although given the small size of production at village levels independence is not impossible. Yet, it is a lesser offence or even legal to produce charcoal for one's own consumption, but not for the purpose of selling it. Note that outside of the reserves a permit or license is not necessary if one produces for oneself. Inside the reserves charcoal making is always prohibited. This makes it safer to claim to produce for oneself. However, from interviews with charcoal traders in Dar es Salaam, we know of the common practice of relatively wealthy individuals hiring and providing food for people to produce charcoal for commercial consumption. If these answers are indeed partly untrue, they should still not distort our findings, since even if someone is hired to produce charcoal, he gets paid – the same amount – per bag of charcoal produced. The only thing we have not taken into account is the extra benefits of the provided food.

Production statistics

According to the PREM survey, self identified charcoal makers do not spend many more days in the forest making charcoal on average, but are just much more efficient. They produce almost 100 bags more than the farmers for just three days more in the forest. A

day constitutes 1.22 bags of charcoal for this group, while the farmers only produce 0.85 bags per day. Generally, the charcoal makers use larger kilns, but there is a lot of variation within the groups. Details about the different characteristics of charcoal producers are provided in Table 2.3.

Table 2.3 Production Statistics.

	Total	Charcoal makers	Farmers
	(n=278)	*(n=183)*	*(n=83)*
No. of days	219	222	219
	(66)	*(54)*	*(84)*
No. of kilns	14	14	15
	(6)	*(6)*	*(6)*
No. of bags	234	267	171
	(141)	*(135)*	*(133)*
Bags per kiln	17.6	20.4	12.1
	(10.3)	*(10.3)*	*(7.4)*
Bags per day	1.10	1.22	0.85
	(0.78)	*(0.57)*	*(1.08)*
Total no of bags produced	64,982	48,930	14,174

Note: Standard deviations are in brackets

Estimated total charcoal supply

To calculate the total charcoal supply from the study area, we have first extrapolated our findings from our sample to the selected villages. This is shown in Table 2.. The totals shown in the table are based on the entire survey sample and are not the sums or averages of the different villages. This makes a slight difference. When the village totals are added up the total production in our seven villages comes to 405,196 bags, but because for some villages the sample is very small, the total sample figure is more reliable. We have no information at this time to compare the villages not surveyed and perhaps make a more accurate extrapolation.

To calculate the total number of bags of charcoal produced in the study area, we again have to extrapolate these numbers to all villages around Pugu/Kazimzumbwi forests. We base this extrapolation on the 2002 census data for these other villages. At this point we only have the total population of the other villages. After we correct this with the population growth in the area, we come to around 14,000 households in the Pugu/Kazimzumbwi area. Assuming the same share of these households is producing charcoal as in our sample (28%), we get 3,920 charcoal producing households. When we multiply this by the average amount of charcoal produced in our sample, we come to a total of 1,015,280 bags of charcoal, weighing 30 kg. Because of the large variance, this is only a very rough estimate. However, it provides some references point to the total amount of charcoal supplied to Dar es Salaam.

Table 2.4 Estimated Total Production in Sample Villages.

	Average no. of bags	Number of households involved in charcoal	Estimated total production per village
Kazimzumbwi	211	133	28,019
(n=45)	*(139)*		
Kifuru	307	86	26,379
(n=11)	*(306)*		
Maguruwe	93	102	9,514
(n=11)	*(51)*		
Kisanga	266	123	32,657
(n=16)	*(184)*		
Kola	208	90	18,713
(n=26)	*(101)*		
Buyuni	235	259	60,896
(n=75)	*(103)*		
Pugu	253	904	229,020
(n=94)	*(139)*		
Total	234	1697	396,671
	(141)		

Note: Standard deviations are in brackets

2.3 Economic domain

With regards to the economics of charcoal, it is important to look at the entire socio-economic context of the villagers and forest dwellers that make up the majority of charcoal producers. In this Section, we will address a range of issues such as income, poverty, ownership, employment, earnings, prices and profits.

Income

In an effort to calculate the cash income of the village households, we included the sale of farm goods, forest products, charcoal, timber, and – for a limited number of households – the income from a household enterprise or the cash transfers from relatives or income from employment. Furthermore, we calculated the value of the subsistence part of farming and forest product collection. We expected this subsistence part to form a major share of household income. However, due to our focus on charcoal makers, the surveyed households are probably more involved in the cash economy than the average villager. The inclusion of subsistence elements in the income means we get an income measure that is much closer to consumption than simple cash income would be, and therefore probably much closer to actual welfare[3].

We calculated a gross household income and have not attempted to deduct the value of household labour from the revenues from sales or benefits of own consumption. By doing this, we follow most other African household studies (Cavendish mimeo). Own la-

[3] Like in most other household surveys we have omitted the valuation of leisure, since this is very hard to quantify or value. For an explanation on how this might lead to errors in the welfare comparison of different households, see Cavendish (1999; p.10).

bour is usually omitted because of the difficulty in measuring the quantity of labour used and in calculating a shadow price for labour.

Valuing subsistence goods and services is especially hard, because it is difficult to attach a price to products that are not marketed. Moreover, other price-related complications exist such as a non-uniform understanding about quantity measures or difficulty in converting certain goods to common units in the first place. It is especially hard to put a price on timber, because we only have information about the number of trees extracted. This forced us to make major assumptions about a number of prices.

Table 2. shows variations in income for various subgroups. If all households are considered, a relatively high income is estimated. This is caused entirely by the timber extractors, and by one very large timber extractor in particular. As was mentioned above, it was difficult to value timber sales, and prices may have been set too high, although timber remains a very lucrative business. By excluding the larger timber extractors, the total and cash income of the sample becomes 918,409 Tshs and 823,468 Tshs, respectively. For rural Tanzania, this is still a relatively high-income level. By excluding all timber extractors, the total and cash income drop to 796,136 Tshs and 696,478 Tshs, respectively.

For all groups the average income is significantly higher than the median income, reflecting the unequal income distribution, which is skewed to higher incomes. For the income shares it matters less if timber extractors are left in or out of the sample. Charcoal is the biggest single source of income, with forest products coming second, even for those respondents who claimed to be mainly farmers.

If we look just at the cash income, which especially for charcoal makers forms a very large share of total income, charcoal becomes even more important. Forest products become almost insignificant, making up only 3% of cash income in the whole sample. Apparently, forest products are mainly collected for home consumption. Similarly, livestock provides only a very minor share of both cash and total income, which is not surprising considering the small number of households with livestock (n=74). However, even if only those households are selected that own animals, income from livestock only amounts to 7% of total income. Livestock is not a major income earner in these areas.

In the evaluation of the non-cash part of total income, we excluded charcoal and timber since we assumed that the majority of these products are marketed for cash income. However, the survey results do suggest that a large share of the households actually use charcoal for their own consumption. This implies that the shares of the other non-cash sources shown in Figure 2.2 are somewhat inflated. The importance of forest products is still evident, however. Forest products were already seen to make up an important share of total income and to be relatively insignificant for cash income. We expected a higher share of crops in non-cash income. Most of the non-cash income from forest products is made up of firewood (95%).

Table 2.5 Average and Median Income, and Income Shares.

	All (n=360)	Charcoal maker (n=185)	Farmer (n=138)
Total income	979,225	890,725	663,524
Median total income	678,100	808,000	437,471
Share charcoal	*58%*	*80%*	*38%*
Share crops	*14%*	*7%*	*25%*
Share livestock	*1%*	*0%*	*3%*
Share forest products	*17%*	*12%*	*26%*
Cash income	884,219	800,646	549,649
Median of cash income	540,000	666,000	308,100
Share cash	*81%*	*87%*	*71%*
Share charcoal	*69%*	*91%*	*50%*
Share crops	*16%*	*6%*	*33%*
Share livestock	*1%*	*0%*	*3%*
Share forest products	*3%*	*2%*	*5%*

Note: Groupings are based on the stated main activity of the household head.

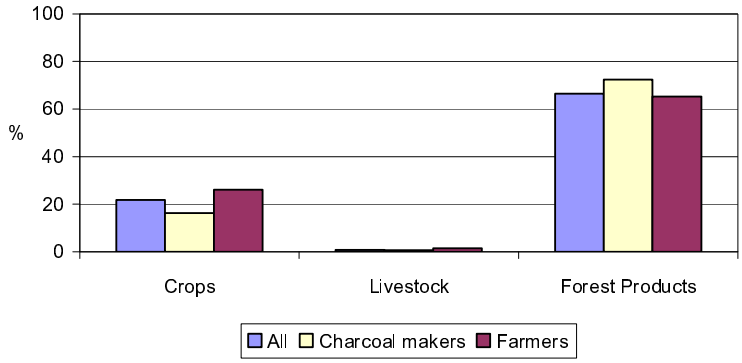


Figure 2.2 Non-cash Income Shares for Different Groups.

Land ownership

The household survey revealed that land ownership is very common (90%+), although the plots are usually small. The predominant land type of the holdings is cropland, but there are some plots that have fruit trees or forest. Plots with cashew nut trees fall under the category cropland. Mixed cropping is generally practiced, so even on plots with fruit or cashew nut trees, there will be other crops planted as well. Therefore, the categories used do not perfectly discriminate between types of land use. A large part of the plots used to be forestland when the owner acquired it. Despite the fact that the majority of owned land is cropland in name, the land is often not actively harvested. Partly this is due to low agricultural prices. If someone has access to another form of livelihood (i.e. charcoal), the landowner tends to leave his or her land idle. However, they are required to manage the land, otherwise the government can reallocate the land to someone else. People who do not live close to their land often pay someone to cut the grass and prevent overgrowing. It is uncommon for people to rent land. In our survey, just 7 households representing 2% of the sample, rented land. For a detailed analysis of land ownership see Hess *et al.* 2006.

Sale and profits from charcoal

Although charcoal is sometimes produced for personal consumption, the majority of the production occurs for commercial reasons (in the rural areas firewood is mostly used for cooking). The income generated from charcoal businesses has significant advantages to both women and men. The cash income is typically used to satisfy family needs such as paying school fees, medical care and investment for agriculture. Yet, within the entire charcoal chain, it is the charcoal producer that makes the least profit. While the initial investment costs to begin production is low, the producer is typically only involved in the production side of the business and must negotiate with charcoal traders, who buy their product and take on the costs of transportation to the city for final sale.

In 2006, the government placed a ban on the transportation of charcoal to the city of Dar es Salaam. Prior to this ban producers would sell a bag for between 1,000 and 3,000 Tshs. When the ban went into effect, traders were reluctant to incur the risk of moving the charcoal and as a result producers stocks began accumulating. A few months later, the ban was lifted and due to high demand in the city the producers found themselves in a position to renegotiate their prices and began selling a bag for around 6,000 Tshs.

2.4 Environmental domain

Deforestation

Deforestation is one of the major environmental problems of Tanzania. The principle cause of deforestation in Tanzania is the felling of trees for the production of charcoal. While charcoal can be produced from a variety of different tree species, most of the trees used for charcoal are from the natural *Miombo* woodlands. Older hardwood trees are the most sought after, as they produce a very high quality, longer burning charcoal. The high reliance on charcoal is already having serious effects; the forests in Tanzania shrank from 44.3 million ha in 1961 to 33.5 million ha in 1998 (Ministry of Natural Resources & Tourism, 2001). The Forestry and Beekeeping Division of Tanzania estimates an annual forest reduction between 130,000 to 500,000 ha, against only 25,000 ha planted annually. Looking specifically at the Coastal Forests, estimates of the deforestation rate there have been put forward by various sources. Ahlback (1992) puts the figure at about 2 cubic meters of forest products per person per year, for the early to mid 1980s, although this was mainly based on a high estimate. According to Burgess and Muir (1994), Tanzania has just 799 km^2 of Coastal Forests remaining.

Looking at spatial images of two specific coastal forest reserves, Pugu and Kazimzumbwi, we recognise this national pattern of deforestation. As shown in Figure 2.3, the land use of the areas surrounding the reserves has changed considerably over the years. Most of the land that was open woodland or bush land in the 1950s was planted with tree crops in the 1980s, and this was still the case in 2005. These tree crops include cashews, mangoes and coconuts.

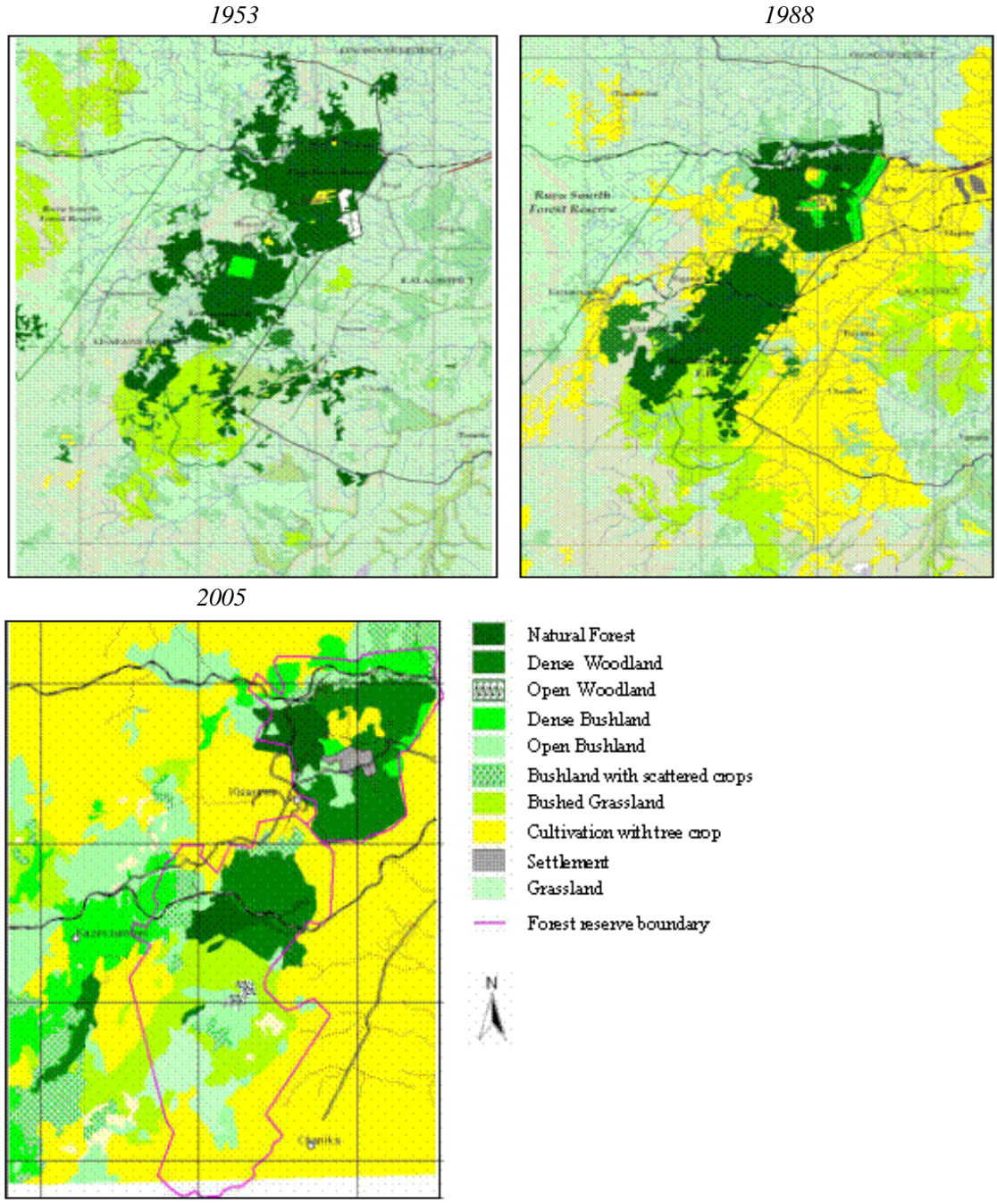


Figure 2.3 Land Cover of the Pugu/Kazimzumbwi Forest Reserves in 1953-1988-2005.

Looking more closely at the reserves themselves, Table 2.4 shows a small increase in natural forest from 1953 to 1987. The increase mostly took place in the southern Kazimzumbwi reserve where bush land including some scattered cropland, but also grassland and open woodland, regenerated into forest. In the northern Pugu reserve, on the other hand, there was some encroachment with plantation forests and cultivated land with tree crops. Since 1951, there has been deliberate clearing of parts of the Pugu and Kazimzumbwi forest reserves for the establishment of rubber, cassia, eucalyptus and pine plantations.

In the second period (1987-2005) the encroachment in Pugu forest continued, and most of the natural forest degenerated into dense woodland. However the major difference be-

tween the two periods is the disappearance of natural forest in the Kazimzumbwi reserve. Some of it has also degenerated into dense woodland, but most is now bush land or bushed grassland.

Table 2.4 Land Cover of the Pugu/Kazimzumbwi Forest Reserves in Hectares.

Land cover type	1953		1987		2005		Percentage change	Percentage change
	Area	%	Area	%	Area	%	1953-1988	1988-2005
Natural forest	3,833	*53*	3,959	*54*	531	*7*	3	-87
Woodland	479	*7*	327	*4*	1,773	*24*	-32	443
Bushland	371	*5*	387	*5*	1,192	*16*	4	208
Bushland with scat. cult.	1,002	*14*	216	*3*	474	*7*	-78	120
Cult. with tree crops	69	*1*	998	*14*	1,754	*24*	1343	76
Grassland	1,328	*18*	1,179	*16*	1,401	*19*	-11	19
Other	183	*3*	201	*3*	141	*2*	10	-30
Total	7,266		7,266		7,266			

Destruction of watersheds

The felling of trees for charcoal also has significant impacts on vegetation, soil and watersheds. It can directly damage adjacent vegetation and cause disturbance to the surface litter layer in the immediate vicinity of the felled tree. Disturbance to the surface litter layer, which is also a seed bank for different herbaceous vegetation, may facilitate seed germination thereby increasing vegetation cover while reducing the germination of new trees (TaTEDO, 2002).

With regards to hydrological impacts, in general it can be said that forest clearance leads to an increase in annual water yield proportional to the percentage of biomass removed. This is the result of the diminished evapotranspiration from the forest. Rainfall infiltration opportunities can diminish through soil compaction as a result of mining, the establishment of roads or settlements or agricultural practices. This in turn can lead to a diminished ground water recharge during the wet season, resulting in a decline in dry season flow. Peak flows and associated flooding can occur more often as a result of the same process. Due to the diminished infiltration opportunities, water runs off immediately leading to excessive flows. If a river channel cannot cope with this amount of water, flooding may occur. We anticipate that this degradation of the watersheds can ultimately lead to a change in stream flow totals and seasonal distribution of the rivers that drain them.

Finally, as noted by TaTEDO (2002) the actual process of carbonizing wood in the kiln also has its impacts:

- All vegetation around the carbonization site is completely burnt but after a short period may be re-established;
- Regeneration of the charcoal sports sites is highly slowed down and may be absent for decades (Chidumayo, 1988a);
- All ground fauna in the immediate location are killed;

- Soil pH in the carbonization site can increase up to 2 units while the phosphorus availability may double (Serenje *et al.*, 1993);
- Soil nutrient level is increased temporarily.

Hydrological change in the study area

As part of our study we examined the conditions of stream flow behaviours in relation to land use and land cover conditions of Kizinga and Mzinga rivers that originate in the two forests of Pugu and Kazimzumbwi. These forests are highly degraded due to poor farming methods, forest extracting and charcoal making practices (Van Soestbergen, 2005).

Based on the findings it can be concluded that the flow regime has changed over the years in both the Mzinga and Kizinga rivers. There is no indication of increased seasonal distribution of flows but total water yields have increased considerably, particularly between the periods 1975 to 1985. This increase cannot be explained by precipitation amounts over the same period. The weak correlation between rainfall and stream flow, especially in the period with the highest increase in stream flow is another indication that rainfall amounts have no direct influence on stream flow behaviours. Plotting of mean decadal monthly flows shows an increase in stream flow over all months for both rivers, implying that both wet and dry season flow volumes have increased. Trend analysis of time series of stream flow also shows this increase. Trend analysis of time series of rainfall also shows an increasing trend but the weak relationship between rainfall and stream flow implies that other processes are responsible for the increase in stream flow.

An important point to take into account when looking at these conclusions is that there are many gaps in the data. Nevertheless, significant trends in rainfall and stream flow can be established.

Land use change in the study area

The land use change study shows that plantation forest and cultivation with tree crops has increased considerably, mainly at the expense of natural forest and bush lands. This means that vegetation density has decreased and that evapotranspiration has diminished, resulting in less water use by vegetation and increased runoff. It should be noted however that the land use change study was only carried out for the Pugu and Kazimzumbwi forest and surroundings. These areas make up only around 10% of the catchments. Therefore similar land use changes, like increased agriculture at the expense of forested areas in other parts of the catchments, could be a major contribution to the effects seen. Annual crops have reduced water use compared to full-grown forests because they have less capacity to intercept and evaporate rainfall but also less capacity to extract water from deeper soil layers during periods of drought. These effects are also true when vegetation density has decreased. Increase in storm runoff (in wet season) can be explained by a reduced infiltration capacity of the soils because of disturbance through other land uses. Reduced infiltration capacity can ultimately impair the recharging of the soil and groundwater reserves.

Environmental awareness

The forest dwellers are beginning to notice the negative effects of deforestation. Almost all respondents in the PREM survey (95%) claimed to have observed the disappearance of the forests (see Figure 2.4), and 80% expected to be very little or nothing left of the

forests in ten years time (see Figure 2.5). The respondents confirmed our earlier conclusion that the production of charcoal had done most damage to the forest (see Figure 2.6). This increasing awareness could be an additional reason for them to consider other livelihood options.

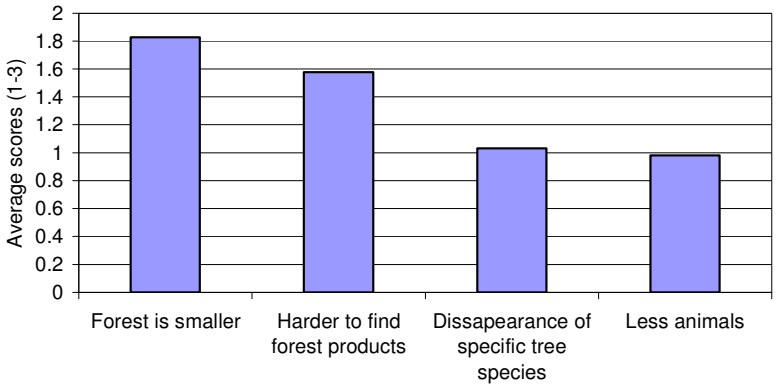


Figure 2.4 Perceived changes over the last ten years.

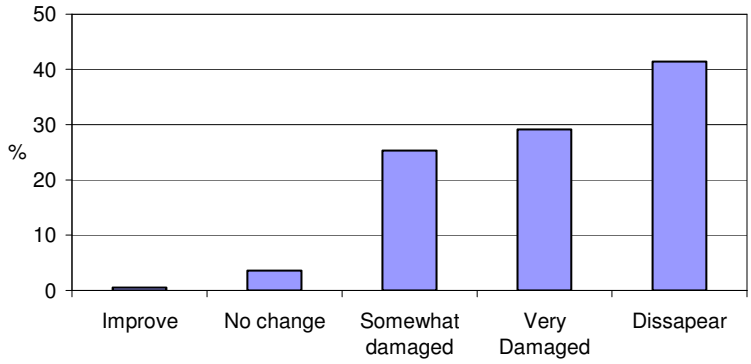


Figure 2.5 Perceived state of the forest in ten years.

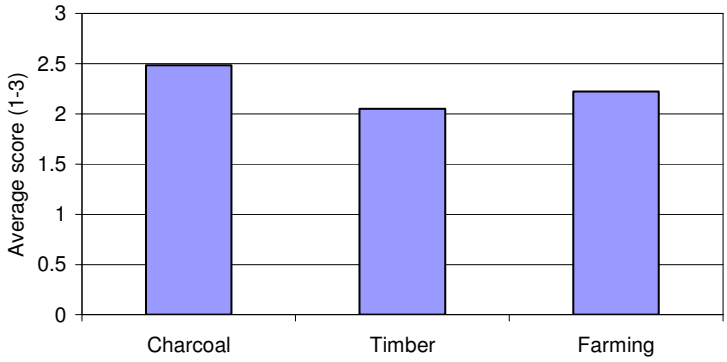


Figure 2.6 Perceived Causes of Deforestation.

2.5 Technological domain

Charcoal kiln efficiency

While there is a variety of charcoal burning kilns, the most common is the traditional (basic) earth mound kiln. The efficiency of the kiln depends on the construction (arrangement of the billets), moisture content of wood and the monitoring of the carbonization process. The efficiency is low when using the traditional basic earth mound kiln. A study conducted by CHAPOSA (2001) showed that the efficiency of the traditional earth

mound kiln ranges from 11 – 30%, however, in other studies the efficiency of the traditional kiln was reported to range between 10 – 20%. The conversion rate ranges from 1 to 2 bags of charcoal taken from 1 cubic meter of fuel wood (TaTEDO, 2002). The efficiency of other types of kilns is shown in Table 2.7 followed by a discussion of these kilns (Taken from TaTEDO 2002).

Table 2.5 Types of kilns.

Kiln type	Traditional kiln	Improved kiln	Efficiency (%)
Earth Pit Kiln	x		10-15
Portable Steel Kiln		x	20-20
Brick Kiln		x	25-35
Cassamance Earth mound Kiln		x	25-30
Earth mound Kiln	x		10-20
Basic Earth mound Kiln	x		10-20
Improved Basic Earth mound Kiln		x	15-25

Source: TaTEDO

Traditional (basic) earth mound kiln: This is the most common traditional earth kiln in Tanzania. It is a very popular kiln used by charcoal producers and it is usually rectangular in shape.

Cassamance earth mound kiln: The improved cassamance earth mound kiln from Senegal has efficiency of 25 – 30 %. The CEK technology was introduced to Kilimanjaro and Coast regions of Tanzania in 1980s. However, the technology was not accepted/adapted due to high investment cost and tedious work involved in its construction and operation process.

Improved Basic Earth mound Kiln (IBEK): This is an improved version of the Traditional Earth mound Kiln. It has been improved by incorporating chimney and apron stakes to control the ventilation system inside the kiln. Field tests have shown that IBEK has an efficiency of 15 – 25%. The benefits of IBEK technology include; increased amount of charcoal produced per kiln, increasing quality of charcoal produced, reduction of wood wastage in the kiln and the time for carbonization process. It is estimated that 9m3 of wet wood are needed to produce one tonne of charcoal from this type of kiln.

Portable steel kiln (PSK): PSK is another type of improved kiln; it has an efficiency of 20 – 25 %. The efforts to encourage and popularize the use of portable steel kilns in Tanzania have been unsuccessful, due to high capital investment cost. It is estimated that the cost for constructing one PSK is about 3 million Tshs (TaTEDO 2001).

Brick Kiln: The Brick Kiln (BK) has a very high efficiency of 25 – 35%; is not movable and hence it is advised that this type of kiln should be constructed in areas with many trees or at the sawmill industries so as to reduce cost for transporting the raw material needed for producing charcoal.

Contribution to greenhouse gas emissions

This section addresses the global warming impact of the emission factors from the charcoal making process. As a result of the relatively low efficiencies, a large percentage of fuel wood is diverted to other products. The carbon balance for the charcoal making

process on a carbon basis is written as follows: Wood = charcoal + ash + condensable liquids + CO2+ CO + CH4 + TNMHC + TSP, (TNMHC) is total non-methane hydrocarbons and (TSP) is total suspended particulates. It should be noted that carbon dioxide (CO2) and methane (CH4) constitute the direct greenhouse gases whereas carbon monoxide (CO) and total non-methane hydrocarbons (TNMHC), as well as total suspended particulates (TSP) are the indirect greenhouse gases. The TNMOC indirectly affect global warming through atmospheric chemical reactions that in turn affect GHG levels. On average, fuel wood carbon is approximately diverted as follows: 52% to charcoal, 24% to CO2, and 10% to PIC. This implies that charcoal fuel cycles constitute some of the largest greenhouse-gas (GHG) emissions in the world. Nonetheless, the complete mapping of the carbonization process and the global impact of charcoal making are matters not addressed at length here.

2.6 Legal and institutional domain

Government

The Tanzanian natural resource management relies on an extensive regulatory, command-and-control approach, carried out largely under the direction of central government agencies. Allocation of land, forestry, water, fishery and mineral resources requires government approvals and annual permits. The system is characterized by a high level of bureaucracy and consequently high transaction costs. The Forest Ordinance, Cap.389, in particular, regulates the use of forests. According to this law forests are classified in forest reserved, by the government, for commercial exploitation or for conservation/protection purposes and forests on unreserved public lands.

In the reserved forests, which are sub-classified in Local Authority Forestry Reserves (LAFRs) and Territorial Forestry Reserves (TFRs), exploitation is not permitted without a license[4]. Exceptions are made in special cases but the activities must be authorized by the District or the Director of the Forestry Division. Once the license is issued, it needs to be renewed annually.[S.M.3] A general collection license for firewood can be purchased from the district forest officers (DFO) at the fee rate of 3,000 Tshs ($3) per cubic meter. The licensing system applies even to the non-reserved lands when the harvesting is done for commercial or industrial purposes. Conversely, no license is required and no taxes are imposed when forest products are harvested for subsistence use. Finally, the ordinance establishes that, despite the category of forest there are certain tree species that are protected and a license is required for their harvest.

Inspections to check the legality of the forest activities are carried out by the forestry guards during their routine monitoring in the woodlands. The Natural Resource Department in Dar es Salaam acknowledges that monitoring of the studied forests occurs one week a month in each forest. Non-adherence to the conditions of the license often leads to confiscation of the harvested products, a fine or a prison sentence. Under the prevail-

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[4] The Forest Ordinance empowers the Director of Forest and Beekeeping to license extraction of forest products from central government forest reserve and unreserved public lands while District authorities can issue licenses only for harvesting activities that take place in local authority forest reserves. Revenues from LAFRs go to the District where the forestry reserve occurs, while revenues from TFRs and non-reserved lands go to the central government. These revenues are collected by the District Forest Officers (DFO) on behalf of the Forest and Beekeeping Division.

ing laws the fine for the offence is 5,000 Tshs ($5) or six months in prison. For second time offenders the penalty is a 12,000 Tshs ($12) fine or one year in prison. If the offence is regularly repeated then both a fine and a prison term can be concurrently imposed. A court may also order an additional payment to the general treasury to cover the cost of reparation in case of serious damage to the resource.

It is interesting to point out that the Forest Ordinance does not directly impact the production of charcoal because it is qualified as a secondary product obtained from harvested or gathered timber. Therefore the only way the government has to control and get revenues from the charcoal business is through a tax system. Taxes are imposed only on the charcoal that is for commercial sale. [S.M.4]

NGOs

Environmental and development groups are active in all seven villages of our study area. The three main NGOs that support environmental village groups are the Forest Conservation Group (TFCG), Wildlife Society of Tanzania (WCST) and CARE. They work together in a joint project called WAHIPUKA, which is the Swahili abbreviation of "The Advocates of the Pugu and Kazimzumbwi Forests". Through the WAHIPUKA project a forest committee has been set up in each village that is supposed to form a local area forest conservation network. Another active organization in the area is MISAKA. It tries to enhance alternative livelihoods for the villagers through savings and credit schemes. More than three quarters of all respondents were aware of the presence of these organizations. At less than 10%, membership of the villager groups is much lower.

Other NGOs and international organizations active in Tanzania in the field of forest and the environment are: WWF, IRA, FAO, IUCN, SIDO, TaTEDO.

2.7 Policy domain

Generally speaking, the lack of enforcement of existing laws and regulations is one of the main problems in Tanzanian environmental policies. It undermines the effectiveness of the entire regulatory and institutional framework, thus jeopardizing the sustainable management of forests. This lack of enforcement is strongly linked to the centralized administrative structure. Centralization is not always, at least in the case of Tanzania, a synonym for clarity and efficiency. Difficulties in governance are, for instance, caused by the fact that some of the institutions that oversee the management of natural resources have, in some respects, overlapping functions. The lack of clarity of the institutional mandates, as well as the unclear definition of the boundaries and the ownership status of the forests, create conflicts and consequently leads to overall inaction.

To a certain extent, the government has become aware of the faults in the current system. Since the 1990s, this awareness resulted in a move away from the state-driven forest management regime towards a more decentralized system. The National Energy policy (1992), the National Environment Policy (1997) and the National Forest Policy (1998) are clear signs of the ongoing process. These three sectoral policies are supportive of each other in areas that directly affect the use of forests and consequently the future supply of charcoal. The common objectives are:

- Ensuring sustainable supplies of forest resources for meeting basic needs for present and future generation;

- Ensuring/maintaining sufficient forest cover under effective management;
- Preventing deforestation and any form of unnecessary vegetation loss;
- Enhancing capacity to manage forests and related environmental renewable energy, in collaboration with other stakeholders such as local communities;
- Raising public awareness.

In particular, the National Forest Policy promotes the participatory forest and woodland management concept. The term participatory forest management implies any forest management regime, which involves other stakeholders. It embraces the concept of Joint Forest Management (JFM) and Community-based Forest Management (CBFM). JFM means involvement of local community or non-governmental organizations in the management and conservation of forests and forestland with appropriate user rights as incentives. CBFM involves a higher level of participation. In this form of forest management local people play a major role.

Despite some positive signals of change in Tanzanian forestry policies, the "command and control" philosophy still prevails and the management of forest resources remains largely centralized. In short, local institutions, which could be more effective, have no real authority to decide on the management of forest resources and little action is taken to actively preserve the forest resources.

Ban on charcoal

In February of 2006, the Tanzanian government attempted to impose a ban on the transportation of charcoal. The reason being that if charcoal could not be moved to the city for final sale then end-users would seek alternative sources of fuel thus mitigating production. However, the ban had little effect on production. Producers continued to manufacture their product during the ban and with traders loath to buy, stocks of charcoal increased in the production areas. The ban was later lifted (it is unclear when exactly) and with the increased demand from the consumers and little stock in the cities producers began doubling their prices from the pre-ban level.

Alternative livelihood programs

From a sustainability point of view, charcoal production cannot go on indefinitely. On the other hand, making charcoal is a very important source of livelihood for the majority of the households. Thus, a strategy to mitigate the production of charcoal must go hand in hand with efforts to ensure alternative livelihoods. As we have noted earlier, agriculture is also a major source of income for many people (especially those in our study area). Therefore, the promotion of agriculture could potentially provide alternative livelihoods to a majority in the villages surrounding the Coastal Forests. Below we detail some of the important crops, as well as agricultural programs, that could play a key role. The analysis again focuses on our study area.

Cassava: Cassava is a drought resistant crop grown in almost all areas of the Coast region. This crop has been treated as a "Life Saver" during droughts and food shortage periods. The Coast region is a large supplier of cassava to the City of Dar es Salaam, where more than 50 % of the produce is sold. The leading districts for cassava production include Kisarawe in which most of our surveyed villages fall. Cassava is produced in all districts of the region, Kisarawe leads in producing more than 30-50 % of the total weight of cassava produced for the years indicated Table 2.6.

Efforts are needed to encourage processing of cassava and to improve transportation of cassava to the markets. There is currently a large possibility for developing industrial demand for cassava especially for making biscuits, breads and construction materials. If such programs were implemented, cassava production would outpace charcoal making and tree felling by a lot.[S.M.5]

Table 2.6 Average Annual Production of Cassava by District 1990-2004 Coast Region.

Districts	1990/93	1994/97	1998/00	2001/2004
Bagamoyo	48,000	94,420	85,600	25,068
Kibaha	40,217	47,118	78,040	45,788
Kisarawe	229,250	104,808	209,300	185,150
Rufiji	47,541	56,820	86,450	75,281
Mafia	5,300	4145	13,860	9,933
Total	370,308	301,311	473,250	341,220

Source: Coast region agricultural Department office, Kibaha 2005.

Cashew nut Production: Cashew nuts are a major crop in the Coast region that contributes to more than 30% of the total regional income. As shown in Table 2.7, the Coast region has a total area of 100,000 hectares planted with a total number of 8,339,680 cashew nut trees (1996). The area with cashew trees is equivalent to roughly 33.4 % of the total land area under cultivation. Distribution of cashew nut trees with areas under cultivation for each district is illustrated in the table below.

Compared to the regional cashew nut production figures, the Kisarawe district contributes a considerable share. However, the production of cashew nuts has been affected by poor marketing, hence making it unattractive to farmers. Farmers in the village are cutting their cashew nuts trees to make charcoal rather than harvest cashew nuts, which they fail to sell due to a very low price. Proper marketing for these crops can largely provide incentives to farmers and consequently convince them to shift from charcoal making.

Table 2.7 Distribution of Cashew trees and Area for Each District Coast Region.

District	Area under cultivation		Number of Cashew trees	
	(Ha)	*%*	*Number of trees*	*%*
Bagamoyo	14,000	14	1,206,180	14
Kibaha	17,000	17	1,375,080	17
Kisarawe	19,000	19	1,563,692	19
Mkuranga	35,000	35	2,903,995	35
Rufiji	14,000	14	1,200,733	14
Mafia	1,000	1	90,000	1
Total	100,000	100	8,339,680	100

Source: Coast Region Agricultural Department Office, Kibaha 1997.

Agro-forestry projects as alternative livelihoods potential: Agro-forestation is another area that can provide alternative livelihoods in the Coastal Forests. Throughout the conduct of this study, it became clear that villages adjacent to the Pugu and Kazimzumbwi forests possess ample idle land that will allow development of agro-forestation projects. We have seen that charcoal production and consumption cannot be phased out in the next few years. But development of agro-forestation could be a way to facilitate the pro-

duction of trees for charcoal making. Agro-forestry can provide a wide range of benefits to local people, for subsistence (food, condiments, fuel, construction materials and medicines); cash income (sale of processed or unprocessed products or tree nursery stock); asset-building (for later financing of major lifecycle events, schooling or home improvement); inputs to farming (animal fodder, green manure and climbing poles); services to farming (windbreaks, fencing, erosion control, soil fertility enhancement through nitrogen-fixing or increased organic matter); and aesthetic and cultural values. In the fieldwork visits and interviews, we noted that currently there is a proposal to introduce a new tree product called jatropha. Jatropha is a drought resistant crop that grows like a bush or a small tree with many branches and can reach the height of about 6m. The crop thrives at the average temperature in the area and can grow in areas that receive little rainfall and are not suitable for agriculture. Jatropha can grow in gravel, sand and alkaline soil. Since it requires little water it has a high resistance to drought.

Cultivation of jatropha has a high potential to assist in alleviating poverty of rural people. Its oil has many uses; it can serve as lamp oil and cooking fuel. It can be used to run motorcars instead of diesel and is said to be more environmentally friendly when compared to diesel. The oil is also used in soap, cosmetics and candle manufacturing. Since it can be grown in fallow areas, it also has a strong environmental benefit in helping to fertilize soil and prevent soil erosion. This is a potential investment that can radically change the life of poor communities living adjacent to the forests.

Promotion and Attraction of Clean Development Mechanism (CDM): An additional important area that can provide alternative livelihoods to the majority of the forest dwellers around the Coastal Forests of Pugu and Kazimzumbwi is the Clean Development Mechanism (CDM) projects outlined in the Kyoto Protocol. To benefit from these projects, Tanzania's government has already worked out the guidelines and modalities that will guide investment in such projects. Important benefits that could accrue from CDM activities include:

- Sustainable industrial development;
- Poverty reductions through improved and increased rural income;
- Employment opportunities to the communities;
- Availability of affordable energy sources to the rural communities, improvement of social services such as education, health, etc.; as well as,
- Enhancement of technology transfer and development.

In agriculture, the CDM allows countries to account for management activities related to cropland and grazing land and places no limit on the credits that can be earned. The agreement provides an accounting framework for these activities that not only recognizes sinks but also provides credits when farmers are successful in reducing agricultural sources of GHG emissions. It provides farmers with an incentive to take a whole-farm approach to managing GHG gases and to adopt sustainable land management practices.

Given that the CDM is the only mechanism under the Kyoto Protocol that involves developing countries, Tanzania in general, and the Coastal forest communities specifically need to seize this opportunity and exploit alternative use of their forests. This form of compensation is reflected in the agreement reached on the core elements of the Kyoto Protocol at Marrakech in November 2001. Besides, the Kyoto Protocol acknowledges the contribution of forest and agricultural land management practices that absorb and

store carbon dioxide from the atmosphere towards achieving the Kyoto greenhouse gas emissions limitation and reduction targets.

In principle, the CDM activities will attract capital investment to Tanzania. Many types of projects could potentially contribute to local livelihoods and ecosystem restoration, as well as to carbon emission offsets, including those using natural forest regeneration, agro forests, improved forest fallows and agro forestry. Table 2.8 displays the outlined potential CDM projects in Tanzania.

Table 2.8 shows that charcoal making areas within the Coastal Forests stand to gain from the type of CDM projects proposed by the Tanzania government. Through CDM projects charcoal makers can benefit from appropriate charcoal making technology, which can reduce the amount of trees used in charcoal production by 50% and reduce production time by 60-70%. According to the overview in Table 2.8, other areas covered in the CDM projects are maintaining existing stocks through forest protection and conservation; and expanding carbon sinks by means of afforestation and reforestation, including agro forestry projects.

Awareness campaigns/willingness to switch activities: As part of the overall PREM survey and research a choice experiment (CE) was conducted to determine the willingness of the people in our study area to switch to alternative income generating activities. The survey and the CE shows that forest dwellers consider charcoal making as a means of last resort. The income generated is sufficient to meet the most basic needs, yet the labour conditions are poor and the constant threat of being arrested make charcoal making a relatively unpopular occupation. Moreover, the growing awareness of the increasing scarcity of forests for charcoal making also provide an incentive for alternative livelihood. Therefore, if reliable options for alternative livelihood are provided, forest dwellers in the Coastal Forest of Tanzania proved to be willing to switch to these other types of employment.

Table 2.8 Potential CDM Project Activities in Tanzania.

Project activity	Description
Energy supply	
- Advanced electricity generation technologies	Install 230 MW of combined-cycle power plants instead of simple cycle gas turbine
- Charcoal production	Improving the conversion efficiency of charcoal kilns
- Coal mining	Optimizing Methane release from coal mining
- Renewable Technologies	Use solar collectors, photovoltaic, wind turbines, and biomass energy sources.
Industry	
Cement production	
- Production management	Installation of automatic control systems for reducing the amount of fuel used and improving production efficiency.
- CO_2 recovery system	Installation of CO_2 recovery systems. Recovered CO_2 can be used for other industrial applications.
- Fuel switching	Substitute natural gas for fuel oil in two production plants
- Productions mix	Produce blended cements such as pozzolanic cements, blast furnace slag cement, and Portland cements in order to reduce the amount of fuel used for calcinations and the amount of lime used per unit of cement produced
Pulp and paper	Optimize the recovery boiler in order to reduce both the amount of
- Efficiency improvement	lime and energy used.
Transportation	
- Urban transport	Implementing public transport and introducing City trains in Dar es Salaam
- Fuel substation	Use of Compressed Natural Gas (CNG) vehicles
- Fuel switching	Use renewable energy; biodiesel, biogas, ethanol-petrol blend and fuel cell
Household & Services	
- Cookstoves	Projects that increase the efficiency biomass cookstoves
- Fuel switching	Population to switch from wood Fuel to charcoal to improve cookstoves and/or liquefied Petroleum gas.
Agriculture & Livestock	
- Agricultural practices	Reduce methane and carbon emissions through better fertilizer application, rice cultivation, and loss of organic Carbon from cultivated soils.
- Livestock husbandry	Better husbandry, including better breeding and feeding projects to reduce methane emissions
Land-Use & Forestry	
- Forest management	Maintaining existing stocks through forest protection and conservation; and expanding carbon sinks by means of afforestation and reforestation, including agro forestry projects.

3. Trade

3.1 General background

The trade of charcoal in Tanzania is primarily informal and it is characterized by a high turnover rate. There is no significant warehousing. All stocks produced are promptly consumed. Abundant evidence of the charcoal trade is visible throughout the cities and surrounding regions. Roads are lined with charcoal bags for sale in the centre of the cities, both on the city outskirts as in the proximity of the production areas.

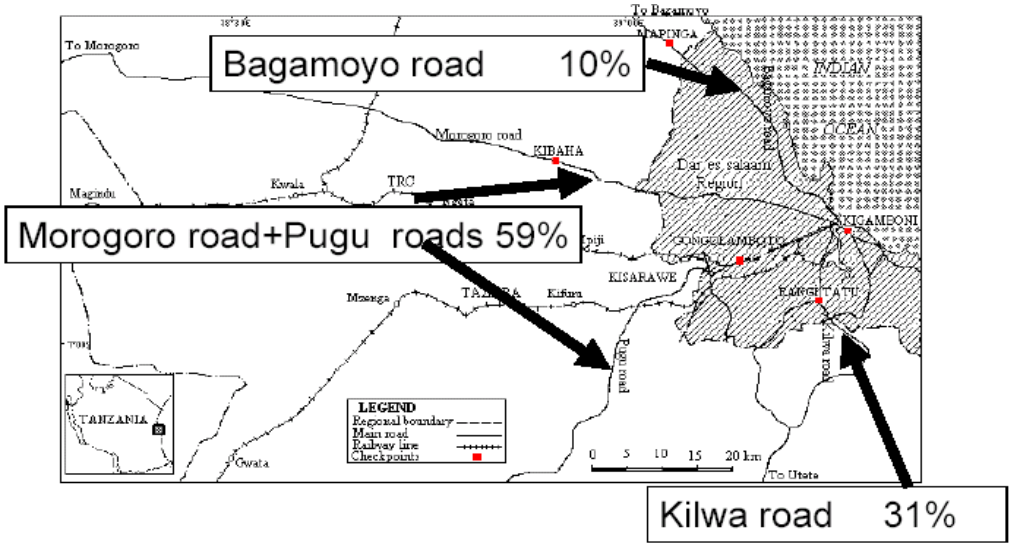
Transport

Almost all charcoal produced in rural areas is transported to the main Tanzanian cities by either trucks or bicycles. Although bicycles account for quite a small percentage of the charcoal transported, they are in common use among rural and semi-urban households linked to the chain. Charcoal producers and business-people trading in smaller amounts primarily use bicycles. The fact that these two categories use bicycles is an indication of their unsteady economic conditions and, consequently, their inability to afford better and safer means of transport.

However, very few producers actually ferry their own charcoal to the cities. Napendaeli, in the "supply –demand chain analysis of charcoal and firewood in Dar es Salaam and Coast region" commissioned by TaTEDO (2004), indicated that more than 60% of the charcoal producers do not transport their charcoal to the markets in urban areas. 36% of them use bicycles to ferry charcoal up to nearby main roads where charcoal dealers come to collect the bags. Only 4% of the producers do hire transport and ferry their charcoal up to wholesalers/ retailers in Dar es Salaam city. They usually do this only when the charcoal production sites are less than 30km from potential markets and there is the opportunity to retain a higher margin of profit there. This is the case in Dar es Salaam, for instance, where there are charcoal production sites along the road to Bagamoyo, in the Pugu Hills area, and Kigambony.

Most of the charcoal produced is ferried to the cities by charcoal dealers. They collect charcoal at the production sites using their own, or in most cases, hired means of transport (i.e. lorries and pick-ups). More charcoal is transported during the dry seasons for reasons related to the larger quantity produced and the better condition of the roads. In the case of Dar es Salaam, the highest amount of charcoal usually enters the city during morning hours (6:00am 12:00 am) through the major routes: Morogoro, Pugu (59%),Kilwa (31%) and Bagamoyo (10%). Note that vehicles carrying natural resource products including other forest products are theoretically not allowed to travel after 6:00 pm. However, only a low percentage of this flow is recorded at the official checkpoints. Checkpoints are located in different parts of the city. The most important ones are Kibaha Maili Moja station along the Morogoro route, Mbagala Rangi tatu station on the Kilwa route, Gongolamboto station on Pugu road and Mapinga on the Bagamoyo road. It has been estimated that only 10% - 20% of the total amount of charcoal entering the city of Dar es Salaam is officially recorded (Napendaeli, 2004).

Figure 3.1 shows the main charcoal routes into the city of Dar es Salaam.



Source: Stockholm Environment Institute (SEI) website – Charcoal potential in southern Africa (CHAPOSA).

Figure 3.1 Principle charcoal routes into Dar es Salaam.

Sale

Once charcoal enters the cities, it is sold at dealer-run outlets, in shops or directly to the end-users. Small businesses, retailers, specialized outlets, kiosks, formal and informal markets, households are some of the available options for selling charcoal. Charcoal is sold in bags of various sizes. Bags of the same size can vary in weight depending on the quality of the charcoal. The most common bag sizes are reported in Table 3.1. In general, good quality charcoal is easily recognizable because of its high density and lustrous black colour.

Table 3.1 Bag sizes and weights.

Unit of measure/bag size	Weight in kg
Lumbesa	55
Gunia	30
Kiroba	15
Sado (10kg)	10
Sado (5kg)	5
Kopo kubwa	2.8
Fungu	1.8
Kopo dogo	0.95

Source: Final report CHAPOSA research project-Tanzania and CEDR.

Usually, bags are larger at the points of production. The average weight of a bag purchased at the kiln site, or just delivered from it, is about 53 kg. After entering the city, charcoal is repacked into smaller bags to be sold to the end-users. The repackaging is done not only for marketing reasons (i.e. households normally buy daily in small quantities), but also to save money on taxes. Taxes are charged on a per bag basis, regardless of the weight and/or volume. Moreover, the quality of charcoal in larger bags is generally of a higher quality because their contents have not been adulterated. When a dealer packs smaller bags for re-sale they often mix good pieces of charcoal with smaller pieces of lesser quality.

Contrary to what has been is noted in some reports (TaTEDO and CHAPOSA), PREM found that dealers tend to sell charcoal in large bags at comparatively higher prices. The study provides a threefold explanation. First that the most expensive bag in terms of price per kilo is the gunia, which is also the most commonly purchased bag, thus dealers can make the most profit from this unit of measure. Secondly, gunias are normally purchased by those with a higher income, at least in the commercial sector, thus they can afford to pay the higher per unit price. Thirdly, the bags of smaller size normally have smaller lower quality pieces of charcoal. Table 3.2 provides a detailed look at the average price per kilo among the different bag sizes.

Table 3.2 Price per kilo for different bag sizes.

Unit of measure/bag size	Price per kg
Lumbesa 55kg	300 Tshs
Gunia 30kg	338 Tshs
Kiroba 15kg	282 Tshs
Sado 10kg	102 Tshs
Sado 5kg	93 Tshs
Kopo kubwa 2.8kg	122 Tshs
Fungu 1.8kg	144 Tshs

3.2 Social and cultural domain

Actors in the chain

Charcoal trading is a key segment in the supply/demand chain, and the dealers are the key actors in this regard. While a detailed profile of the small dealer/cyclist can be found in the CHAPOSA report (2002)[5], a similar profile of a medium to large dealer is not available. Despite the relevant role of the large dealer, this type of trader remains the least known actor of the chain. Nonetheless, data from the PREM survey on charcoal trade in the city of Dar es Salaam, Tanzanian NGOs' reports on the charcoal chain and fieldwork observations confirm the crucial role dealers have in coordinating and financing production, transport and sale. They also recognize their function in selecting and negotiating with the producers, interacting with the government officials and in some cases dealing directly with the end users.

Most charcoal dealers reside in large and dynamic cities like Dar es Salaam and operate their business from there. This allows them to be in close contacts with the end markets and maximize any profit opportunity. Entering the trade is fairly easy. It entails having a low starting and operating capital as well as basic marketing skills and contacts with producers in the forests. Only a minority of the people involved in the trade has actual technical expertise on charcoal production per se.

As noted before, a limited number of dealers own their own vehicle. Usually, they hire trucks when needed. This is not an obstacle for the dealers' marketing activities, given

[5] A typical charcoal dealer/cyclist is male, in his mid twenties-thirties, residing in the peri-urban or rural areas adjacent to the city. His job consists of transporting and selling charcoal at the inner edges of the city. The bicycle is his main asset. He works for six days a week from 5:00 am to 10:00 pm and conducts his business two to three times a week.

the fact that they generally interact with their selected network of producers. Dealers prefer light open trucks with a carrying capacity between 3 and 5 tonnes. In the case of Dar es Salaam, trucks transport over 80% of the daily charcoal flow, whereas bicycles represent only 10% of it (see Table 3.3). Note that a bicycle can carry up to two large bags of charcoal weighing from 50-70 kg each (CHAPOSA, 2002). These statistics confirm the limited role of producers and small dealers in the charcoal trade.

Table 3.3 Proportion of Means of Transportation used to ferry charcoal to Dar es Salaam per day.

Transport Means	Percentage (%)
Pickups	8.37
Light Trucks (3-5 tones)	53.53
Medium Trucks (6-10 t)	26.84
Heavy truck (>= 11 tones)	1.01
Other vehicle (e.g. tractors)	0.16
Bicycles	10.10

Source: TaTEDO

3.3 Economic domain

Earnings, prices and profits

To enter the charcoal business, dealers generally need a low start up capital. The 2005 PREM assessment among traders in Dar es Salaam quantified it in the range of 50,000Tshs - 800,000Tshs ($50-$800).

Dealers are also expected to pay 50,000 Tshs, every year, to buy the trading license. However, considering the informal structure of the business, few traders actually pay the licensing costs. In addition, dealers pay for transport and taxes. The CHAPOSA report (2002) gives transportation costs of about 1,000-1,200 Tshs per bag. The cost of transport decreases if the charcoal is collected from fewer points. This forces charcoal producers to cluster in the same geographic areas or produce in larger quantities in order to minimize the dealers' transport cost and, consequently, maximize their selling opportunities. Instead of making small kilns due to decreased wood stocks, charcoal producers now tend to make bigger kilns (44 bag kiln) [S.M.6]to attract traders.

It has been noted that when charcoal is used for centralized, urban markets, it is likely that transport distances will increase over time, as nearby stocks of forests are depleted. As a result, transport cost is expected to represent a much greater amount of the total cost. Information obtained from the Forests and Beekeeping Division in the Ministry of Natural Resources and Tourism (2001) indicates, for instance, that Dar es Salaam's charcoal supplies come from within a radius of 100 - 150 km, from Coast and Morogoro Regions. In general, the sites have shifted from 50km in the 70s to about 200km in the 90s. In line with what has just been said, we recorded a ferrying cost from the production sites to the city of Dar es Salaam of about 4,000 Tshs per bag.

As for the taxes, dealers in Dar es Salaam pay on average 1,600 Tshs per bag, regardless of its weight and/or volume. A more detailed outline of the tax system is provided in section 3.5.

Despite the reported costs, being a charcoal dealer remains a lucrative activity. In fact, thanks to their strategic position in the chain, the dealers retain the highest margin of profit and are far better off than the producers and any other secondary intermediary. However, it is worth pointing out that the profit is not large enough to afford the cost of new vehicles. According to our 2005 survey on charcoal trade in the city of Dar es Salaam, dealers buy a bag for 2,000 to 3,000 Tshs ($2-$3) at the production site and sell it for 10,000 Tshs ($10). This variation mostly depends on accessibility which in turn is determined by weather conditions, means of transport used, taxes payable to different authorities and, of course, the margin of profit. Price differentials exist not only between production sites and end markets but also among different locations in the city.

PREM's most recent study provides a clear overview of the price differential and of how charcoal prices reflect the character of the business (Hess *et al.* 2006). In the forest a gunia (30kg bag) would fetch a price of 1,000-2,000 Tshs. Just a few meters outside the forest, the same bag would already be sold for 3-4,000. This variation in price is justified by the risk one incurs by carrying charcoal out of the forest. The risk of being fined and have the charcoal confiscated is, therefore, translated in a premium of about 2,000 Tshs. Within the Dar es Salaam region, but outside the actual city, at Gongo la Mboto, a gunia costs around 7,000 Tshs. This market is located just before the checkpoint where taxes are paid. In the city itself the price is 10,000 Tshs.

A strong increase in dealers' profits has been recorded as a result of the ban on charcoal imposed by the Tanzanian government in February 2006. After the imposition of the ban, large stocks of charcoal were left at the production sites, as it was difficult to get the charcoal into the cities. The induced scarcity and the consequent unsatisfied demand raised the price of charcoal artificially. However, while the price at which dealers and retailers sold the little charcoal entering the cities rose sharply, the price at the production sites remained stable since it was difficult for the producers to get buyers. After the ban was lifted, charcoal trading went back to normal but the sudden and abundant demand caused an increase in price at the production sites.

In the case of Dar es Salaam, we calculated that the selling price for the dealers rose from 10,000 Tshs to 15,000 Tshs as a reaction to the ban and remained unchanged after the ban was lifted. This means that in the post-ban period the dealer's profit slightly diminished due to the rise in price at the production sites (from 3,000Tshs to 6,000Tshs) but was in any case significantly higher than the initial period.

Overall, the potential profits and the comparatively low initial and operating costs related to the charcoal trade attract more and more people every year. Though a reliable estimate of the people employed in this sector is not available, given the informal and unstructured nature of this business.

3.4 Environmental domain

As mentioned in the previous sections, the highest percentage of charcoal enters Tanzania's main cities on trucks. In most cases, they are old and cause excessive emissions due to the partial combustion of fuels. Among the substances released, CO, CO_2, NOx and SO_2 are the most dangerous. The quantity of emissions is not known. In the case of Dar es Salaam, for instance, it has been noted that 27% of the total charcoal hauled to the city is ferried on vehicles registered in the 1980s (CHAPOSA, 2001). A common explanation

for using old vehicles in charcoal transportation is that charcoal trade does not generate enough profit to pay for the upkeep and purchase of new vehicles.

In any case, old and malfunctioning trucks not only contribute to the already high level of urban pollution, but they are also a major cause of noise pollution and road accidents. Finally, dumping of charcoal dust around charcoal depots has significant impact on the aesthetic appearance of the surroundings but, more importantly, also increases the risk of water sources pollution.

3.5 Legal and institutional domain

Taxation

In the previous chapter, it was highlighted that the law governing forest utilization does not directly impact the production of charcoal, as it is regarded as a secondary product obtained from harvested or gathered timber. Therefore, the only way the government can control and get revenues from the charcoal business is through the tax system. However, only the charcoal for commercial sale is taxed. This is easily identified because it is transported in large quantities by trucks (about 80 bags of 30 kg or more per truck).

Taxes, as already mentioned, are charged on charcoal traders and paid at official checkpoints. Truck drivers usually pay on behalf of the charcoal dealers. For instance, in 2005 the average tax in the Dar es Salaam region was 1,000 Tshs per bag, of which about 700 Tshs was a central government levy while the remainder was a district levy. In 2006, the average tax was about 1,600Tshs.

Monitoring and enforcement

Tax evasion in the trade segment of the charcoal chain is a common practice. It is done to keep the final price low, attract more consumers and, as a result, maximize the profit of the charcoal traders. Dealers claim that, in dry seasons, levies can wipe out their profit entirely because of the higher prices at the production sites. Overstuffing bags and transporting charcoal overnight or hidden in vehicles are some of the most common means to evade taxation. Moreover, as in the case of Dar es Salaam, traders take advantage of the differences in tax levels among districts (Ilala, Temeke, Kinondoni). They manage to pay taxes in the lowest charging district, despite their charcoal being produced in areas adjacent to districts with higher fees/royalties.

Lax monitoring at the checkpoints by the government officials is also a major cause of uncollected government revenues. In the case of Dar es Salaam, for instance, it is estimated that only 10%-20% of the total amount of charcoal entering the city is recorded (Napendaeli, 2004). The remaining 80%-90% bypasses government checkpoints unchecked. A considerable amount of charcoal bypasses the official controls when transported by bikes. Paradoxically, this flow of charcoal is considered perfectly legal based upon the fact that charcoal transported by bike is assumed to be for personal consumption. The national forest policy establishes that extraction for household use does not require a license and, consequently, no tax should be paid on forest products obtained from this activity. Military loads are also unrecorded (CHAPOSA, 2002).

All this reinforces the notion that the Tanzanian charcoal tax system is not effective and fails to collect a considerable amount of revenues that could be efficiently invested in forest protection. Nationwide, it was calculated that the government, through the Forest

and Beekeeping Division (CFBD), could have collected 17.5 billion Tshs ($17.5 million) in the year 2002, only if effective revenue collection would have existed at all check points[6]. Calculations were based on the assumption that 43.7 million bags weighing 28kg were produced and 400 Tshs ($ 0.4) was collected as royalty for each bag (CFBD, 2000). Although levy taxes per bag vary from one district to another, most of the district Councils apply the same levy as that by the Ministry of Natural Resources and Tourism which is 400 Tshs per bag. Other taxes are paid to the Central government (400 Tshs per bag) and to the city municipal (100 Tshs per bag) (CHAPOSA, 2002).

PREM's most recent estimate of the government's lost revenues due to tax evasion has been calculated in the city of Dar es Salaam, which accounts for almost 50% of the national consumption (Massey and Di Prima, 2005). As shown in Table 3.4, it was estimated that the commercial sector and the households combined generate a total annual consumption of 530 million kilograms of charcoal or 17.6 million gunia (30kg bag). Considering that each bag entering the city was taxed 1,000 Tshs ($1) on average, PREM estimated annual revenue of 17.6 billion Tshs ($17.6M) for the city of Dar es Salaam alone. Conversely, the Dar es Salaam City Commission in 2004 recorded the total number of bags entering the city annually at 5.6 million gunia[7], with corresponding annual revenue of only 5.6 billion Tshs ($5.6M). This equals a loss of 12 billion Tshs ($12M) in potential revenue.

Table 3.4 Comparison between official and estimated annual flow of charcoal into Dar.

	Official Records (2004)	CHAPOSA (2002)	PREM Estimates (2005)
N° of Gunias	5.6 M	15M	17.6M
Revenues in Tshs	5.6 Billion ($5.6M)	n/a	17.6 Billion ($17.6M)

Licensing

Linked to the topic of taxation and the inability of the government to raise the expected revenues from a business that accounts, nationwide, for over 218.5 billion Tshs (Sawe, 2002), is the ineffectiveness of the licensing system. In order to operate their business charcoal dealers have to acquire a license from the Natural Resource Department. The license is obtained at the beginning of every financial year at a total cost of 50,000 Tshs. The license has to be renewed annually. However, given the informal structure of the business and the lack of enforcement from the government side, very few traders actually buy a license and if they do they tend not to renew it due to the high transaction costs of a highly centralized system.

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6 See "an overview of charcoal industry in Tanzania-issues and challenges" E.N.Sawe-TaTEDO, 2004.

7 This is far below the PREM estimates and those of CHAPOSA who estimate total demand in the city to be 15 million gunia. The 2002 CHAPOSA report focuses on the demand for charcoal among households, while they consider the commercial sector in their estimate for the total end-user demand for charcoal in Dar, they did not conduct a detailed survey. Nevertheless, the similarity in the scale of demand between the PREM report and that of CHAPOSA lends credence to PREM calculations.

3.6 Policy domain

Although we haven't researched this issue elaborately from the point of view of policy efficiency, it seems as if the Tanzanian government has failed to address the problem of the limited sustainability of the charcoal chain adequately. The drastic ban at the beginning of the year confirms the government's inadequacy. On the basis of the limited information available to us, we observe the following:

- The potential revenues should serve as the biggest motivator for increased oversight of the charcoal business and consequently the government should devise an effective method of revenue collection;
- In doing this, the government should take into account the interests of the various actors involved in the chain, such as the Forest Division, local communities, producers, dealers, retailers and consumers, etc;
- In the interest of government revenues that can be used to manage the forest, the aim is to establish a mechanism of *earmarked taxation* whereby each actor holds a fair stake and the revenues collected are directed back to the management of different aspects of the chain. This would formalize and regulate the charcoal trade industry and, most importantly, ensure the sustainable management of the resources;
- Finally, the government should address the problem of the enforcement of the inefficient tax rules in combination with a rise in the level of taxes levied on charcoal (increase revenues).

4. Consumption

4.1 General background

Charcoal is consumed almost exclusively in urban and peri-urban areas. In rural areas where charcoal is produced, people normally use firewood. Consumers buy charcoal from various sources, such as stores, markets, kiosks, trucks and bike sellers, located along the roads in the proximity of the production areas as well as in the city centre. In most cases, they burn charcoal in conventional stoves to satisfy their cooking needs.

In 2002, the population census reported that the Tanzania urban population was more than 8 million people. About 85% of it (6.8 million) used charcoal as its primary source of household energy and cooking (Sawe & Iiskorg, 1999). With a total population of over 3.5 million and the largest number of commercial enterprises, Dar es Salaam's charcoal intake represents about half of the national urban demand.

Households represent the most relevant source of charcoal demand in the city by far. Several studies have given different estimates on the percentage of Dar es Salaam households depending on charcoal as a source of energy for cooking purposes. According to the 2002 CHAPOSA study carried out by the Stockholm Environment Institute, households[8] account for the 69% of the total demand and generate an annual consumption of 365 million kilograms. Other estimates include TaTEDO (2001) estimated at 85%, and Ishengoma and Ngaga (2001) at 86% of the total demand.

The second largest consumer of charcoal is the commercial sector, which consists of petty food vendors, mamantilie (makeshift eateries) and restaurants/hotels. Charcoal is also used by small-scale industries which include small textile finishers, food processing industries (breweries, smokeries, etc), agro-processing industries (tobacco curing, tea drying and beeswax processing industries) and industries involved in the production of building materials (burnt bricks, lime, smiths, foundries, pottery and ceramics). Whereas the service sector, which consists of secondary schools, colleges, hospital/health centers and prisons, as well as institutions, represent a marginal share of the total demand for charcoal. We estimate the total number of commercial enterprises[9] in Dar es Salaam to be nearly 42,000, 63% of which are unlicensed.[10] As much as 99% of the commercial entrepreneurs interviewed in the PREM survey claimed to use charcoal in some capacity while only 28% used electricity. As a whole they account for about 31% of the end-user demand for charcoal. This translates into a total annual consumption of 165 million kilograms of charcoal with an average annual expenditure of 33 billion Tshs ($33M).

4.2 Social and cultural domain

Population growth

Charcoal is the single largest source of energy in urban areas of Tanzania. Far from decreasing, the use of charcoal has grown, especially in Dar es Salaam. Empirical surveys (see for example, TATEDO, 2002, CHAPOSA, 2002) suggest that Dar es Salaam consumes about 50% of charcoal consumed nationwide. At the heart of the issue of demand is the growing population of the country. For Tanzania as a whole, population has grown monotonically from about 10 million in the 1960s, reaching over 34 million in the last census of 2002.

The analysis of demand for charcoal presented in this section is crucial for three major reasons. First, the demand for charcoal in both Dar es Salaam and Coastal Regions has grown over time. To satisfy the ever-growing urban demand for charcoal, wood is taken illegally from state land of Pugu and Kazimzumbwi forest reserves, making charcoal production one of the major causes of deforestation. Second, while energy policies for urban areas have nearly always been supply driven, in the expectation that urban economic development would allow for an upward fuel switching to fossil based fuels or electricity within a relatively short period, there is no evidence that charcoal will phase out in urban areas, including Dar es Salaam. Far from decreasing, the use of charcoal has remained constant or grown, especially in Dar es Salaam.

Table 4.1 describes trends in charcoal demand over the period 1978-2001. The amount of charcoal reported is based on per capita consumption of charcoal reported in previous

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[8] In the CHAPOSA report, an average household consists of 5.7 people and its average daily consumption is estimated to be 2.8 kg. The consumption per household has gone up since the early 1990s, probably because of an increase in the price of alternative commercial fuels.

[9] A detailed profile of the small commercial enterprises in Dar es Salaam can be found in the PREM report 2005. Briefly, commercial enterprises vary in size. They range from micro with 0-4 employees to medium 31-99 employees. The majority, 60%, are micro. The average number of working days per week is 6.5. The available fuel mix consists of charcoal, wood, electricity, kerosene, and various forms of wood and plant waste.

[10] No official government records exist listing the total number of commercial enterprises.

studies (see for instance TATEDO, 2000, 2002). The results reveal that charcoal demand was about 3 million bags[11] in 1978, when population size in Dar es Salaam was 0.7 million. Twenty-five years later, the consumption of charcoal is about 14 million bags with the population reaching 2.8 million. This is equivalent to a four-fold increase. By 2005, PREM estimated the total consumption to have reached over 17 million bags.

Table 4.1 Trends in Charcoal Demand and for Urban Dwellers in Dar es Salaam

	1978	1988	1998	2001
Total Population	730,000	1,370,000	2,200,000	2,800,000
Number of households	169,767	318,605	511,628	651,163
Number of Charcoal Bags	3,734,874	7,009,310	11,255,816	14,325,586
Cubic meters Consumed	876,000	1,644,000	2,640,000	3,360,000
Growth in Demand (%)	NA	87 %	61 %	27 %

Source: National Population Census (1978-2002), charcoal demand figures are computed using the per capita consumption estimated in the study area.

Reasons to use charcoal

Charcoal is deeply ingrained in Tanzanian people's daily life and is used by all income levels. In addition to it being the most affordable fuel in the cooking ladder for many low-income people, especially in urban areas, consumption of charcoal is also a matter of culture and tradition. The majority of urban and peri-urban people use charcoal because of its availability, reliability of supply, and low initial investments costs; traditional charcoal stoves are quite inexpensive and need almost zero maintenance. Charcoal is also preferred due to its high calorific value per unit of weight, cooking properties and the particular traditional taste food gets when cooked on it.

Consumers can easily buy charcoal all year round during both the dry and rainy seasons, even though the price is slightly higher during the rainy season. The purchasing choice is based upon quality, price and convenience.

Charcoal is often used in combination with kerosene and more rarely with electricity. However, both kerosene and electricity have comparatively higher prices than charcoal and are mainly used for lighting. Electricity, in particular, is almost exclusively a privilege of high-income groups. The increase in the price of alternative fuels partly explains the increase in the household charcoal consumption since the early 1990s.

Due to the above favourable factors and lack of affordable alternatives, charcoal is expected to continue to be a major source of household energy for cooking in urban and peri-urban areas of Tanzania for the foreseeable future.

4.3 Economic domain

Prices

As stated in the chapter on trade, charcoal is sold, especially in urban areas, in bags of different sizes and consequently at different prices. Among restaurants and commercial enterprises the larger bags (i.e. 30 kilograms or more) are the most frequently purchased. Interestingly, these bags have the highest price per kilogram. Presumably this is due to

[11] A bag of charcoal weighs around 30kg. This weight refers to all bags mentioned in the report.

the fact that those who buy in larger quantities can afford the higher price. Individuals, households, and micro-enterprises tend to buy charcoal on a daily basis and purchase bags of smaller quantities. Table 3.2 outlines the price per kilo for different types of bags.

Looking at charcoal price trends, our analysis shows that between 1995 and 2001 the price remained relatively flat. From 2002 the price began to steadily increase, almost doubling by the end of 2006 (see Figure 4.1). On the one hand, this can be explained by the increasing scarcity of charcoal. On the other hand, the ban imposed on the transport of charcoal in February 2006 (since repealed) has had a major influence on the rising charcoal price. During the ban charcoal traders, those acting as middlemen buying charcoal from the forest producers and selling to charcoal merchants in the city, were loathe to conduct business. This led to large stockpiles of charcoal at production sites and shortages in the cities. When the ban was lifted, producers began charging more for their product. Figure 4.1 shows prices before, during and after the ban.

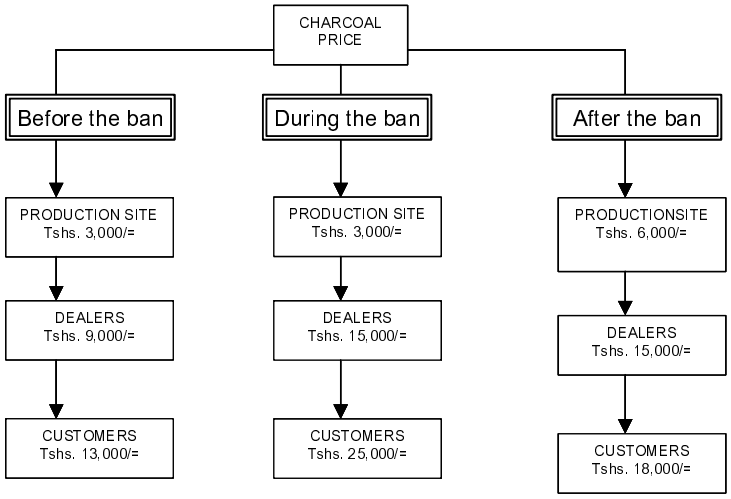


Figure 4.1 Price trends of charcoal before, during and after ban.

From our study among commercial enterprises of Dar es Salaam we found that the demand of charcoal is rather price inelastic. Most respondents to our survey claimed they would continue to buy charcoal even if the price doubled. For a detailed look at price elasticity of charcoal among commercial enterprises see Massey and Di Prima (2005). The inelasticity of charcoal prices can be directly related to the price of alternative fuels. While kerosene, LPG and electricity are existent and viable alternatives, their price as related to charcoal has remained higher over the years. This has been shown in Figure 4.2.

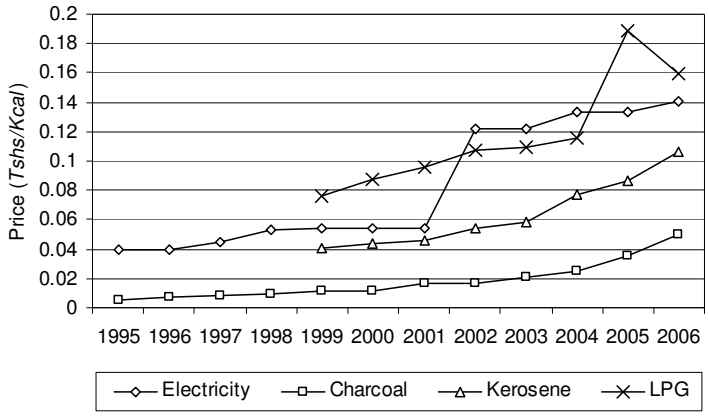


Figure 4.2 Price trends of fuels per Kcal 1995-2006 in Dar es Salaam.

The fact that these alternatives remain outside the purchasing power of most individuals provides an indication of the level of poverty in Tanzania. Figure 4.3 shows the percentage of people living below the poverty/food line. The food poverty line is the minimum expenditure required to attain basic food needs.

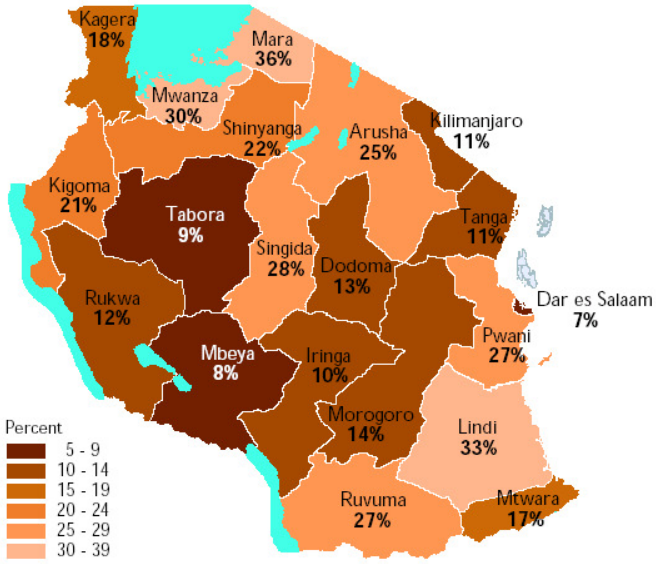


Figure 4.3 Poverty map showing share of population below the food poverty line.

4.4 Environmental domain

Human health impact

Burning charcoal produces carbon monoxide. The severity of impacts on human health depends on the size and design of the stove used, the time of exposure and the ventilation available. In the case of small and poorly ventilated houses, like the ones in which most Tanzanians live, indoor charcoal usage causes dangerous air pollution, resulting in several casualties each year. The most affected are women and children. They are exposed to elevated concentrations at least three times a day. It is estimated that the carbon monoxide content of gaseous emissions from traditional charcoal stoves range from 0.3% to 0.9%. These percentages are alarming considering the fact that the European safety emission standard recommends a maximum exposure of 0.005%.

Environmental awareness

While there is little awareness of the risks associated with indoor charcoal usage, environmental awareness about the impacts of charcoal consumption seem quite strong (at least among commercial enterprises that use charcoal). Of the respondents to our 2005 survey, 68% stated that there would be less charcoal in the future. The majority attributed the future anticipated scarcity to deforestation, showing sensitivity to the impact of unsustainable forestry activities. On the other hand, as to the provenance of their charcoal (especially high quality charcoal, which usually originates from trees in protected forests[12]), there was little knowledge: 62% of the commercial enterprises interviewed had no knowledge of the provenance of their charcoal and 75% said that they did not know that high quality charcoal, in general, comes from protected forests.

4.5 Technological domain

Stoves

Types of stoves used to burn charcoal vary considerably in size, shape and design, depending upon their intended use. The majority of charcoal burning stoves is used for cooking and tends to be simple and crude. Most are homemade or otherwise handmade, are inexpensive and require almost zero maintenance. They generally consist of an uninsulated metal basin (flat or convex) with legs attached and sometimes a top; there is no common standard design. These types of stoves are highly inefficient and radiate their heat in all directions. So-called “improved” stoves exist and tend to be convex in shape and insulated on all sides save for the cooking area. Because of their insulation, these stoves are much more efficient and require less charcoal to generate heat and retain their heat much longer. There are NGOs in Dar es Salaam, TaTEDO being one of them, that specialize in designing and promoting these stoves. According to the CHAPOSA report, 51% of the households in Dar es Salaam use conventional charcoal stoves, whereas 41% utilizes improved stoves. Several households have both types, the conventional stove being used as a backup or in the case the improved one is damaged.

While usage of the improved stoves is increasing, their popularity is still quite limited. In fact, not only are improved stoves heavier and less durable than conventional stoves, but also their cost is also higher than what one can make or find at local markets. Gas and gas stoves are available, however, their average price is far above what most Tanzanians can afford. One company sells gas stoves for domestic and commercial usage beginning at 68 Euros apiece.

4.6 Legal and institutional domain

The usage of charcoal in Tanzania is completely unregulated. As stated above, there are NGOs that specialize in designing and promoting more charcoal/energy efficient stoves. TaTEDO, in particular, is active in lobbying for supportive policies that enhance provision of better energy services, facilitating/strengthening the development of renewable energy related to SMEs through business support and in partnership with financial insti-

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[12] Trees in protected forests tend to be older, larger and denser thus more suitable for making very high quality charcoal.

tutions, providing technical extension services, facilitating SMEs linkages with technical/business/market development and training institutions

4.7 Policy domain

Tanzania's Energy policy, amended by the Ministry of Energy and Minerals in 2000, places emphasis on the development and efficient utilization of indigenous energy resources in order to reduce dependence on imported energy and pressure on natural forests. The goal is to ensure adequate, environmentally safe, affordable and sustainable energy supplies for economic growth and social development. In particular, it promotes the exploitation of hydroelectric power sources, the implementation of more efficient wood fuel technologies and the use of treated coal for domestic purposes.

Since independence, Tanzania's government has attracted substantial investment in commercial energy sources. Petroleum, hydropower and coal are the major sources in the country.

Petroleum and natural gas

Petroleum is imported. The transport sector is the main consumer of petroleum products. Presently, only 70 per cent of the demand for petroleum is met. There are a number of companies exploring for oil, but so far there have been no positive results. However, natural gas is likely to be the substitute for oil. There might be initial difficulties to promote the use of natural gas, but the potential is very promising. The total proven reserves of natural gas at Songo Songo range from 0.8 to 1.0 Tcf. 0.8 Tcf of natural gas is sufficient to fuel 500 MW of combined cycle generation for about 33 years. Natural gas has also been found in the Mnazi Bay. Yet, the reserves are uncertain and while the field is located too far from the main electric grid there are plans for development of a 15 MW plant to supply a local mini-grid in the Lindi and Mtwara regions.

Capacity-wise, most of the charcoal demand, especially in Dar es Salaam, can be easily met with gas supply when all necessary requirements are in place. Currently there is a company named ORYX, which is promoting use of gas. This company sells gas stoves for domestic and commercial purpose. Efforts are under way to design more programs to enhance use of gas. It remains to be studied whether the natural gas can be a direct substitute for charcoal, or whether the natural gas can only be utilised to generate power, which in turn can form the fuel source for cooking.

Hydro-power

Electricity in Tanzania is mainly generated through hydropower - which is prone to drought effects- so some thermal power stations have been installed. There are plans to connect the neighbouring countries of Zambia and Uganda to the national grid to boost the supply of electricity. Only three quarters of the country (mainly urban areas) is connected to the national grid. There is an intention to connect the rest of the country (i.e. an estimated 8,200 villages). If such intentions are met, this could be a precondition for curbing deforestation. Tanzania has a per capita electricity consumption of 46/KWh per annum, growing at the rate of 11 – 13% annually. Hence, the government is encouraging investment to expand the generating capacity, the distribution system and developing indigenous sources of energy.

Coal

Tanzania has significant quantities of coal, which can be developed to mitigate the reliance on charcoal. Proven coal reserves in Tanzania are estimated to be about 159 million tons. The coal sites include Kiwira, Northwest of Lake Malawi and Mchuchuma/Katewaka on the southeast of the lake. The Mchuchuma/Katewaka coalfield is located about 750 km inland in the south-western part of Tanzania. The proven reserves at Mchuchuma are reported to be more than sufficient to fuel a power plant of up to 400 MW capacity for a period of 35 to 50 years.

Renewable energy

Given the high environmental and social cost of charcoal production and the fact that the deforestation impact of charcoal production has reached a critical level, Tanzania is also promoting the use of alternative renewable energy sources. In addition to major hydroelectric, thermal stations and geothermal generation projects, Tanzania has the potential to generate power from:

- Wind Energy
- Solar Energy
- Biomass
- Mini Hydro

A comprehensive national strategy of sustainable energy should focus on all these alternatives to relieve charcoal use. Table 4.2 summarizes the current energy supply mix in Tanzania.

Table 4.2 Energy supply pattern in Tanzania.

Energy source	Supplied source	Supplied capacity	Remarks
Electricity	Hyro	557 MW	Only 10% of the population has access to electricity. Of which only 1% of rural area is electrified.
	Thermal	202 MW	
	Isolated diesel systems	28 MW	
	Independent power producers (IPP) Kiwira Coal Mines and Tanganyika Wattle Company	4 MW	
	IPP diesel plant	100 MW	
	Import from Uganda	8 MW	
	Import from Zamabia	5 MW	
Petroleum	Imported petroleum products (Petroleum, gasoline and kerosine)	1.2 million tones	Uses 26 % of the total export value of the country. 92% of the imported kerosene is for household.
Natural gas	Songo Songo	30 billion cubic meters	
	Mnazi bay	15 billion cubic meters	
Renewable energy	Biomass energy		Account for 90% of energy consumed in the country. Operated in the informal sector
	Micro-hydro		Characterized by low level of awareness, high facilities import duty and lack of adequate design, manufacture, market and distribution capacity.
	Geothermal		
	Wind and Solar PV Biogas		

Source: TaTEDO

Subsidies

In theory, direct energy subsidies can be provided to low-income households. They usually spend a higher fraction of their income on energy compared to other groups. In the case of charcoal, they pay more for the same level of energy use because their appliances are generally less efficient than those used by wealthier households, and also because low-income households usually purchase fuel in smaller (more expensive) amounts. However, in the context of Tanzania, energy subsidies are ineffective in assisting poorer households. In most instances, they receive only a small fraction of the total subsidy given. For example, in the case of kerosene, subsidies usually benefit wealthier households who can afford to buy it (Hosier and Kipondya, 1993; Hoogeveen, forthcoming). Therefore, subsidies on energy have not the desired effect for the poor.

5. Conclusions and policy recommendations

5.1 Introduction

The high reliance on charcoal makes Tanzanian producers, traders and consumers vulnerable to environmental problems such as deforestation. Increasing the sustainability of the charcoal chain in Tanzania calls for a comprehensive approach that includes a multitude of dimensions (e.g. technological, economic, social and environmental). At present, the development of such a comprehensive policy is hampered by lack of information about the charcoal chain as well as the limited recognition of policy makers in Tanzania of the interdependencies between the segments within the charcoal chain.

This paper aims to provide a comprehensive analytical overview of all three components of the charcoal sector: production, trade and consumption. This overview contributes to the development of a comprehensive policy regarding the role of charcoal in Tanzania's energy strategy. In this concluding Section, the main findings of the study are emphasised and policy recommendations are formulated for the improvement of the sustainability of the charcoal chain in Tanzania.

5.2 The charcoal chain is a massive industry

Our new calculations show that the total revenue generated by the charcoal industry for Dar es Salaam alone amounts to 350 billion Tshs ($350 million) and generates employment for more than a million workers. These facts combined with an estimated clientele covering 85% of the urban population (Sawe, 2004) makes the charcoal chain a core sector for the Tanzanian economy. To increase our insights into these large numbers, we assembled a graphical representation of the charcoal chain for Dar es Salaam in 2006 (Figure 5.1), based on various sources of information, addressing quantities, prices as well as employment levels.

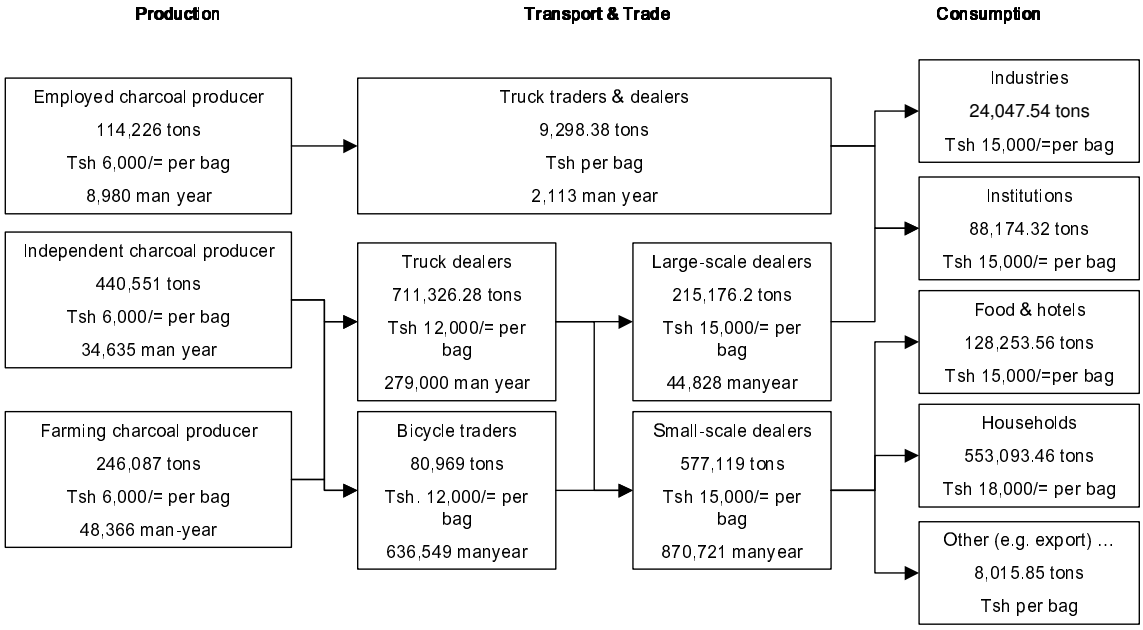


Figure 5.1 Charcoal production, trade and consumption per year in Dar es Salaam.

The vast magnitude of the industry means that changes in the sector can only be realized gradually with a comprehensive approach as a basis. The charcoal industry has been present since the 1970s and cannot be transformed or eliminated overnight. A more gradual approach is needed, in which policy interventions are properly prepared, and the involved stakeholders are sensitized to the situation.

5.3 Charcoal is a means of last resort to escape extreme poverty

While forests in general and the Coastal Forests in particular remain the sole source of livelihoods to millions of Tanzanians, they continue to be heavily deforested, partly by the poor who live adjacent to them and partly by the forest product dealers for commercial and subsistence purposes. The demand for forest products is determined by factors such as the total population, household size, cooking methods, prices and availability of alternative fuels, and household income. Thus, deforestation and poverty are strongly linked: any destruction of these forests points to reduced livelihoods of the poor depending on them.

The survey among charcoal producers reveals a number of new insights into the characteristics of charcoal makers. First, charcoal forms the most important source of income to different people involved in the chain (i.e. full-time producers, subsistence farmers, employed producers). Second, environmental awareness is high among the charcoal producers, but their poverty leaves no alternative but to continue the profession of charcoal making. Charcoal producers are willing to shift to alternative livelihood options, but these are currently not available. Conditions that facilitate a shift away from charcoal include the improvement of agricultural efficiency and a better access of the rural communities to markets for agricultural products, so that producing for these markets provides an alternative cash income. Third, the current kiln efficiency is extremely low. This deficiency enhances the rate of deforestation. Projects supporting the improvement of kiln efficiency would greatly support local communities as well as the environment.

5.4 Charcoal induced deforestation causes ample externalities

The high rate of deforestation is expected to have substantial off-site hydrological impacts, including local flooding, (gully) erosion, sedimentation of streams and reservoirs, and drying up of the water sources. The proximity of forests to the main city of Dar es Salaam, increased pressure from demand for farming land, expanding furniture and construction sectors due to the population explosion, rapid urbanization and above all charcoal demand, are among the major threats to the existence of the Coastal Forests.

In recent years, water resources feeding into the hydro-energy plants have diminished substantially. As a result of this water crisis, electricity supply to the main capital Dar es Salaam was jeopardized significantly. The rapid rate of deforestation was seen as one of the main causes of this crisis. Being aware of this relationship, the Tanzanian government officially banned the production of charcoal in February 2006.

Because of the suggested relationship between hydrological conditions downstream and the state of the forest upstream, innovative economic instruments such as Payments for Environmental Services (PES) should be considered. PREM has made the primary investigations for the implementation of a PES scheme in the Coastal Forest region, while a collaborative effort by WWF, CARE International and PREM is ongoing in the Uluguru Mountains. These initiatives could serve as a basis for future policies.

5.5 Current policies directed at the charcoal chain are inefficient

The charcoal industry largely remains in the hands of the informal sector. The government has neglected to formally organize and manage charcoal and as such there is no comprehensive strategy or policy that addresses charcoal production, trade and consumption in an integrated manner. The regulations and polices, which do exist are patchy in nature and are generally poorly enforced.

Some typical examples of policy deficiencies include the following:

- While it is illegal to fell trees for charcoal (or for any other purpose) in Tanzania's protected forests, and licenses are required to harvest wood elsewhere, resources for patrolling forests are scant;
- Licenses given out for forest harvesting and charcoal trade do not compare in any way with the quantities traded to Dar es Salaam. This implies that much of the activities in the charcoal chain are unregistered;
- Although charcoal that is transported to urban centres legally should be taxed, the government loses millions a year as a result of checkpoints going unmanned;
- In 2006, the government imposed a ban on the transportation of charcoal (now repealed) to stem the flow of charcoal into urban areas and mitigate its use. However, the ban proved to be ineffective and only served to increase the demand and prices.

The command and control policies dominating the approach of the current Tanzanian government need to be supplemented by market-based approaches. The command and control approach focuses too much on the symptoms of the problem why market based instruments are more likely to address the causes of the problem.

5.6 Next steps

With the current overview of available information on the charcoal chain in Tanzania, as presented in this report, a beginning has been made for a more structured evaluation of the weaknesses of this sector. Without any doubt it can be concluded that the charcoal chain in Tanzania is not operating in a sustainable manner. With current trends in the charcoal chain continuing, forest resources will become scarcer, environmental externalities will cause more damage to other sectors in the Tanzanian economy, poverty will increase further, and government revenues will remain insufficient to reverse these negative trends.

Potential improvements can be made across the charcoal chain in Tanzania. However, because funds for interventions are limited, it is important to conduct a systematic sector-wide prioritisation on the cost-effectiveness of the various intervention options. However, at present, several information gaps exist that need to be addressed before such a prioritisation process can occur. For example, some of these gaps include the issues:

- On the supply side, can the need for forest resources be met in a cost-effective manner by expansion of production forest or plantations?
- On the demand side, what policies and technological innovations would be needed to enhance the attractiveness of substitutes for charcoal?
- On the production level, could Payments for Environmental Services (PES) provide the necessary incentives for the producers to move away from charcoal production to more sustainable forms of livelihood activities?

Given the current interest of the Tanzania country office of the World Bank to improve the sustainability of the charcoal chain in Tanzania, we hope to find sufficient policy support to continue the work in the charcoal chain. By filling the identified gaps in the knowledge base, more effective decisions can be made by the Tanzanian government.

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- World Bank Environment division

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Appendix I Preferred tree species for charcoal production

Local/Swahili name	Botanical name
Mkambala	*Acacia negrescens*
Mnhondolo/Mhangala	*Jurbelnadia globiflora*
Myombo	*Bragistigia boehmii*
Mhungilo	*Lannea schimperi*
Mbona	*Bragistigia speciformis*
Mkongowe	*Acacia gerrardii*
Msolo	*Pseudolachnostylis maprouneifolia*
Mlama mweusi	*Combretum spp*
Mgama	*Mimusopsi kumme*
Mkwaju	*Tamarindus indica*
Mgovu	*Ptelopsis myritifolia*
Mnyenye	*Xeroderris sturhrmanii*
Mkongo	*Afzelia guanzensis*
Mzikoziko	*Crossopteryx ferbrifuga*
Msisimizi	*Albizia harvey*
Mfumbuli	
Mtonga	*Strychnos spinosa*
Mninga	*Pterocurpus mildebriedii*
Mpugupugu	
Mcharaka	*Spirostachys africana*
Mkuruti	
Mkuluka	*Boscia salicifolia*
Mtundu	
Mtang	*Terminalia molis*
Mgonji	*Pteleopsis myrtifolia*
Msakulankwale	*Margaritaria discoides*
Kifunganymbu	*Acacia nilotica*
Myunguyungu	
Mfiligisi	
Muwanga	
Mtebeti	
Mtogo	*Diplorhynchus condylocarpon*
Mholo Mkumbi	
Mnyenyembwe	
Mkole	*Grewia spp*
Kisasa	*Acacia goetzei subsp. Goetzei*
Mpuru	
Mtopetope	*Annona senegalensis*
Devu lanyani	
Kisaraluli	
Mtunduru	
Mtete	
Msosowana	

Source of data Kaale and Sawe, 2000