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CHAPOSA

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Charcoal Potential in Southern Africa (CHAPOSA)

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Contents

Abstract: CHAPOSA project

Objectives

The objectives of the project were to investigate the trends in deforestation and forest depletion in areas supplying three urban centres in Sub-Saharan Africa: Lusaka in Zambia, Dar es Salaam in Tanzania, and Maputo in Mozambique. Additional objectives were to identify indicators of over-exploitation, and to increase the understanding of the reasons for charcoal production. The time scope was the last decade of the previous century.

Activities

The research framework and areas of study were defined. Ecological potential for charcoal production for three cities was assessed at sample plot locations. Land cover changes was assessed based on satellite images. Assessment of the spatial dynamics and a socioeconomic analysis of the charcoal production system was assessed through surveys. A model for the charcoal system was developed.

Methodologies

The methods used in the project include remote sensing analysis, field surveys, participatory appraisals, computer modeling, scenario building and evaluation.

Results

The results show that around all three major cities, woodland cover has been reduced during the study period, partly due to charcoal production, partly due to increased cultivation. Cleared areas can regenerate into woodlands or continue to be degraded, depending on management regimes. The potential for charcoal production from most of these areas will be substantially reduced in the coming 15 years if no measures are implemented.

Indicators of non-sustainable forest use for charcoal production include that ecologically fragile areas such as woodlands on hill and escarpment are being encroached upon, that non preferred tree species are being exploited for charcoal production, and that the cutting in a longer time perspective is higher than the regrowth. Woodland regeneration takes place, and some areas which were cut twenty years ago are now again being used for charcoal production. In the future, most production will be from regrowth areas.

Charcoal production has become one of the major income sources for rural people in areas where transportation to the big cities is possible. In Southern Mozambique, 70% of the cash income was from charcoal. In Tanzania, 75% of the farmers in investigated areas had charcoal as an important source of income. In Zambia, with the collapse of the agricultural market, charcoal is virtually the only income source in rural areas.

Charcoal prices do not increase in real terms, although inflation causes the current prices to increase. In Zambia and Tanzania, the charcoal price has been fluctuating around the same level since at least twenty years back. In Mozambique prices were higher during the war, but have since normalised.

The key to implementing changes to the system is to revise and enforce the licensing and fee system for the charcoal trade. This will lead to increased prices for consumers, but should create resources for forest management and incentive for improvements and fuel substitutions on the user side. It is essential, however, that alternatives to charcoal production are made available for rural people to earn a living. Failure to provide this will result in increased misery among the rural poor. Hence an enforced fiscal system must be supported by increased efforts to provide fuel alternatives in urban areas, and alternative income sources in rural areas.

Problems

There were difficulties to secure appropriate satellite images for the areas and time periods defined for study. The disbursement system of INCO-DC caused delays and problems in implementation due to lack of liquidity in participating institutions.

Steps taken to ensure application of the results

A seminar with participation of policy makers from the region was held in Maputo on 29th October, 2001. Results are presented on the project internet page http://www.sei.se/chaposa/chaposaindex.html

Final summary report

Objectives

Seven objectives were stated in the project description:

1. To investigate the trends in deforestation and forest depletion in areas supplying three urban centres in Sub-Saharan Africa (SSA).
2. To identify indicators of over-exploitation of the forest resource
3. To identify areas suitable for charcoal production not currently utilized;
4. To improve the understanding of how, why and where charcoal production areas are established
5. To propose possible interventions that can be carried out in order to secure the supply of charcoal to the low-income population and to mitigate adverse effects of charcoal production;
6. To outline different scenarios of forest status in view of different energy options.
7. To inform policy makers, energy analysts, forestry officers and relevant groups about the research and its outcome.

Activities

The project was organized in five phases, each of which addresses a set of core tasks. The objectives of each phase are presented in this section.

Phase 1: Definition of Research Framework and areas of study

Coordination and harmonization of the work of all partners and definition of interfaces between tasks to allow integration of results of phases 1-4 into phase 5. Definition of the catchment areas to be studied.

Phase 2: Definition of the ecological potential for charcoal production for three cities

The objective was to determine the ecological potential for sustainable production of charcoal to supply the urban population of the three selected cities.

Phase 3: Assessment of the spatial dynamics and a socioeconomic analysis of the charcoal production system

The objective of phase 3 was to identify and map economic, legal, social and demographic aspects that may affect charcoal production and use; and to collect and interpret information on the economic geography of charcoal production in the studied areas in order to understand the circumstances and mechanisms behind the establishment of charcoal production areas.

Phase 4: Modelling the charcoal supply system and the demand and all related energy flows and costs

The objective of this phase was to develop scenarios of energy use and forest reduction based on information from phases 1-3. The model should take into consideration ecological as well as social and economically quantifiable data.

Phase 5: Development of appropriate policy intervention strategies

The objective was to suggest indicators on when and where government interventions may be appropriate, and how such intervention may be implemented. Scenarios of

development should be presented, taking into account the factors identified in the project.

Methodologies

The methods used in the project include remote sensing analysis, field surveys, participatory appraisals, computer modeling, scenario building and evaluation.

Results

The potential for charcoal production around three major cities in southern Africa has been investigated: Lusaka, Dar es Salaam and Maputo. The time frame has been the last decade of the last century (1989-1998). The results show that forest resources for charcoal production are being reduced in all three locations. Reduction in land covered by closed forest in the study areas was significant during the period. In the Lusaka area reduction was 25% (from 32 to 24% of area covered), Dar es Salaam area 22 % (from 22 to 17% of area covered), and Maputo 74% (from 3 to 1% of the area covered). At the same time there was strong increase in land used for agriculture in all the areas. The future development scenarios of wood resources in the three countries according to modelling is very different. Based on projected population growth and wood fuel use trends, the Lusaka supply area would remain with about 80% of current wood resources in the year 2015, the Dar es Salaam area with 20%, and the Maputo area with 15% of current resources. The percentage of closed (natural) forest remaining in the three areas would be 60, 20 and 0%, respectively for Lusaka, Dar es Salaam and Maputo. It could be noted that the land coverage of closed forest in the Maputo area was only 1% already in the year 1998.

Still, substantial wood resources exist in open forest and bushland. This is shown in more detail in the annexes. Also, there is considerable regrowth taking place in most of the areas. Except for the Lusaka area, most of the wood resources available in 2015 are from regrowth.

It is difficult to determine the forest area lost to agriculture, since the typical form of African subsistence agriculture is integrated with the woodland ecology. Shifting agriculture is practised in many cleared areas, but since stumps are not cleared, and cultivation continues only for a few years, forest regeneration is not greatly disturbed by it. Permanent agriculture is a very marginal activity in the areas studied, except in the Maputo study area. On the other hand, charcoal is a common means of gaining capital while clearing for shifting cultivation. Instead of just burning the trees on location, charcoal is made from them and some cash is earned for agricultural implements. In such cases, it appears inappropriate to state that charcoal production is responsible for clearing, although clearly it precedes cultivation.

The system for producing, transporting and marketing charcoal employs a large number of actors, and is largely operated as a market system with limited interference from authorities. Charcoal production itself has become one of the major sources of income for poor people in rural areas, in the production areas this income is more important than income from alternatives such as agriculture. It is mostly men who are engaged in charcoal production.

Hence charcoal production is a means to reduce poverty among rural people, on their own and without external support. But it is also a means to improve the conditions

for the urban poor, by providing a reliable, convenient and accessible source of energy for cooking at all times and at a surprisingly stable cost.

The study has shown that charcoal prices (in "real" terms) have been stable over at least the past ten years. In addition, the charcoal trade provides income opportunities for many people in the urban areas, through small scale retail business. Mostly women are engaged in this business.

The use of forests and woodland for charcoal production has several ecological implications. Initially, there is a depletion of mature woodlands and trees favoured for charcoal production. As the favoured species grow scarce, the less favoured mature trees are used. When no mature trees remain, charcoal production can not be sustained in an area. The fate of the area at that time depends on external factors. If population has increased in the area, some of the previous woodland will be used for cultivation. If it is shifting cultivation, usually the land will be abandoned after a period, and left to regenerate as shrubland or woodland. If cultivation is of a permanent kind, stumps will be cleared and the land will remain cleared indefinitely. A similar fate will be the result if the land is used for heavy grazing, in which case only species unsuitable for forage will proliferate.

In areas where the land cleared for charcoal production is abandoned, regeneration takes place. Initially this regeneration is mostly from coppice, since charcoal producers usually leave the stumps of trees cut. Hence the species composition will remain essentially similar to that before charcoal production, since it is actually the same trees - the same individuals that have been cut - that continue to grow. This process gives rise to a number of stems from each old stump, and the view of many thin trees per area is an indication of regrowth. In some areas under strong pressure from charcoal production, regrowth is again cut for charcoal production after about twenty years, although the trees have not reached maturity at that stage. Regeneration can be improved by fire control (early burning), selective cutting of non-viable coppice, and protection from grazing.

The charcoal production system shows several traits of a free market system, which, according to the given wisdom, should ensure that the resources are put to the best use. It is a system of many actors, working more or less independently of each other. Information on market features is essentially free, the entrance fee into the market is affordable even by poor people, and the final product is a very widespread consumer product. Usually the entrance fee is personal labour. The exception is in the transportation segment, especially for long distance transport, where there is need for vehicles, roads and fuel. Still, the profit level in charcoal transportation is not very high, as illustrated by the use of old and dilapidated vehicles. The basic resource for the whole system is the tree in the forest. Net present value calculations of the basic resource shows that it is perfectly rational to cut the trees for charcoal production under existing forest resource regimes, rather than saving them for other future uses or spending cost and labour on management into higher quality wood.

How should the forest be valued? At the present, the whole value of the wood resource is the commercial value it can attain at harvesting. Although this value is limited in terms of charcoal (a mature tree would yield about 5 bags of charcoal, at the producer stage this is 15-20 dollars in monetary terms). Obviously there is no interest rate so low that this value would be positive in a net present value calculation over the

thirty to fifty years it takes a tree to mature. This implies that market forces work only in the direction of felling the trees, not of protecting them.

If there should be other than commercial values ascribed to the wood resource, then there needs to be an authority to uphold them. The government could be such an authority, especially since in all the three countries investigated the state owns substantial parts (or all) forest resources. However, in all the cases, the government is a poor owner of wood resources. Even if policies exist to protect forests for certain reasons, the resources assigned to enforcing the policies are pitifully inadequate.

Even the part of management which directly yields income to the treasury is inadequate, and the rules and regulations are complicated and opaque. Thus, in the Maputo area it was estimated that only about 1% of the fees and licenses were actually collected for the woodfuel sector. In Zambia the estimate was about 10% and in Tanzania about 25%.

The forests in the countries investigated are largely an open access resource, similar to, for instance, fish in the ocean. This is in spite of the fact that the state in all the three countries has declared its ownership of the forest resource, and instated rules and regulations to this effect. But the state is ill equipped to take the responsibilities of an owner, and to enforce the rules of government. Thus, he who cuts the forest gets the benefit from it, and cares little for future users (or rightful owners). In this situation, it might be expected that some users start to develop production methods in order to gain more in a shorter time. In the fisheries example this would be by investing in larger boats, more efficient trawls and gear to navigate and find the fish. In the forest example, the producers would invest in chain saws, tractors and kilns with higher productivity, the transporters in modern cross-country vehicles, and the marketeers in packaging and advertising and expansion into new markets.

This has not happened in the charcoal sector, probably largely due to the forest produce policies in place, inadequate as they may be. Although these policies are only enforced to a small degree, enforcing them would effectively wipe out the profit of larger investments. This has most clearly been demonstrated in the Tanzania case, where paying all the legal fees and duties effectively wipes out the profit of charcoal trade. In addition, there are other risks, such as fluctuations in supply due to weather changes. In drought years, farmers go into charcoal production and producer prices are reduced. In flood years, the production areas are inaccessible.

The result is that the charcoal industry remains dispersed and ill developed, and little capital is attracted to it. Those entering the industry do so with little more than their own labour as input. This attracts poor people in search of a means to make a living. At the same time the many small actors in the industry give each other a protection similar to that of a fish school; if one is caught by authorities it does not affect the industry at large very much. The effect is that a source of income is created to many poor people in rural areas. These contribute to the provision of an essential commodity to poor people in urban areas by supplying an affordable, convenient and accessible energy source at relatively stable prices. This is a feat that modern society has not been able to provide. Electricity infrastructure is insufficient and unreliable, petroleum fuel prices are widely fluctuating due to world market changes, and changes in domestic policies. The indigenous, renewable woodfuels prevail.

Policy options

In all the study areas, forest management is inadequate. This goes to the protection of indigenous forest, as well as to the possibility to enhance regrowth and the possibility to increase productivity from the forest. There is a need to strengthen the capacity of forest authorities to assess, demarcate and protect certain areas, and to help introducing management systems that benefit local communities and the natural resource availability. This can come about only with increased resources to the forestry and natural resource sectors.

Existing natural resource policies in all the countries include fees for removal, transportation or trade in forest resources. Collection of these fees and licenses would result in substantial amounts that could be used for the above management requirements. This fiscal system is, however, inadequately enforced and revenue collection is but a fraction of what it should be. Hence, reviewing the fiscal system is an important task with the objective of improving natural resource management. But in most cases, the existing licensing systems cannot be simply enforced, since they are instated for various objectives. The systems must reviewed, so that fees and licenses are universally applicable, equal for the actors involved and serving the purposes of the system. It is important, that the enforcement of the fiscal system is carefully and gradually implemented, and that the resources gained to a large extent must be invested in the sector. The system must be self-reproducing and able to pay for all costs it accrues internally. Income gained from increased enforcement must be used to a great extent to reinforce the actors responsible for forestry and natural resource management, whether government or others. Objectives of, for instance, forest management, community participation, improved production or utilization techniques, information dissemination, should all be covered by the system. Primarily the income would go gradually to build up the system itself, so that conquered ground would not have to be abandoned after a short period. Only after this is achieved, the income would go towards the necessary management measures.

Enforcing the fiscal system for forest resources will increase consumer prices, and reduce producer prices. As seen from the Tanzania example, it would, under current circumstances, effectively wipe out the profit from the charcoal transportation sector. Thus, it could be expected that capital is withdrawn from the industry, especially in the transport segment. This will increase the hardship for poor people, by reducing the income opportunities in rural areas, and increase the charcoal cost in the urban markets. Hence, enforcing the fiscal system must not be done in isolation.

Enforcing the fiscal system for forest resources will make poor people search for substitutes for charcoal at both ends of the chain. At the producer end, such substitutes could be agricultural production, timber extraction or poaching. At the consumer end, other energy sources than charcoal, and more efficient devices for charcoal, would become more attractive. Thus, at the same time that these changes are forced by increased hardship, they are also the way out of the present dilemma.

In order to reduce the negative effects of increased prices, and to make substitutes feasible, efforts must be made also in other sectors.

In rural areas it will be important that the system for agricultural production is working, and supplying the necessary credits, implements and market for produce. In this way, agricultural production can be an alternative source of income to substitute for charcoal production. There is a need for such measures in all the supply areas stud-

ied, but maybe most pronounced in the Lusaka area. Furthermore, the effects of improved management should be able to provide some income to rural communities through employment in the forestry sector, and through increased extraction of forest resources for other purposes than energy.

In the urban areas, increased consumer prices will make it more realistic to introduce fuel-saving appliances, and for consumers to shift to other energy sources, if available. A real challenge is to provide substitutes for charcoal altogether. This would largely mean increased investment in the electricity sector, in distribution, in deferred payment schemes for connection fees, in provision (maybe support to development) of stoves suitable for the cooking habits, and finally in environmentally acceptable generation of power. Distribution of power in urban areas, and power generation would probably be profitable right from the start, and could be assigned to the private sector to provide. However, removing the barriers for low income people to articulate their demand probably needs political enforcement. It should be clear that the objective is actually to supply enough power to reliably provide large numbers of consumers with alternatives to wood fuels. This could be in the form of conditions to the concessions given to the industry, especially in order to reduce the high entrance fees to the electricity market.

Recommendations

It must be acknowledge that charcoal is not a minor forest produce, but a major one, and in most cases the only one. The natural forests surrounding large cities in southern Africa are being depleted, partly due to charcoal extraction. In spite of this, the forest resources are likely to be able to supply charcoal for at least another decade through the regrowth, and areas further afield could be exploited in the future. The depletion is most severe around Maputo, where the natural closed forest is essentially removed already today. In Zambia and Tanzania the resource situation is less severe, but ecologically sensitive areas are increasingly becoming exploited. There is a need for natural resource management measures.

- Enforcing the licensing systems is the option with which to induce changes in the system. This will increase consumer prices and reduce rural income and is politically sensitive. At the same time this is also the seed to a thorough change in the system, and to development.

The demand for alternatives and saving measures induced by the price increases must be met by other measures.

- In the rural production areas this can be done by improving the situation for agricultural production in rural areas and by offering roles for rural people in the natural resource management and extraction.
- In urban areas, use of fuel-efficient stoves should be encouraged, but most importantly, the demand for alternative energy sources should be met. The most realistic alternative is electricity supply, which needs to be expanded. High entrance fees to electricity use must be reduced. Increased electricity supply and distribution is most probably going to be profitable, and could be provided by private actors who accept certain conditions. Fossil options are not considered here for environmental reasons, but could be feasible alternatives.

These policies must be implemented together. Enforcement of the fiscal system for natural resources will provide the impetus and market for changes in the other sectors, but if implemented in isolation will cause severe hardship to many poor people. Agricultural smallholder production needs support and consistent long-term policies in order to be able to provide alternatives to charcoal production or illegal logging. The electricity sector needs to provide power to large numbers of low-income consumers, and needs to learn how to manage such operations.

If these recommendations are not enforced together, or in close sequence, then it might be better to sacrifice the natural forest than to bring more hardship on already severely tested people.

Problems

During project implementation, the disbursement model applied by INCO-DC has caused problems, especially for the partners in Africa. These institutions do not have the liquidity to forward the costs entailed in a project of this size. The coordinating institution (SEI) has forwarded credit, but this has not been sufficient on all occasions. The result has been delay in implementation, and hardship for these partners.

Communication between the partners has been another problem. While important messages and direct questions can be exchanged via email, this is not quite enough for the scientific discussion required in a project of this magnitude. In retrospect it appears justified to have spent more resources on a meeting and partner exchange budget than what was actually done here. Instead of one meeting per year, probably two meetings would have been more satisfactory.

Acquisition of satellite images caused unforeseen problems. An important experience is that, although the satellite systems have full cover of the earth both geographically and temporally, not all images are of the quality needed for this type of project. This has induced some changes in selected study areas and time frames from what was initially planned.

Steps taken to ensure application of the results

Project reports are presented on the project home page.

Internationally published papers are available.

A dissemination seminar with representatives from the governments (forestry and energy sectors) in the three countries was held in Maputo in the fall of 2001.

Consolidated scientific report

Objectives

Low-income households in African cities are still using large amounts of biomass based energy in the form of charcoal. The project set out to investigate the effect and implications of this in the supply areas of three major cities in Southern Africa: Dar es Salaam (Tanzania), Lusaka (Zambia) and Maputo (Mozambique).

The objective of this project is to expand the knowledge about the biomass potential for supplying charcoal to urban centres and find workable policy tools that will enable sustainable production and use of charcoal in the medium term perspective.

Objectives and output of CHAPOSA project.

Objective	Output
To investigate the trends in deforestation and forest depletion in areas supplying three urban centres in Sub-Saharan Africa (SSA).	Trend maps of forest cover and land-use for the three cities
To identify indicators of over-exploitation of the forest resource	Presentation of indicators taking account of biological aspects, (e.g. species composition and abundance), physical factors (e.g. climate and soil composition), and social aspects (e.g. population growth, migration and employment opportunities)
To identify areas suitable for charcoal production not currently utilized;	Utilising the developed indicators and land use maps it will be possible to select areas suitable for production
To improve the understanding of how, why and where charcoal production areas are established	Report on the social dynamics of charcoal production
To propose possible interventions that can be carried out in order to secure the supply of charcoal to the low-income population and to mitigate adverse effects of charcoal production;	List of realistic and workable policy and management options with specification of the conditions for their application
To outline different scenarios of forest status in view of different energy options.	Scenarios applicable for the three cities, methods for producing scenarios for other locations (modelling)
To inform policy makers, energy analysts, forestry officers and relevant groups about the research and its outcome.	Publications, seminars

Activities

Project implementation was organized in five phases, each with a number of specific activities:

1. Definition of Research Framework and areas of study
2. Definition of the ecological potential for charcoal production for three cities
3. Assessment of the spatial dynamics and a socio-economic analysis of the charcoal production system

4. Modelling the charcoal supply system and the demand and all related energy flows and costs
5. Development of appropriate policy intervention strategies

Several of the phases overlapped and were implemented in parallel with each other. Methods used included remote sensing (satellite image analysis), field observations and surveys of biomass, sample surveys of social groups and computer aided modelling and scenario building.

Results achieved

Phase 1: Definition of Research Framework and areas of study

The research framework was developed at an inception meeting of all the partners in Lusaka in early 1999. Each group defined the appropriate research area for study in each location. The research areas are shown in Figure 1.

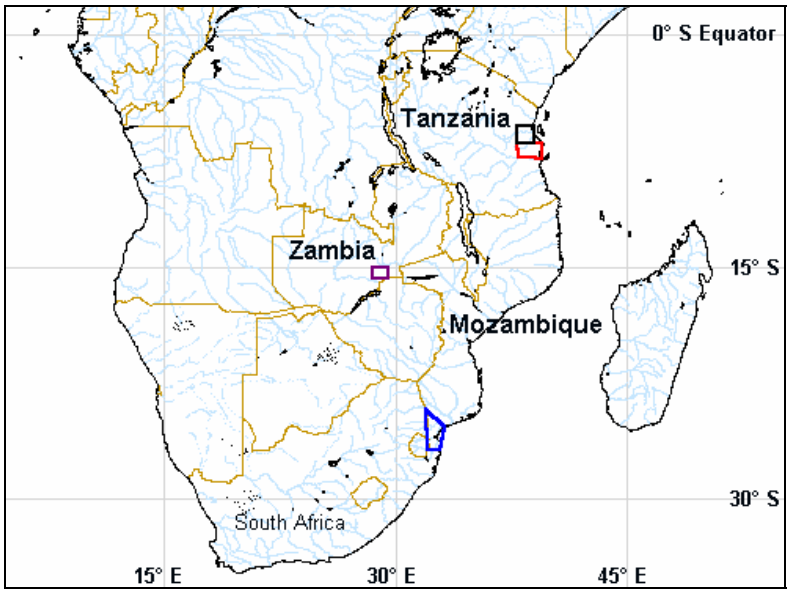

Figure 1 Location of CHAPOSA study areas in southern Africa

Lusaka is an inland city with supply from all sides. Here, a selection was made of the eastern supply areas, representing about a quarter of the supply of charcoal to Lusaka (purple selection). Existing field studies guided the selection of this area.

In Mozambique, the whole of Maputo Province was selected (blue selection), largely due to poor wood resources. Subsequent studies showed that the neighbouring provinces of Gaza and Inhambane are already providing wood fuel resources to Maputo.

In Tanzania, the selected area was initially to the west and north of Dar es Salaam, but following information gathered during the study, and the opening of a new road to, an area further to the south was included for some analyses (red selections).

The outline of the study areas are shown in more detail in the maps below. In the Tanzania map, there is also an outline of the Kisangani (green) and Mbwewe (blue) field study areas.

The decade immediately preceding the start of the project was selected for study, or about 1988-1998.

Figure 2 Close-up of study areas. Map source: Southern Africa 1:4000 000 © Falk Verlag AG/Geo Data

The framework for the ecological study is illustrated by the model in Figure 3. The project evolves around the linkages between the various states of woodland. A crucial question is to which extent the box "Permanent wasteland" actually does exist.

A number of critical issues were identified and ranked as a set of indicators of the state of the system. These included ecological, social, economic and actor aspects of the system as shown in Table 1. These are discussed at greater length in the partner's reports and in the annexes.

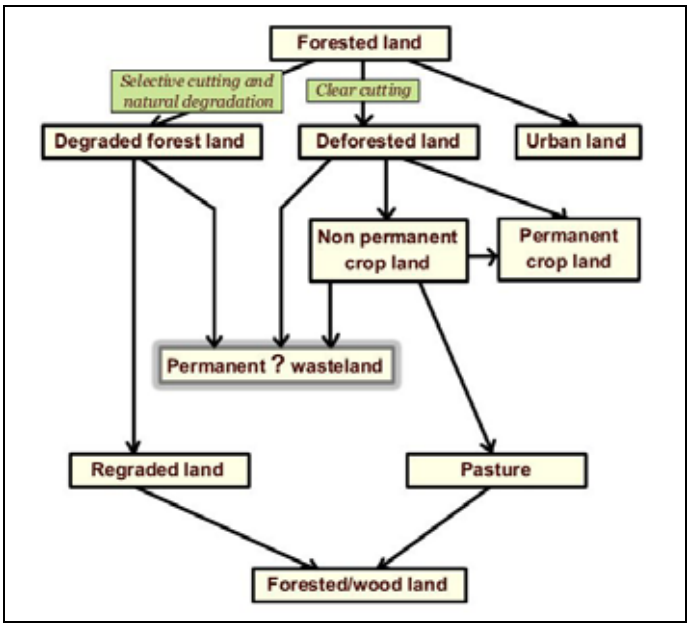

Figure 3 Chaposa discussion model of interactions in the woodland

Table 1 Indicators of the state of the charcoal system

Rank	Ecological	Socio-economic	Combined	Market/actor
1	Biomass cleared in relation to mean annual increment (MAI)	Trend in real charcoal price	Change in distance to charcoal production areas	Type of charcoal users
2	Type of forest cleared for charcoal production	Potential/ capacity to use alternative cooking energy sources	% annual loss in forest cover in relation to population growth rate	Market structure
3	Fragility of forest area (slope)	Real cost of a hot meal	Land use succession	Stakeholder analysis
4	Change in supply catchment area	Competition/ conflicts between local and outsider charcoal producers	Cropland pressure	Transportation modes
5	Change in species structure of the cleared forest	Change in charcoal demand	Population pressure on forest/ national reserves	
6	Efficiencies of charcoal stoves and kilns.	Urban population growth		
7	Forest regeneration potential	Lack of involvement of local communities in forest management		
8		Temporal dynamics in the structure of urban household		
9		Undervaluation of natural forest wood products		
10		Unequal distribution of returns from charcoal		
11		Weak land tenure control		
12		Cost of primary delivery of energy		

Phase 2: Definition of the ecological potential for charcoal production for three cities

This task includes the field assessment of woodland in the catchment area of the cities. Ecological assessments need very long time spans in order to yield significant results, thus already existing data, or long-standing research, in the areas determine the possible outcome of individual studies.

Lusaka study area

In the Zambia study area, observations from the past twenty years were available. The project extended the existing time series, and consolidated knowledge about the dry miombo ecosystem. From the Zambia ecological study the following main conclusions were drawn:

1) The miombo woodland used for charcoal production in Chongwe district has the potential to regenerate and can be used again for charcoal production in the future. However, this potential cannot be realized in the near future because of:
   a) lack of proper forest management and absence of areas dedicated to charcoal production
   b) on-going conversion of forest reserves to urban and agricultural development,
   c) encroachment into forest reserves
   d) inadequate forest management in areas cleared for charcoal production on customary land.
2) Although soil productivity does not appear to be negatively affected by deforestation, drought and poor forest management have the potential to reduce woodland productivity.
3) Charcoal conversion efficiency in earth kilns is relatively good (20-25%).
4) There is no enforcement of the stumpage licensing system by the Forest Department in Chongwe district.
5) Cultivation is the major cause of deforestation and currently, about 30% of the area deforested for charcoal production in Chongwe district is not converted to cultivation.

The clearing of escarpment/hill and riverine woodland and cutting of none charcoal trees indicate that forest resources are being over-exploited for charcoal production.

Dar es Salaam study area

The Tanzania study area is mostly open lowland forest, partly of miombo type, of which much has been cut for charcoal production in the past forty years. Forest degradation is especially strong near to main roads. An extremely large number of small stems per unit area indicate both disturbance and active regeneration processes.

The study has demonstrated that charcoal production is an important factor in the dynamics of miombo woodlands. It has been responsible for the degradation of the woodlands and, together with agriculture, for large-scale deforestation that has occurred in the area between 1991 and 1998. Tree species suitable for charcoal production have been depleted at the roadside and the average distance to charcoal sites has increased. Tree cover is less dense today than ten years ago due to charcoal production. These observations have wide policy implications, given the increased demand for charcoal from the growing city population with no reliable and affordable alterna-

tive sources of energy. Most of the closed woodlands (74%) and more than half of the open woodland (54%) of the open woodlands, remain relatively unchanged; most of these are in forest reserves. However, these areas are also undergoing modification due to encroachment for charcoal, timber and other forest products.

It is true that in the absence of any further disturbance after tree cutting, the areas may progressively revert to woodland. However, in the face of increased population and the demand for agricultural land, such areas may not be given enough room to regenerate. This calls for appropriate management strategies to be put in place in areas where trees have been cut, in order to encourage regeneration. Proper management of woodlands is also necessary to ensure that the remaining woodlands continue to supply charcoal to Dar es Salaam city and other urban areas. This study has shown that regeneration has occurred in areas previously cut, if they have not been converted to farmland. This increases the potential of the regrowth woodland to supply charcoal over a much longer time period.

Maputo study area

The forest cover in the Maputo study area is much different from that in the study area in the other countries. Primarily, the naturally occurring type is not miombo, but mostly munga (acacia) woodland. Secondly, most of the closed, natural forest was reduced already before the time period of observation, so that only 3% of the land was covered with closed lowland forest in 1990. Thirdly, the development situation in Mozambique is also different, since part of the observation period coincided with the restructuring period after the war. Hence increased areas under cultivation could be largely explained by the return of farmers to previously abandoned areas that had been left to regenerate in the meantime.

Charcoal production for urban energy supply is an old activity and in certain areas charcoal production to supply urban Maputo in the 1950s. In the case of Maputo province the degradation and fragmentation of forests and the predominance of thickets and woody grasslands has been seen as a consequence of charcoal production, agriculture encroachment and frequent fires occurrence.

The areas for charcoal production have increased: in the 1980s charcoal was produced within 50-60 km from Maputo. In the 1990s firewood and charcoal was coming from the natural forests located within a radius of 60-100 km from the capital city. The use of distant supply areas along the railway line was also registered. At end of the century, charcoal production areas to supply Maputo were located within an average distance of 150-200 km. Reports of charcoal being brought by railway from distances as far as 600 km are common, and recently charcoal produced within Inhambane and Sofala provinces has been transported up to Maputo city by trucks.

Charcoal production is characterized by a “clear felling system” since almost all species are used. The location of charcoal production areas is determined by the occurrence of accessible roads and desired tree sizes. Charcoal makers in areas with abundant forest resources operate on a shifting charcoal production system, similar to shifting agricultural production system. This type of production system requires abundance of forest areas to allow the forest regrowth. This need for large areas of charcoal production is re-enforced by the slow growth of native forests in southern Mozambique combined with huge amounts of charcoal demand for urban supply.

Large areas for charcoal production are needed if sustainable production is foreseen, and a long time between harvest activities is needed to allow forest regrowth. In the charcoal production areas located near the urban centers the time allowed for forest regrowth is not enough due to the constant pressure of charcoal burners. As a consequence, signs of desperate search for biomass are being seen in the oldest charcoal production areas. Harvest of small diameters, harvest on slopes and higher mountain areas is recorded, as well as the use of stumps for charcoal production. Lack of trees have been pointed by the charcoal producers as one reason for abandoning certain areas.

The efficiency of traditional kilns was found to be in the range of 14 – 20%, where full-time producers reached the higher levels. The time allocated on kiln construction and the time needed for combustion were seen as more important than efficiency by charcoal producers. This has contributed to lack of adoption of more efficient kilns.

Phase 3a: Assessment of the spatial dynamics of the charcoal production system

The spatial dynamics of charcoal production was assessed with the help of satellite images of the study areas, supported by field truthing of land cover. Scenes from the beginning and end of the period for study were selected. The result of these studies show the change in land cover in great detail, a summary of which is provided in this consolidated report.

Due to different traditions and ecotypes, the land cover classes used in the different location do not exactly coincide. The picture presented here (Figure 4) is an approximation made for comparison only. For detailed information, please see the individual reports in the annexes.

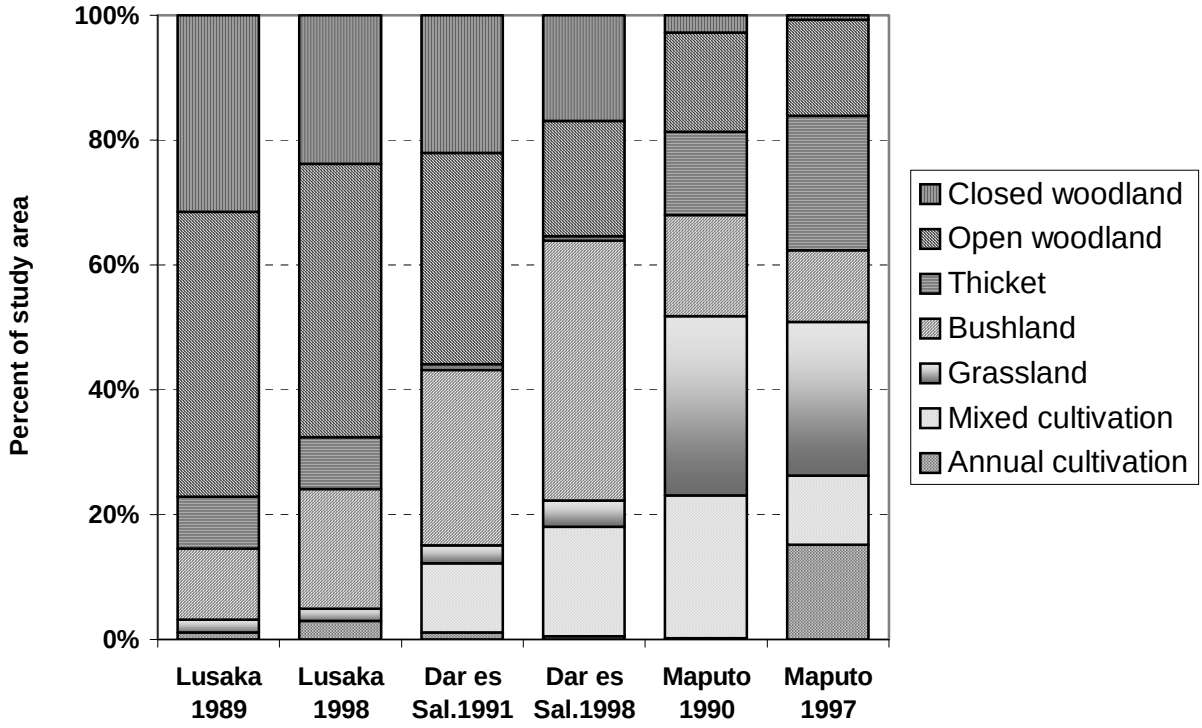

Figure 4 Land cover changes in the study areas

All study areas show a reduction in closed forest cover. The relative reduction is less in the Lusaka and Dar es Salaam areas. In the Maputo area, two thirds of the closed forest was removed in the observed period, but there was little even before that time.

The most dramatic change is in land used for annual cultivation in the Maputo area. The relative change of this land cover type is more than +9000%. This land is cleared from vegetation, and much of it is reclamation of old cultivation land since before the war. Note that in 1990, the war was still on in Mozambique, and security in rural areas was very poor, as well as agriculture marketing opportunities. In Zambia, mixed cultivation does not exist as a separate category. Here mixed cultivation is covered in the bushland and thicket categories, as well as to some extent open woodland. In Tanzania the most important change is from open woodland to bushland, which is typically due to charcoal production.

Dar es Salaam study area

In Tanzania, a detailed analysis of the changes was made, showing the development of the various types of land cover (Figure 5). Degradation is shown in closed woodland, which is converted into open woodland and bushland, and in open bushland which is converted into bushland. Some regeneration is shown to have taken place with closed woodland occurring in areas previously covered with open woodland and bushland.

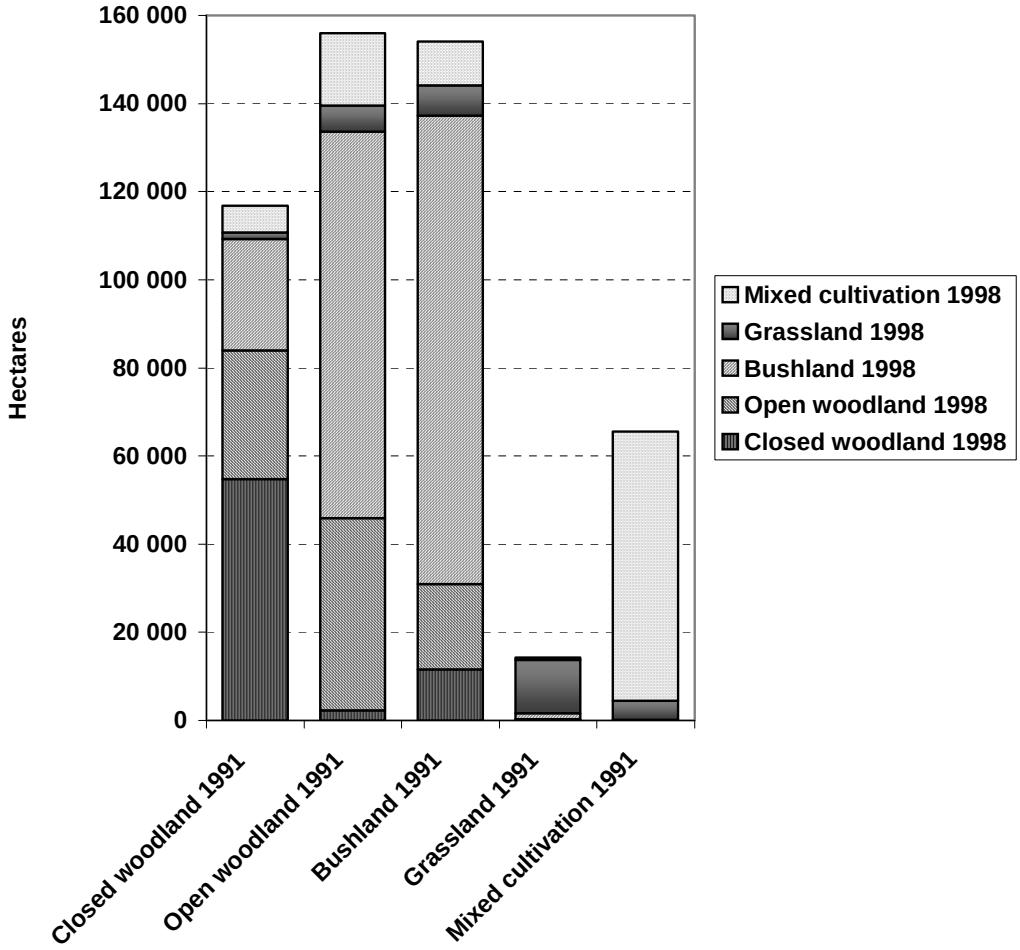

Figure 5 Change detection 1991-1998 in the Tanzania study area

A good potential for charcoal production exists in areas covered with closed and open woodland. The potential is less in areas with thicket and bushland, including some areas used for mixed cultivation. Areas without potential for charcoal production are cleared areas (including annual cultivation), grasslands and some of the mixed cultivation areas.

Forest degradation in the Dar es Salaam study area is more pronounced along the main roads. Calculations based on the Tanzania case show that the time needed for the degraded woodland to attain harvestable status, will be about 23 years at roadside and 16 years 5 km away from the highway. However charcoal production could also be sustained at the levels observed beyond 10 km distance from the highway within shorter rotation times.

A forecast of the remaining wood potential for Dar es Salaam was calculated based on the studies and assumptions of forest and population growth, energy consumption etc.(Figure 6). It shows that with no management measures put in place, the remaining forest resources for the Dar es Salaam area will be down to 40% of the present in 2015, and suggests the need for interventions to assure the long-term supply of energy for the urban dwellers.

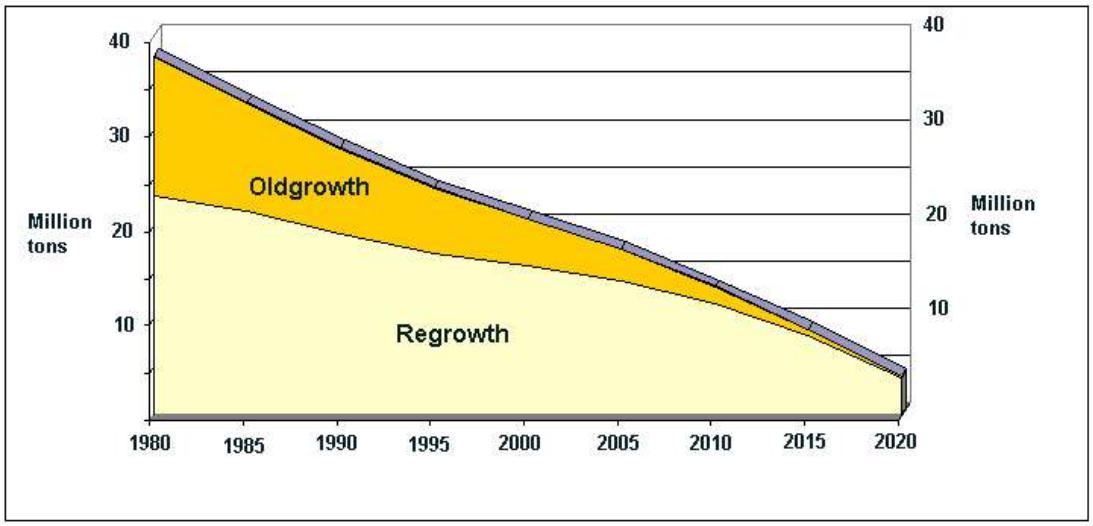

Figure 6 Woodland standing stock development trend without interventions in Dar es Salaam supply area

The results presented in Figure 6, Figure 8 and Figure 10 are based on the forest model, which is part of the scenario building phase of the project. The underlying assumptions and drivers are presented in more detail in the annex.

Lusaka study area

The major process that is transforming woodland cover in the Lusaka study area is the conversion to cropland and clearance for charcoal production (**Figure 7**). At the 2000 levels of charcoal production from the Lusaka study area, the supply to Lusaka can be sustained for the next 10 to 20 years. However, much of the woodland is on hills and escarpments and in a national park, which if cleared without adequate planning and supervision could have adverse effects on catchment hydrology and biodiversity. Currently there is little capacity to regulate charcoal production and control encroachment into forest reserves and national parks. The prognosis for the future therefore is that charcoal production will continue but at considerable, although not as yet quantified, environmental cost.

Previous charcoal production areas on customary land are being settled although large areas were just abandoned. Aerial photographs taken in 1991 covering a former forest reserve and a previous charcoal production area were analyzed to determine conversion of these areas to cultivation (also see Figure 7, page 23, for differences in land cover types between deforestation for charcoal and cultivation). In the former reserve 80% of the deforested area was under cultivation compared to 20% in the customary land area. However, on an overall basis, in 1998 only 31% of the deforested area could be attributed solely to charcoal production.

The conversion of forest reserves to other land uses and the slow woodland regeneration on customary land suggest that charcoal production areas will continue to shift further away from Lusaka City. However, most of the remaining woodland area is now in the escarpment and therefore is ecologically unsuitable for exploitation for charcoal production. Signs of over-exploitation are already emerging in the study area. For example, of the 139 charcoal kilns found during field surveys in previous and current charcoal production areas, 9% were in ecologically sensitive areas, such as riverine (dambo) vegetation and hills, 14% were in immature re-growth miombo

and another 9% were made of wood from trees unsuitable for charcoal and from timber trees.

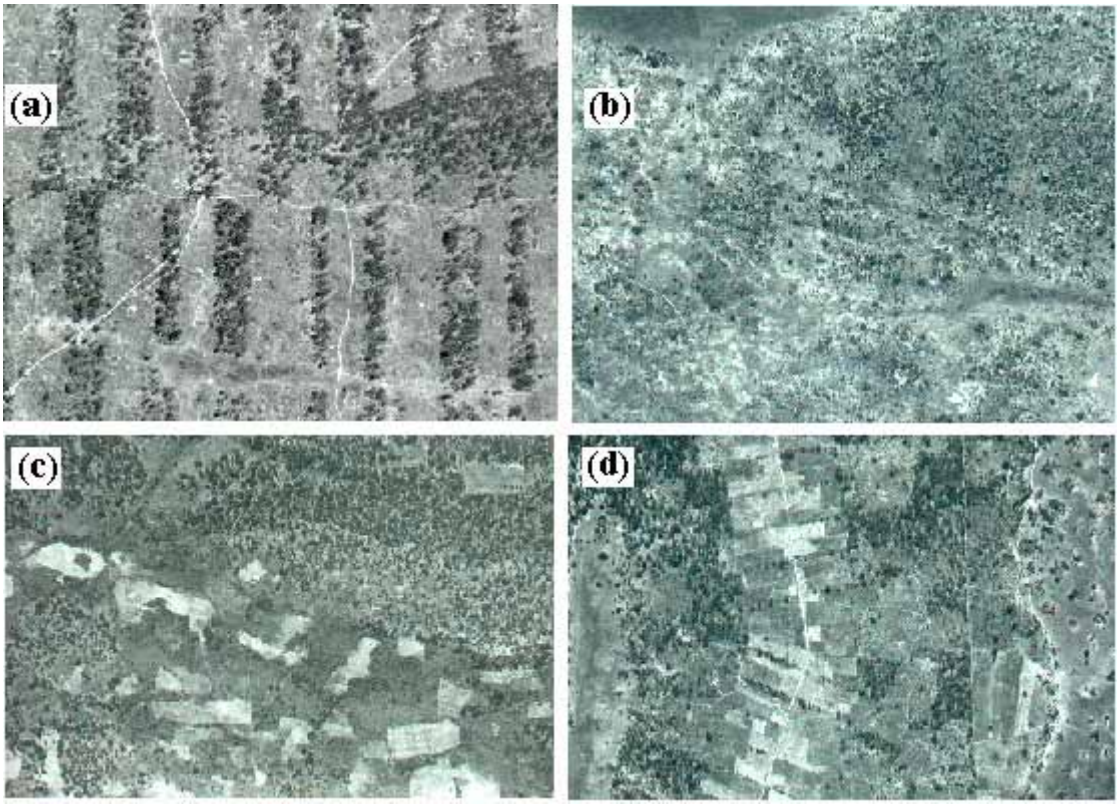

Figure 7 Causes of land cover change in Lusaka study area: (a) planned and regulated coupe and shelterbelt charcoal production system in a forest reserve, (b) unplanned charcoal production without conversion to cultivation on customary land, (c) subsistence cultivation and (d) semi-commercial cultivation.

In spite of this, deforestation trend in the Lusaka study area does not show as alarming signs as that for the other countries studied. As seen in Figure 8, the projection without management intervention suggests that the wood resources in 2015 will remain at 90% of the level in 2000.

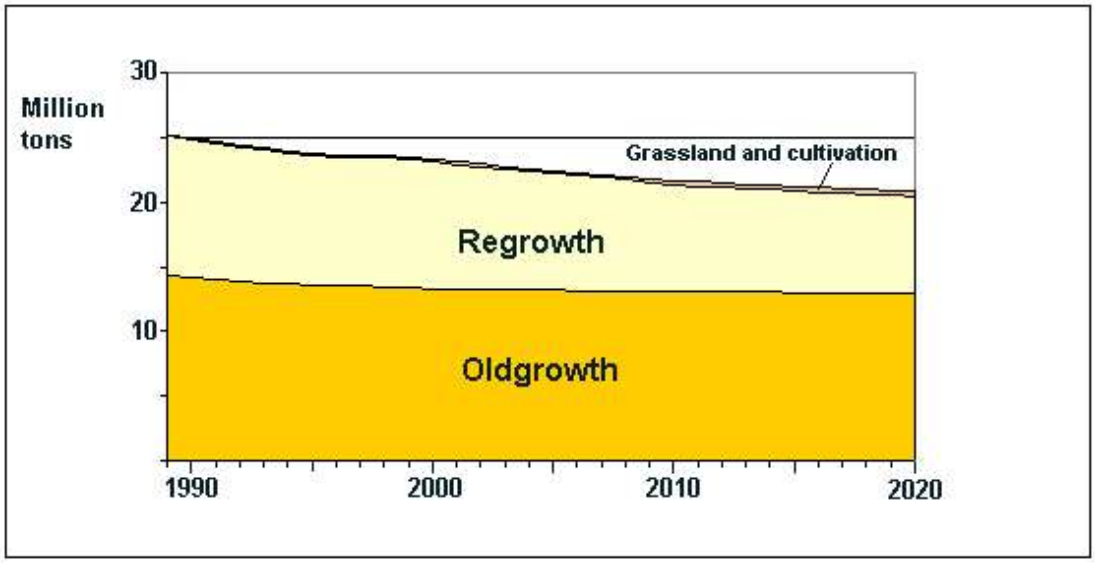

Figure 8 Woodland standing stock development trend without interventions in Lusaka study area

Maputo study area

The main charcoal and fuelwood supply areas for Maputo city consumption fall within Maputo province boundaries. Gaza province supply presently represents about 10% of the urban consumption. The biomass distribution within Maputo province was classified into 5 categories (Figure 9). 60% of the total area falls within the categories very low to low biomass potential, with only 26% of the biomass. The remaining 40% of the area is considered to be of high and very high biomass potential and has 74% of the biomass.

Satellite images from 1997 and 1990 for the Maputo study area show relatively small changes in broad terms, when subcategories are grouped together. Seen in this way, agriculture and shrubland have increased, while forest and grassland have reduced. While the total area for agriculture had increased by 14% between 1990 and 1997, the type of agriculture had completely changed. The major change was that large areas, previously under some form of shifting agriculture, had been converted into more permanent forms of agriculture.

The various categories of lowland forest show great changes. The closed lowland forest has reduced to a small fraction of what it used to be (27% of original area), and the medium closed forest was reduced to about 77%. Open lowland forest increased by 12 %, which may be a result of degradation of the more closed forest types. However, the overall reduction in lowland forest indicates that it has also been converted to other categories, such as cropland (agriculture) and other open vegetation types.

The open vegetation types (grassland, bushland, thicket) also show different trends between categories, where thicket had increased quite dramatically (by 63%), and all other types had reduced. There was virtually no overall change in cover area of the open vegetation categories combined (-1%). However, it is difficult to distinguish between various forms of open vegetation from satellite images, such as thicket, shrub, wooded grassland and long fallow agriculture, and some of the changes between these categories may be the result of different interpretations.

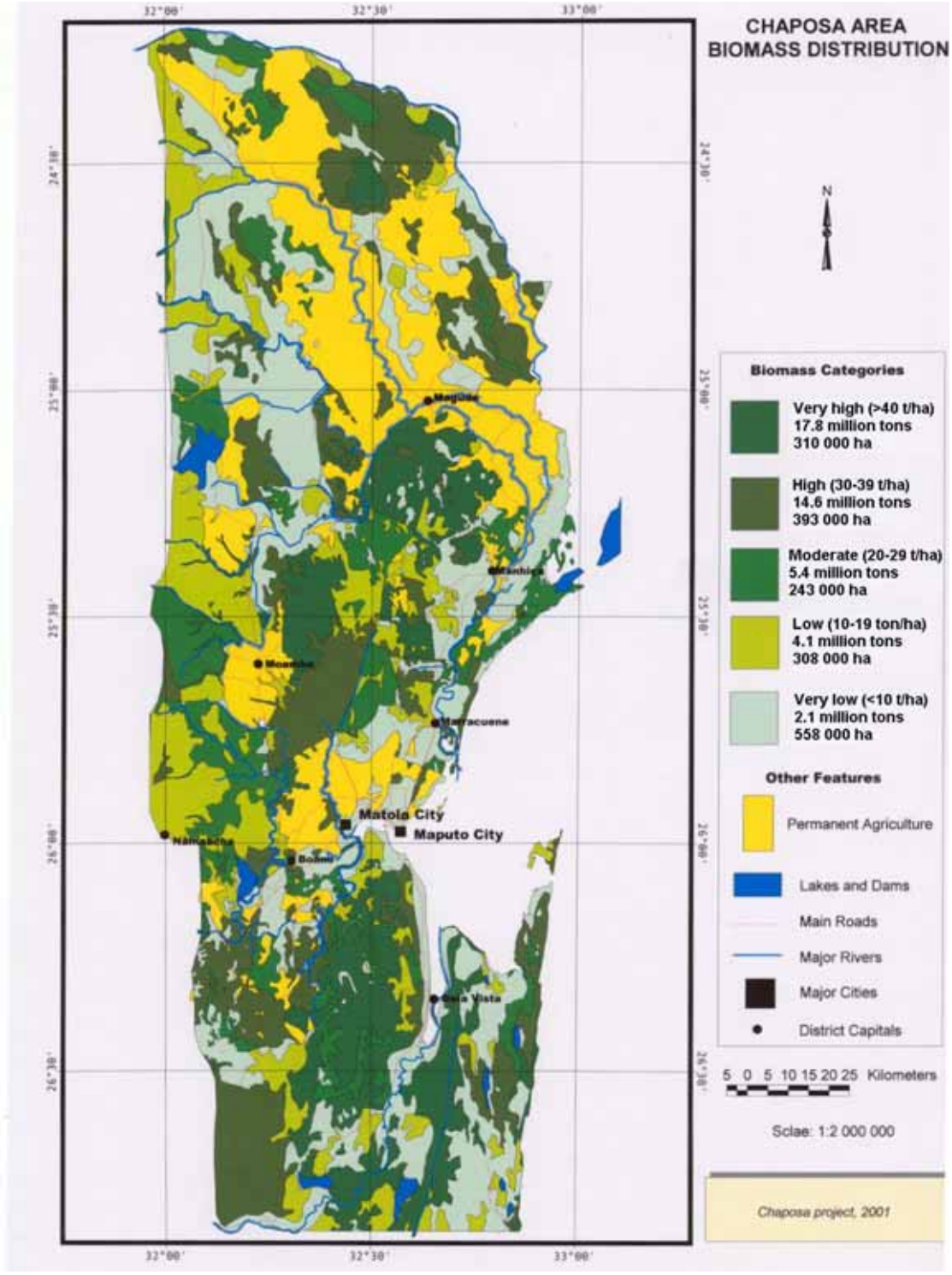

Figure 9 Maputo area present biomass distribution

The development trend for the woodlands in the Maputo study area shows that, without interventions there will be very limited wood resources left by 2015. Already at the present, most of the wood resources are from regrowth, and by the end year there will be slightly more than 20% left.

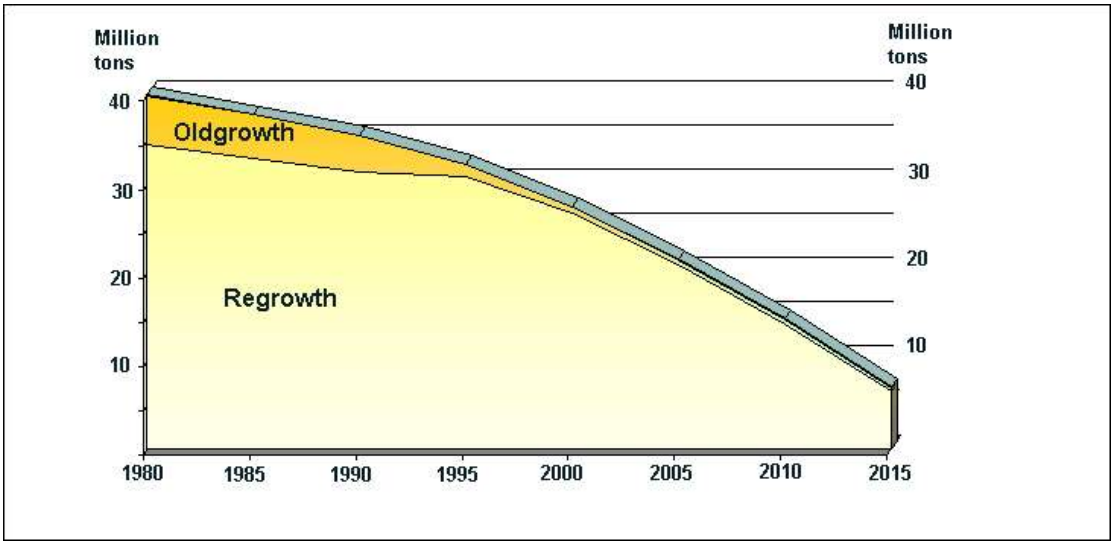

Figure 10 Woodland standing stock development trend without interventions in the Maputo study area

Phase 3b: Socio-economic analysis of the charcoal production system

The Chaposa project studies show that charcoal production is a major source of income to rural people in the supply areas of the large cities. This is for several reasons, as outlined below. It is relatively easy to start charcoal production, since little capital is required. The basic resource (wood from the forest) is effectively an open access resource, and it is a commodity with a steady market. These factors contribute to rural income, forest degradation and a stable charcoal supply. The latter is illustrated by the virtually constant (and surprisingly similar) charcoal price at slightly below USC 10 per kg in the three study areas over at least the past decade.

This is illustrated in

Figure 11, which is compiled from several project and other sources. The prices has been converted to US cents per kg to reduce the confusion from various currencies and different size of local charcoal units.

The long term real price development does not suggest any scarcity in supply, which might be expected if wood resources become scarce and have to be sought further afield. Increased distance to charcoal production areas, which was reported in all cases, has not been shown to affect the selling price in town very much.

All exceptional prices appear to be due to factors outside of the charcoal trade itself. There where high prices in Tanzania in the early eighties, a time of general recession in the country. In Mozambique in the eighties the war caused prices actually higher than those USC 20 indicated here for sake of scale. In 1985 the price was equivalent to USC 77 per kg, and in 1986 it was USC 31. The high price in Zambia in 1989 was due to extremely heavy rains, and the all time low was due to a two year drought in 1991-1992.

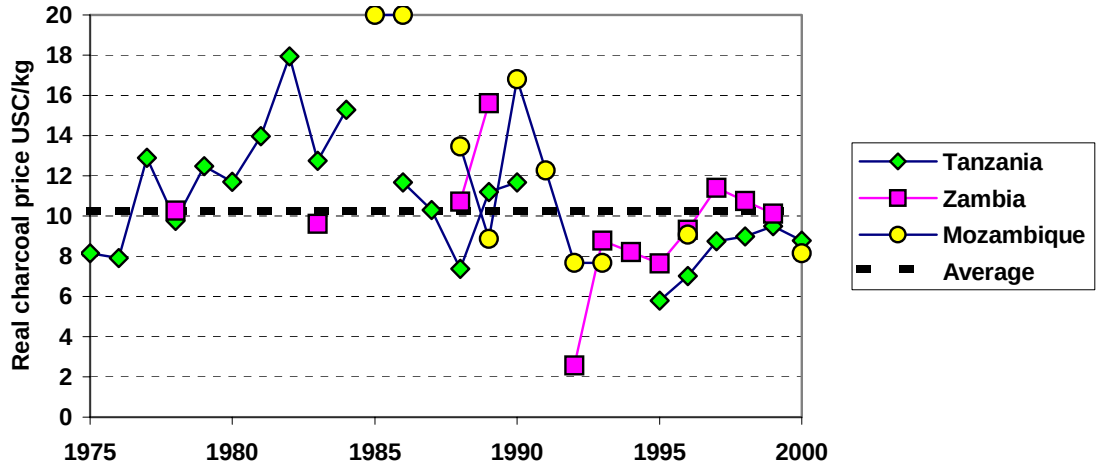

Figure 11 Real price of charcoal in the markets studied[1]

Considering that the energy value of one kg of charcoal is around 7 kWh (25 MJ), and the efficiency of a charcoal stove is at 15-20%, this suggests that urban people are paying around USC 7-10 per useful kWh for their cooking energy. This is slightly near the long range marginal cost of electricity and suggests that many would be able to pay a reasonable price for electricity if it were reliably supplied. The impediments to increased use of electricity are both on the supply side and on the demand side. Poor infrastructure and low quality supply, inadequate generation capacity (except in Zambia) on the supply side. On the demand side, the relatively high cost for connection and appliances form barriers for low income people to articulate their demand.

Charcoal industry size and consumption of charcoal

The majority of urban households in all the three cities studied use charcoal for their cooking requirements. In addition, numerous restaurants, food vendors, and other establishments use charcoal in their trade. Approximate values for charcoal consumption is given in Table 2. It is emphasized that these are very rough approximations. The table also shows an attempt to make an approximate calculation for the number of actors involved in the various steps of the trade. The figures are based on Chaposa study results. Productivity has been assumed to be similar to the average reported from the Lusaka area (160 bags per person per year). There is a great variation in this figure, so that full-time producers generally have a higher productivity than part-time producers.

The number of transporters and retailers have been calculated on the basis of data from the Maputo team. Retailers include all who sell charcoal, from those full-time engaged in the large markets, to those who sell an occasional heap or bag in the backyard. The relatively higher consumption per capita in Lusaka compared to Dar es Salaam and Maputo may be partly explained by the need for space heating in the cold season.

Although most income opportunities in the charcoal industry are not to be considered as full-time employments, it is obvious that this is a large and important industry in all

[1] Exchange rates as of January 2002: USD 1 = TZS 960 = ZMK 3850 = MZM 23 850

the countries studied, dwarfed only by the agriculture sector. The value of the commodity given in the table is calculated as the final consumer price multiplied by the total demand.

Table 2 Total charcoal demand and number of actors in the charcoal industry in the three cities

	Maputo	Dar es Salaam	Lusaka
Demand, Tons charcoal/year	130 000	440 000	250 000
Producers	20 000	54 000	37 000
Transporters	350	1 200	700
Retailers	20 000	70 000	40 000
Total	40 000	125 000	78 000
Consumers served, million	1	2	1
Value million USD/year	13	44	25

Dar es Salaam study area

Each village in the study sites has land for agriculture located either along river valleys, near homesteads or near forest reserves. The location of most of the farmland is highly influenced by the distance from a homestead. Land for agriculture is owned on customary basis, hence no privatization of land. It is mainly obtained through inheritance. Each farmer owns a plot individually of about 4 ha of which about half is cultivated and the other half is left fallow. On the average, each household maintains about 57% of the farmland as fallow which implies that land is not yet a scarce commodity in the study sites.

Woodlands, and mainly degraded miombo constitute the main natural resource occurring in the study sites. Woodlands under General land are mainly under the Local Governments and are managed by the District Councils through Village Governments. Due to poor control most of these are generally open access resources. They continue to be freely exploited and in some places they have been depleted to the extent that the woodlands are now standing disjointed in the degraded landscape. It is in these woodlands that charcoal production takes place.

In all the study villages, households derive more than 50% of their cash income from sale of forest products such as charcoal, honey, wild fruits, and firewood. Peri-urban households derive almost 70% of their cash income from the woodlands.

Charcoal production in eastern Tanzania has been shown to contribute substantially to the economy of rural people. Charcoal trade has been found to be a major source of employment and income to many rural and urban dwellers.

People are also moving into the study area from different parts of the country. The rate of immigration of people increased in the 1980s, the period characterized by Structural Adjustment Programme (SAP) policies. About 99% of these immigrants are from towns where they have failed to make a living due to retrenchment and unemployment. These people had to emigrate to the rural areas where they engage

mainly in farming, extraction and trade of forest products such as charcoal, pitsawn timber and casual employment in sisal estates.

Charcoal producers are moving from one production site to another for various reasons, such as scarcity of kiln construction materials, scarcity of preferred tree species, and to avoid soil destruction as the area could later on be used for crop production. The survey results also indicate that there has been an increase in distance from village to charcoal (kiln) site over the last 10 years, in search of better charcoal making sites. The average distance from village to charcoal site is 3-5 km. The search for such sites for charcoal making activities has also opened up forests/woodlands for agricultural activities and timber production.

Maputo study area

In areas with reasonable accessibility, charcoal is the main cash crop of the rural households. If there is no accessibility and no trucks go to remote rural areas to buy charcoal this product is not manufactured and the rural households complain about lack of income.

In the Licuati region south of Maputo, the annual average household income is USD 690 per year with USD 450 per year derived from charcoal production. This shows that charcoal provides a considerable income in rural areas. Extractives activities are the main source of income in rural areas: charcoal, fish and traditional drink market. None of these activities require expensive tools or formal education and are time and labour intensive.

The subsistence farmers or residents, especially women, produce charcoal to obtain some cash during the agriculture slack season (dry season). This also is the favored charcoal production period due to less kiln losses through humidity or rain. The professional charcoal makers make charcoal through out the year.

Figure 12 Earth mound kiln in Licuati region

Where there is abundance of forests and trees have large diameters in areas where chainsaws are not available the trees are felled by burning the base. Where the forest resources are scarce and not even small tree sizes can be found, even the remaining stumps are used for charcoal production.

The kiln production varies from 10 to 60 charcoal bags/kiln. In Licuati region male charcoal makers produce an average of 30 bags/month while women charcoal makers produce about half of that.

Conflicts between the non-resident charcoal makers and residents in rural areas for the access of forest resources are becoming frequent and reported in some of the districts supplying Maputo.

Lusaka study area

Charcoal producers from Angola first introduced charcoal as a household energy source in the Copperbelt region of Zambia around 1947. By 1962 virtually all African households in the Copperbelt towns were using charcoal for cooking. The government through the Forest Department even encouraged the use of charcoal instead of firewood in Lusaka town in central Zambia during the early 1960s. Since then the consumption of charcoal in Lusaka city has steadily increased. Currently charcoal used in Lusaka town comes from distances as far as 300 – 400 km from the city.

Production of charcoal in Chongwe district for the Lusaka urban market started in the early 1970s and has continued to today (see Figure 4.5). Surveys of charcoal transportation into Lusaka city showed that in 1992, 36% of the charcoal used in Lusaka came from Chongwe district but this had declined to 25% in 2000.

Charcoal production for sale is an important source of income and livelihood among the rural people. The income from charcoal represented a per capita income of USD 24 and 14 in 1990 and 2000, respectively, which was 1.8 and 4.8 times the per capita income from sale of agricultural produce in the same years.

From the rural survey, it was estimated that annual production is 160 bags per producer but producers from Tanzania produced significantly more bags (250) than Zambians. There was no significant difference in production between all-year and seasonal charcoal producers.

Charcoal production is the second largest economic activity in the district, after agriculture but generates more revenue for the rural economy in Chongwe than agriculture. Incomes from charcoal are used to purchase food for households and agricultural inputs and farm implements. Often vegetable crops, such as pumpkins and cucurbits and even maize are grown on kiln sites where charcoal was made and the soil is more fertile. Forestry is, therefore, a source of subsidy for crop production.

Apparently land was allocated to the producers for farming purposes, but many started charcoal production as a form of land clearing, and because of problems in the marketing of agricultural crops. About a quarter of the producers indicated that they would request for new or additional land from the headman and/or Chief to continue with charcoal production once trees on their current land are depleted and the majority were going to continue with charcoal production for the next 1-10 years.

Most of the producers wait for traders from town to come and buy the charcoal but some travel to town or roadside to find buyers. The sale arrangements range from cash only to credit, cash and barter (exchange with clothes, foodstuffs, fertilizer etc.). The credit option is usually offered to buyers with a long business relationship with the producer.

Measures for ensuring that new traders buying charcoal on credit pay include the trader leaving behind empty bags, producer accompanying trader to town to collect the money or know the place where the trader lives and sells charcoal, withholding a

national registration card or a good recommendation from other producers. Even so, half of the producers indicated that many traders default and such traders are usually reported to other producers in the area and to the village headman so that they can be blacklisted. Many producers were reluctant to report such defaulters to police because they feared getting in more serious trouble with government authorities, as they do not have licenses from the Forest Department.

The majority of urban charcoal traders are relatively new in the charcoal business and are mostly men (80%). Many of the traders became aware of the charcoal business from friends and relatives and were motivated to enter the business because they had no source of income. The majority paid cash for the transportation of charcoal to town while others use cash and credit, or fuel and part credit. A small proportion of the traders use their own vehicles to transport charcoal.

Regulation and licensing of the charcoal industry

Tanzania

Exploitation of forest products such as charcoal from the woodlands in Tanzania is regulated through permits and licenses. Presently, restriction on the use of woodlands is implemented through various means which include taxes, royalty fees, bans, licenses, permits and patrols. However, the results have been poor due to failure by government and villages to enforce their property rights. Causes of this failure include: breakdown of traditional management systems and power structures at the local level; inadequate legislation; and lack of resources to enforce laws thus indirectly allowing people to use woodlands illegally. These have rendered woodlands open access resources.

In the study area, woodland regulating measures mentioned to be in force include: permit payment, restriction of endangered species utilization and permit to harvest only large trees. Licensing forms the legal basis for forest activities and serve a s a means of control. Issuing of licenses is done by the Director of the Department of Forestry and Beekeeping. The exception are forests under village jurisdiction where local authorities may grant licenses. Forest product extraction for commercial purposes, unlike extraction for household consumption, requires a license. Pitsawing and charcoal production are some of the important activities taking place in the woodlands that require a license.

In the study area revenues realized from licenses are still insignificant compared to the needs for forest management operations in the woodlands; and the local population have not received any direct benefits from the revenue collected by the authorities. The crucial aspect in the whole licensing system has been to ensure that the forest owner's interest (i.e. Government) are guaranteed by the licensing system. While the long-term interest of the forest remain with the government, the immediate interest of license holders has been to exploit the resources as efficiently as possible while paying little attention to the impact on the remaining resource.

However, differences exit due to locality, authority involved and nature of the forest produce harvested in the study sites. Since there is no public announcing of the license holders, the license holder is obliged to carry a copy of the license to be shown on request as proof of legal activity in the woodlands. Inspection to ensure adherence to the conditions of the license is carried out during operation in the woodlands. Non-

adherence to the conditions of the license often leads to confiscation of harvested produce, a fine or a prison sentence. Under the prevailing laws, the fine for the first offence is TZS 5000 (USD 5.5) or six months prison term, which is increased on subsequent offences. These penalties, however, are very old and have outlived their usefulness to cope with the present economic realities.

Local foresters and respondents reported that the licensing system does not work well due to many reasons:

(i) conflict of interest between the local forester and the buyer of license.
(ii) inadequate human and financial resources to monitor licencsees in the woodlands.
(iii) long distance (geographical and administrative) from the decision maker to forest sites
(iv) inadequately detailed or vague license
(v) over- licensing in one area of woodland leading to overexploitation.
(vi) lack of forest education.

Most of the respondents reported that there are no patrols by local foresters. Only one in six conceded to have seen somebody arrested by the local forester.

Mozambique

Since 1965 the forest regulation states that harvesting of any kind of natural forests has to be done with harvesting permit and according to forest regulation and rules established by the provincial forestry services.

According to the law, any person that makes charcoal for commercial purposes has to be licensed. Consequently almost all charcoal that enters into Maputo is illegal. A comparison between the amount licensed in Maputo province and the urban consumption showed that the licensing system only covered about 1% of the biomass consumption in town.

The licensing is designed to collect fees for the Agrarian Development Fund. This fund was created with the purpose of promoting small-scale rural activities and rural development as well as reforestation programs. The charcoal production fee is 2500 MZM/charcoal bag plus 15% of reforestation fee. The Government has only collected an annual average of 240 million MZM/year (USD 11 000) for the period 1993-2000 from charcoal/firewood production, which represents the important forest product.

The licensing systems is a component of the overall scheme of logging control. Road checkpoints located at strategic points between the forests and the market places are the key elements in the present licensing control system. Due to the limited equipment of forest guards (no vehicles or motorbikes) and the vast options of secondary roads entering into town, the checkpoints have little impact on the illegal logging control. The immediate consequence is the low level of fees captured by the forest services and no reliable statistics on forests and products being harvested. Uncontrolled harvesting is the main characteristic in charcoal production.

In the last years, there has been a movement to transfer the charcoal licensing fees from the transporters to the producers, imposing an extra cost per bag to the producers in some community forest management pilot areas. The only way to cover such extra cost at the producers level is to increase the scale of production since up to now no different selling prices have been practiced in these pilot areas. Therefore, due to a desperate attempt to increase control on charcoal production and to obey the law, charcoal producers which represent the most vulnerable group with less price negotia-

tion maneuver and willing to preserve the resources were punished through an extra tax and a complicated bureaucratic system.

Zambia

Half of charcoal producers are aware about the law requiring them to have a license to produce charcoal for sale but only 20% claimed to have had a license and the total amount paid to Forest Department in license fees was for the equivalence of about 339 cubic m of cord wood, which represents only 0.05% of the value of cord wood stumped to make charcoal in 2000.

A trader transporting charcoal from a production site to an urban market is required by the forest law to pay a charcoal conveyance fee of USD 0.1 per standard grain bag that contains about 40 kg of charcoal. This regulation is enforced by mounting road check-points by police or Forest Department officials. Some traders complained about harassment by these officials even after obtaining conveyance permits from the Forest Department. This is one likely reason that more than half of the charcoal transport to Lusaka takes place in the night time, when the road blocks are not manned. The whole payment and enforcement system relating to the conveyance fee was not adequately studied due to the sensitivity about the issue by those involved.

Phase 4: Modelling the charcoal system and scenario building

In order to be able to assess the effect of some possible changes in the forest resource and energy use system, a computer model for energy planning was used. Primary data from the studies was fed into the model, which was then made to run under various assumptions on future development. Lack of reliable population data and information on actual forest growth was a limitation in some of the cases. The model is described in great detail in Annex 4.

The model focuses on the effect of applying more efficient production and consumption techniques, and shows that if such measures could be introduced on a large scale, charcoal consumption could be reduced substantially, allowing for charcoal use much longer into the future (Figure 13 - Figure 15). The range in the different scenarios is largely decided by different assumptions in population growth rates. It should be noted that the model is calculated on the basis of wood needed, i.e. before the conversion into charcoal.

One problem with this kind of technology-driven scenario is that it assumes a very strong market penetration in a relatively short time. It has proven relatively difficult to introduce improved stoves in all of the cities studied. The greatest success has been achieved in Dar es Salaam, with a more or less free-market oriented dissemination. In fourteen years, the market penetration for improved stoves is about 40%. It has proved even more difficult to gain acceptance for improved kilns. By now it can be safely stated that any type of fixed cover kilns can not be successfully introduced in the present charcoal production system. This is mainly due to lack of capital, power tools for cutting and haulage systems in the production areas. Instead greater hope is attached to improving the earth mound kiln techniques, making use of the skills of experienced charcoal producers.

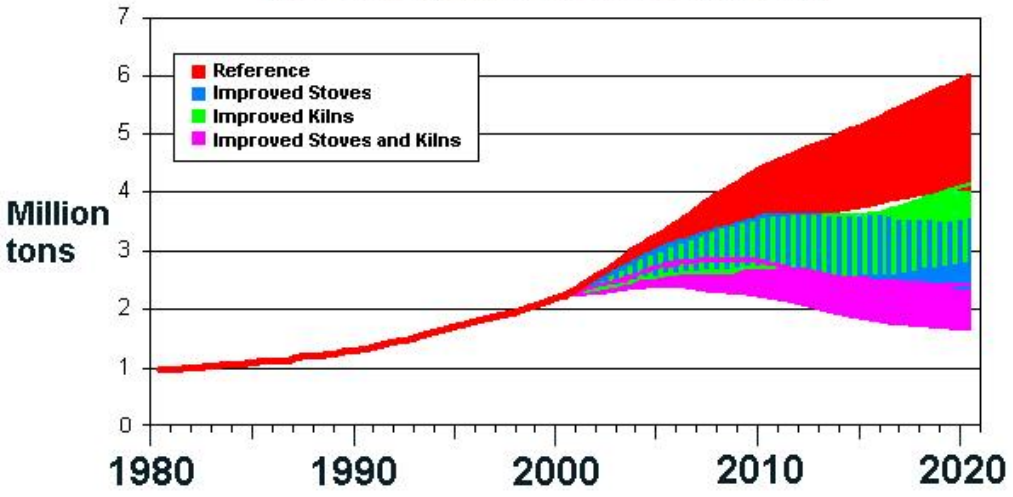

Figure 13 Wood required to satisfy firewood and charcoal consumption in Dar es Salaam under different scenarios

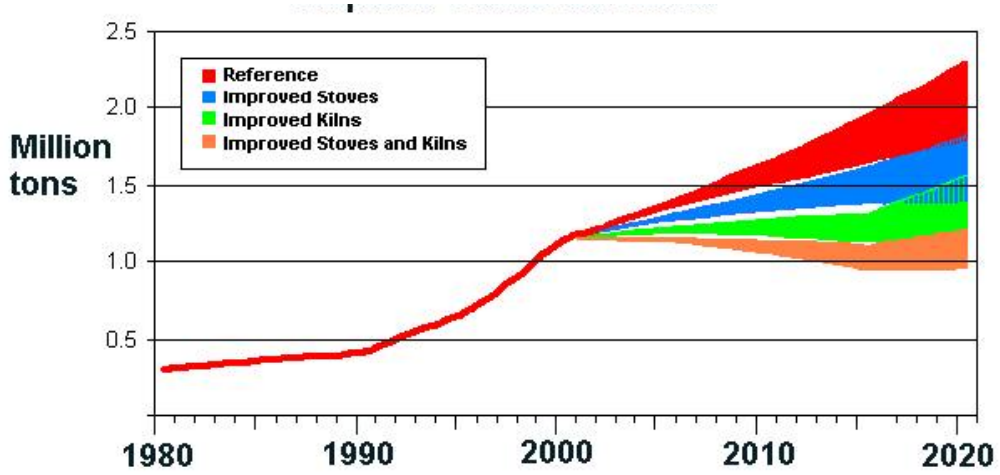

Figure 14 Wood required to satisfy firewood and charcoal consumption in Maputo under different scenarios

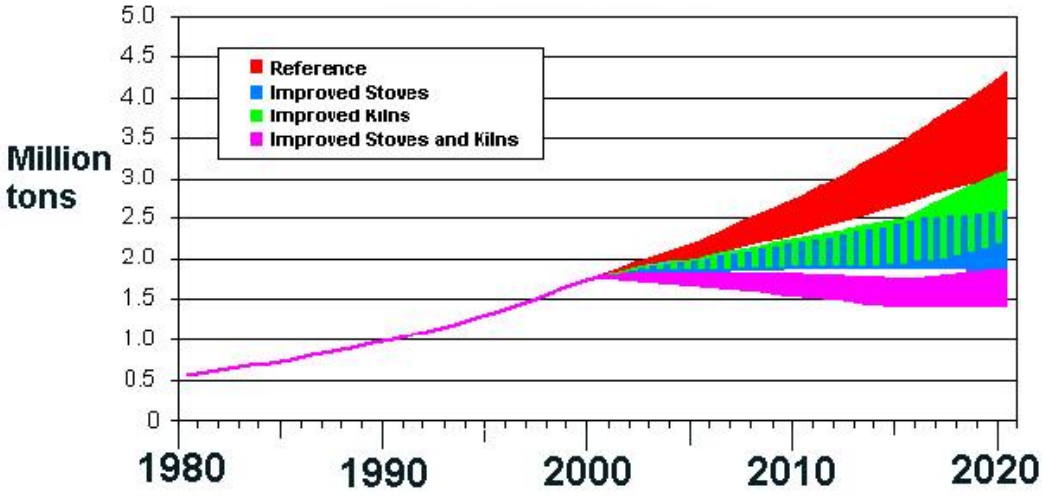

Figure 15 Wood required to satisfy firewood and charcoal consumption in Lusaka under different scenarios

An important issue is also that improved production techniques do not only refer to improved efficiency in wood conversion, but also to improved productivity of the actors. While this is a normal process which will occur if the production forces are mature, one of the effects will be reducing the number of producers required to supply the demand. This will reduce the spread of rural income so that few will earn more.

Another scenario, which was not investigated for lack of reasonable assumptions, is the possibility of fuel substitution. As mentioned above, low-income urban households are already paying amounts which are similar to the cost of electricity for their cooking energy requirements. Still, the expansion of electric cooking has been very slow. Among the reasons are the high entrance fee to electricity (connection, wiring), but this is not the whole truth. Substantial numbers of even low-income households in the cities do have electricity connections, but do not use it for cooking. Stoves are high cost, low quality and ill suited to cooking the traditional staple maize porridge (*nshima, shima, ugali*). Power supply is further erratic, with frequent cuts and voltage fluctuations, and in most cases not sufficient to meet the demand of hundreds of thousands of new users. This makes back-up systems at household level necessary anyway. Finally, the top priority among appliances is usually not the stove, but the television set. It might be that this is a gender issue. The analysis of this issue requires further effort.

Phase 5: Development of appropriate policy intervention strategies

The charcoal industry and its output affect a great many people, and hence a great many sectors and policies are involved.

The situation is complicated and requires a keen insight and delicate touch. On the one hand, forest resources are being depleted. On the other hand they are probably contributing more to poverty reduction with present use patterns than they would with almost any alternative. The result is that urban people are using fuels that are less convenient than modern alternatives. However, modern alternatives have not been able to compete with charcoal.

Too quick and sweeping changes of the charcoal supply system are likely to cause great hardship for many poor people. This was illustrated in a campaign carried out by the government in Zambia in June, 1994. During two weeks, all road blocks were actually manned around the day and night for two weeks. The effect was an immediate increase in charcoal prices in the urban markets, and little else.

What then are the policy options, and what should be the objective of policy changes? The problem is compounded since the policies of several sectors are involved.

Looking at natural resource policies, all countries have policy objectives of protecting the environment, species diversity and natural forests. The resources to implement the policies and protect the natural environment are, however, ubiquitously lacking. Natural resource or environmental departments typically have little or no presence in rural areas, and enforcement of laws and regulations is virtually non-existing.

In recent years it has become popular to include local stakeholders in the management and control process. Experiments with local co-management of resources have been undertaken, and local communities have been given a share of the responsibility as well as a share of the income from licensing and fees. This system is largely based on wildlife management experiences, where local communities get a share of the income from hunting by foreigners. The difference with the forest system is that the unit

price of the produce is much less, and that it is generated over a long time by many actors spread over large areas. An experiment was conducted in the Maputo area, where local people were given the extraction licenses, and became the only legal producers of charcoal. This became a failure, however, since the license cost was shifted to the poorest segment of the charcoal marketing chain, with little opportunity to recover the cost. In adjacent areas, illegal charcoal producers were continuing to produce charcoal without the onus of any license fee, keeping the prices down. Application of new management practises needs working enforcement of rules to become feasible.

The valuation of the forest resource is a core issue to the policy choices. With a negative net present value of the resource, it is not feasible to invest in strong management measures. The existing situation tells the tale: mature closed woodlands are being depleted, and left to regenerate as best they can. But if market forces cannot assign adequate values to the resources, then the fiscal system must do it. And one of the major findings is that the fiscal system for forest management and revenue collection is inadequate in all the three countries studied.

The environment policy is akin to the natural resource policy, but with the difference that it is more highly invaded by external interests. Environmental concern can give strong effects locally, especially if backed by international environmental organizations. The actions are usually transient, however, and focussed on aspects other than the welfare of rural people. The concern is more often for rare species of frogs, birds or mammals, than for the common tree species that serve the subsistence of local people.

Agriculture policy is of great importance in rural areas. In Zambia, agricultural policy was changed in the early nineties to involve more of private initiative. This led to the collapse of the existing system of credits, supply of seeds and fertilizer, and marketing of the produce. Farmers were reverted to subsistence farming, and were forced to go into charcoal production for cash earning. Policies need to provide increased market access for rural producers, increased input of implements such as seeds and fertiliser, and a system that could resist fluctuations in harvest due to rains and drought. This would be a policy of agricultural subsidies, which is difficult to sustain for poor countries in the third world, especially since they have to compete on an often hostile world market, subsidised by rich countries in support of their own farming populations. In the end, the rationalization and improvement of agriculture anywhere has resulted in fewer farmers producing more, and an exodus from the rural areas to the cities.

Energy policy in the countries studied essentially deals with electricity and petroleum products. These policies are strongly influenced by political actors in need to keep peace with urban elites. The result is policies that do not serve the urban poor and that do not benefit the rural populations.

Traditional energy sources are usually covered in policy statements, but there is little influence of these policies. The traditional energy sources are the realm of Energy Departments of the governments, departments which are understaffed, underpaid and with no presence in the areas of production and marketing. Restrictions and changes can not be enforced, due to lack of resources. It is usually here that projects on improved stoves and kilns have their base, although many such projects are implemented independently by various donors. Experience has shown that improved stoves have

great difficulties in securing a market share, mostly because saving energy is not an issue for the households who use them. This includes also low-income households and is testimony to the service and low price that the present charcoal industry provides. For an improved stove to have a chance on the market, it has to be as cheap, durable and convenient as the traditional stove in addition to saving fuel. Failure to achieve this results in failure of the stove introduction. One of the most successful introductions of improved stoves is actually in Dar es Salaam, where the Department of Energy with support of the World Bank built up local production and marketing of improved ceramic lined stoves at the end of the eighties. Present market penetration rate is variously quoted as 30 to 50%.

Improved kilns have an even more dismal history. Various forms of improved kilns have been tried in the past twenty years, and in spite of real efficiency improvements they have failed for other reasons, including extreme need of capital, need for wood processing before carbonisation, need for transport of wood to the kiln site instead of the opposite. In recent years more hope has been tied to the possibility to achieve improvements through improved management of the kilns. This implies studying how experienced producers behave, and then trying to formalise this behaviour and teach less experienced producers to do the same. In Zambia a manual for best practise has been produced and printed in English, Bemba, Nyanya and Portuguese. In Tanzania it is argued that improved practises can give substantial yield improvements. Based on years of study of charcoal production it appears unlikely, however, that yields would increase dramatically even if best practises were applied by all. The likely improvement would probably be from the present 15-20% to maybe 20-25% in practical applications.

Energy substitution remains an objective with some hope for the natural resource sector. We have shown that low income people are already paying for their energy needs in amounts that would be sufficient to pay for electricity, even at long range marginal costs. Hence, policies aiming to override the barriers for poor people to become electricity users are necessary, especially in conjunction with policies that increase the cost of wood fuels. The barriers to increased electricity use in urban areas are high connection fees, low quality appliances unsuited to the cooking practises, low quality of supply with frequent black-outs, and finally limited generation capacity.

The potential income to state treasury from the charcoal industry is a strong temptation for authorities to instate fees, licenses and restrictions. However, in all the three countries studied, the income accounted for is but a small fraction (1-25%) of what it could potentially be. The rates are rarely reviewed, and so are eroded by inflation. Finally, government income is limited from all sources, and there is little incentive to plough back any substantial amount accruing from the charcoal sector and into its management.

Summary

Large areas of natural forests in Southern Africa are being depleted for charcoal production for urban consumption. At current trends, variously large areas will be converted, and the potential to supply fuel in fifteen years time will be down to 15% of the present in the Maputo area, 20% of the present in the DSM area, and 80% of the present in the Lusaka area. This implies that wood fuel resources will have to be found in other areas if there is no change in energy use pattern in the urban areas, or

change in production techniques. Such areas exist in all countries, but are more distant and difficult to reach than the present supply areas. Hence, from a fuel supply perspective, there is no risk of absolute scarcity, although transportation distances will increase.

Charcoal prices in real terms have been relatively stable during at least the last decade in all the countries. Thus there is no indication of increased scarcity, or higher transport costs, although this could be masked by greater supply and lower producer prices in the rural areas. Urban consumers are paying slightly less than USC 10 per kg of charcoal in all the three cities, and have been doing so for the past twenty years, except in extraordinary circumstances of war, flood and drought.

The charcoal industry provides income opportunities to large numbers of poor rural people, and affordable and reliable energy supply to the majority of poor urban people. Thus, changes to the present system, for whatever reason implemented, will affect a large number of poor people. Since the most realistic changes would include restrictions in either supply or price, such changes would be for the worse for most people included. Hence, policy interventions must be carefully deliberated.

Conclusions

In all the study areas, forest management is inadequate. This goes to the protection of indigenous forest, as well as to the possibility to enhance regrowth and the possibility to increase productivity from the forest. There is a need to strengthen the capacity of forest authorities to assess, demarcate and protect certain areas, and to help introducing management systems that benefit local communities and the natural resource availability. This can come about only with increased resources to the forestry and natural resource sectors.

Existing natural resource policies in all the countries include fees for removal, transportation or trade in forest resources. Collection of these fees and licenses would result in substantial amounts that could be used for the above management requirements. This fiscal system is, however, inadequately enforced and revenue collection is but a fraction of what it should be. Hence, reviewing the fiscal system is an important task with the objective of improving natural resource management. But in most cases, the existing licensing systems cannot be simply enforced, since they are instated for various objectives. The systems must reviewed, so that fees and licenses are universally applicable, equal for the actors involved and serving the purposes of the system. It is important, that the enforcement of the fiscal system is carefully and gradually implemented, and that the resources gained to a large extent must be invested in the sector. The system must be self-reproducing and able to pay for all costs it accrues internally. Income gained from increased enforcement must be used to a great extent to reinforce the actors responsible for forestry and natural resource management, whether government or others. Objectives of, for instance, forest management, community participation, improved production or utilization techniques, information dissemination, should all be covered by the system. Primarily the income would go gradually to build up the system itself, so that conquered ground would not have to be abandoned after a short period. Only after this is achieved, the income would go towards the necessary management measures.

Enforcing the fiscal system for forest resources will increase consumer prices, and reduce producer prices. As seen from the Tanzania example, it would, under current

circumstances, effectively wipe out the profit from the charcoal transportation sector. Thus, it could be expected that capital is withdrawn from the industry, especially in the transport segment. This will increase the hardship for poor people, by reducing the income opportunities in rural areas, and increase the charcoal cost in the urban markets. Hence, enforcing the fiscal system must not be done in isolation.

Enforcing the fiscal system for forest resources will make poor people search for substitutes for charcoal at both ends of the chain. At the producer end, such substitutes could be agricultural production, timber extraction or poaching. At the consumer end, other energy sources than charcoal, and more efficient devices for charcoal, would become more attractive. Thus, at the same time that these changes are forced by increased hardship, they are also the way out of the present dilemma.

In order to reduce the negative effects of increased prices, and to make substitutes feasible, efforts must be made also in other sectors.

In rural areas it will be important that the system for agricultural production is working, and supplying the necessary credits, implements and market for produce. In this way, agricultural production can be an alternative source of income to substitute for charcoal production. There is a need for such measures in all the supply areas studied, but maybe most pronounced in the Lusaka area. Furthermore, the effects of improved management should be able to provide some income to rural communities through employment in the forestry sector, and through increased extraction of forest resources for other purposes than energy.

In the urban areas, increased consumer prices will make it more realistic to introduce fuel-saving appliances, and for consumers to shift to other energy sources, if available. A real challenge is to provide substitutes for charcoal altogether. This would largely mean increased investment in the electricity sector, in distribution, in deferred payment schemes for connection fees, in provision (maybe support to development) of stoves suitable for the cooking habits, and finally in environmentally acceptable generation of power. Distribution of power in urban areas, and power generation would probably be profitable right from the start, and could be assigned to the private sector to provide. However, removing the barriers for low income people to articulate their demand probably needs political enforcement. It should be clear that the objective is actually to supply enough power to reliably provide large numbers of consumers with alternatives to wood fuels. This could be in the form of conditions to the concessions given to the industry, especially in order to reduce the high entrance fees to the electricity market.

Recommendations

It must be acknowledge that charcoal is not a minor forest produce, but a major one, and in most cases the only one. The natural forests surrounding large cities in southern Africa are being depleted, partly due to charcoal extraction. In spite of this, the forest resources are likely to be able to supply charcoal for at least another decade through the regrowth, and areas further afield could be exploited in the future. The depletion is most severe around Maputo, where the natural closed forest is essentially removed already today. In Zambia and Tanzania the resource situation is less severe, but ecologically sensitive areas are increasingly becoming exploited. There is a need for natural resource management measures.

- Enforcing the licensing systems appears to be the feasible route with which to induce changes in the system. This will increase consumer prices and reduce rural income and is politically sensitive. At the same time this is also the seed to a thorough change in the system, and to development.

The demand for alternatives and saving measures induced by the price increases must be met by other measures.

- In the rural production areas this can be done by improving the situation for agricultural production in rural areas and by offering roles for rural people in the natural resource management and extraction.
- In urban areas, use of fuel-efficient stoves should be encouraged, but most importantly, the demand for alternative energy sources should be met. The most realistic alternative is electricity supply, which needs to be expanded. High entrance fees to electricity use must be reduced. Increased electricity supply and distribution is most probably going to be profitable, and could be provided by private actors who accept certain conditions. Fossil options are not considered here for environmental reasons, but could be feasible alternatives.

These policies must be implemented together. Enforcement of the fiscal system for natural resources will provide the impetus and market for changes in the other sectors, but if implemented in isolation will cause severe hardship to many poor people. Agricultural smallholder production needs support and consistent long-term policies in order to be able to provide alternatives to charcoal production or illegal logging. The electricity sector needs to provide power to large numbers of low-income consumers, and needs to learn how to manage such operations.

If these recommendations are not enforced together, or in close sequence, then it might be better to sacrifice the natural forest than to bring more hardship on already severely tested people.

Problems encountered

Inadequate financial resources due to EU regulations on release of funds affected the performance of the project in Zambia. Lack of recent spatially explicit population data also affected the proper analysis of socio-economic and some ecological factors that affect the charcoal energy sub-sector in Zambia.

Few shortfalls were apparent in executing the study, these include: poor population statistics, absence of long term tree growth data and poor quality of the satellite images which made difficulties in their interpretation. Because of this it was not possible to get images for the entire study area. Thus images were acquired for the eastern and southern parts of the study area only.

Technology implementation plan

Not relevant to CHAPOSA project

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Pereira, C.R.: Charcoal and firewood transportation - A survey of the transport system (mode of transportation, vehicle fleet characteristics and actor profile) used to supply the Maputo City markets with charcoal.

Management report

Organization of the collaboration

The organization of the collaboration has been that of a consortium among equals. Each partner has appointed a national coordinator to lead the project work of that partner. Each partner has had a relatively large freedom to interpret and implement the research plans. This has resulted in emphasis on different aspects of the research.

Meetings

The partners have met in annual review meetings.

Exchanges

There have been no exchanges, barring occasional visits between the partners outside of the research programme.

Problems

The disbursement policy of INCO-DEV has caused major problems to the African partners. Since they do not have the required liquidity to implement research without funding, progress stalled after the initial year when adequate advances were paid out. This forced the coordinating institution to give loans to the partners in for implementation of project tasks. Even so, these funds have not been sufficient to complete some of the activities of the partners.

Communication has sometimes been erratic between the partners. In hindsight it would have been wise to invest more in meetings, so that at least biannual meetings would have been possible. Alternatively, the coordinator should have been able to visit the partners more frequently during project implementation. As it was, visits were only possible when the coordinator had other business in the countries.

Acquisition of satellite images caused more problems than anticipated, mostly because undisturbed images over the requested areas and time periods were very difficult to acquire.

Individual partner reports

University of Zambia report

Objectives

Charcoal Potential for Southern Africa (CHAPOSA) was a research project involving three African and two European partners that was funded by the European Union. The objective of Chaposa project was to increase the possibility to ensure an affordable and sustainable supply of biomass energy for low-income households in urban areas of southern and eastern Africa.

Activities

Chaposa was designed to undertake the following activities: (i) assessment of biological, social and economic factors underlying forest depletion around Lusaka, (ii) identification of indicators of forest overuse and (iii) recommend policy measures that effectively address the biomass energy situation that take into account the perspectives of natural resources management, social and economic development.

The project was organized in five different phases over a 3-year period (1999 – 20001) and each preceding phase provided relevant information for the succeeding phases. The five phases were:

1) Definition of research framework and areas of study.
2) Definition of the ecological potential for charcoal production for Lusaka
3) Assessment of the spatial dynamics and socio-economic analysis of the charcoal production system.
4) Modelling the charcoal demand and supply system and all related energy flows and costs (University of Stuttgart in Germany).
5) Development of appropriate policy intervention strategies (Stockholm Environment Institute with input from each African partner).

The Chaposa study in Zambia was conducted in Lusaka city and Chongwe district (15.00 – 15.45° S, 28.50 – 29.50° E) in central Zambia (Figure 16). Existing data in literature was reviewed by the ecological and socio-economic components of the project. Activities in the ecological component also involved forest surveys, assessment of the efficiency of the charcoal production technology, soil productivity assessment, analysis of population-woodland relationship, acquisition and analysis of satellite imagery of the study area for 1989 and 1998, digital image processing and field land cover and use verification. Activities in the socio-economic component included urban household energy surveys and rural socio-economic surveys and charcoal transportation surveys and data analyses. In addition, four local planning meetings were held and Zambia attended all the four international annual project planning and review meetings held in Lusaka, Morogoro, Stockholm and Maputo.

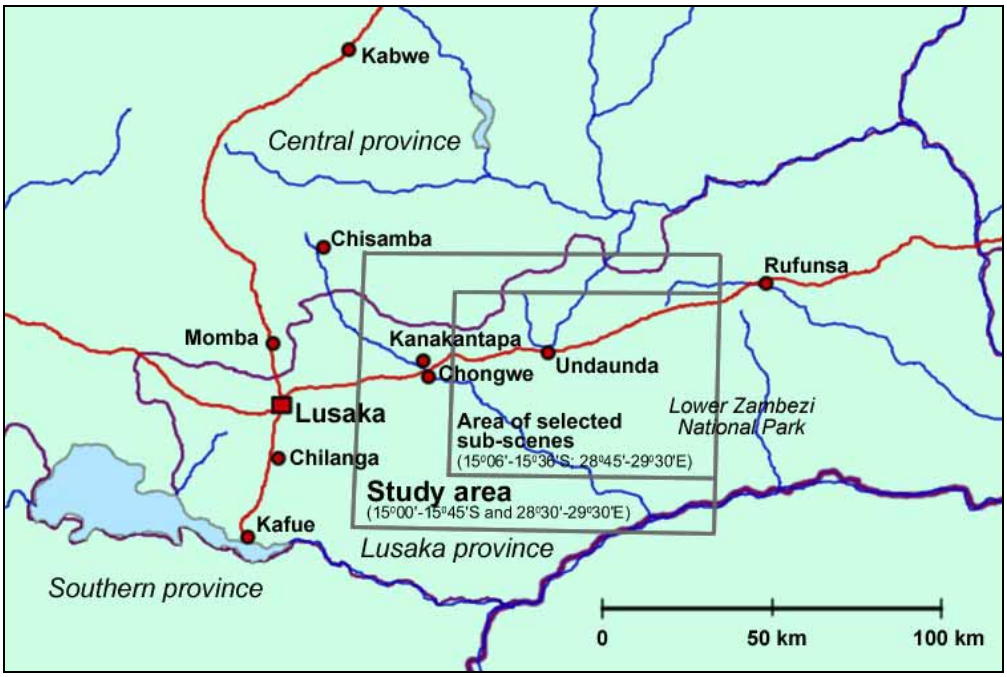

Figure 16 Lusaka study area

Results

The rural study area

Chongwe district has a population of 144700 and grew by 5.12% during 1990 to 2000. The population density is 12.9 km^{-2} but in charcoal producing areas the density was 3.4 km^{-2} compared to 58.6 km^{-2} in non-charcoal producing areas. The major source of population increase in charcoal producing areas during 1990 – 2000 was immigration which has resulted in a very heterogeneous community. Customary land tenure, in which Chiefs and their village headmen/women play an important role in land allocation but lacks mechanisms for land use controls, is predominant in the study area. About 85% of the population in Chongwe is engaged in agriculture with maize, sunflower, soybeans and cotton as the main crops. Annual per capita income from agriculture declined from US$13 in 1993 to US$3 in 1997 largely because of the removal of subsidies on agricultural inputs and liberalisation of agricultural marketing by the government in 1992. Use of fertiliser in crop production also declined by 80% during the 1993-1997 period.

In Lusaka city the population in 2000 was 1103410 with a growth rate of 4.5% during 1990 – 2000. The total number of households was 198290 in 2000 with 90% being dependent on charcoal for cooking.

Ecology

The two main woodland vegetation types in the Chongwe study area are *Brachystegia – Julbernardia* (miombo) and *Acacia* (munga) woodlands. The bulk of the charcoal is produced from miombo woodland trees. Above ground wood biomass varies across the landscape from 72t ha^{-1} on plateau sites to 55t ha^{-1} on hill and escarpment sites. Munga woodland has a biomass of 41t ha^{-1}. Trees preferred for charcoal making in miombo woodland comprise 88% of the biomass while valuable timber and fruit trees

comprise 2% and 3% of the biomass. The remainder is made up of none-charcoal trees.

Charcoal is produced in earth kilns constructed by covering a pile of logs with soil clumps dug from around the kiln site. Trees are selectively cut at about knee or waist height with axes. Wood carbonisation takes a number of days or even weeks for large kilns. Wood to charcoal conversion efficiency ranged from 25 to 28% on oven-dry weight basis. Charcoal production is regulated by the Forest Department which issues stumpage licenses at US$ 0.5 per m^3 stacked cord wood but enforcement is weak and less than 1% of the charcoal producers in the study area had stumpage licenses. The are no officially designated charcoal production areas in Chongwe; production is therefore haphazard and scattered over a large area. Areas exploited for charcoal are either converted to agriculture or abandoned with no management to ensure optimum forest regeneration, especially on land under traditional tenure. In forest reserves woodland regeneration after exploitation was estimated at 2 – 4 t ha^{-1} compared to less than 1t ha^{-1} on traditional land. Mean annual increment in mature miombo woodland was estimated at 2 – 3% of the standing stock. Woodland in former forest reserves that had been exploited for charcoal production in the 1970s were being recleared for charcoal making in the 1990s, although some reserves have been converted to other land uses. This indicates that sustainable use of miombo woodland for charcoal production is possible under good forest management. There were no significant changes in soil productivity following woodland clearing for charcoal production.

Table 3 Land cover change in the central area of Chongwe district between 1989 and 1998 based on satellite imagery analysis.

Land cover type	Area (km^2)		Change	
	1989	1998	9-year (km^2)	Annual (%)
Bare/cleared land	60	160	97	18
Open scrubland	600	1000	410	7,6
Dense scrubland/low forest re-growth	440	440	0	0,0
Valley vegetation	110	100	-6	-0,6
Escarpment/hill miombo woodland	2400	2300	-88	-0,4
Plateau miombo woodland	1700	1300	-412	-2,7
All types	5300	5300		

Agriculture accounted for 70% of the deforestation in the study area and the remaining 35% was attributed to charcoal production. Ecological indicators of over-exploitation of forest resources included charcoal making in young re-growth, hill and riverine areas and cutting of none-charcoal trees. Woodland cover in the study areas declined by 1.34% per year over the 1989 to 1998 period (Table 3). The highest rate of change was in plateau woodland that decreased by 9.4% per annum. As a result, open scrubland increased by 7.6% per annum due to both woodland clearance and regeneration on exploited areas and abandoned cultivated areas. Total woodland clearance was significantly correlated with population density which suggests that popula-

tion growth is influencing the rate of woodland cover change in the study area. Nevertheless, estimates indicate that there are adequate forest resources in Chongwe district to continue supplying charcoal to Lusaka city for the next 10 to 20 years, as long as production is properly regulated.

Socio-economic aspects

The Chongwe area has supplied 25 –35% of the charcoal used in Lusaka city since the 1970s, although distances to production areas and transportation costs are increasing (Figure 17). Per capita income from charcoal production was estimated at US$14 in 2000 and this is five times the per capita income from agriculture production. The majority of producers have been making charcoal for 1-5 years and production is done either seasonally or throughout the year. Most producers that do not produce charcoal throughout the year engage in crop production when they are not making charcoal. Urban traders purchase charcoal at production sites either on cash or credit basis and hire vehicles in town to transport charcoal to urban markets. The bulk of the charcoal is transported in lorries.

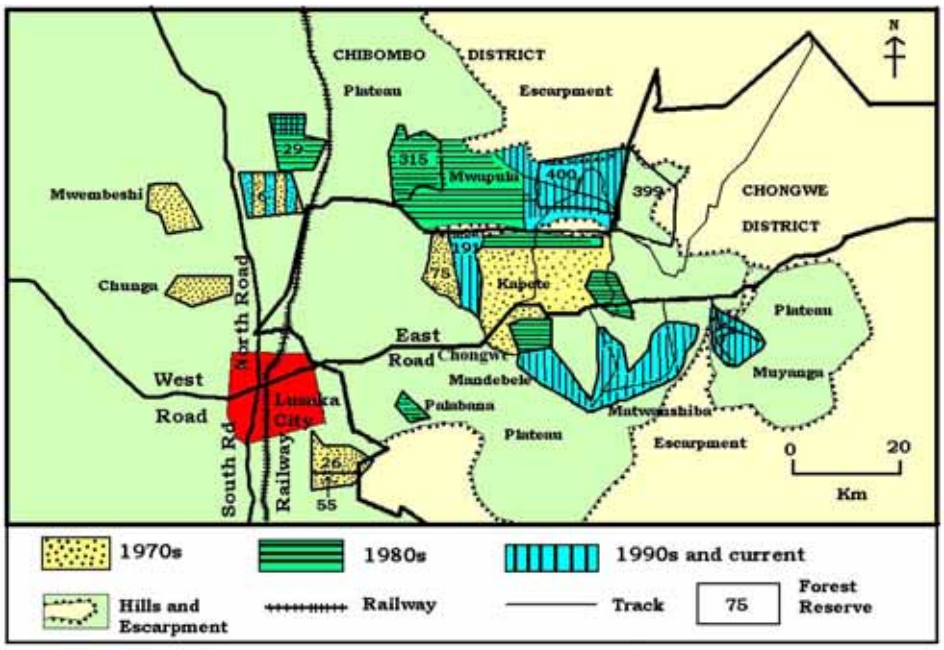

Figure 17 Past and present major charcoal production areas supplying Lusaka urban markets in the Chaposa study area.

Charcoal demand in Lusaka city increased by 4.1% per year during 1990 to 2000. Total consumption in 2000 was estimated at 245000t. For 65% of the households, charcoal was the only energy source used while the rest of the households used charcoal in combination with firewood (23%), kerosene (17%) and electricity (1%). Charcoal prices, in real terms, have remained stable at about US$3 per bag over the period 1992 – 2000. Consequently, there was no economic indication that forest resources are being over-exploited for charcoal production. Profits from the charcoal business are marginal both at production and retail stages. However, production is maintained because of low opportunity costs in rural areas as a result of failure in the agriculture industry and decline in formal employment opportunities in urban areas. The demand

for charcoal in urban areas is also growing due to lack of alternative household energy sources. The supply of kerosene is erratic and the majority of urban households perceive electricity tariffs as too high.

Conclusions

The following are the main conclusions of the study

1) The project area has been an important source of charcoal for Lusaka city since the 1970s.
2) Although agriculture is the main economic activity, incomes from the sale of agricultural produce have declined sharply since the removal of agricultural subsidies and liberalization of agricultural marketing in 1992.
3) Cultivation is the major cause of deforestation and currently, about 30% of the area deforested for charcoal production in Chongwe district is not converted to cultivation, although charcoal production is the most important source of income in Chongwe district.
4) The miombo woodland used for charcoal production in Chongwe district has the potential to regenerate and can be used again for charcoal production in the future. However, this potential cannot be realized in the near future be-cause of:
   a) lack of proper forest management and absence of areas dedicated to char-coal production and the on-going conversion of forest reserves to urban and agricultural development,
   b) encroachment into forest reserves
   c) inadequate forest management in areas cleared for charcoal production on customary land.
5) Economic and agriculture policies have made charcoal production and trading attractive sources of income, although profitability is either low or negligible and although distances to charcoal production areas and charcoal transportation have increased during the 1990s, the charcoal price, in real terms, has remained stable on Lusaka urban markets. As a result, there appears to be no economic indication of over-exploitation of forest resources due to charcoal production.
6) Household charcoal demand in Lusaka increased by about 41% during 1990 to 2000, partly because of the impact of the general increase in tariffs of alternative household energy sources, such as electricity and kerosene.

Problems encountered

Inadequate financial resources due to EU regulations on release of funds affected the performance of the project in Zambia. Lack of recent spatially explicit population data also affected the proper analysis of socio-economic and some ecological factors that affect the charcoal energy sub-sector in Zambia.

Technology implementation plan

Not applicable to Chaposa project

Publications and papers

Chidumayo, E N 2001. Land cover transformation in central Zambia: role of agriculture, biomass energy and rural livelihoods. Paper presented at the COE International

Conference on Area Studies: past experiences and future visions, Center for Area Studies, Kyoto University, Kyoto, Japan, 19-22 January 2001.

Conclusion

The major benefit of the project was the generation of data and knowledge for a better understanding of the dynamics of land cover change and charcoal business in central Zambia. Useful policy recommendations were made which if implemented could improve forest management and sustainable charcoal supply to low-income households in Zambia.

The Chaposa project performed well and achieved most of its objectives.

Training

The following post graduate students visited and carried field research on Chaposa study sites during 2000-2001.

1. Kwibisa, L. 2001 Effects of indigenous cultivation practices on the recovery of dry miombo woodlands in central Zambia. M.Sc. dissertaion in Ecology and Systematics, University of Zambia.

2. Trouet, V. (under preparation) Dendrochronological study of the miombo woodland. Ph.D thesis, University of Leuven, Belgium.

Sokoine University of Agriculture, Tanzania partner report

Objectives

The dynamics of charcoal production in terms of ecological and socio-economic aspects have been researched but only to a limited extent. The CHAPOSA project which commenced in November, 1999 aimed at increasing the understanding of the effects of charcoal use in three countries in southern Africa. The objectives of the project were to assess the extent of environmental degradation due to charcoal production; to identify indicators that can show where such degradation is taking place, and the conditions for it; and to identify policy alternatives that can address the issue of non-sustainable charcoal production while allowing production that is sustainable in the long run.

Methodology

In order to undertake the study, two main areas of concern were identified; the catchment as the charcoal source, and the consumption areas. These areas were further subdivided into three specialized sections as follows:

Aspect of study	**Partners responsible**	
	Main Researchers	**Research Assistants**
1) Ecological aspect in the charcoal production areas	Prof. R.E. Malimbwi & Prof. S.B. Misana	Mr. E. Zahabu & Mr. J. Nduwamungu
2) Social and legal aspects of charcoal production	Prof. G.C. Monela	Mr. E. Zahabu
3) Charcoal transportation, marketing and consumption	Dr. G. Jambiya	Ms. B. Mchome

Choice of study area

The study focussed on Dar es Salaam city as consumer and the surrounding charcoal production sites. Dar es Salaam city with a population of 3 million is the largest city in the country and main business centre. It was anticipated that the greatest impact of charcoal dynamics would be realized in Dar es Salaam and its surrounding ecosystems.

Activities

Ecological Aspects

The main ecological activities carried out in order to understand the impact of charcoal production on the ecology include:

- Determination of species composition and diversity through forest inventory
- Determination of mean annual increment for Kitulangalo area from two time series measurements of 1996 and 1999.
- Charcoal tree species and size gradient as influenced by proximity to access roads in Kitulangalo and Mbwewe areas through forest inventory
- Kiln efficiencies, species and tree sizes preference for charcoal making for Kitulangalo, Mbwewe and Bana areas.
- Woodland cover change between 1991 and 1998; and 1991 and 2000 in the northern and southern catchment parts respectively using satellite imageries.

Socio-economic Aspects in the charcoal production areas

Socio-economic data were collected from Kitulangalo, Mbwewe and Bana. The selection criteria for these sites were: presence of actual charcoal production activities; accessibility relative to other areas in the earmarked catchment area for the study; representative-ness of the study sites in making broad conclusions of the study and availability of ecological and socio-economic data.

The sample comprising of 113 heads of households were interviewed in the selected villages: 60 households from 6 sampled villages in Bana area, 28 households from 2 sampled villages in Mbwewe area and 25 households from 2 sampled villages in Kitulangalo area.

Charcoal transportation marketing and consumption

Count of charcoal bags passing at each of the four major routes entering Dar es Salaam was made from 6.00 a.m. to 6.00 p.m. The stations were placed on Kilwa, Morogoro, Pugu and Bagamoyo roads. The Railway stations visited include Mpiji, Soga, Ngeta, Kwala and Magindu on the TRC railway line and Kifuru, Mzenga and Gwata on the TAZARA railway line.

The charcoal consumption survey was conducted in the three city districts (or municipalities), of Temeke, Ilala and Kinondoni using a semi-structured questionnaire. Respondents were randomly selected in urban households. Peri-urban and more remote areas of the city were excluded. The survey was done in three phases, with the aim of covering the dry and wet seasons. During the first phase 405 households were interviewed, in the second phase, 431 households and in the last phase 93 more households were surveyed to make a total sample size of 929 households.

Results

Inventory results

Species composition and diversity

The dominant species in the general lands (public lands) and reserved forests at Kitulangalo and Mbwewe are shown in Table 4. Tree and shrub species diversity in both locations is relatively high. However, reserved forests appear to be more diverse than the public land (general land).

Table 4 Dominant tree species in the study area

Land category	Reserved forest	General land
	Tree species	
Kitulangalo area	*Julbernardia globiflora*	*Julbernardia globiflora*
	Combretum molle	*Brachystegia boehmi*
Mbwewe area	*Brachystegia boehmii*	*Acacia polyacantha*
	combretum molle	*Lannea schimperi*

Removal intensity, growth rate and sustainability

The harvesting intensity estimated from new and old stumps revealed that there is more harvested wood in general land (19.6 $\pm$ 2.6 m^3/ha) than in the forest reserve (7.1 $\pm$ 1.2 m^3/ha). Most of these trees cut were intended for charcoal production and were mainly from *Julbernardia, Combretum* and *Brachystegia* species. The Mean Annual Increment (MAI) was found to be 2.35 $m^3 ha^{-1} year^{-1}$. The estimated annual removal of 6.4 m^3/ha/year in general land greatly exceeds the observed mean annual increment

(MAI). Interventions are therefore needed if sustainability of forest product supply is to be achieved, assuming removals are on annual basis and land is scarce.

Changes in standing stock as an indicator of ecological degradation

The distribution of stem numbers, basal area and volume by size of exploitable trees for charcoal at various distances from the highway are shown in Table 5. There is generally an increase in stand parameters with distance from the highway for the tree species used for charcoal making.

Table 5 Distribution of tree species of suitable size for charcoal making in the public lands

Distance	DBH classes						*Total*		
	10 – 20 cm			>20 cm					
	N	G	V	N	G	V	N	G	V
Road side	5	0.05	0.29				5	0.05	0.29
5 km	106	1.68	11.06	12	0.50	4.20	119	2.18	15.27
10 km	90	1.64	11.23	35	2.48	23.96	125	4.13	35.19
15 km	59	0.97	6.5	45	3.00	28.01	103	4.00	34.55

N : Stocking number ha^{-1}; G : Basal area m^2ha^{-1};V : Volume m^3ha^{-1}

Charcoal production system

Suitable tree species and sizes for charcoal making

The prefered tree species for charcoal production in order of priority are Mkambala *(Acacia nigrescens)* 22%; Mnhondolo/Mhangala (*Jurbernadia globiflora)* 17%; Myombo (*Brachystegia boehmii)* 16% and Mhungilo (*Lannea schimperi)* 16%. These results are in line with those of other workers. Charcoal makers expressed preference to use large trees (above 10 cm dbh) due to concentrated wood volume near the kiln thus enhancing economies of scale, especially for labour which is relatively scarce.

Charcoal making process.

Household labour is usually used for charcoal making. The process involves wood cutting, kiln preparation, carbonization and finally unloading charcoal from the kiln. While 13, 10 and 14 days are spent for wood cutting, kiln preparation and carbonization, respectively, unloading the charcoal kiln takes only about 4 days. The average working days per month are 20 while the average working hours per day are 7. On the average, each household produces about 35 bags a year, mostly for sale.

Charcoal kiln efficiency

Data from twenty-one kilns from four sites reveal the mean kiln efficiency of 19% ranging from 11-30%. This value is in line with those reported by Chaposa partners and others. On average, 18 trees of 32 cm dbh are used to produce 26 bags each weighing 53 kg of charcoal from these areas. One m^3 yields 2.6 bags of about 53 kg of charcoal. Other calculations using a conversion rate of 1:0.85 volume to biomass in m^3 and tons, respectively and kiln efficiency of 19 % show yield of 3.0 charcoal bags of 53 kg each from a cubic meter of wood.

Woodland change

Land cover change in the northern part of the study area between 1991 and 1998

The land cover changes in the northern part of the study area are shown in Figure 18. In order to reveal the actual succession of cover types, a change detection matrix was also prepared as shown in Figure 5, page 21 of the main report. This reveals that

much of the closed woodland has been converted to either open woodland or bushland and other cover types, including cultivation.

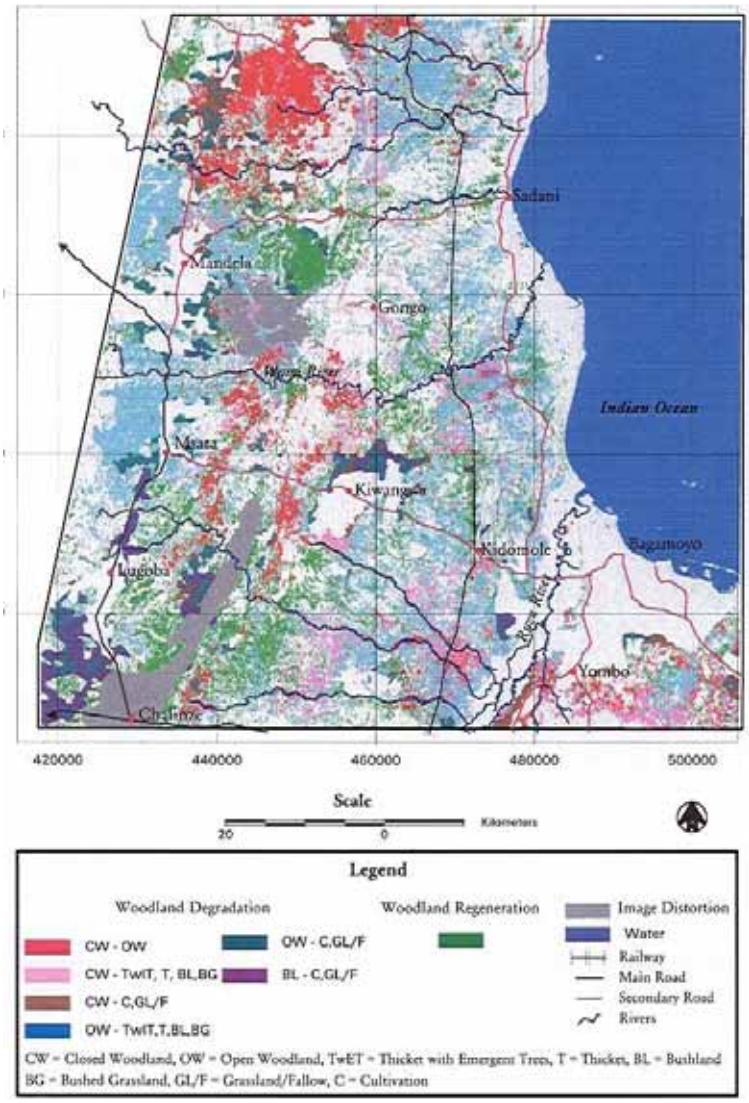

Figure 18 Land use/cover change detection map for the northern part of the study area 1991-1998

Out of the original 119 000 hectares of closed woodland in 1991, less than half has remained unchanged (most of this is in protected forest reserves and areas that are not easily accessible), while 25% had been degraded to open woodland and 20% to bushland by 1998. 6000 hectares (5.0%) had been converted to mixed cropland, which is a mixture of annual and tree crops as well as remnant trees of the original vegetation. A similar trend can be seen in the open woodland category where only 43600 hectares (24%) of the 183 000 hectares present in 1991 remained in 1998. Almost half of the open woodlands had been transformed into bushland while 9% had been converted to mixed cropland. On the contrary, only 2300 hectares (1.3%) reverted to closed woodland.

Other significant changes can be observed in bushland category where 7% reverted to closed woodland and 12% to open woodland by 1998. The bushland in this case could

have been created by disturbance which then recovered to woodland between the period of 1991 to 1998. 4% were converted to bushed grassland and 7% mixed cultivation during the same time period while 67% remained unchanged.

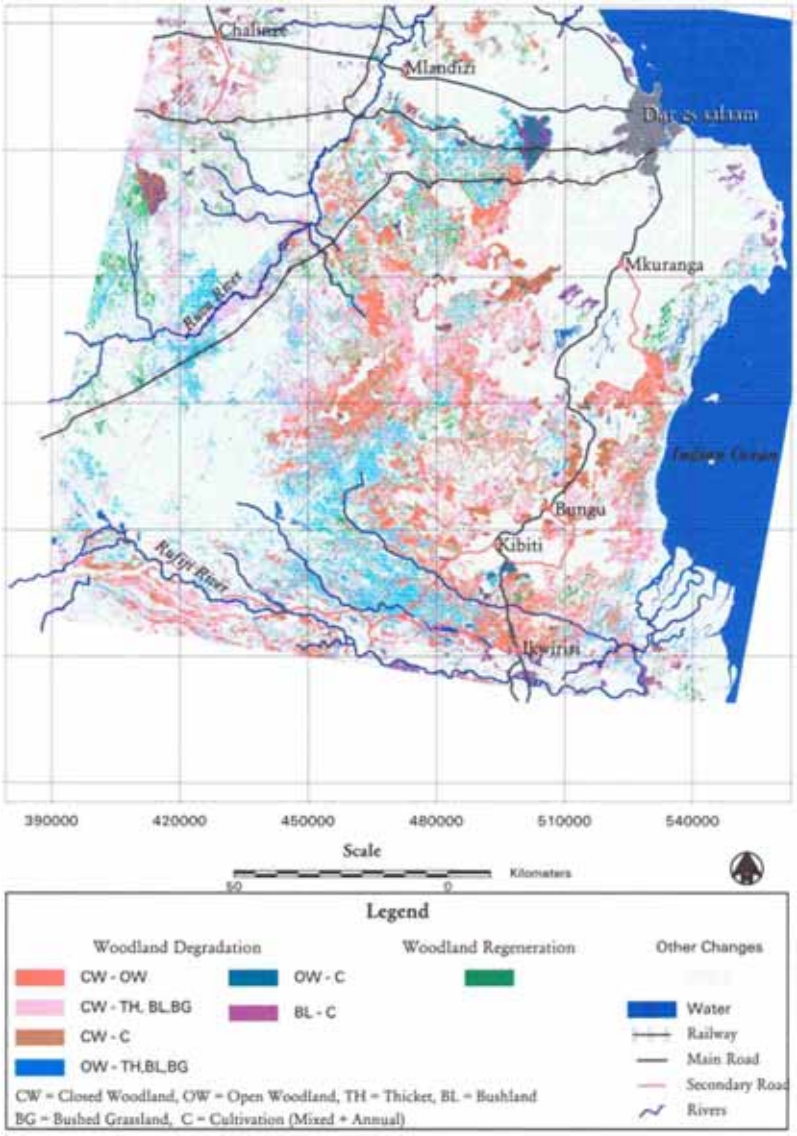

Figure 19 Land use/cover change in the southern part of the study area 1991-2000

Land cover change in southern part of the study area between 1991 and 2000

In the southern part of the study area, it was observed that a large part of the closed woodland was converted to open woodland, bushland and bushed grassland, most likely through tree harvesting. Similarly, much of the open woodland was converted to bushed grassland and bushland. Only 27,800 ha of closed woodland and 7,000 ha of open woodland were converted to mixed cultivation compared 80,000 ha and 110,000 ha, respectively which were converted to bushed grassland. This pattern of change is very similar to that observed in the northern part of the study area.

Reasons for changes in woodland cover.

The woodlands in the study area have experienced highest rates of degradation and

deforestation compared to other cover classes. This could be attributed to harvesting for charcoal production and agriculture. Charcoal production is responsible for degradation of 30 000 hectares (25%) of closed woodland and deforestation of 23 000 hectares (20%) of closed woodland and 93 000 hectares (51%) of open woodland. It will be noted that where there is bushland, most of it is regenerating from coppice, indicating that trees had been cut most probably for charcoal production. Typical of such areas are the areas around Mboga and between Lugoba and Msata along the Chalinze-Segera highway, which are characterized by regenerating *Combretum* bushland. These areas are believed to have had trees in 1970s-80s but were clear-felled for charcoal production. The regrowth was cut again for charcoal in 1990s.

Social and legal aspects of charcoal production in some selected sites of eastern tanzania

Legal and social aspects of charcoal production

Tenure on land and trees

In Tanzania all land belongs to the state which can allocate it to various users. The present land tenure system in Tanzania provides four main possibilities of acquiring land for one's use as specified in the Land Act (1999) as follows: government leasehold, rights of occupancy, customary land tenure, and village land ownership.

In the study sites the government owns land for the reserved forests in Bana area. The rest of the land is owned by individuals through customary land tenure system, which operates within the village land ownership system.

Legal rules for charcoal production

Exploitation of forest products such as charcoal from the woodlands in Tanzania is regulated through permits and licenses. In the study area, woodland regulating measures mentioned to be in force include: permit payment, restriction of endangered species utilization and permit to harvest only large trees. Licensing forms the legal basis for forest activities and serve a s a means of control. Issuing of licenses is done by the Director of Forestry and Beekeeping or any person thereof authorized by him or her. The exception are forests under village jurisdiction where local authorities may grant licenses.

Local foresters and respondents reported that the licensing system does not work well due to many reasons:

(vii) conflict of interest between the local forester and the buyer of license.
(viii) inadequate human and financial resources to monitor licencsees in the woodlands.
(ix) long distance (geographical and administrative) from the decision maker to forest sites
(x) inadequately detailed or vague license
(xi) over- licensing in one area of woodland leading to overexploitation.
(xii) lack of forest education.

Household dynamics in charcoal production

Importance of charcoal production in the rural household.

Like in most parts of Tanzania, the economy of people in the surveyed villages largely depend on subsistence agriculture. However, in the study sites charcoal making is also an important economic activity. In all surveyed villages, about 74% of the

respondents indicated that they were involved in agricultural activities and about 23% were involved in charcoal production only.

In all the study villages, households derive more than 50% of their cash income from sale of forest products such as charcoal, honey, wild fruits, and firewood. Peri-urban households derive almost 70% of their cash income from the woodlands. Due to the proximity to urban centres, the peri-urban households benefit more from trade in charcoal than households in the intermediate and remote sites. This is because charcoal is more widely used in urban than in rural areas. Consequently, depleted woodlands are mostly around urban centres where charcoal business is more lucrative.

Charcoal production system and market places

Important market places for charcoal were at the production site, and in the village. However the survey indicates that the most important place in which charcoal is sold is at the production site, where dealers from Dar es Salaam and other urban centres come to collect charcoal bags for their business. The survey results further indicate that more than 95% of the customers come from outside the villages where charcoal is extracted. Thus while most extraction is done locally, buyers are mainly outsiders from urban centres.

Charcoal Transportation, Marketing And Consumption

Charcoal transportation

Large quantities of charcoal flow in the city of Dar es Salaam daily. Study surveys at check points gave a daily estimate of about 6000 bags of charcoal entering the city. The highest amount of charcoal comes from Morogoro and Kilwa directions.

Most of the charcoal is transported during morning hours (6:00 a.m. to 12:00 p.m). Open trucks with carrying capacity greater than 2 tons transport into the city the highest amount of charcoal. However, bicycles haul in an important amount of charcoal as well, not in terms of quantity but in frequency terms indicating that the charcoal business is attractive to mostly low income class. Although there are some vehicles with new registration numbers, the greatest percentage of vehicles involved in charcoal transportation are old and most of the charcoal transported to the city is for commercial use.

The profit margin in charcoal transportation and trade is relatively small, especially for transportation by truck in the dry season. This gives a strong incentive to evade paying taxes and levies. Evasion is apparently through many means, including night time transportation which is forbidden for biomass resources, and various forms of collusion and payments to guards at the check points.

Charcoal marketing

Charcoal retailing in Dar es Salaam is a very well structured system making charcoal accessible to different consumers. At the one end of the retailing system there are outlets for bulk purchase that are often along the city's main roads. At the other end, there are small shops with the 4 litre tin as measure for charcoal that are often found within very close proximity to the households, often less than 1-2 minutes walk.

The measures and prices at which charcoal is sold in the city is shown in Table 6.The price of a *fungu/kopo* measure ranges between 100/= to 250/=, depending on the size of the kopo and where the bag was purchased and at which price. A kopo weighing

950 grams cost TZS 100/= and a 2,800 grams cost TZS 250/=.[2] Prices and measures, however, differ from one location to another in the city.

Table 6 Size and price of charcoal in various selling units

Measures	Weight kg	Price	Price/kg
Lumbesa	53	3750	68
Gunia	30	2500	83
Kiroba	15	1300	87
Kopo kubwa	2,8	250	89
Kopo dogo	0,95	100	105
Fungu	1,77	175	99

The average weight of a bag of charcoal purchased on site or just delivered from site, which is loaded extra (with *lumbesa*), weighs about 53 kg, while a bag retailed at the charcoal store is about 30 kg.[3] The small scale retailers buy the larger bags of about 53kg at between TZS 3,500/= to TZS 4,000/= and from which they can measure out an average of 31 *kopos* or *fungus* fetching around (31 x 175/=) TZS 5,425/=. The profit margin is between TZS 1,925/= and TZS 1,425/= per bag. This means that the poorer households, which are obliged to buy almost on a daily basis, are cumulatively buying a bag of charcoal at the most expensive price in the city.

Charcoal prices in production areas vary with selling sites depending on accessibility, means of transport used and fees payable to different authorities. Table 7 presents the average charcoal prices at different selling sites.

Table 7 Charcoal producer prices at different selling sites in the study area (TZS).

Kiln site	**1100**
Village	**1400**
Roadside	**1500**

Source: Field survey data, 1999, Exchange rate 1 USD = T.Shs 900 in mid-2001 and TZS 750 in 1999.

For charcoal entering urban centres such as Dar es Salaam city, traders are currently obliged to pay fees to the following authorities; central government (TZS 400 per bag), city municipal (TZS 100 per bag); and district council (TZS 400 per bag). Altogether the tax payable is TZS 900 which when included in the prices inflates it substantially to the disadvantage of the consumer. Therefore traders strive to evade paying some of these fees as a way of keeping prices low and to attract consumers while maintaining some profit margin.

[2] A random survey in which 100 small units of charcoal units were taken and measured provided these figures.

[3] The reason for filling the extra large bag (*lumbesa*) is to maximise profit. On site and at the gates, charcoal is charged per bag, regardless of weight, so it makes sense to fill it as much as possible and then, once in town, the extra can be reduced to create additional bags of charcoal, which now averages 30 kg. The same applies to the owners of vehicles, since they charge on a per bag rate, the trader gets more profit by filling each bag to its maximum capacity.

Charcoal demand in Dar es Salaam

Dar es Salaam charcoal consumption

The average daily consumption of charcoal was found to be 1.5 tins (2.8 kg) per household (the average weight of a tin is about 1875 grams). Based on this figure, the total daily consumption for households using charcoal as first choice would be 1 million kg or 1000 tons of charcoal per day, which is equivalent to 18 800 bags (of 53 kg each) per day. With the lack of precision in parameters, the range of daily consumption could actually be between 800 tons and 1400 tons.

The commercial sector, including restaurants and food vendors is the other important sector using charcoal. Pombe shops, bakeries and prisons do not use charcoal in their business, rather they use firewood. Table 8 shows the total consumption of charcoal by households and other groups in Dar es Salaam.

Table 8 Estimate of total charcoal consumption in the city of Dar es Salaam

	Number	Kg/unit/day	Tons/year	Percent
Households	350 000	2,8	345 000	73%
Food vendors	25 000	9	43 000	17%
Restaurants	1 300	90	83 000	9%
			471 000	100%

Considering all charcoal consumers in the city the total consumption is estimated to be about 24 000 bags of charcoal per day.[4] This figure is four times higher than that arrived at through the transportation survey. This suggests that the incentive to evade check points is extremely strong, and that, in fact, most of the charcoal is unaccounted for in the check points.

With a kiln conversion efficiency of 19%, 2 million tons of wood are required annually to produce this charcoal. This is equivalent to about 2,3 million m^3 of wood at a weight/volume ratio of 0,85. At a mean annual increment of about 2,4 $m^3ha^{-1}yr^{-1}$ it would take the growth of 1 million hectares to produce the wood needed annually.

Energy mix among households for cooking fuels

In the city of Dar es Salaam, 69% of the households use charcoal as their first choise fuel for cooking. However, most of households (88%) combine two or more types of energy sources/fuels. This is partly because they tend to use certain fuel energy sources for certain foods. Others factors influencing combination of fuels include: **availability** (35 %), **price** (18 %) and **convenience** (8 %). Charcoal, for instance, has different prices in different areas of the city. People closer to the sources of charcoal, for example people residing in Ukonga and Pugu (peri-urban areas), will opt for charcoal because it is cheap and its availability and quality was assured.

Price trends for charcoal

Although there have been slight charcoal price fluctuations particularly between the wet and dry seasons, the price of charcoal, in real terms, does not show any increasing trend over the years. This can be taken as an indication that access is essentially free. Any proposal to restrict the access must also deal with the prospect of increasing charcoal prices for the urban population.

[4] One bag = 53 kg, one year = 360 days.

Limitations

Few shortfalls were apparent in executing the study, these include: poor population statistics, absence of long term tree growth data and poor quality of the satellite images which made difficulties in their interpretation. Because of this it was not possible to get images for the entire study area. Thus images were acquired for the eastern and southern parts of the study area only.

Policy options

Charcoal extraction in the woodlands is one of the most important economic activities providing employment and income to many rural households in the charcoal production areas. Charcoal production seems to happen out of necessity as a last resort to earn income to these households. Thus lack of alternative income sources is a compelling factor for the decision to engage in charcoal production. Commercial production is only induced from urban centres. There are indications for a strong link between charcoal extraction and ecological degradation in the study sites.

The study concludes that charcoal production is a consequence of social, legal and economic factors. Improving charcoal extraction methods is one of the necessary measures to increase the productivity and hence profit. However, this may put poor, small producers out of business. Introduction of cheaper alternative energy sources will reduce high dependence on charcoal and firewood. These measures should take place concurrently with an efficient system that will promote sustainable management practices in the woodlands. According to the existing forest policy, involvement of local communities in forest management through benefit and responsibility sharing is envisaged as an effective strategy towards sustainable forestry management. This strategy should also embrace improvement of agricultural production as the main economic activity in order to create reliable alternative employment opportunities in rural areas and relieve the need for employment solely though charcoal production. Based on these conclusions, the following policy options are recommended:-

Direct Subsidies

Direct energy subsidies are often provided to help people who are living in poverty. Low-income households normally spend a higher fraction of their disposable income on energy compared to other groups, and in the case of charcoal, they pay more for the same level of energy service. This is because their appliances are generally less efficient than those used by wealthier households, and also because low-income households usually purchase fuel in smaller amounts.

Energy price subsidies may be ineffective and inefficient in assisting poorer households since in most instances, they receive only a small fraction of the total subsidy given. For example, in the case of kerosene use in Tanzania, subsidies were found to benefit mainly better off households who were able to purchase. TANESCO has a form of tariff rate that is meant to encourage low income households to use electricity for cooking, there is room to reduce further these tariff given that the cost of electricity in Tanzania today is the highest in East Africa. It is therefore recommended that the low-income electricity tariff should be reduced.

Promoting Sustainable Charcoal Production

Dar es Salaam city has a high demand for charcoal and this demand, under current circumstances, will continue to grow. Thus production areas deserve special consid-

eration for promoting sustainable charcoal production. There are two options for harvesting that may improve production of charcoal sustainably. The first is selective harvesting of trees large enough (10 cm dbh has been proposed as the minimum size) for charcoal production in order to allow the small trees to grow. The second is clear-felling whereby all trees are cut for charcoal production. Both regimes require demarcation of the forest into annual coupes or periodic blocks indicating clearly the sequence of felling cycles. This can best be implemented under the current thrust by the government to involve local communities in forest management. Local communities are better placed to manage forest resources adjacent to their villages. With clear-felling, to ensure successful regeneration, the clear-felled area should be protected against disturbance mainly from cultivation, grazing and fires.

Promotion of Fuel Substitution in charcoal consumption

In the immediate hinterland of Dar es Salaam, and indeed other urban areas in Tanzania, wood resources are diminishing and biomass is becoming increasingly scarce. Not only is the harvested area being extended, but also increasingly smaller trees and a wider range of species, including common farm trees such as cashew and mango, are being cut. It was observed that low-income households rely on a different set of energy types to the better off households, and most tend to use fire wood and charcoal for cooking.

If substitution is part of the solution, then for domestic fuel energy substitution to take place incomes will have to increase. In an earlier charcoal consumption study in Dar es Salaam, it was found that the income has an influence on the consumption of electricity for domestic use. A 1% increase in income results into a 0.5% increase in the consumption of electricity in the long run. Thus substitution is unlikely to be the result of improved income, and may have to be supported by other measures such as restriction on the use of general land enforcing the actual licensing system.

Price Adjustments

In the study area, most village producers collect the wood for charcoals making almost free of charge (open access resources)[5] and use their own labour. For the village producers, there is no or very little cash investment. Although, the trader/transporter pays some fees/royalties, several ingenious fee evasion mechanisms are employed. This results in reduced revenues accruing to the village, local and central governments together with lowering charcoal prices to urban households. The combination of these factors made charcoal prices to remain relatively low compared to other fuels, and urban expansion and slight income improvements have in combination led to the increased demand for charcoal, and is likely to grow even more. This situation is contributing to wrong price signals (market failure) that indicate a situation of abundance in the production areas.

Product prices will need to be indirectly controlled to reflect more realistically the environmental and social costs involved. One possibility is to apply economic instruments, by adjusting taxes and fees/royalties on charcoal and other fuels. Given the complexity of the situation, and the dispersed nature of the business of wood fuel and charcoal, this will be difficult to implement, though not impossible. Much of the increase (for charcoal and wood fuel) through taxes and fees will be passed onto end-

[5] And especially so in poorly protect government forests.

users, many consumers will be obliged to switch to alternative fuels or adopted more efficient charcoal stoves. For charcoal producers, increased taxes/fees/royalties on the raw materials will force them to respond by adopting more efficient kilns to maintain their own incomes.

Adoption of Energy Efficient Technologies in charcoal consumption

The study revealed reasons for the slow improved charcoal stoves adoption rates to include higher initial costs (investments) of shifting from standard (less efficient) stoves to the improved types and the fragile nature and short life span of improved stoves. Low-income households buy charcoal in small amounts almost on a daily basis, but the small amounts tend to be the most expensive. Thus, perhaps the low-income households in the city have the highest expenditure per unit on cooking energy.

Against this situation, a combination of approaches will be required. These range from further technological improvements that focus not only on efficiencies but also on duration of use, low cost repair and other conveniences associated with the use of improved stoves. Included here is also the possibility of subsidizing these strategies using funds from taxes on the same wood energy resources (via local councils through partnerships with local entrepreneurs) and/or through levies on petroleum at central government levels.

Adoption of Energy Efficient Technologies in charcoal production

The range of charcoal kiln efficiencies in this study was found to be 11-30% with an average of 19%. Therefore there is a possibility of improving charcoal kiln efficiencies to about 30%. In the current system there are no incentives for charcoal makers to adopt efficient production technologies, because of a combination of reasons, including: market failure; unrealistic fees and royalties; behaviour towards open access resources; weak monitoring of forests and reserves; haphazard issuance of permits (legal and otherwise); ignorance; long term problems associated with land and tree tenure/ownership; and poor monitoring. Any combination of these factors coupled with the growing numbers of unemployed and underemployed in rural and urban areas, including some of the impacts of structural adjustment policies have led to the onslaught of forests. Furthermore the uneven and unregulated fee structures by different district councils further compound the situation. The current situation is simply that producing charcoal in an efficient manner is not a priority.

A fresh set of initiatives is thus required to encourage the use of improved kilns to address the inadequacies and constraints aforementioned. Thus the use of a combination of economic and legal instruments should be applicable. Technological and economic awareness of the use of improved kilns is equally important.

Integration with New Forestry Development Approaches

The New Forest Policy of Tanzania (1998) facilitates the introduction of new forestry development strategies that are now being pursued to allow local communities and other players to participate in forestry development. The Community Based Forest Management (CBFM) and Joint Forest Management (JFM) Guidelines (MNRT, 2000) is set to facilitate the process of community participation in forest management in Tanzania. Community participation addresses the issue of wood fuel supply through tree planting and forest conservation generally.

Participatory forest management would enhance efficient natural resource utilization. A fair mode of benefit sharing between the government and local communities should be set in place as a motivation for the later to take charge of forest management. Clarification of land tenure and land use allocation should be made in order to maximize resource utilization by different stakeholders. This includes allocation of forestland to village communities for charcoal production according to approved management plans.

University Eduardo Mondlane, Mozambique partner report

Introduction

The use of charcoal and wood fuel as energy source has become more popular in the Mozambique capital in the beginning of the 70s in the last century. Charcoal production has been usually pointed as one of the responsible for forest degradation and deforestation in Mozambique and wood fuel gathering and charcoal production to respond to the increasing urban need of energy sources has creating some concerns on those involved in energy planning, natural resources and environmental management.

This work gives an overview of the charcoal production potential for Maputo province, the actors, the supply areas, the impact of charcoal production and its role on the overall rural development and economy. It was designed to support policy makers in finding tools that will enable sustainable production and use of charcoal in the future.

This report summarizes the main results and findings of a research team set of studies and more detailed information can be found in each study, namely:

- Felling areas for supplying Maputo city with firewood and charcoal – April 1999, Chaposa/FAEF/DEF
- Price analysis of fuelwood and charcoal in markets of Maputo city, Falcão M.P., 1999 Chaposa/FAEF/DEF
- Wood to ashes: results of a survey among consumers of wood fuel in Maputo, Mozambique, Brouwer R. & Falcão ,February 2000, Chaposa/FAEF/DEF
- Licensing and law enforcement for charcoal and firewood production in Maputo province, 2000 Pereira C., Chaposa/FAEF/DEF
- Vegetation Change assessment in selected districts of Maputo and Gaza provinces, Monjane M. March 2001, Chaposa/FAEF/DEF
- Other studies made in Licuati area – Matutuíne district, were also used to complement and understand the charcoal production, forest ecology and rural population livelihood.

The aim of this study was to link ecological, social and environmental aspects of charcoal production and use in order to obtain an overall picture of the process. The charcoal production, its implication to forest regeneration and degradation, the actors, the costs, the types of fuel used in towns, and in what quantities are important questions for those concerned with the sustainability of forests resources and have been addressed by this study.

Mozambique has a total area of 80 million hectares, of which 62 million hectares are covered by savanna and forests (Barne, 2001). Forests supply shelter, construction material, medicinal plants, energy, cultural values and other products to the Mozambican population. Woodfuel is by far the most important forest product. In 1997 it represented 62 % of the total forest products licensed in the country (DNFFB, 1997). Generally the use of woodfuel has been reported since the beginning of humanity forming part of tradition and culture of local population in Africa.

Almost all rural Mozambican population depend on wood for domestic energy purposes and about 70% of the urban population utilizes woodfuels as energy source (SADCC 1988; Williams 1993).

The national consumption of woodfuel was estimated as 12 million tons/year (PIED, 1997), that is about $1m^3$/capita/year. Woodfuel is the main form of energy consumption for domestic purposes Although the rural consumption of woodfuel represents 76% (9,1 million tons/year) of the national consumption. The rural domestic consumption is spread all over the country and usually in a form of dead and dry wood. Hence it does not represent a pressure or a threat to the forest resources and it plays an important role in the livelihood of the rural households. Charcoal is very seldom consumed in the rural areas.

The situation in urban areas is the opposite. The urban consumption has a share of 24% (2,9 million tons/year) of the total country's consumption and it is generalized in all provincial capitals of the nation, with the capital city having the biggest share. In urban areas charcoal represents the main form of biomass energy (69% of urban consumption) and wood fuel has nowadays a secondary role. The urban consumption of woodfuels constitutes a concentrated demand that has to be supplied all year round, creating pressure on the surrounding urban forest areas.

The Maputo study area

The Maputo study area comprises essentially Maputo Province in southern Mozambique (Figure 1). The major supply areas of fuelwood and charcoal to the capital city are the remaining forests of the surrounding areas in Maputo province. The areas around the railway line Maputo – Chicualacuala in Gaza province, just north of study area are also suppliers of woodfuel for Maputo city (Chaposa, 1999; Magane, 2000). Due to the vast and non-contiguous fuelwood supplying areas of Maputo city, the study area was concentrated within Maputo province.

Forest types

The vegetation of south of Mozambique falls within the Savanna biome and it's a mosaic of sand forests, scrub forests, evergreen and semi-evergreen bush-land and thicket, in a matrix with secondary grassland and wooded grasslands. In the coastal areas floodplain, pan systems, swamp forests, mangroves and edaphic grasslands can be found. The area is cut by five important rivers (Matola, Incomáti, Umbelúzi, Tembe and Maputo) running to Maputo estuary. The western part of the province is covered by the Lebombo mountain system with volcanic rocks. The highest formation is the Mponduíne mount in Namaacha with an altitude of 800 metres . On the coastal plateau the altitude is less than 100 metres.

Within the study area the vegetation classification used was developed by Saket (1994) taking in account three criteria: (1)floristic composition, (2) physionomy and (3) ecology, resulting into 11 map units.

The vegetation of Maputo province is a mosaic of low forests with few patches of dense and evergreen forests. Thickets and wooded grasslands are most common vegetation types, mainly in areas with low rainfall in the northern part of the province. The floristic and physiognomic gradient form north to south is considerable pronounced, were stature and deciduousness decrease towards south. The position of such vegetation in the heart of one of the most diversified floras of Africa, make bush-lands and thicket show some floristic overlap with other major vegetation formations namely, the coastal forests and broad-leaved Zambezian woodlands. In the south, the bush-land commonly known as shrub, may grow up to 6 meters in height. The northern

variant of these formations may reach up to 9 meters in height, are usually widely spaced and sometimes referred as wooded bush-lands.

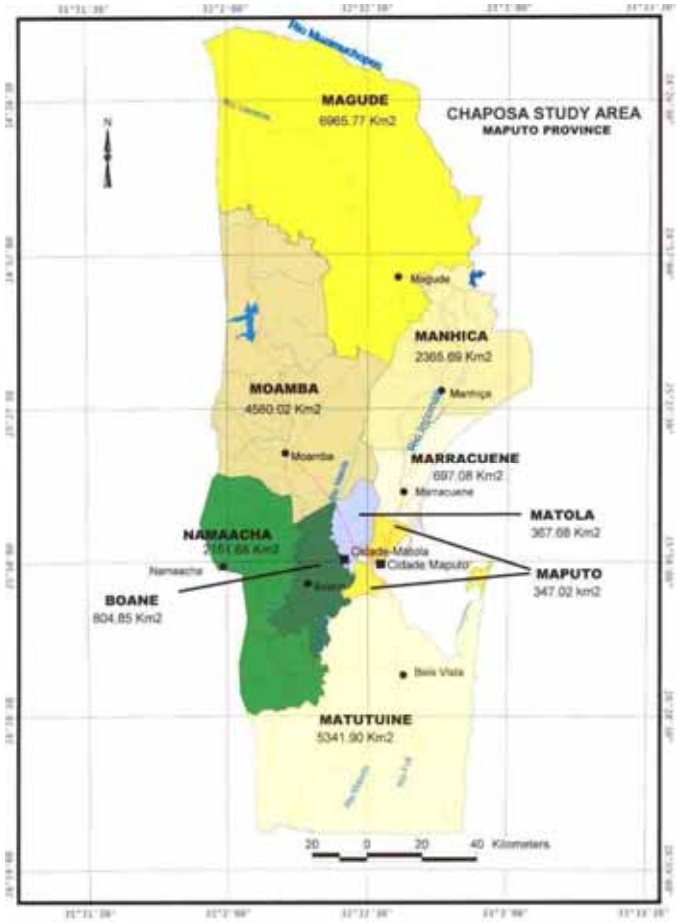

Figure 20 Chaposa study area in southern Mozambique

Land use and tenure

Like in several other countries in the region, in Mozambique land is owned by the State, which can grant title for occupation and use, but not for ownership. Despite that, the new Land Law recognizes the existence of customary rights of rural communities.

In Licuati region, land and resources use is regulated by a clan system in which rights of residence, cultivation and other forms of resources use and access are dictated by the traditional chief or “regulo” (Mangue, 1999). Within the boundaries of each “regulo”, several zones can be found, and in each there is a “chief of land” which represents the “regulo” in all matters related to land and resources use.

Some rites and beliefs related to forest resources use have prevailed in the Licuati area, despite the increasing influence from the outside world. The most important is the prohibition of residence and charcoal production inside the Licuati sacred forest. The sacred forest plays an important role in birth and burial rites, initiation and rain ceremonies. This role and these beliefs have been the main forest guardian of the sacred forest throughout the times and history.

In non sacred forest areas, certain traditional beliefs and myths have played an important role in the preservation of individual species like *Sclerocarya birrea* (nchane).

Forest growth rates

In Mozambique there is no data on forest growth rates. The most recent growth plots in the country's southern region were established in Licuati forests in 1997 and re-established and monitored in 1999. More measurements are needed to draw any conclusions on growth and the Chaposa study did not considered the monitored plots data. Several authors have estimated an interval for forest growth from 0.1 m^3/ha/year to 2.5 m^3/ha/year based on the precipitation (Table 9). Data from savanna growth in eastern Transvaal in south Africa was estimated at 0.9 ton/hectare/year (1.2 m^3/ha/year) (Scholes & Walkers, 1993). Therefore an increment of 0.4 ton/ha/year can be considered as a conservative figure.

Table 9 Productivity data (m^3/ha/year) in west African savanna in terms of precipitation

Rainfall in mm	Clément 982	Goudet 1985	Catinot 1985
500	0.3	0.1 - 0.5	0.3 - 0.8
700	0.6	0.5 – 1	0.5 – 1.8
900	0.9	0.5 - 1	1.3 - 2.5

Source: Fao, 2000

Vegetation changes

Satellite images from 1997 and 1990 of some selected districts of Maputo and Gaza province, show relatively small changes in broad terms, when subcategories are grouped together. Seen in this way, agriculture and shrubland have increased, while forest and grassland have reduced (Figure 21). These broad categories cover 99% of the area analyzed.

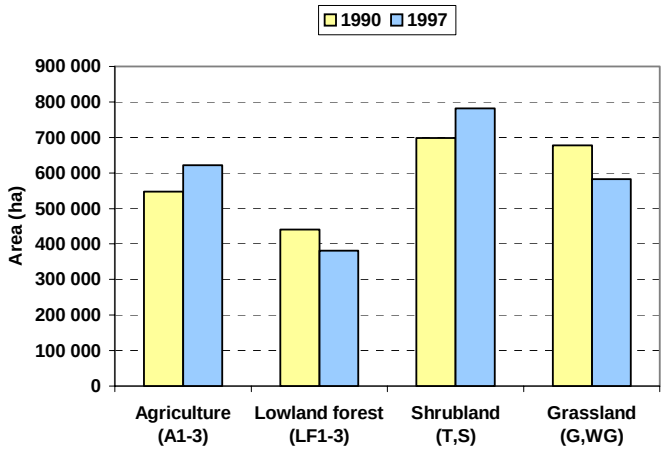

Figure 21 Macro view of vegetation change in Maputo Province 1990-1997

Biomass distribution and potential

Out of the 44 million tones of biomass available in the province, 74% have a potential for biomass production while the other 26% area restricted due to erosion risk concerns and biodiversity conservation areas (reserves).

Maputo province was divided into two major areas biomass areas: conservation areas and potential production biomass areas according to the present land use and erosion risk areas. Agriculture areas represent 22% and conservation areas proclaimed by the government represent only 4% of the province area. The total biomass available within the production potential areas is 32,5 million tons (Table 10).

Table 10 Potential for charcoal production in Maputo province

	Area		Biomass	
Present land use	**ha**	**%**	**tons**	**%**
Agriculture areas	518 000	22%	0	0%
Biomass production restricted areas – river buffer zones	133 000	6%	2 200 000	5%
Proclaimed conservation areas	91 000	4%	3 600 000	8%
Biomass production restricted areas - erosion risk areas	315 000	14%	5 600 000	13%
Biomass production potential areas	1 272 000	55%	32 500 000	74%
Total	2 329 000	100%	44 000 000	100%

Source: Monjane, 2001- chaposa

Charcoal production

All charcoal produced in Maputo province is manufactured in traditional earth mound kilns. The production is mostly labor intensive with manual tools (axes, hoes and shovels).

The traditional charcoal kiln yield varies from 14 to 20% according to several factors such as species, kiln covering material, log arrangement within the kiln and experience and skills of the charcoal burners (Joaquim, 2001).

In most areas around Maputo, there are two types of charcoal producers: residents or subsistence farmers and the specialized migrant charcoal burners locally called "ninjas" (Brouwer & Mangane, 1998). A comparison between the resident farmers within the Matutuíne district and the full time charcoal makers in Moamba ("ninjas") showed that the latter had more efficient kilns (20%) with less residues (Table 11).

Table 11 Charcoal kiln yields from different types of producers

		Farmers	**Full time producers "ninjas"**
District		Matutuíne	Moamba
No. of trees	n/kiln	5	8,5
Average DBH	cm	28	26
Total weight	kg/kiln	2500	3000
Total volume	m^3/kiln	1,8	2,5
Average charcoal weight	kg/kiln	330	630
Average residues weight	kg	130	3
No. of charcoal bags	n/kiln	11	17
Average yield	%	14,1	19,9

Source: Joaquim A. (2001)/ chaposa

Social, economic and legal aspects of charcoal production

The role of charcoal production in rural areas

In areas with reasonable accessibility, charcoal is the main cash crop of the rural households. If there is no accessibility and no trucks go to remote rural areas to buy charcoal this product is not manufactured and the rural households complain about lack of income.

The legal aspect

According to the law, any person that makes charcoal for commercial purposes has to be licensed. Consequently almost all charcoal that enters into town is illegal. Data from the annual statistical reports shows that the licenses for fuel production and transport reached the highest value in 1997. For the period from 1992 to August 2000 the Provincial Forestry and Wildlife Services allowed the harvesting of an average of 250 000 stere/year. A comparison between the amount licensed in Maputo province and the urban consumption showed that the licensing system only covered about 1% of the biomass consumption in town (Pereira, 2000).

The licensing is designed to collect fees for the Agrarian Development Fund. This fund was created with the purpose of promoting small-scale rural activities and rural development as well as reforestation programs. The woodfuel / charcoal production fee is 2500 MZM/mst or 2500 MZM/charcoal bag plus 15% of reforestation fee. The Government has only collected an annual average of 240 million MZM/year (USD 11 000) for the period 1993-2000 from charcoal/firewood production, which represents the most important forest product.

The licensing systems is a component of the overall scheme of logging control. Road checkpoints located at strategic points between the forests and the market places are the key elements in the present licensing control system. Due to the limited equipment of forest guards (no vehicles or motorbikes) and the vast options of secondary roads entering into town, the checkpoints have little impact on the illegal logging control. The immediate consequence is a low level of fees captured by the forest services and no reliable statistics on forests and products being harvested. Uncontrolled harvesting is the main characteristic in charcoal production.

In the last years, there has been a movement to transfer the charcoal licensing fees from the transporters to the producers, imposing an extra cost per bag to the producers in some community forest management pilot areas. The only way to cover such extra cost at the producers level is to increase the scale of production since up to now no different selling prices have been practised in these pilot areas. Therefore, due to a desperate attempt to increase control on charcoal production and to obey the law, charcoal producers which represent the most vulnerable group with a less favourable price negotiation position, and willing to preserve the resources, were punished through an extra tax and a complicated bureaucratic system.

The economic aspects of charcoal manufacturing and trade

Charcoal commodity chain consists of three main actors: producers, wholesalers and retailers. Based on the costs, prices and profits, Brouwer and Magane (1998) established a comparison between the sustainable use of forests to charcoal production through the net present value of the allowable cut and use of all stock. The calcula-

tions showed that under those existing conditions (charcoal prices and discount rates) sustainable management is less profitable than immediate exploitation of the stock, and therefore from the net present value perspective was perfectly rational to destroy the forest. Two suggestions were made based on this model:

(1) price differentiation between unsustainably and sustainably produced charcoal and

(2) a reduction of discount rate to 7% or less.

The relatively higher prices of alternative urban households energy sources in urban areas has promoted the charcoal business proliferation.. While the trend of nominal prices of charcoal has increased throughout the years, the real price (including devaluation, inflation) of fuelwood and charcoal have remained essentially stable for the last decade (Figure 22). The dramatic changes up to 1992 may have been the result of abnormal conditions during the war (Falcão, 1999). The real price trend does not suggest that there is any scarcity of biomass for fuel in the area supplying Maputo. An increase in supply and access to forests in remote areas can be a reason for this trend.

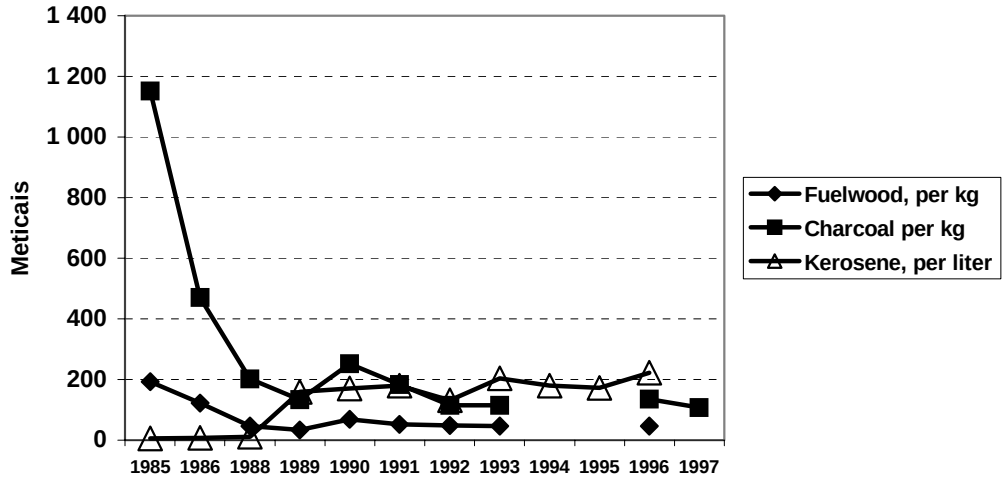

Figure 22 The real prices trend of three sources of energy in Mozambique

Transport, market and wood fuel consumption

The urban markets are the main destination of charcoal cargoes transported to town where they are retailed either in heaps or in tins. The majority of retailers are head of families and have been in the business for more than eight years. Charcoal is the preferred product among forestry products sold in the various markets in Maputo and Matola cities. Fernandes (1995), had already stressed the preference of retailers for selling charcoal:

"*it sells well, it doesn't go rotten and children don steal it*".

Maputo and Matola cities have a population of about 1,4 million people and 76% of the households in Maputo city rely partially or exclusively on woodfuels for cooking. About 12.5% of the households are totally dependent on woodfuels.

The household consumption represents the biggest share (90%) of the total urban woodfuel consumption. The current per capita wood fuel domestic consumption ranges from about 0.92 to 1.00 m^3 as compared to 0.82 m^3 in 1988. This rise in per capita firewood consumption with about 20% is probably the result of two factors: (1)

an increase in income and thus in consumption and (2) a shift from firewood to charcoal.

Rarely people use just one type of energy source. People use charcoal in combination with paraffin, and, to a less extent, electricity and/or gas. When income rises, the latter two types of fuel tend to replace woody fuels, but the substitution is not complete.

Firewood is typically a fuel of the poor. It is used by larger families in the poorer income strata. Charcoal is also used by relatively large households, but can also be found among the higher income classes.

The household income level also influences the use of fossil fuels. The poorer strata tend to use paraffin, whereas the higher income strata use more often electricity or gas. A comparison between 1992 data (SEI/ Faculdade de Medicina) and 2000 data confirmed that there was a shift from the type of fuels used (Table 12).

Table 12 Proportion of households and fuels used in 1992 and 2000

Fuel	1992 %	2000 %	Significance (alfa: 0.05)
Firewood	78	22	Significant
Charcoal	76	75	Not significant
Paraffin	14	44	Significant
Gas	12	21	Significant
Electricity	12	26	Significant
Total (n)	952	208	

Source: Brouwer & Falcão, 2001

Through out the times the percentage of charcoal users has remained stable. The same is not true for firewood where has been the reduction of the percentage of households that used firewood from 78% to 22%. Another important shift was made in the paraffin share, where the percentage of paraffin users has tripled while the percentage of gas and electricity users has doubled.

Indicators of over-exploitation

A number of variables were chosen as possible indicators of over-exploitation of forest resources due to charcoal production and use. Based on the existing data the most important indicators are here analyzed.

Annual biomass cleared in relation to MAI

Sustainable use of forest resources presupposes that annual harvested biomass cannot be greater than the annual increment. Therefore the annual consumption of Maputo/Matola was compared to the mean annual increment to understand the level of pressure on the native forests within Maputo province. Two case were considered: (1) if only the biomass production potential areas are used and (2) all areas within the province are used for charcoal production except the proclaimed reserves, which in fact reflects the current practices (Table 13).

For the first case the annual increment can supply 43% of the annual urban consumption while if all areas are used for charcoal production the annual increment of such areas represent 71% of the urban consumption. In both cases the annual increment of Maputo province forests is less than the annual consumption. The level of consump-

tion of Maputo city has overcome the level of sustainable supply from the existing forest resources within the province boundaries.

Table 13 Annual biomass consumption versus the mean annual increment

	Area (ha)	MAI [2] (m^3/ha/year)	Annual urban consumption of Maputo/ Matola (m^3/year) [1]	Biomass cleared /MAI
Biomass production potential areas	1 300 000	740 000	1 400 000	1,8
All areas (except proclaimed reserves)	1 700 000	1 000 000	1 400 000	1,4

1) 1 m^3/person/year for Maputo and Matola city population.

2) 0.58 m^3/ha/year

Therefore, signs of environmental degradation like charcoal production in slopes, forest reserves, and with almost every tree diameter and specie are expected to be common.

If the level of per capita urban consumption is maintained, the annual increment has to be more than 1 m^3/ha/year to supply the urban demand. The lack of solid growth rate assessments make it difficult to draw any definite conclusions.

Trend in real charcoal price

In general, prices of charcoal in real terms have declined or stayed stable for some 10 to 20 years (see Figure 22) failing to give clear signals to governments that the resource base is declining or incentives to users and producers to use charcoal more efficiently (Plas, 1995). Mozambique was not an exception and the trend in real charcoal price over the years has shown that charcoal prices have remained stable.

From the economic point of view the price trend does not indicate an overexploitation or scarcity of forest resources. The charcoal prices do not reflect the environmental costs of its production and the access to remote forest resources and an increase in supply areas can be a reason for this situation.

Change in distance to charcoal production areas

In general the average distance of charcoal production centers to town has increased from the 80s to now as a clear indicator of lack of forest resources nearby the consumer center. Nevertheless this variable can be affected by many factors, and the most important one: the road network existence and conditions. Railways can also give relatively low cost access to remote charcoal catchment areas.

Annual loss in forest cover in relation to population growth rate

The average population growth is estimated as 2.4%/year (INE, 1997) and the overall deforestation rate for Maputo/ Gaza province was estimated as 5.6 %/year (Monjane, 2001). The overall deforestation rate is double than the population growth and therefore, the charcoal consumption is not the main reason for deforestation in rural areas. Agriculture expansion and other activities have been as much responsible for deforestation as charcoal consumption.

Conclusions and recommendations

Low growth rates (0.1 to 1.8 m^3/ha per year) of native forests mean that vast areas under proper management and control are needed to obtain the amount of wood required

to supply the urban areas. Vast forest areas are increasingly rare, and even if they are available, there is need for monitoring and control systems regarding species selection, sizes and appropriate cutting cycles. Most of the governments in Africa cannot afford this, unless incentives and a higher value is given to forest and biodiversity.

Efficient energy use and improved kilns are usually seen as alternative to reduce the impact of charcoal production in the native forests, but not much hope can be placed in such measures. Research made in Tanzania over twenty years showed that the maximum wood to charcoal conversion rates of 35% can be obtained (Malimbwi et all, 2000). At local producer level, other parameters than efficiency rates in a kiln are also valued (preparation time, preparation difficulties, risks involved, costs and material availability etc). Those parameters and the forest abundance in some areas have hampered the dissemination and adoption of more efficient kilns.

Both the two institutions responsible for the biomass supply and consumption (Ministry of Agriculture and Ministry of Energy) have almost no influence on the activities in the sector. The actual main role of Ministry of Agriculture is to supervise forest harvesting through tax collection and only collects 1% of what is supposed to get. The Ministry of Energy has little influence on the urban consumption pattern of woodfuel. There is no policy on incentives to promote sustainable forest management.

The government influence on the charcoal commodity chain is based on the production fees and on the forest guards collection system. That system is not working and there is a huge potential to increase the tax collection. The transfer of a portion of such taxes to local communities involved in sustainable management is a condition needed to favor those areas willing to preserve forest resources.

The transference of charcoal licensing system to the producers is not sustainable and should be avoided until price differentiation can be obtained.

Forest has been harvested for charcoal production under simple license system with no control or fees collected. Harvesting under forest concession system must be introduced among charcoal business companies, in order to promote the sustainable management of forest areas and assure secure supply of raw material.

Forest licensing and fees collection has to be simplified, improved and the share of fees collected from charcoal production increased, in order to allow the improvement of forest law enforcement as well as to reduce illegal logging and transference of a portion of fees to local communities. Taxes collected from charcoal should be transferred to local communities in order to promote sustainable management.

It is important to stress that both institutions responsible for agriculture and energy sectors should improve the coordination and act together not only on the level of strategy and policies but on incentives to fuel substitution and rural development.

A general overview on sustainability of charcoal urban supply from the existing forest areas within the boundary of Maputo province shows that the urban consumption overcomes the annual increment of province the natural forests. As a consequence, areas know as biodiversity valuable and with endemic species have been used for charcoal production, as well as timber valuable species. The present system is not working where both institutions responsible for controlling and guiding charcoal production and consumption have almost no influence and scarce resources to carry out this activity. Laws and regulations are not followed and the government its incapable to control its implementation. Therefore, despite that the use of timber valuable spe-

cies for charcoal production being strictly forbidden as well as forest harvesting in fragile areas (slopes, near rivers, water sources, endemic areas, etc) those rules are not applied and controlled.

Therefore, due to the impossibility to control the charcoal production system, government structures should act more as guiding institutions concentrating their efforts and scarce resources to strongly and effectively discourage charcoal production within those areas with valuable ecosystems (national parks, reserves and fragile ecosystems, like Maputaland endemic region and hilly mountains). They should transfer not only the responsibility of forest management to local communities but to transfer back the taxes collected by charcoal production to local communities in order rise the interest of local population to manage their forests. The present charcoal potential production areas constitutes only an indicative work that should be refined up to the level of excluding not only the proclaimed reserves but also the fragile ecosystems from charcoal production.

If real price of charcoal has decreased and prices of other alternative household energy sources have increased, the use of charcoal will remain in the future, as long as forest resources and economic profit are present. The environmental costs of forest degradation are not usually considered at all, and therefore use of charcoal as the main urban energy source has been regarded as natural phenomenon and without considering the environmental consequences.

This position, together with the lack of cash generation opportunities in rural areas, particularly in the agricultural sector, charcoal has became a key survival factor in rural areas. Unless there is a review in the agricultural and energy policy, charcoal will remain an important source of urban energy with all its consequences to the environment and human livelihood.

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University of Stuttgart, German partner report

Objectives

The main objective at IER was to model the charcoal supply and demand system for the three sample areas i.e. Maputo Province (Mozambique), Dar es Salaam (Tanzania) and Lusaka (Zambia). The focus was to define the model and build up strategies on the basis of scenarios.

Activities

At IER the structured energy and environmental planning of CHAPOSA system was done. The first step of the planning was to identify the existing problems. In the second step the goals were defined. The next phase was to determine the time period and the regional allocation of the analysed charcoal system (production and household side). The limits of the RES-structure were also defined. In the next steps necessary data were collected from the partners and other institutions. This was an ongoing process as there are always some gaps which have to be filled. The iterative process lead to a data base more and more precisely. The next steps were to define scenarios and to calculate strategies.

The phases as mentioned above was an ongoing process during the project. The decision makers can decide now if and how the strategies will be implemented. This phase should be accompanied through monitoring.

The table as mentioned below describes briefly the project activities at IER. Activities from the administration and the support of other departments of IER are not mentioned in this activity report.

Main Researchers at IER:

Dr. Christoph Schlenzig, Jörg Bauer, Bernhard Gräber, Bernhard Frey, Markus Neubauer

Title	Description
Workshops and Meetings Jörg Bauer	Participation and Presentations
Bernhard Gräber	First co- ordination meeting in Stockholm
Bernhard Frey, Markus Neubauer	Second project meeting in Morogoro Third co- ordination meeting in Stockholm
Bernhard Frey, Markus Neubauer	Project meeting in Tanzania as mentioned in the minutes.
Bernhard Frey	Final meeting in Maputo
Presentation of CHAPOSA on the IER Homepage with updates	http://www.ier.uni-stuttgart.de Presentation of the approach and methodology to give a short overview and a link to the official Homepage of CHAPOSA

Scope of work IER

1. definition of the Scope of the models
2. definition of the involved energy resources
3. first report
4. definition of methodology
5. assessment of quantifiable parameters suitable for the model
6. analysing the study area of one country
7. preparation for the baseline model
8. collecting data on bases of data sheets
9. research and summarising of papers and references
10. visiting different institutions e. g. forest faculties in Germany
11. second annual report
12. identification of missing parameters
13. development of the RES-structure
14. refine of the RES-structure with hierarchical levels
15. entering the equations in PlaNet
16. first calculation of the energy model
17. definition of the forest model in the Analyst
18. defining Scenarios and Strategies via E-mail
19. presentation and Discussion of the model in Stockholm
20. implementation of required changes of the model
21. implementation of the model into the new version
22. modelling of the charcoal demand system of the three countries
23. modelling of the woodland system
24. combination of the two models through an interface
25. producing new data sheets for collecting missing information from the partners in an ongoing prozess
26. collecting missing data from other institutions as an ongoing prozess
27. visit of Tanzania to collect data and to discuss further scenarios and strategies
28. proposal of strategies based on different scenarios
29. internal report for meeting in Stockholm
30. draft reports for the meeting in Maputo
31. discussions on the model and new model runs after the meeting in Maputo
32. Final report on basis of the draft final reports of the partners as far as required

Results of the Energy model calculations based on the final report and their references

For the household energy system of the three examined cities, the most important driver is the growth of the urban population. So, three different scenarios for a possible population growth are determined for the three cities. Each city is going to grow very much in the next years. The population of Dar es Salaam, Lusaka and Maputo is going to be doubled in the next 20 to 30 years.

The total wood consumption in Maputo/Matola City was about 1,16 million tons in 2000. This amount will rise up to about 2 million tons of wood in the year 2020. With the introduction of “improved stoves and kilns“ only about 1,1 million tons of wood would be demanded for the year 2020. In Dar es Salaam City the total wood consumption in the year 2000 was about 2,23 million tons. This amount could rise up to about 5,1 million tons of wood in the year 2020 for the reference case. In the year 2000 the total wood consumption in Lusaka City was about 1,8 million tons. This amount is going up to about 3,8 million tons of wood in the year 2020 in the reference case.

The wood consumption of the cities can be reduced in an enormous way by using different strategies and cases. Strategies of the energy sector are: propagation of improved kilns and propagation of improved stoves. For Zambia also, these strategies were chosen to remain on the wood-fuel related level. The propagation of other stoves like kerosene, gaz or stoves was not seen as a real alternative in the next years for Lusaka City. The Lusaka City household energy market is already characterized by a higher number of kerosene and electrical stoves.

In Zambia 80% of the total wood demand is used for charcoaling, another 10% as firewood in the year 2000. The part of wood which has other uses than for charcoaling plays a bigger role than in Mozambique or in Tanzania. Therefore this aspect was regarded specially. The part of wood in Zambia for charcoaling is calculated with 80% in the reference case in 2020, like in 2000. By execution of all discussed measures until 2020, the part of wood for charcoaling can be reduced to 60%. This shows that there is also a big potential in saving wood by searching for other measures, such as the substitution of wood stoves for example.

The simulation of Zambia with the strategy „improved stoves“ leads to a total wood demand of 2,27 million tons in the year 2020. The wood saving of the strategy „improved kilns“ is about 28%, with a simulated demand of 2,7 million tons in 2020. The strategy „improved stoves and kilns“, which combines the two measures, leads to a total wood demand of about 1,7 million tons in 2020. This means about 54% of wood can be economised compared to the reference case in 2020. In the best case reference "improved stoves and kilns" the total demand of wood is even smaller than today. Nevertheless the population of Lusaka City is increasing, and with it the household energy demand, so it is possible to reduce the wood consumption to a smaller volume than today by using more efficient stoves and kilns.

The biggest part of the wood demand is consumed by the charcoaling process with about 1,1 million tons for Maputo (95% of wood demand) , 2,1 million tons for Dar (94% of wood demand) and 1,5 million tons of wood for Lusaka (83% of wood demand) in the year 2000 for the reference case. The actual charcoal consumption of Maputo is about 140.000 t, of Dar is about 314.000t and of Lusaka City is about 240.000 t in the year 2000. The modelled urban charcoal consumption for the year 2020 is about 240.000 (Maputo), 720.000 (Dar) and 507.000 t (Lusaka) in the reference case. With the measure „propagation of improved stoves“, this can be reduced to about 180.000 (Maputo), 390.000 (Dar) and 260.000 t (Lusaka) for the year 2020.

The strategies "improved stoves" and "kilns with higher efficiency" lead to an evident decrease of wood consumption. Combined with the „optimist“ scenario in the case „optimist, improved stoves and kilns“ in Zambia the simulated wood demand is with 1,4 million tons even about 20% under the demand of today, meaning an absolute saving of 360.000 t in 2020 compared to 2000.

The Household energy demand of Lusaka increased from 94.000 toe in 1980 to about 300.000 toe in 2000. There are four important energy carriers on the Lusaka household combustible market: charcoal, firewood, kerosene and electricity. The biggest part of consumed energy are the wood fuels with about 78% consumed toe in the year 2000, about 55% charcoal and 23% firewood. In Maputo other household combustibles like gas, paraffin or electricity only play a minor part, as almost 85-90% of the energy demand in the households is satisfied by wood based fuels. In the Dar es Sa-

laam household energy market fire wood plays no big part, so does electricity. There is even no gas used as household combustible in urban Dar es Salaam. The part of the charcoal as energy carrier sunk from 93% in 1980 to 83% of the consumed toe in 2000. In the same time the part of paraffin rose to 12% of the consumed toe in 2000 to become the second important energy carrier in Dar es Salaam's households.

Woodland development of the study area of Mozambique is different in comparison to Tanzania and Zambia in terms of growth rates and ecology. The vegetation of the study area of Mozambique is savanna biome, the vegetation of Tanzania and Zambia is miombo woodland.

90% of the wood or charcoal demand of Maputo is satisfied through the study area. The woodland in this area would be completely finished before the end of year 2018 without measures. Woodland development reacts very slowly to woodland strategies. Even the immediate implementation of certain strategies would not prevent the woodland from decreasing. This situation in the study area of Mozambique has even intensified through the slow growth rates of the savannah biome. Therefore sustainable forest management practices become difficult. The option of additional forestation can be regarded as a maximum at the available area with an average growth rate of 54t/km²a on the grassland and agriculture areas and additional 5,4t/km²a in the open woodland areas beginning in the year 2003. Nevertheless the strategy with forest measures would not be sufficient as the demand from the study area is much higher.

Forest measures are not sufficient, as it is the case in Mozambique, to take the pressure away from the woodland.

Combined strategies are only suitable to prevent the forest from a complete destruction in the next 30 years. The biggest issue is the increasing demand of charcoal because of population growth rate in Maputo and Matola.

A lot of charcoal entering Dar es Salaam comes from the closed and open miombo woodlands. It is assumed that about 80% of the total charcoal demand is satisfied through the study area.. The trends of degradation is going to increase in the next years due to the enormous population growth rate. The increasing population in Dar es Salam and the expansion around the city could have big impacts on the not yet exploited woodland areas.

The option of additional forestation can be regarded as a maximum in the available area with a growth rate of about 116t/km²a on the grassland and agriculture areas and an additional 11 t/km²a in the open woodland areas beginning in the year 2003. By using consequent forest strategies as well as the introduction of some household measures the woodland could be prevented from exploitation. This is possible according to the dynamic development of the Tanzanian miombo woodland in the study area.

For the Woodland Development of the zambezian study area it is important to know that only 25% of the charcoal for Lusaka comes from the study area. Zambia could be divided in the three land types: plateau, hill and flat topography.

The development in the plateau area of Zambia declined constantly from about 9.550.000 in 1989 to 7.140.000 t in 1998. The further development is down to 4.270.000 t in 2020. That means that the wood production in the same area would be bisected within less than 30 years. It can be assumed that the potential of the regrowth woodland after certain cuttings becomes weaker and probably soil erosion

takes place as well as fire. Another part of former re-growth or nature woodland was converted into agriculture.

In comparison to the plateau development, the development of the hill stand is totally different. The nature woodland goes slightly down from 1989 to 2020. At the same time the re-growth woodland is increasing from almost 2.250.000 to 3.370.000 t. Therefore the possible wood production of this region decreases only from about 13.370.000 in 1989 to 12.950.000 in 2020.

The re-growth wood production of the Flat country stand development has increased a lot between 1989 and 1998. It is supposed that there was nature woodland before and other parts were under agriculture or cutting areas. As there seems to be a quite good potential in this area for making charcoal, the development should decline up to 2010 and likely grow again because of coppicing and re-growth from former agriculture.

In the Zambian study area the influence of making charcoal seems to be less than in the other countries. With a mix of strategies, it should be possible to come back to the same wood productivity level under a low population growth rate.

The most important factor for implementing forest measures is the involvement of the villagers. This is guaranteed only if a profitable participation of the villagers is found as discussed during several meetings.

Trainings

Thesis ongoing on the base of CHAPOSA (Wendelin Waiblinger)

PhD ongoing on the base of collected data (Bernhard Frey)

Minutes from CHAPOSA meeting in Tanzania to collect and discuss data for the model. 26th June to 2d July 2001

TaTEDO

(Participants: Estomih N. Sawe, Jean Nduwamungu, Prof. Dr. Salome Misana, Bernhard Frey, Markus Neubauer, other staff of TADEDO)

With a propagation program, an introduction of improved Kilns seems to be possible and feasible in future

Increase of efficiency up to 20-25% compared to 15% of traditional earth kilns

at the moment the improved kiln type “Casamance-Kiln” is not accepted by the charcoal makers

- Introduction of improved charcoal stove Straight Wall Jiko Bora (thermal efficiency up to 35%)
  - o Target: 45% Market Share by 2003
  - o Reached:~ 35% Market Share

Thermal efficiency of the Double Liner Jiko Bora about 44%, cost Shilling 4.000,--, Production of 8.000 pieces/month

Gas pipeline is planned from Songosongo to Dar es Salaam (280km)

- 531.000 households in Dar es Salaam, 231.000 households using improved charcoal stoves (44%) and nearly all of them also have traditional ones.

- one household needs 1,08t charcoal/a using the traditional charcoal stove or 0,37 t charcoal/a using the improved charcoal stove.
- Estomih N. Sawe, Executive Director of TADEDO thinks that the use of improved charcoal stoves reduces the quantity of charcoal demand per household. He comes to the conclusion that households using the traditional charcoal stove must pay 108.000,-- Tanzanian Shilling for charcoal/year and households using the improved charcoal stove only 37.000,-- Tanzanian Shilling.

That would mean that the introduction of improved charcoal stoves could be regarded as a strategy to reduce the use of charcoal per household.

Improved charcoal stoves are much more expensive than traditional ones. Life time of the improved charcoal stoves is reduced in comparison to the traditional charcoal stoves. Improved charcoal stoves are less stable (because of the ceramic inlay) and have to be replaced earlier. According to Estomih N. Sawe the investments into improved kilns have a long term return on investment.

Energy Sector in Tanzania

The estimated total energy consumption is more than 22 million tons of oil equivalent (toe) or 0,7% toe per capita. Approximately 91% of the total energy consumed is wood-fuel, about 8% petroleum products and 1,2% electricity. Contribution from other renewable resources are negligible.

The rural areas account for about 85% of total energy consumption in Tanzania.

The most important energy resources for electricity production are hydropower, coal and natural gas. The rest of the demand is satisfied through imports from Kenya, Zambia and Uganda. The total importation is about 55.000.000 kW/a. All plants are property of the state except the coal power plant which is driven by the private company TANESCO. Commercial and industrial users account for around 1/3 of the electricity consumption. A growth rate of 10% per year is expected until 2003.

Electrical energy produced from:	Installed Capacity [MW]	Effective Capacity [MW]	Demand, 2000 [MW]
Hydropower	561	555	
Gas Turbines, Diesel	202	147	
Coal Power Plant	6	6	
Total			~ 880

CHAPOSA Discussion

(Participants: Prof. Dr. Yusufu H.M.B. Malende, Prof. Dr. Rogers Malimbwi, Prof. Dr. Salome Misana, Dr. Boniface P. Mbilinyi., Dr. Emmanuel J. Luoga, , Jean Nduwamungu, Bernhard Frey, Markus Neubauer)

Efficiency of kilns should be seen as the average. It is possible to train the people to reach a certain knowledge of how to build good kilns..

Strategies and measures

Improved charcoal stoves

Their introduction seems to be a good strategy and should be feasible. With reference to the discussion with TADEDO, the improved charcoal stoves in Dar es Salaam have a market share of about 35% and it is still increasing.

Introduction of an industrial production should be reachable. With policy intervention there could be probably an exponential growth rate in the next 5 years

The comparison of other stoves are seen as follows:

Electrical stoves are very expensive and the tariffs of electricity are much higher than those for the use of charcoal.

Gas stoves are not safe.

Kerosene or paraffin stoves are usually used for preparing breakfast only.

Coal stoves are not suitable because of lack of hard coal. There is no mining industry. This might possible if the industry required a lot of coal so that mining could bring some benefits to the mining industry. At the moment there is only one coal power plant (private company TANESCO) which imports the coal.

Kilns

Fuel efficiency

Traditional Kiln	15 – 20%
Improved Kiln	20 – 25%, additional advantage: less dust
Professional	No difference with the improved one

The major problem to implement the strategy of introducing improved kilns is not mainly the need of a chimney, nor that the charcoalers refuse to learn how to build better ones. The main problem is that the local people think on short term basis only. This was mentioned by the charcoal makers we interviewed on Thursday in the field. They are afraid of not making money during the training day. One possibility could be a job training only for a few charcoal makers so that it can spread up, as we know that charcoal makers learn mainly from each other rather than from their families.

Therefore introduction of improved kilns could be an additional strategy

A forestation and additional planting on wide open woodland and degraded land

Mainly two different types in the Miombo woodland: selective and clear cutting. There is flowing transition between areas of selective and clear cutting.

Coppicing, Coppicing with the standards, Clear cutting, Selective cutting, Agroforestry. Strategies with coppicing with the standards and fire control on public land is possible as long as the villages are involved.

At the moment there is an additional point: wood is for free.

One solution mentioned was to introduce a tax on the stand and to raise a higher fee for the charcoal production which goes directly to the villages. On the other hand the fees for the districts should be reduced if possible.

Completed catalogue page

Summary before project:

A majority of the urban population in Sub-Saharan Africa (SSA) depend on charcoal as their main source of energy. In spite of this, the understanding of the potential of the natural resources to supply the urban consumers with charcoal over a medium time perspective is limited. This has implications on the affected countries regarding their ability to design and implement appropriate energy policies that can intervene in the charcoal sector. While policies relating to "modern" energy sources are usually straightforward and effective, these affect the energy supply mostly for the modern sector and middle to high-income households, which are in minority. The policy relating to charcoal mainly affects the low and middle income urban population who are the most dependent on charcoal as a fuel, as well as the rural population for whom charcoal production is an important source of income. Even if this is acknowledged, and attempts have been made in several countries to implement policies related to biomass energy, these have rarely been effective, mostly due to lack of understanding both of the forest ecosystem, but also of social, economic and market factors involved in the process. General declarations to the effect that governments should aim at a sustainable natural resource management, protect species diversity and encourage saving of biomass fuels will remain ineffective as long as these factors are not addressed and understood. What is required is specific information, related to specific areas, and with specific recommendations of what can be done, by whom it can be done, and the implications of actions or lack thereof on the supply of biomass energy for a large number of poor people.

Comments after project:

The project has shown that charcoal potential is relatively good in the eastern Lusaka area, acceptable in the Dar es Salaam area (especially SE of Dar es Salaam), and poor in the Maputo area. Much of the potential for charcoal production is in the regrowth of woodlands. In all study areas, charcoal is being extracted in ecologically sensitive areas, indicating over-exploitation of forest resources. Improved management of forest resources is needed especially in the Maputo and Dar es Salaam areas. The way to do this is to review and enforce the existing system for licensing and collecting revenue from the forest sector. This will lead to increased costs for urban low-income people and less income for the rural poor, and must be accompanied by measures to provide alternative energy sources in urban areas, and alternative income opportunities in rural areas. If this can not be achieved, then enforced fiscal measures should not be implemented.

Project data sheet

1. Dissemination activities

Number of communications in conferences	3
Number of communications in other media (internet, video…)	8
Number of publications in refereed journals (published)	0
Number of articles/books (published)	0
Number of other publications	30

2. Training

Number of Ph.Ds	3
Number of MScs	9
Number of visiting scientists	0
Number of exchanges of scientists (stays longer than 3 months)	0

3. Achieved results

Number of patent applications	0
Number of patents granted	0
Number of companies created	0
Number of prototypes/products developed	0
Number of tests/methods developed	0
Number of norms/standards developed	0
Number of new softwares/codes developed	0
Number of production processes	0

4. Industrial aspects

Industrial contacts		yes		no	x
Financial contributions by industry		yes		no	x
Industrial partners:	Large	yes		no	x
	Small	yes		no	x

5. Comments

The project is not aimed at developing industrial applications, but for the policy level. Hence patents and industrial aspects are not part of the expected output.

Annexes

CHAPOSA Final partner reports appended under separate cover:

1. Zambia: Chidumayo, E.N., Masialeti, I., Ntalasha, H., Kalumiana, O.S. (54 pages)
2. Tanzania: Malimbwi, R.E., Misana, S., Monela, G., Jambiya, G., Nduwamungu, J. (66 pages)
3. Mozambique: Pereira ,C.R., Brouwer, R., Monjane. M., Falcão, M. (44 pages)
4. Germany, B. Frey and M. Neubauer (75 pages)

Minutes of the Plenary Session of the Chaposa Dissemination Workshop in Maputo, 30/10/01

Reported by Roland Brouwer, UEM

01/11/01

1. Relation between Environmental Impact Assessment (of Charcoal Production) and the Chaposa Research Project.

Chaposa was never meant to be an EIA of charcoal production. However, through its integrative approach, which included ecological, social and economic aspects, one might say that to a certain extent, unwillingly, Chaposa has acted as a kind of EIA.

Moreover, some specific aspects have been studied which are close to EIAs. One is the point of erosion in relation to changing land use and the recommendations about zoning and gazetting. Another is the attention that has been paid to the natural regeneration capacity of charcoal producing woodlands and the factors that inhibit this regeneration.

2. How to interpret charcoal production

It seems that charcoal producing areas have a strong regenerative potential, but that certain factors inhibit it. One is that charcoal production, to be sustainable, requires a large extension. Moving charcoal producers is one condition for regrowth. As in particular in the Mozambican study area regrowth is extremely slow, this implies that large areas will be necessary to sustain charcoal demand. On the other hand, such areas are available in a big and relatively sparsely populated country.

It might be true that at a large scale the system may sustain charcoal production, and thus it may seem that the problem is solved. However, at a local scale it may have disastrous results and affect livelihoods through the destruction of the natural resource base.

The success of regrowth depends on management practices. Two options are feasible: rotate the producers or spread the producers so that their density is low enough. Rotation will than be localized. Both options require a clever management plan.

In Mozambique space may be available. This is not the case in Malawi and other smaller and more densely populated areas. Here, spreading is no option and what will happen is probably the import of charcoal from neighboring areas such as Mozambique in the case of Malawi and Zambia (Copperbelt) in the case of RDC.

3. Regulation, gazetting and quota system.

An important question is whether we can expect self-regulating mechanisms to set a balance between production and demand. In that perspective, we should take into account that conversion of woodland into farmland may be economically more profitable. Regulation is also dangerous because we are dealing with an extremely important sector, especially for the urban and rural poor. Changing prices by levies and taxes will immediately affect purchase power and livelihoods of the poor in the urban and rural areas.

Regulation is a means to control flows, to protect biodiversity, to enhance non-market-values (externalities) and thus is necessary to correct the functioning of a deregulated market economy. If no regulation were to exist, complete destruction of woodlands and centers of biodiversity and endemism are to be expected.

An interesting conclusion of Chaposa is that actually charcoal is not a typically "poor men's business". In the urban areas, poor and wealthier households alike consume charcoal, although dependency among the poorer households is higher. In the rural areas, charcoal burners may well earn more than 400 USD/year/capita, which is more than an average gross per capita product. So we should not make the mistake that not interfering with charcoal will protect the poor.

Sustainability cannot be reached by price and licensing mechanisms alone. Education and raising awareness among the charcoal producers is of key importance. Gazetting and zoning are insufficient and difficult to enforce.

Yet, zoning is an important instrument. We researchers have to use zoning to indicate the areas that are more sensible and should be conserved, and the areas that can be used for production.

Zoning and other instruments are part of a forest policy. In Tanzania and elsewhere, forest policies are being reviewed and more emphasis is put on community involvement and co-management. New laws and regulations attribute more power to the communities. However, research is still needed on the models and assumptions these policy documents and laws are based on. The efficiency of these models and assumptions and policy measures has to be evaluated. One key issue is that failure in agricultural development is one of the factors that push people into the forest. As they cannot make a living from farming, they have to look for an alternative and charcoal is such an alternative. We should try to develop new perspectives, in particular on:

- The role of people in regeneration; we should find means to make people central o regeneration;
- Potentials and limitations of the interventions designed under the new forest policy;
- Participatory resource use at the community level;
- Develop extension models to disseminate Chaposa findings to stakeholders (simplified versions)

4. Silviculture and regeneration

Regeneration depends largely on coppicing. However repeated coppicing will reduce growth diminish as well as productivity. It also diminishes potentials for regeneration through seed. These are the impressions we have from current data. However, more research is needed to confirm these impressions, and to allow for monitoring and evaluation.

5. Low taxation rates. Can we increase them?

The question has to components: a) the amount collected through the charging of a higher proportion of total charcoal production (varying from 25% in Zambia to only 1% in Mozambique); and b) whether the collected amounts are transferred totally or partially back to the forest to promote better forest management. Usually, at the central level, they are redirected to agriculture or administration. Theoretically it may be feasible to improve the system, but the question is how to get it implemented. In Tanzania fees are partially sent back to the areas where they were collected.

Forests are buffering the rural population from poverty. So we need to invest in forests. Therefore we need an efficient levy system that allows us to plow back money into the forests.

Local revenue collection has been experimented in Zambia. This is a big achievement, because in Mozambique it has been impossible to implement such an experiment. The problem is, that, when there is no money, we have a problem. However, as soon as there is money, we have even more problems, because people do not think the forest as a priority, even if it is the source of that money. If colleted at the local level, the returns are often used for other aims such as schools, clinics, water supply, etc. Forest management normally doesn't constitute a priority among forest dwellers. If revenues from fees do not return to the forest, it doesn't make sense to improve levying.

Our responsibility is to demonstrate at all levels that transferring revenues to forest management is a *sine qua non* for the future preservation of the forests.

6. Charcoal is too important

The forests can only be saved, if charcoal becomes less important at the urban and the rural level. Only then it will be possible to implement interventions that affect prices and livelihoods of the producers and consumers.

Indeed, charcoal production should be replaced by a system that produces higher revenues. These activities should however have an individual character and not a community character. Charcoal burning is an individual activity, and if it is to be made less important, it should be substituted or complemented by other income generating activities at that level.

Even if full substitution is impossible, one has to help rural economies to diversify. This will enhance livelihoods, food security and make charcoal less important.

One possible alternative is honey. Bees need standing and flowering trees, so if bee keeping is developed, this will help to reduce the burning of charcoal.

The problem of bee keeping is that it needs tracts of intact woodland. Degraded and regenerating forests, i.e., charcoal production areas, are not very appropriate for honey production because they do not produce enough flowers.