

Proceedings of the “Conference on Charcoal and Communities in Africa”

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Edited by

Ralf Kwaschik

Coordinator, Global Non-timber Forest Products (NTFP) Partnership

International Network for Bamboo and Rattan (INBAR)



International Network for Bamboo and Rattan



Foreword

At least 80% of the African population continues to rely upon traditional sources of biomass fuels , mainly charcoal and firewood , to meet their energy needs. The demand for charcoal in most countries in the region continues to grow at high rates owing to the ever-increasing rural-urban migration. These trends coupled with inefficient charcoal production and consumption practices, and inaccessibility by most households to other reliable and affordable commercial energy forms indicates the continued and probably growing dependence on the already dwindling biomass resource for energy.

At the same time, charcoal is one of the most important commodities produced by the rural poor across Africa which is largely used in urban areas. It is an important and simple means of income generation and in rural areas its production can be more important than other activities such as agriculture. Charcoal is a reliable, convenient and accessible energy source for cooking at all times and at a stable cost. Additionally, charcoal trade offers income generation opportunities for many people in the urban areas, through small scale retail businesses mostly run by women who sell it in the urban roads. In Mozambique alone, a study has shown that annually approximately USD 200 million of charcoal is sold in the towns and cities where it is primarily used for cooking.

Charcoal leads to considerable deforestation, which is now one of the most pressing environmental problems faced by most African nations. Deforestation has negative implications both for the local and the global environment. Also, deforestation leads to reduction of natural resources on which the poor depend, and land degradation, contributing to the downward spiral of poverty.

Against this background, the Global Non-timber Forest Products (NTFP) Partnership, coordinated by the International Network for Bamboo and Rattan (INBAR), with funding from the International Fund for Agricultural Development (IFAD) implemented a project on "Assessing and Developing Replicable Methodologies and Approaches for Sustainable Charcoal Production for Livelihood Development, Rural Energy Security & Environmental Protection". One of the main activities of the project has been the international "Conference on Charcoal and Communities in Africa", held in June 2008 in Maputo, Mozambique. The conference brought together stakeholders from different constituencies and provided an opportunity to learn about different aspects of the charcoal continuum, i.e. household energy, livelihoods, supply chains, deforestation vs. sustainable production, carbon emissions, health, and policies. In addition to a range of presentations and lively discussions, a major part of the conference was dedicated to working groups, which elaborated major findings and recommendations including project ideas and concept notes in the fields of livelihoods, environment and health, policies, and information and technology transfer.

Our special thanks go to the Ministry of Agriculture of Mozambique, the National Directorate for Land and Forests (DNLF), and the Mozambique Agricultural Research Institute (IIAM) for organizing and hosting the event, to IFAD for providing funding, to GTZ for facilitating their experts' participation, and to all participants for their contributions and enthusiasm. We express our hope that the information shared and especially the findings and recommendations of the conference participants will bring about a renewed awareness of the importance of charcoal and lead to actions by stakeholders including donors in this presently somewhat neglected area.

Dr. Coosje Hoogendoorn

Director General, INBAR

Dr. Ralf Kwaschik

Coordinator, Global NTFP Partnership

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Sumário

Realizou-se entre os dias 16 e 18 de Junho de 2008, a conferência Internacional subordinada ao tema “Carvão e Comunidades de África”. O evento teve lugar em Maputo, na Sala de Conferências do Hotel Girassol e foi organizado pelo Ministério da Agricultura através da Direcção Nacional de Terras e Florestas (DNTEF) e o Instituto de Investigação Agrária de Moçambique em parceria com a Rede Internacional para o Bambu e o Rotim (INBAR) especificamente a Parceria Global para os Produtos Florestais não Madeireiros dos quais o carvão faz parte. O evento contou com cerca de 60 convidados entre representantes de Instituições Governamentais, e não Governamentais nacionais e internacionais, a citar SPFFB, DNTEF, FDA e IIAM como parte do Ministério da Agricultura; Direcção Nacional de Energias Novas e Renováveis do Ministério da Energia; INBAR, GTA; parceiros de cooperação GTZ, FAO, USAID, Embaixada da Itália, Dinamarca e Finlândia, bem como especialista na área do carvão provenientes do Ghana, Etiópia, Alemanha e Índia,

Procedeu a abertura do evento Sua Excia a Senhora Vice-Ministra da Agricultura que agradeceu a participação de todos e enalteceu a importância do evento para a luta contra a pobreza no país, tendo em conta que mais de 80% da população vive nas zonas rurais e depende da energia tradicional de biomassa, especificamente a lenha e carvão para a satisfação das suas necessidades. Durante a sessão de abertura fez-se ainda uma breve introdução ao seminário, nomeadamente os antecedentes, objectivos e resultados esperados da conferência.

A conferência com o lema “Pela produção e fornecimento sustentável do carvão em África”, tinha como objectivos:

Entender a severidade da dependência de energia lenhosa em África e a nível global

- Entender melhor os fluxos de carvão especialmente: i) as tendências de desmatamento devido a produção de carvão, ii) identificar as áreas apropriadas para a produção de carvão e actualmente não usadas e iii) encontrar fontes alternativas efectivas para a produção de carvão para controlar o desmatamento e aquecimento global incluindo a promoção de energia de bambu.
- Propor possíveis intervenções políticas para assegurar a oferta de carvão para as populações de renda baixa e para mitigar os efeitos adversos da produção de carvão
- Explorar o potencial e facilitar a transferência e adaptação de tecnologias
- Estabelecer uma rede técnica a nível de África para discussão de assuntos ligados ao carvão
- Desenvolver ideias e projectos
- Consciencializar e criar interesse entre a comunidade de doadores

Durante o primeiro dia de trabalho fez-se a apresentação de estudos de caso sobre tecnologias, políticas e outros aspectos ligados a produção e uso do carvão em alguns países de África. As apresentações foram agrupadas em 6 temas principais:

1. Situação geral da energia doméstica em África
2. Cadeias de comercialização de carvão
3. Desmatamento Vs. Produção sustentável de Carvão
4. Carvão e emissões de Carbono
5. Carvão e saúde
6. Políticas sobre o carvão

Os 11 documentos apresentados tem como titulo:

Produção e uso do carvão vegetal em Moçambique, malawi, Tanzania e Zambia: dados históricos, situação actual e perspectivas – Mário Paulo Falcao

Produção de carvão e redução da Pobreza no Ghana – Samuel Nketiah

Cadeias de comercialização – considerações gerais – Steve Sepp

Cadeia de comercialização de carvão na Etiópia - Yisehak Seboka

Cadeia de comercialização de carvão em Moçambique – Nilza Puná

Mapeamento Geral Integrando oferta/procura de Combustível Lenhoso (WISDOM) para Moçambique – Carla Cuambe

Produção de carvão e manejo sustentável das florestas; Exemplo do Ghana - Michael Kwaku

Protocolos internacionais e convenções relativas ao Carvão vegetal e emissões de carbono -Almeida Siteo

Aspectos de saúde ligados a produção e uso do Carvão – André Seidel

Políticas de energia de Biomassa – Marta Penicela

Moldando políticas de carvão: contexto, processo e instrumentos exemplificados pelo caso de alguns países – Steve Sepp

Durante o segundo e terceiro dia de trabalhos foram debatidos em trabalhos de Grupo varios aspectos relacionados com a problematica do carvão, tendo se obtido os seguintes resultados:

I. Propostas de planos de acção e recomendação de políticas

- Realização de um inquérito Nacional de combustíveis lenhosos,
- Elaboração de uma politica e estratégia especifica para Biomassa,
- Criação de uma entidade intersectorial para coordenação e supervisão dos assuntos de Biomassa cuja natureza e mandato carecem de estudo,
- Estabelecer taxas de licenciamento diferenciadas,
- Promover concessões energéticas

II. Identificação de ideias de projectos sobre aspectos da produção e uso de carvão relacionados com

1: Carvão e modo de vida das comunidades

- Estabelecimento de produção de carvão através de tecnologias melhoradas

2: Carvão e Ambiente

- Reflorestamentos para a produção de carvão e lenha
- Produção de fornos e fogões melhorados

- Sequestro de Carbono

3: Políticas (Quadro Legal dos Combustíveis lenhosos)

- Projecto regional para a coordenação, harmonização, troca de informação e apoio interinstitucional.
- Criação de uma base de dados nacional e realização de um inquérito nacional de combustíveis lenhosos
- Recursos de biomassa e Governação

4: Informação e transferência de tecnologia

- Projecto de disseminação de tecnologias de produção e uso de combustível lenhoso

III. Acções de seguimento

- Criar a Rede técnica para discussão de assuntos relacionados com carvão
- Preparar as notas conceptuais dos projectos identificados e garantir financiamento
- Preparar a publicação dos artigos apresentados durante a Conferência

Constatações Gerais

Durante as apresentações e discussões em plenária, os participantes apresentaram aquilo que eram as suas inquietações em torno da produção e uso do carvão e estas podem ser resumidas em:

- Técnicas de produção e uso de carvão pouco sustentáveis ameaçam a sustentabilidade do recurso florestal.
- A eficiência dos fornos usados nos países da África varia entre 10 a 25%. Os fornos melhorados embora possuam uma eficiência maior entre 25-32%, têm tido fraca aceitabilidade devido a sua exigência em termos de mão de obra, o forno casamance é um exemplo pois apesar de apresentar eficiência elevada em relação aos fornos tradicionais, em Moçambique a sua adopção tem sido baixa.
- Existe pouca informação sobre a situação do carvão para apoiar na tomada de decisões e o carácter informal deste negócio dificulta estatísticas neste sector.
- A existência do sistema WISDOM é uma grande vantagem para Moçambique pois esta ferramenta permitira a tomada de decisões sobre que acções implementar em diferentes áreas no país de acordo com o balanço energético da procura e oferta de carvão.
- Além dos aspectos culturais, a inexistência de fontes acessíveis de energia alternativa é a principal causa dos elevados índices de consumo actualmente registados. Moçambique tem muitas potencialidades energéticas, mas a maioria destas energias no país ainda continua cara. Apesar de se ter alargado a rede eléctrica para as zonas urbanas, os custos elevados desta energia têm sido proibitivos e faz com que a população moçambicana continue a usar maioritariamente a energia de biomassa para a confecção de alimentos.
- Já existem em África exemplos de fornos mais eficientes e boas experiências de produção de carvão usando resíduos agrícolas e de serrações que podem ser partilhados
- quadro legal actual apresenta muitas vantagens para o manejo sustentável do recurso florestal para a produção do carvão. Exemplos são os valores de 20% das taxas de exploração destinados as comunidades locais e os 15% da sobretaxa de exploração destinados ao repovoamento florestal e

faunístico. Contudo, ainda não existe uma cultura de estabelecimento de plantações para fins energéticos e portanto não tem sido muito visível o objectivo da cobrança de tais taxas.

- Apesar de se ter um bom quadro legal, a implementação e fiscalização deste tem sido deficientes devido a falta de capacidade por parte do estado.
- Dados preliminares de estudo feito para a cadeia de Maputo apontam a um rendimento médio de cerca de 2000 e 3600 Mt/mês por produtor o que enfatiza a contribuição deste sector para a economia local e para o alívio a pobreza rural. Entretanto sabe-se que existe uma tendência cada vez maior de “invasão” das áreas de produção por indivíduos alheios as comunidades da zona.
- As fontes de produção de carvão estão cada vez mais distantes exemplo de Chicualacuala e Massangena localizados a cerca de 400km de Maputo.
- Existe uma tendência de migração dos produtores de Maputo para a Província de Gaza e pouca cultura de manejo dos recursos florestais.
- As taxas cobradas actualmente pela exploração de espécies produtoras de carvão vegetal são muito baixas e não estimulam a conservação e ameaçam a sustentabilidade deste a longo prazo.
- A cobrança das taxas de exploração do carvão usando a equivalência de 1 estere para um saco tem criado uma tendência para o uso de sacos cada vez maiores o que faz com que tanto o produtor como o Estado percam em favor dos intermediários. Mais ainda, os custos de produção não são reflectidos no preço final do carvão.
- Um dos problemas de poluição ambiental está ligado a produção de carvão por este constituir um dos processos que emite maior quantidade de poluentes ambientais, que além de acentuar os efeitos das mudanças climáticas, causa também problemas de saúde para os produtores de carvão
- O uso de carvão vegetal é o principal responsável pela produção de monóxido de carbono que causa infecções agudas e doenças respiratórias como o cancro do pulmão e a asma. As mulheres e crianças têm sido maiores prejudicados o que leva em muitos casos a mortalidade de crianças com idade inferior a 5 anos
- Actualmente existe pouca coordenação intra e interinstitucional entre os vários intervenientes ligados ao sector de biomassa no país. Isto faz com que haja acções descoordenadas e os esforços envidados não surtam o efeito desejado.
- O actual sistema de posse de terra não estimula a conservação do recurso uma vez que não existe muita segurança de acesso e posse dos recursos por parte dos usuários.
- As espécies usadas na zona sul são maioritariamente o mopane e o mondzo, esta última que foi reclassificada e não deve ser usada para a produção de carvão

Recomendações:

- São as seguintes as recomendações saídas do evento:
- Necessidade de se implementar acções antes que se chegue ao caso da Etiópia que perdeu grande parte da sua cobertura florestal contando actualmente com apenas 3% de cobertura florestal.
- Garantir a sustentabilidade dos projectos previamente implementados para evitar retrocessos após a saída/fim do projecto.
- Necessidade de melhorar o sistema de registo de informação por forma a incluir dados sobre a quantidade de carvão produzido, número de intervenientes e dependentes desta actividade, valores envolvidos e geração e partilha de rendimentos ao longo dos intervenientes no negócio. Uma

alternativa seria a implementação de um inquérito Nacional sobre o carvão vegetal e a sistematização de informação sobre tecnologias de produção e uso de carvão no país e na região.

- Garantir a existência de informação para alimentar o WISDOM- mapeamento Geral Integrando oferta/procura de Combustível Lenhoso para tomada de decisões apropriada
- Necessidade de introdução de energias alternativas acessíveis com vista a redução dos níveis actuais de consumo de carvão nos centros urbanos e peri-urbanos
- Identificar alternativas para garantir que a renda adquirida pela produção de carvão permaneça a nível rural.
- Rever o sistema de cobrança de taxas para valorizar os recursos florestais, uma alternativa seria a cobrança de taxas por unidade de peso (Mtn/Kg).
- Promover/incentivar a produção de carvão no país usando resíduos como casca de coco, resíduos de serrações, resíduos da produção de carvão, etc.
- Repensar num mecanismo para assegurar o uso de métodos mais sustentáveis de produção. Uma possibilidade seria o encarecimento da Licença simples
- Promover a exploração em regime de concessões florestais para fins energeticos tanto privadas como comunitárias.
- Assegurar que os valores dos 20% das comunidades e os 15% de sobretaxa para o repovoamento florestal e faunístico sejam reinvestidos no sector ao nível das áreas de produção de carvão.
- Garantir o envolvimento cada vez maior de associações de produtores e dos comités de gestão nas áreas de produção de carvão vegetal por forma a melhorar o controle
- Melhorar a coordenação entre os intervenientes no sector de biomassa.
- Criar uma agência Para-estatal ligada aos combustíveis lenhosos poderá ser parte da solução deste problema.
- Garantir a participação activa de todos intervenientes no processo de elaboração da politica sobre energias novas e renováveis

Summary

The conference on “Charcoal and Communities in Africa” was held in Maputo at the Girassol Bahia Hotel between the 16 and 18th June, 2008.

The conference was organized by the Ministry of Agriculture through the National Directorates of Lands and Forests (DNTF) and the Agrarian Research Institute of Mozambique (IIAM) in partnership with the International Network for Bamboo and Rattan (INBAR) through the Global NTFP Partnership.

The event hosted 63 people representing the Government and Non Government Institutions such as the SPFFB, DNTF, FDA and IIAM from the Ministry of Agriculture; National Directorate of New and Renewable Energies from the Ministry of Energy; NGOs (ADEL, GTA); technical agencies such as GTZ, FAO, INBAR, Tropenbos, USAID; Italian, Danish and Finnish Embassies as well as international specialists from Ghana, Ethiopia, and Germany.

Opening Ceremony

Her Excellency the Vice-Minister of Agriculture of Mozambique opened the ceremony. She started her speech thanking all the participants for attending the conference and emphasizing the importance of the event for the country’s poverty reduction efforts taking into account that more than 80% of the people in the country relies on the biomass to meet their basic energy needs.

Her Excellency’s opening speech was followed by words from the organizers who introduced the conference background, objectives and expected results.

The conference had the following objectives:

- To understand the severity of dependence on wood for energy needs in Africa and globally
- To understand charcoal flows, specifically (i) to understand the trends in deforestation due to charcoal production, (ii) to identify areas suitable for charcoal production not currently utilized, and (iii) to find effective and alternative sources of charcoal production, in order to curb deforestation and global warming, including the promotion of bamboo for bio-energy
- To propose possible policy 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
- To explore the potential and facilitate technology transfer and adaptation
- To establish a network and create a community of practice
- To develop project concept notes
- To raise awareness and create interest among the donor community

The first day saw presentations of case studies about technologies, policies and other aspects related to charcoal production in selected African countries. Presentations were grouped under 6 main themes:

- The African household energy outlook
- Charcoal supply chains
- Deforestation vs. sustainable production
- Charcoal and carbon emissions
- Charcoal and health

- Charcoal policies

Eleven documents were presented at the conference:

Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia: historical overview, present situation and outlook - Mário Paulo Falcão

The Prospects Of Charcoal Production Contributing To Poverty Reduction In Ghana – Samuel Nketiah

Analysis of Charcoal Value Chains - General Considerations – Steve Sepp

Charcoal Supply Chain study in Ethiopia - Yisehak Seboka

Charcoal Supply Chain Study in Mozambique - Preliminary Results – Nilza Puná

Woodfuels Integrated Supply Demand Overview Mapping (WISDOM) for Mozambique – Carla Cuambe

Charcoal Production and Sustainable Forest Management: The Example Of Ghana - Michael Kwaku

Charcoal, Carbon Emissions and International Conventions/Protocols - Almeida Siteo

Health Aspects of Charcoal Production and Use - Andre Seidel

Renewable Energies Policy in Mozambique: Aspects Related to Charcoal – Marta Penicela

Shaping Charcoal Policies: Context, Process and Instruments as Exemplified by Country Cases – Steve Sepp

The second and third days were devoted to group work on (i) charcoal and livelihoods, (ii) environment and health, (iii) policies, and (iv) information and technology transfer.

Main findings of the conference

During the conference the participants presented and discussed in plenary various issues regarding charcoal production and use which can be summarized as follows:

- Unsustainable charcoal production and use techniques threaten the forest resources' sustainability.
- Efficiency of most of the kilns used for charcoal production in African countries varies between 10 and 25%. Improved kilns with better efficiencies of around 25-32% still are hardly used because they are labor intensive. The Casamance kiln is an example of these kilns because despite its efficiency, its adoption rates in Mozambique are still low.
- There is little information regarding the charcoal situation to support decision making processes and the informal character of the sector makes it difficult to collect sector statistics.
- Mozambique has an advantage through the WISDOM system that may be used to aid decision making processes about where to implement different actions in the country based on the biomass energy supply demand balance.
- The absence of affordable alternative energies is the main cause for the current high consumption rates of charcoal. Mozambique has many energy potentials, however, most of these energies are still too expensive for the majority of the local communities. Despite the expansion of electric grid to urban and suburban areas, high costs of these energies still prohibit their usage by a majority of Mozambicans.

- There are good examples of efficient kilns in Africa and good experiences in usage of agriculture and forest wastes for charcoal production and these should be disseminated and shared among different countries
- A legal framework is necessary for the sustainable management of charcoal production resources. Examples are the 20% of the fees for forest exploitation activities that should revert to the local communities and the 15% of the exploitation fee that should be used for forest and wildlife breeding programmes in Mozambique. However, there are still no examples of plantations established for energy purposes hence the objective of these fees is still not visible.
- Despite the good legal framework, legislation implementation and enforcement is still deficient due to the Government's lack of capacity.
- Also, the actual land ownership regulations do not stimulate the resources conservation because there is little security over the resources by the users.
- Preliminary results of the Maputo charcoal supply chain study point to a net income of around 2000 and 3600 Mt/month for each producer, which shows the contribution of this sector to rural poverty reduction. However, there is a growing trend of "invasion" of production areas by individuals that do not belong to the local communities.
- Species that are mainly used for charcoal production in the South of Mozambique are mopane (*Colophospermum mopane*) and mondzo (*Combretum sp.*), the latter having recently been reclassified and can not therefore be used for charcoal production
- Charcoal supply areas are becoming more distant from the consumption areas, for instance, charcoal is currently being brought to Maputo from Chicualacuala and Massangena, which are located over 400km from Maputo city.
- There is also a growing trend of migration of producers from Maputo to Gaza Province because there is little left in Maputo. Additionally these producers have no culture of managing the forest resources that they use for charcoal production. Current exploitation fees for charcoal production species are very low, which does not stimulate the resources conservation and therefore threatens its long term sustainability.
- The assumption by Provincial Services of Forest and Wildlife (SPFFB) that one cubic meter of woodfuel is equivalent to 1 bag of charcoal has been stimulating the use of bigger charcoal bags which leads to losses by both producers and the government. Moreover, this leads to charcoal prices that do not reflect the production costs.
- Charcoal production is one of the most polluting stages of the charcoal supply chain. Pollutants are likely to contribute to global warming as well as to cause health problems to the charcoal producers.
- Indoor charcoal usage is responsible for the production and inhalation of carbon monoxide which causes lung problems such as cancer and asthma. This amounts to 4% of the global burden of disease and leads in many cases to death. Women and children below 5 years of age are the most affected in developing countries.
- Currently there is little inter and intra institutional cooperation between the various stakeholders working on the biomass energy sector. This results in uncoordinated actions and the efforts made do not produce the desired effects.

General Recommendations:

- It is urgent to implement actions in Mozambique to avoid a situation where the country will be left with only a small portion of the forest cover such as the Ethiopian case where there is only 3% of forest cover remaining.

- There is a need to ensure the sustainability of the projects that have been implemented after the project is finished.
- It is necessary to improve the information registration system to include data on the quantities of charcoal produced and traded, number of stakeholders and their dependents, values involved and benefit sharing along the supply chain to aid the decision making processes. An option would be the implementation of a survey at a national level that would also systematize the information on production and usage technologies in the country and region.
- It is crucial to ensure there is updated information to feed the WISDOM system
- The introduction of affordable alternative energies is important to reduce the current consumption rates of charcoal in the urban and peri-urban areas
- It is necessary to identify alternatives to ensure that incomes generated at the rural level remain there to develop the area.
- It is important to review the actual exploitation fees to value the resources and think of a different system for applying the fees instead of the price/cbm or bag. An alternative would be to charge the fees per weight.
- Promote the production of charcoal using agriculture and forest wastes in the country.
- Ensure the use of sustainable production methods. An option could be to increase the prices of the licenses.
- Promote concessions for biomass energy for both private entities and communities.
- Make efforts to ensure that the 20% end 15% of the charcoal exploitation fees in Mozambique are reinvested in the production areas.
- Ensure more involvement of the local communities in the forest resources management through producers' associations or local management committees to improve the law enforcement system.
- It is important to improve the coordination between the various stakeholders involved in the biomass energy sector. The establishment of a government institution dealing with the biomass energy could be part of the solution.
- It is necessary to ensure the participation of all stakeholders in the elaboration of the New and Renewable Energies Policy that is currently being developed in Mozambique.

The following policy recommendations and project ideas/concept notes resulted from the group work:

Policy recommendations:

Livelihoods:

- Government should develop policies for protection and development of the charcoal sector;
- Government should control charcoal prices;
- Government should subsidize the acquisition of improved kilns;
- Government should be involved in the dissemination of new technologies;
- Government should organize fairs for charcoal sales where the improved kilns can be shown and charcoal production technologies can be demonstrated;

- Government should disseminate the production of “poupa lenha” (mud) stoves to reduce charcoal consumption;
- Government should invest in micro-credit banks in the communities to help the producers;
- Communities should establish demonstration sites for [sustainable] forest management;
- Involvement of communities in the discussion of legislation pertaining to the conservation of forest resources;

Environment and health:

- Biomass should be a priority for the renewable energies’ policy;
- Ensure the sustainable supply of woodfuel energy;
- Ensure coherence in definitions of biomass policies;
- Government should set up policies to incentivize/promote the use of alternative energies;
- Law enforcement should be improved

Policies:

- Carry out a national survey on woodfuel in the country,
- Development of a policy and strategy that will specifically address the biomass energy issues,
- Creation of an inter-sector entity responsible for coordination and supervision of activities related to biomass energy, for which mandate and nature should be discussed and decided,
- Establish differential fees system for woodfuel licenses,
- Promote establishment of concessions for biomass energy

Information and technology transfer:

- Evaluate the adoption level and impact of disseminated technologies;
- Organize producers associations and establish concessions for charcoal production;
- Train associations in business management to ensure their growth;
- Correct and adapt disseminated technologies;
- Define clear policy orientation lines for the biomass energy with emphasis on the rural areas

Project ideas and concept notes related to charcoal production and use:

1. Charcoal and Communities’ Livelihoods

- Establishment of charcoal production systems using improved production technologies

2. Charcoal and environment

- Reforestation for firewood and charcoal production
- Production of improved kilns and stoves
- Establishment of carbon sequestration programs in the country

3. Policies (Woodfuel Legal Framework)

- Regional project for coordination, harmonization, exchange of information and inter-institutional support.
- Establishment of a national database and implementation of a national survey on the woodfuel to support/aid decision making processes
- Biomass Resources and Governance

4. Information and Technology Transfer

- Dissemination of improved charcoal production and usage technologies

Speech of the Vice-Minister of Agriculture - CONFERÊNCIA INTERNACIONAL SOBRE O “CARVÃO E COMUNIDADES DE ÁFRICA” - DISCURSO DE ABERTURA POR SUA EXCELENCIA O MINISTRO DA AGRICULTURA

MAPUTO

Senhor Director Nacional de Terras e Florestas

Senhor Director Geral do Instituto de Investigação Agrária de Moçambique

Senhor Representante da Rede Internacional para o Bambu e Rotim

Exmos Senhores Representantes de Parceiros de Cooperação

Digníssimos Representantes de Organizações Governamentais e Não Governamentais

Ilustres Participantes e convidados

Minhas Senhoras e meus Senhores,

É com grande honra e satisfação que me dirijo vós na abertura desta conferência internacional subordinada ao tema “Carvão e Comunidades de África”. Permitam-me, em primeiro lugar, em nome do Ministério e em meu nome pessoal, endereçar as boas vindas a todos os participantes. Faço votos para que se sintam bem acolhidos e que tenham uma estadia agradável no nosso país.

Para Moçambique é uma grande honra e privilégio acolher um evento tão importante como a Conferência sobre o “Carvão e Comunidades em África”. Também me sinto pessoalmente honrada e dignificada, por estar diante de técnicos e profissionais de muito mérito a nível nacional e internacional, cujo empenho e dinamismo têm contribuído substancialmente para a melhoria do sector de Florestas a nível de África.

Como é de conhecimento de todos, este encontro acontece particularmente num momento de grandes desafios para o nosso Governo, destacando-se entre outros, a luta para o alívio à pobreza absoluta. O sector de Terras e Florestas, tem uma grande responsabilidade neste desafio, considerando que mais de 80% da população do nosso País vive nas zonas rurais e depende quase inteiramente dos recursos florestais e faunísticos para a sua sobrevivência.

Mais ainda, pelo menos 80% da população moçambicana continua dependente da energia tradicional de biomassa, maioritariamente carvão e lenha para a satisfação das suas necessidades energéticas.

O carvão é um dos bens mais importantes produzidos pelas famílias rurais e largamente usado em áreas urbanas. É uma forma importante e simples de renda que em algumas áreas de produção chega a ser mais importante que outras formas de rendimento alternativas como a agricultura. O carvão também contribui para as condições de vida das populações urbanas ao providenciar uma forma fiável, conveniente e acessível de energia para confecção de alimentos em todas as épocas do ano a custo relativamente estável. Adicionalmente, a venda de carvão fornece oportunidades de renda para muitas pessoas nas áreas urbanas, através da venda a retalho maioritariamente efectuada por mulheres.

Grande parte da madeira para o carvão é cortada em florestas secundárias e, em alguns casos primárias. Sendo assim, a produção de carvão conduz a um desmatamento considerável que é actualmente uma das maiores pressões que leva a problemas ambientais vividos por muitas nações africanas. Por exemplo, apesar dos esforços envidados pelo Governo no sentido de se tornar a utilização do recurso florestal regrada, ao longo das principais estradas em Moçambique tem-se assistido a uma redução da cobertura vegetal sendo a produção de carvão um dos maiores causadores deste fenómeno. O desmatamento tem consequências negativas tanto para o ambiente local (aumento da erosão) como para o global (aceleração das mudanças climáticas, ameaça a conservação da biodiversidade). Mais importante, o desmatamento leva a redução de recursos naturais sobre os quais os pobres dependem, contribuindo deste modo negativamente para a espiral da pobreza.

No país, bem como em outras nações africanas, a procura de carvão tem estado a crescer a um ritmo elevado devido a crescente migração rural-urbana. Estas tendências combinadas com as práticas de produção e consumo ineficientes de carvão e a inacessibilidade de muitos agregados familiares a outras fontes baratas de energia comercial apontam para o provável contínuo aumento da dependência pelas já reduzidas fontes de energias de biomassa. Sendo assim, a ausência de acções com vista a produção mais eficiente de combustíveis tradicionais poderá fazer com que a longo prazo a produção destes seja insuficiente para satisfazer as crescentes demandas urbanas. Mais ainda, espera-se que a disponibilidade de recursos para as comunidades pobres decline o que intensificará a degradação ambiental nessas comunidades.

Neste contexto, surgiu a iniciativa da realização deste evento, que visa juntar esforços para o combate a pobreza absoluta e o manejo sustentável dos recursos usados para a produção de carvão.

Minhas Senhoras e Meus Senhores

O Encontro que hoje inicia, deve ser visto como tendo relevância para o desempenho do Sector, porquanto pretende dar resposta a uma série de dúvidas e inquietações em torno do Maneio sustentável dos Recursos Florestais, com particular ênfase para a produção e utilização do carvão vegetal. Portanto, não devemos nos dissociar deste nosso objectivo central que é também o lema com o qual viemos a este encontro “Pela produção e fornecimento sustentável do carvão em África”.

A gestão sustentável dos recursos de florestas e fauna bravia está reflectida e espelhada como sabem na política e lei de FFB, na lei de terras, na lei do ambiente, seus regulamentos entre outros instrumentos existentes no país.

Ao juntar africanos fazedores de políticas, intervenientes e outros peritos internacionais, a conferência pretende facilitar o entendimento sobre as tendências do desmatamento e redução dos recursos florestais devido a produção de carvão em África bem como discutir como este problema cada vez mais acentuado pode ser atacado por forma a suprir a procura de energia pelas populações urbanas e rurais.

Existe uma necessidade de explorar as possibilidades além fronteiras e para troca de experiências e transferência de tecnologia existentes noutros países. O envolvimento das ONGs será um aspecto importante de futuras intervenções e a conferência criará esta oportunidade.

A conferência irá também debruçar-se sobre as necessidades de desenvolvimento e intervenções políticas apropriadas e harmonizadas para suprir as necessidades da populações sem afectar a cobertura florestal. Mais importante, a conferência é também importante para entender que a produção e comercialização de combustíveis de biomassa tradicional não podem ser somente estáveis, devem também poupar as florestas do desmatamento e contribuir para a conservação ecológica, tornando-se assim numa estratégia de desenvolvimento rural.

Sendo o “*Manejo sustentável do carvão*”, lema deste encontro, deixa-me deveras esperançada que temas como carvão e pobreza, carvão e ambiente, carvão e saúde e políticas de carvão serão profundamente abordados neste importante evento.

Posto isto, gostaria de saudar aos organizadores do evento, fazendo votos para que o encontro seja produtivo, sirva de contributo para a melhoria do manejo do carvão e melhore a contribuição deste recurso para a redução da pobreza rural em Moçambique. Desejo a todos uma frutuosa partilha de

opiniões e uma participação dinâmica para que os objectivos definidos para este encontro, sejam de facto atingidos.

Sendo assim, declaro aberto o Encontro sobre o “Carvão e comunidades de África”. Bom trabalho a todos!

MUITO OBRIGADA!

Speech of the Vice-Minister of Agriculture translated into English - International Conference on “Charcoal and Communities in Africa” - Opening speech by Her Excellency the Vice-Minister of Agriculture

MAPUTO

National Director of Lands and Forests

Director General of the Agricultural Research Institute of Mozambique

Representative of the International Network for Bamboo and Rattan

Representatives of the Cooperation Partners

Distinguished Representatives of Non-Government Organizations

Distinguished Participants and Guests

Ladies and Gentlemen

It is with great honor and satisfaction that I address you in the opening of this International Conference on “Charcoal and Communities in Africa”. Allow me to first welcome all participants in my name and in the name of the Ministry. I hope you feel well and you have a pleasant stay in our country.

For Mozambique, it is a great honor and privilege to host an important event such as the conference on “Charcoal and Communities in Africa”. I also feel honored and dignified for being in front of professionals and technicians of merit at both national and international level, whose work and dynamism have contributed to improve the forest and wildlife sector.

As you may all be aware, this meeting takes place at a moment of big challenges for our government, in the context of the fight against poverty. Lands and forest sectors have a huge responsibility in this challenge taking into account that more than 80% of the population in the country live in rural areas and depend mostly on the forest and wildlife resources for their lives/survival.

Moreover, at least 80% of the country’s population is still depending on the traditional biomass energies mostly charcoal and firewood to meet their energy demands/needs.

Charcoal is one of the most important goods produced by rural families and which is largely used in urban areas. It is an important and simple means of income that in many cases is more important than other income sources such as agriculture. Charcoal also contributes to the livelihoods of urban populations while providing for a reliable, convenient and accessible energy for cooking throughout the year. Additionally, charcoal sales offer income generating opportunities for many people in the urban areas through the retail sales mostly done by women.

A great part of the wood used for the charcoal production is cut from primary and in some cases from secondary forests. Thus, charcoal production leads to a considerable deforestation that is currently one of the main environmental problems faced by many African nations. For instance, Government efforts have been focused on making the natural resources use sustainable, but throughout Mozambique it is possible to note the reduction of forest cover and charcoal production is amongst the main causes for this phenomenon.

Deforestation has negative consequences for both the local (e.g. increased soil erosion) and global environment (e.g. acceleration of climate change and threat to biodiversity conservation). Most importantly, deforestation leads to reduction of natural resources on which the poor depend, contributing to the downward spiral of poverty.

In Mozambique as well as in other African nations, demand for charcoal is increasing rapidly due to rural-urban migration. This trend, combined with inefficient production and consumption practices as well as inaccessibility by many households to other reliable and affordable sources of energy indicates the continued and probably growing dependence on the already dwindling biomass resource for energy. Therefore, the absence of actions to increase the production efficiency of the traditional fuelwood may lead to insufficient supply of these products. Moreover, it is expected that the availability of resources for the poor communities may decline which may possibly intensify the environmental degradation in these communities.

It was in this context that the initiative of this event emerged in a way to join efforts to fight against absolute poverty and for the sustainable management of resources used for charcoal production.

Ladies and Gentlemen

The event that begins today should be seen as having huge relevance for the performance of the sector as it may address the doubts and concerns around the sustainable management of forest resources with emphasis on charcoal production and usage. Therefore, we should not forget our main objective which is also the theme we bring to this event “for the sustainable production and supply of charcoal in Africa”.

The sustainable management of forests and wildlife is reflected as you are aware in the forests and wildlife policy and legislation, in the land and environmental legislation and respective regulations.

By bringing together African policy makers, stakeholders and international experts, this conference will facilitate the understanding of trends in deforestation and forest depletion due to production and use of charcoal in Africa and how this ever growing problem can be addressed to meet the energy needs of the rural and urban populations.

There is a need to explore possibilities for cross-border information exchange, technology transfer and exchange of existing advanced technologies in other countries. NGOs involvement is an important aspect for future interventions and the conference will create that opportunity.

It will also address the need for developing appropriate, harmonized policy intervention strategies towards meeting energy requirements without harming the forest cover. Furthermore, the conference is also important to understand that production and commercialization of biomass fuels can not be sustainable without saving the forests and contributing to the ecological conservation making it a rural development strategy.

With “charcoal sustainable management” being the theme of the event, I am really hoping that subjects such as charcoal and poverty, charcoal and environmental, charcoal and health and charcoal policy will be deeply debated in this important event.

At this moment I would like to congratulate the event organizers and hope that the event will be productive and serve as contribute to the improvement of charcoal production and management as well as for the reduction of rural poverty in Mozambique. I wish you all a fruitful and dynamic sharing of opinions so that the objectives of the event are achieved.

As such, I solely declare open the Conference on “Charcoal and Communities in Africa”. Wishes for productive work to all of you!

Thank you very much!

Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia: historical overview, present situation and outlook.

Falcão, M. P.¹

SUMMARY

The present paper is an overview of charcoal production and use in selected countries in the SADC region (Mozambique, Malawi, Tanzania, and Zambia).

The objective of this overview paper is to highlight the major trends, charcoal production technologies, charcoal markets and lessons from success and failures regarding the management systems, technologies and, community enterprises in selected countries in SADC. T

The main vegetation cover used by the households to produce charcoal in the study countries is obtained from miombo woodlands, which are dry tropical woodlands. Most of the charcoal in Mozambique, Malawi, Tanzania and Zambia is produced by the traditional earth kiln method, is labour intensive and, mainly carried out by men.

Charcoal production efficiency in the study countries varies between 10% to 25%. Efficiency varied between kilns, which though similar in design, are usually different because the size, species and composition of wood used as well as the time taken for carbonisation, are different. More technologically advanced kilns such as the Mark IV, Cusab Kiln, and Gayland Batch Charcoal Retort give higher efficiency rates of 25–32%, but these kilns are usually out of the financial reach of most charcoal burners and they use much more labour than the system applied now. This means they are unlikely to be implemented by the charcoal burners.

Woodfuel (charcoal and firewood) consumption in the study countries is close to 1 m³ *per annum per capita*. The key factors influencing woodfuel trends are economic growth, population growth, policies and institutions.

Although woodfuel is the most important forest product for Mozambique, Tanzania, Malawi and Zambia, reliable statistics on its production, trade and consumption are not readily available. The dominance of the informal sector makes it difficult to obtain reliable information on production and trade of woodfuel. Estimates of firewood and charcoal production and consumption depend on the results of ad hoc surveys.

It is recommended that each study country establish its own Wood Energy Unit and this Unit should prepare a Dendroenergy Strategy, using participatory methods and involving all stakeholders.

1. INTRODUCTION

1.1. Overview

Fuelwood and charcoal accounted for about 91% of Africa's roundwood production in 2000. In southern Africa region, more than 90 per cent of rural households depend on woodfuel, including fuelwood and charcoal, for their energy requirements. The sustainability of this high dependence is

¹ Lecturer at Forestry Engineering Department, Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University. E-mail: mfalcao@uem.mz or mariopaulofalcao@hotmail.com

questionable and, increasingly, African countries are looking at the energy opportunities offered by other resources, including solar and wind energy.

1.2. Objectives

The objective of this overview paper is to highlight the major trends, charcoal production technologies, charcoal markets and lessons from success and failures regarding the management systems, technologies and, community enterprises in selected countries in SADC. Woodfuels in the SADC region are an important source of income to the families and their importance in the agenda for donor support has diminished.

1.3. Scope of the study

Four countries in the SADC region were selected, namely Mozambique, Malawi, Tanzania and Zambia. They are included in this overview paper due to the availability of charcoal literature and their similarities.

For the purpose of this study woodfuel includes firewood and charcoal. Fuelwood is synonymous to firewood. Included in this study are other materials obtained from other parts than stems of trees and shrubs to be used as fuel for cooking, heating or generating energy through direct burning, not only in households but also in rural industries like curing and smoking.

Woodfuel needs refer to the least possible amount of woodfuel necessary regarding the lowest energy estimated to be indispensable for household consumption, artisanal purposes and rural industries, in line with local conditions and the share of woodfuel in their energy supplies.

2. CHARCOAL

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

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

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

charcoal burners and they use much more labour than the system applied now. This means they are unlikely to be implemented by the charcoal burners.

Charcoal is a fuelwood by-product obtained by the process of carbonisation. Wood destillation is another method of making charcoal. The equipment needed for wood destillation is more complicated than that for conventional charcoal production, but the process is also more energy-efficient. Making *Rhizophora* charcoal in a retort and condensing the effluent gases can substantially increase the amount of energy recovered. Countries making charcoal in this way have much to gain simply from the extra energy obtained. Additionally, they can use the by-products in simple but effective ways. For instance, in Ghana and Costa Rica the gases produced are used to dry fuelwood used in heating systems and their liquids employed as an effective wood preserver.

According to Frisk (1984), a kiln of 6.7 m diameter and 7 m in height is estimated to require 9 tonnes of clay, 9 tonnes of fine sand and 15,000 – 17,000 pieces of bricks (6 cm * 11 cm * 23 cm) to build. Using 1984 prices, this type of kiln will cost about US\$ 7,000 including the roof shelter.

According to producers in the study countries, good properties for charcoal production are long burning, little smoke, sparks or ash, and generation of high temperatures. In accordance with several studies, the most common trees species for charcoal are: *Brachystegia spiciformis*, *Brachystegia bhoemii*, *Julbernardia globiflora*, *Millettia stuhlmannii*, *Pterocarpus angolensis*, *Azelia quanzensis*, *Burkea africana*, *Khaya nyasica*, *Parinari curatellifolia*, *Afromazia angolensis*, *Sclerocarya birrea*, *Erythrophleum suaveolens*, *Ozora obovata*, *Dalbergia melanoxylon*, *Crossopteryx febrifuga*, *Lannea* sp., *Combretum* sp., *Dombeya shupangae*, *Dichrostachys cinerea*, *Combretum apiculatum*, *Markhamia obtusifolia*, *Acacia sieberiana*, *Pterocarpus rotundifolius*, *Schrebera trichoclada*, *Cussonia arborea*, *Combretum fragrans*, *Acacia* sp., *Senna senegaliensis*, and *Boscia salicifolia*. This list includes species such as *Azelia quanzensis*, *Dalbergia melanoxylon*, *Erythrophleum suaveolens*, *Millettia stuhlmannii*, and *Pterocarpus angolensis* that are valuable commercial timber species and forest law does not allow them to be used for charcoal making in the study countries (Brouwer and Falcão, 2004; Luoga et al., 2000a, BTG, 1990; Adamo et al. 1997; Vilanculos 1998; Muchanga et al. 1997; Howell, and Convery, 1997; Mangue and Wate, 1998).

3. WOODFUEL CONSUMPTION

The demand for woodfuel is rising due to the relatively high cost of electricity and petroleum-based fuels (e.g. paraffin) as well as the rapid human population growth, particularly in urban areas in Mozambique, Malawi, Tanzania and Zambia. Demand for woodfuel in the urban areas of developing countries is usually higher than in rural areas. One of the main reasons for this is inability of the households to have access to other fuels such as gas and fossil fuels in the energy mix of the urban areas. There is a kind of ladder of energy sources in the urban areas: from fuelwood at the bottom, through charcoal, kerosene and gas, to electricity at the top. People generally climb this ladder as their income increases. Therefore charcoal, which is hardly used in the rural areas because of availability of free wood, is quite popular in urban areas because of higher income and other factors such as its light weight and non-smoking nature (FAO, 1993; Brouwer and Falcão, 2004; Luoga et al., 2000a).

For the study sites it is estimated that 75% urban households use charcoal and all poor households use it for cooking, about 50% use charcoal for heating water for bathing and water for drinking, and 70% use charcoal for heating in cold season (Brouwer and Falcão, 2004; Luoga et al., 2000a and many others). Table 2.2 shows woodfuel consumption levels in several countries (Agarwal, 1986; Brouwer and Falcão, 2004; and many other authors).

Table 1. Woodfuel consumption in some African countries

Country	Consumption per capita (m3/annum)
Angola	0.96
Kenya	1.48
Madagascar	0.59
Malawi	0.90
Malaysia	0.50
Mali	0.58

Mozambique	0.96
Niger	0.58
Nigeria	0.84
Senegal	0.55
Sudan	1.75
Uganda	1.77
Zaire	0.91
Zimbabwe	0.96

Source: Agarwal (1986), Brouwer and Falcão (2004).

3.1 Key factors limiting woodfuel trends

The key factors that affect the outlook of demand and supply include the current state of forest resources and their use, population, income, technology, institutions and policies, prices of forests products, substitute products and wood raw material. Each of these factors affects both demand and supply of wood. The state and potential of existing forests is a factor in the development of the future supply of products and services while past and current levels of consumption are factors in determining the future demand for products and services (Brooks et al., 1996; Conteh, 1997).

The demand for and supply of wood change in response to changes in population, economic growth, technology, policy and institutional aspects and the price of forest products and substitute products. It should be recognized that these factors differ in their effects on demand for fuelwood and demand for roundwood although factors such as population growth and economic growth are important for both. The demand for industrial roundwood is derived from the demand for forest products. Therefore, an understanding of the dynamics of the supply and demand process of these markets can be brought to operation in understanding future developments for this component of wood demand and supply. This situation is contrary to fuelwood demand structure and the supply processes are quite different from those for industrial products. Three billion people depend on wood to meet basic energy needs and much of the production of fuelwood is based on gathering from forests and scattered trees by individual households and through exchange in informal markets. Where alternative (fossil energy) fuels are available and affordable, they are often preferred; however, where fuelwood is scarce and in demand, there are often few alternatives (Brooks et al., 1996).

3.2 Population growth

Population growth has historically been a major factor influencing wood consumption and it is not likely that the close relationship between population growth and growth in consumption will change significantly in the foreseeable future. World population increased from 2.4 billion people in 1950 to 5.5 billion people in the mid-1990s. World population grew at a rate of 2.0% per year in the early 1970s and is currently increasing at a rate of 1.7% per year.

On a per capita basis, world consumption of timber, both fuelwood and industrial round-wood, declined slightly over the past four decades to 0.6 m³ per person from 0.7 m³ per person (Brooks et al., 1996). There have been changes in patterns of consumption (among developing and developed countries) and in the composition between fuelwood and industrial roundwood, and among industrial products), but the net result has been little change in global per capita consumption. To this end, growth in population can provide a crude but an effective indicator of trends in aggregate consumption. The basic dynamics of population change create social, economic and technological change that effect health, fertility and longevity.

3.3 Economic growth

Economic growth will have a particular impact on the demand for fuelwood, because the marginal propensity to increase consumption of commercial energy in developing countries is very high and highest among the poorest countries with currently high dependence on wood and biomass. The strong preference for convenience, efficiency and cleanliness in cooking and heating fuel may be expected to lead to substitution of commercial fuels as income rises. Energy is of particular importance in the context of wood demand as it constitutes both a basic need of human civilization and an essential component in economic activity and development. World energy consumption tripled in the first fifty

years of this century and then increased four fold in the forty years to 1990. In their global energy perspective the World Energy Council and IIASA present a range of scenarios projecting world consumption of primary energy at least doubling and possibly more than tripling over the period 1990-2050 (IIASA, 1995).

Throughout human history wood has been an important source of fuel. Up to the industrial revolution it was the main fuel for both domestic and industrial needs. The discovery of fossil fuels and the technology to use them, to transport them and to distribute electrical energy widely led to the virtually complete replacement of wood as fuel, so that over the span 150 years of the 19th and 20th centuries the contribution of fuel consumed in today's developed economies has changed from virtually 100% fuelwood and charcoal to the situation where fuelwood contributes only 1-2%. In developing countries wood remains an important source of energy averaging 15% with some of the poorest countries still in the position of depending on wood or other biomass for 70% or 80% of their energy supply (IIASA, 1995).

Income growth permits, in the first place, purchase of improved stoves which reduce the quantity of fuelwood and then the substitution of more convenient commercial fuel. This movement will tend to be led by urban communities where the supply price of woodfuel is higher due to transport cost and the availability of discretionary income allows the choice. Rural population may experience lower rates of growth of per capita income and thereby lower rates of growth in demand for forest products. Both the lower levels of disposable income and distance from markets may slow the trend towards the substitution of commercial energy for fuelwood. Fuelwood may be expected to remain the principal fuel of poor rural communities with low income and better access to wood supplies. Thus the demand for fuelwood may continue to grow in those areas. Several factors may favour some future increase in the use of wood biomass as a source of industrial energy. Increase in cost of commercial energy or improved efficiency in the recovery of wood residues such as off-cuts, sawdust and bark and spent pulping-liquors and improved efficiency in use to generate heat and energy, would favour their use for energy supply within the process for sale. In view of the importance of wood and paper in urban waste, a contribution to reducing the volume of waste may be made by utilization of the portion of wood and paper waste not suitable for recycling in industrial production, for heat or energy generation. This would constitute an increasing supply trend. Growing wood absorbs carbon dioxide, in this way the use of wood for energy, with replacement on a continuing basis may be seen as neutral in relation to the release of greenhouse gases. Growing additional woody biomass for energy would increase supply (IIASA, 1995).

Global energy perspectives (IIASA, 1995), suggests the gradual replacement of traditional renewable fuels such as fuelwood and biomass by high quality commercial fuels. End use conversion of biomass would be improved significantly. This would be seen to be consistent with the expectation of substitution by commercial fuels with increased income and urbanization. It is also consistent with an expectation of increased demand for industrial wood products with increased population and income. The increased contribution of biomass is projected to over 8 billion tons of oil equivalent (TOE) by 2100. However, the enormous commitment of land this would involve should be recognized. A feature of fuelwood use is the widely varying level of per capita domestic consumption both between countries and within countries. Consumption levels vary greatly even between countries where wood constitutes the main source of energy. In many countries, per capita consumption is around one cubic metre per annum. This figure is incidentally similar to that for the consumption of industrial wood in many developed countries. Considerably higher levels characterize some African countries such as Sudan and Uganda, while much lower rates are typical of many Asian countries. Generally, per capita consumption levels correlate with the extent of forest and woodland and with the availability of the resource. In parts of the developing world where fuelwood is plentiful, 2 000 kg or more may be used per person per year, while in areas of scarcity only one-quarter of that amount may be used (Eckholm et al., 1984).

Economic factors are also, of course, a major influence on levels of consumption. They tended to reach a maximum in developing countries in the middle range income (Laarman, 1987). As income rises, more fuelwood is initially consumed, but beyond a certain level its use decreases as other fuels such as oil are substituted. According to Foley (1985), price influences the amount of fuel that is consumed, but does not have a great influence on choice between fuels. This conclusion has not answered the question of what determines the transition from wood to other fuels as a country becomes richer. Real income and an index of commercial energy prices are significant factors in relation to demand, but adjustment

in consumption in response to these factors tends to be very slow and slight (Laarman and Wohlgemut, 1984). These authors also found that a contracting forest area was a significant variable in terms of supply, but that it had a stronger braking effect on fuelwood consumption in middle-income than in low-income developing countries. Since levels of consumption appear to depend on the availability of the resource and on income, it is not surprising that consumption levels also vary greatly within countries. In Tanzania, for instance, household consumption in villages near wooded areas is three times higher than in villages with little or no woodland (Agarwal, 1986). Similarly in Nepal, people moving to the well-wooded plains, where firewood is relatively abundant, consume twice as much as those remaining in the forest-depleted hills. In essence, people use more wood when it is readily available than when it is scarce. Reasons for variation in consumption levels are confusing between local people and visiting consultants or researchers, and mistaking of actual levels of consumption is a result of suspicion or apprehension of tax collection or forest regulations. Levels of use of fuelwood also, of course, depend on the availability and price of alternative fuels, and therefore vary through time. Much uncertainty therefore exists over the concept of fuelwood needs, and this uncertainty is matched in some areas by that surrounding the availability of fuelwood.

Of the 3 400 million m³ of roundwood felled for human purposes in 1991, 5% had been used as a source of energy in the form of fuelwood and charcoal, 89% of it in developing countries. The total fuelwood and charcoal consumption in developing countries was 1600 million m³ in 1991 and is growing more or less parallel to population growth (Steinlin, 1994).

Wood energy serves not only domestic purposes but also small local industries. The overcutting of forests for fuel needs is exacerbated in drier and densely populated areas, leading to serious forest depletion in many regions.

The main sources of domestic energy in Mozambique, Malawi, Tanzania and Zambia are electricity, liquid petroleum gas, kerosene, charcoal and firewood. The first three are available only in urban centres, and to the wealthy members of the community. Kerosene is usually used by the low income groups for lighting. Charcoal and firewood are the main sources of heat to the majority of rural people and town dwellers.

3.4 Policies and institutions

Energy policy relates to forestry and forest products in several ways (Solberg, 1996). Measures that lead to increased price of fuelwood stimulates the production of wood for fuel, encourages forest industry to economize in energy and to increase the utilization of wood residue from its manufacturing process to generate energy for own use or sale. Policies that support the marketing of energy from biomass and the other renewable resources facilitate the latter. Increased energy cost also means increased cost of transportation which has an impact on supply. The response to the oil crisis in the mid 1970s demonstrated this in many regions, as did the more recent movement to market pricing of energy in the former USSR. Russian experience also shows the effect of increasing energy price reducing supply through increased transport cost for timber from Liberia. It has also resulted in increased demand for fuelwood in many regions of the former USSR and some Eastern European countries.

Subsidization of commercial energy has the effect of reducing the demand for fuelwood and is a measure that has been used to reduce the pressure of fragile protection forests in some arid countries. Subsidizing smokeless fuels or restricting the use of smoky fuels and fire places, to reduce air pollution in urban areas has a similar impact on diminishing the demand for woodfuels (Brooks et al., 1996).

In urban areas the problem of waste disposal has grown into a major problem. Approaches to reduce the volume to be disposed of have included consideration of reducing consumption, requiring the recycling of used material and utilising waste in energy generation.

The forestry sector with its association with natural forests and less developed areas has through history had a lower priority in societies' choices for institutional development. In most countries forestry education and training are recent additions, the earlier cases mainly dating from the late 1800s and early 1900s. Similarly most government forestry organisations are recently established. Some countries do not have these organisations yet, or have them only in very preliminary forms. Many government

agencies responsible for the implementation of forest policy lack the resources to establish or implement the measures to carry it out. There are also many cases where the legal framework for the implementation of forest policy is weak or lacking (Solberg, 1996).

With increasing demand for the products and services of forests driven by the population increase and increase in wealth, the demand for the institutional framework and infrastructure to regulate the use of that scarce resource increases. A supply response, improving the strength of the institutional framework, will be increasingly necessary to reduce uncertainty and to ensure an approach to the optimum investment in institutional infrastructure. This will lead to increased aggregate supply of forest products and services, although the supply of wood may decline, all other factors being equal. Forest cover plays a significant role in sustaining global environment systems. Forests also have a direct role in sustaining humanity by providing food, fuel, services and income. Striking an enduring balance among the various uses of forests presents the formidable task of choosing between use and preservation. Countries are faced with the complex decisions on the allocation of resources to alternative uses some of which are in competition (Solberg et al., 1996).

4. WOODFUEL SURVEYS

Although woodfuel is the most important forest product for Mozambique, Tanzania, Malawi and Zambia, reliable statistics on its production, trade and consumption are not readily available. The dominance of the informal sector makes it difficult to obtain reliable information on production and trade of woodfuel.

Estimates of firewood and charcoal production and consumption depend on the results of ad hoc surveys. These include some national surveys which are more frequently limited to urban households, rural households for specific regions and surveys of woodfuel consumption by specific industries. Many of these surveys are undertaken in conjunction with multilateral and bilateral agencies and include expatriate staff and external financial support. There are wide variations between estimates. These result from different surveys because of the differing populations and diverse objectives. Estimating present woodfuel demand is generally a difficult task because systematic data on past consumption by type of forest product are not always available. Oral inquiries and rough sampling may be a satisfactory approach to this problem (FAO, 1983).

Fuelwood and charcoal are important items of wood consumption in developing countries like Mozambique, Malawi, Tanzania and Zambia. They may comprise some 90 percent of total wood consumption. The consumption of woodfuel could be sampled in connection with population sampling. It would then be possible to establish a relationship between the family size and the fuel consumption. The effect on fuel consumption of the income level could possibly be desirable to detect the trend, if any, in the consumption per head (or per family or household). If it is not possible, then one could assume that the unit consumption will remain constant over a given period.

FAO (1983) mentions that, woodfuel surveys can be, and have been, undertaken for a variety of purposes. The most important purpose for carrying out a survey is to prepare for action; that is, to collect information needed to improve the rural energy situation, so as to facilitate the development process. Within such a framework surveys may need to be undertaken for a spectrum of purposes, ranging from the estimation of the magnitude of fuel use, and/or the spatial variation in this use, to the planning of a specific project (or projects). Different surveys are likely to be needed to serve the planning process at the macro, sector or project level, and they can differ widely.

The planner at the national level, concerned primarily with the share of fuelwood in the country's forest product balance, or of woodfuel in its energy balance, needs only broad aggregate estimates. To establish energy balances, more details would be needed to differentiate use by household, commercial, industrial and transport sectors. Still more detail is needed if the aim is to differentiate among different types of fuel (FAO, 1983).

Estimates of traditional fuel use, even those requiring information on end use, sector, fuel, and spatial variation, can be used on surveys of demand characteristics. Traditional fuels in this context are those which are part of the broad class of energy supplies based on renewable resources. Project evaluation of energy investments that depend on fuelwood requires a kind of survey that differs from consumption

surveys. In many cases investment planning requires understanding of supply resources, the existing and potential demands, and the nature of the systems in which these supplies and demands are balanced. Woodfuel surveys will not be effective in providing the information that will allow the identification and planning of successful interventions in fuelwood shortage situations, unless they reflect the relevant inter-relationships within the surrounding systems, and are correctly designed to show the appropriate level of detail. These points are to be emphasized because most past work on fuelwood has not fully met these criteria (FAO, 1983).

To assess the likely magnitude of local fuelwood needs, the starting point will be the measurement or estimation of the quantities used at present. It should also take into consideration how usage might change, or could be changed, in the future. If the fuelwood used is purchased, it may be necessary to assess the quantities involved somewhere along the distribution chain, that is by recording how much is sold by the fuelwood merchants, or how many lorry loads or donkey loads are brought in for sale over a particular period, and how much wood there is in such loads. In the more usual situation, where fuelwood is gathered rather than bought, it is unlikely that useful estimates can be obtained except by direct measurement at the household level, by means of a sample survey. If the population to be surveyed encompasses areas or groups which are likely to exhibit markedly different usage patterns (hill and valley locations, groups with different income levels), then a stratified sample survey should be designed which will allow these differences to be identified, and then taken into account (FAO, 1978).

Weighing is likely to be the most accurate form of measurement of fuelwood, but care must be taken to record the type of wood, and whether it is green or dry, in order to be able to translate this weight information into equivalent volumes of standing wood. In most areas fuelwood use varies markedly with the season. In mountains more is needed in the cold season than in the hot season, in the tropics less tends to be used in the wet season than in the dry season. The measurement of fuelwood use must therefore be repeated at sufficient intervals to establish the nature and magnitude of this seasonal fluctuation, in order to arrive at a realistic estimate for the year as a whole. The survey should also incorporate measurements or estimates of such other information as will be needed in assessing future change and alternative solutions to the fuel requirement (FAO, 1978).

5. WOODFUEL MARKETS

Woodfuel supports lucrative local trade. Trade in charcoal is a major source of income for many households in the study countries. For example, in Zambia, the charcoal industry generated about US\$30 million in 1998 alone, and in the same year about 60,000 Zambians directly depended on charcoal production for the bulk of their income (Kalumiana 2000).

As charcoal becomes an important tradable commodity, there is an opportunity for governments to recognize and regularize charcoal production by putting in place long-term plans for sustainable production, while at the same time creating a supportive legal and economic framework for micro- and small and medium enterprises (SMEs) development. Increasing efficiency and ensuring that the development of this sector does not accelerate deforestation requires appropriate policy interventions. There is ongoing research to develop more efficient charcoal production methods using improved kilns in a number of countries in Eastern and Southern Africa. There is also research on charcoal briquettes production using wastes such as farm refuse, sawdust and woodchips (Kalumiana 2000). These initiatives can be supported through active private sector involvement.

According to Kalumiana (2003), Zambia had in 2003 about 50,000 charcoal producers, 3,500 transporters and 10,000 distributors and retailers. In Mozambique about 150,000 families are employed in charcoal production and on average the annual income generated is about 250-300 US\$ per family (Falcão, 2004).

6. WHERE DO WE GO FROM HERE?

In Tanzania, Zambia, Mozambique and Malawi the areas next to the main urban centres are badly deforested. In general in areas that are cleared for charcoal production subsistence farming (shifting cultivation) is practiced in the more fertile (arable) patches, where the land is cultivated for about 3 to 6 years before it is left fallow for about 3 to 4 years (Frost, 1996; Luoga et al., 2000a; Falcão, 2005). This

fallow period is too short for the woodland trees to regain their original stem diameters, thus subsistence farming is another cause of land cover change. The negative impacts of land cover changes on biodiversity and ecosystem function in miombo woodlands have not been well studied.

Commercial plantations for fuelwood and construction timber are big business in South Africa, Zimbabwe, Malawi, Tanzania and Zambia. Mozambique is benefiting in the last 3 years from investment in forest plantations mainly from South Africa and Swedish investors, but none of these investments is for fuelwood.

There is an urgent need to develop environmentally sound methods of sustainable fuelwood production and exploitation. In Mozambique, Tanzania, Malawi and Zambia considerable effort has been expended to alleviate fuel-wood shortage through the introduction of fast growing exotic trees, agroforestry, and use of energy saving stoves. In Kenya in the past conventional agroforestry approaches have met with little success because of inappropriate species, long cropping intervals and inadequate husbandry techniques used by the harvesters, mostly the rural poor (Young and Francombe, 1991).

In these four countries, most of the interventions in wood energy sector to face wood energy shortages and demand can be grouped into two broad categories namely, (a) those aimed to enhance the supplies and (b) those that attempted to reduce consumption either through enhancing energy efficiency or through encouraging substitution. According to Nair and Tieguhong (2004), a general indication of these interventions is given below:

- There have been substantial efforts to establish woodfuel plantations primarily through public sector investments, often supported by bilateral and multilateral agencies. While some of these plantations have become important sources of woodfuel, there are also instances of failure (for example in Mozambique) on account of economic, policy and institutional factors. Getting all the necessary and sufficient conditions for success right has been extremely difficult. Consequently the share of woodfuel produced by plantations remains low, although no precise estimates are available. In general, most woodfuel is produced from natural woodlands with very limited investments in their management. Also a significant share of woodfuel comes from trees and other growth outside the forests. A key issue as regards woodfuel production is the absence of investments in management of the woodlands as a result of poorly developed markets.
- Demand reduction strategies have primarily focused on enhancing energy efficiency through the use of improved cooking stoves and encouraging substitution. Here again the performance of the different approaches have been patchy. Energy efficient stoves have found wider use in urban areas where woodfuel has to be purchased, whereas in rural areas with better access to woodfuel and other biomass, their impact has been rather marginal. There are also several other cultural and social aspects that impact the use of improved stoves. Substitution has focused on providing alternative fuels, especially kerosene, coal, electricity and liquefied petroleum gas (LPG). The effectiveness of such options is largely related to economic viability and more particularly ready availability of the alternatives. Mozambique for example has substantial fossil fuel resources, the access to these resources by rural poor people is often very limited. The main factors that determine substitution are relative prices of different fuels and the income of the households.

Exploring the possibility of using indigenous trees and shrubs for sustained yield harvesting can be very attractive and potentially viable economic and ecological alternative. This is especially so in arid and semi-arid areas, which have numerous and often extensive stands of tree and shrub species.

7. CONCLUDING REMARKS AND RECOMMENDATIONS

Wood energy systems are complex and very site specific. Firewood and charcoal are fuels and sources of income for the poorest of the poor. Woodfuels are part and parcel of the problem of poverty and sound wood energy systems are tied to the development process.

Although commercialisation of wood resources provides tangible monetary benefits to rural communities, it also contributes to environmental degradation (massive depletion of woody vegetation) that will ultimately threaten the long-term survival of these communities. The weak enforcing control mechanisms to check overuse of resources, needs to be strengthened in these countries.

From the current literature review for the study countries the following emerges:

- Data bases on charcoal aspects are extremely weak;
- Institutional arrangements exist but need to be enhanced;
- Some actions are undertaken but should be articulated, planned and organized;
- Joint actions with public and private partners needed;
- Community Based Natural Resource Management (CBNRM) has played an important role but is insufficient to ensure sound wood energy systems.

It is recommended that each study country establish the following:

- A Wood Energy Unit and this Unit should prepare a Dendroenergy Strategy;
- Wood Energy data base and planning tools are vital and they should be included in the strategy
- Community Based Natural Resource Management (CBNRM) can support field action;
- Kyoto and Johannesburg (WSSD) can help implementing Dendroenergy Strategy.

Dendroenergy strategy should be developed using participatory methods and involving all stakeholders (private sector, donors, agencies, governments, civil society, etc.). The layout of the proposed strategy is indicated Appendix 1.

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Appendix 1. Dendroenergy strategy – lay out.

Phase 1	Strategy Preparation					
	Nr	Outputs	Nr	Main Outputs	Nr	Activities
	1.1	National WEIS (Wood Energy Information System) [Note: Joint work with forestry and energy statistics units]	1.1.1	Collection of existing data	1.1.1.1	
			1.1.2	Verification of data	1.1.2.1	Preliminar National WEIS - Desk DB
			1.1.3	Field verification and fill data gaps	1.1.3.1	Selection of pilot areas
					1.1.3.2	Information System -
					1.1.3.3	Training of surveyors
					1.1.3.4	Field work
					1.1.3.5	Data collation
			1.1.4	National Wood Energy Information System WEIS	1.1.4.1	First draft
					1.1.4.2	National workshop
					1.1.4.3	National WEIS publication
	1.2	National WISDOM (Woodfuel Information Supply Demand Overview Mapping = Wood Energy Maps). [Note: Joint work with GIS experts and forestry inventory units]	1.2.1	Preparation data set		
	1.2.2		Initiation National WISDOM	1.2.2.1	National training of the WISDOM users	
				1.2.2.2	First draft of national WISDOM	
	1.2.3		Analysis and interpretation of data	1.2.3.1		

			1.2.4	Preliminary WISDOM	1.2.4.1	National workshop
			1.2.5	Finalization of National WISDOM	1.2.5.1	National WISDOM publication
	1.3	Strategy formulation	1.3.1	Technical studies	1.3.1.1	Kiln efficiency
					1.3.1.2	New production techniques
					1.3.1.3	Identification new technical solutions for industrial wood energy uses
					1.3.1.4	Identification of new wood fuel supply areas
			1.3.2	Economic studies	1.3.2.1	Cost & prices of woodfuels
					1.3.2.2	Market arrangements
					1.3.2.3	Economic analysis of new opportunities
					1.3.2.4	Income distribution within the marketing chain
			1.3.3	Environmental studies	1.3.3.1	Analysis of local impacts
					1.3.3.2	Carbon inventories
					1.3.3.3	Deforestation rates from different activities
					1.3.3.4	
			1.3.4	Socio-economic studies	1.3.4.1	HHD revenue from agriculture vs charcoal making

					1.3.4.2	Effect of HIV on dendroenergy
					1.3.4.3	
			1.3.5	Institutional & legal studies		
			1.3.6	Strategy preparation	1.3.6.1	First draft of national strategy
					1.3.6.2	National workshop
			1.3.7	Strategy finalisation	1.3.7.1	National woodfuel strategy
	1.4	Project formulation for external internal support	1.4.1	Project formulation	1.4.1.1	Project formulation to support WE Strategy Development
					1.4.1.2	Submission to donors
					1.4.1.3	Project implementation
					1.4.1.4	Other projects
					1.4.1.5	Submission to donors

THE PROSPECTS OF CHARCOAL PRODUCTION CONTRIBUTING TO POVERTY REDUCTION IN GHANA

K.S. NKETIAH, TROPENBOS INTERNATIONAL - GHANA

Summary

The link between poverty and the environment has been adequately discussed in the literature, so has the linkage between woodfuels (particularly charcoal) production and the environment. Poverty has been blamed for dependence on woodfuel; it has even been argued that unless the problem of poverty has been addressed, people will always use woodfuel. The merits of such arguments are however doubtful, given the socio-cultural dimensions of woodfuel usage.

Instead of blaming poverty for people's dependence on charcoal, this paper discusses how charcoal production and trade could be a response to rural poverty in particular. Woodfuel production, harvesting, transportation, marketing and use constitute income-generating activities for a great number of people, both rural and urban. However, an enabling environment has to be created to enhance the prospects of the charcoal trade contributing to poverty reduction.

Key aspects of this are a comprehensive and effective policy, a holistic view of the charcoal trade beyond domestic energy; backward and forward integration of charcoal production, through resource creation to product development, marketing and use, including industrial use. Others are access to credit and conditions that make investment in woodlot profitable. Tree and land tenure reforms that give communities greater stake in trees, access and even ownership to land would also be key. All these discussions are situated in the context of Ghana.

1.0 Introduction

1.1 Charcoal and poverty

*"Wood and charcoal are and will remain a major source of energy for developing countries. It is a delicate, complicated and important subject which is part and parcel of the problem of poverty and underdevelopment affecting 3rd world countries"*².

Poverty is thus considered as one of the constraints that should be removed or taken into consideration for the solution of wood energy problems in developing countries³. In this paper, however, we posit that woodfuels, in this case charcoal, should be seen as a possible response to rural poverty. Woodfuel production, harvesting, transportation, marketing and use constitute income-generating activities for a great number of people of rural and urban areas from which they obtain some income to cover their basic needs.

Charcoal is the fuel for most urban poor households because it is sold in smaller quantities at a time and so is affordable in the short term (even though over a period, charcoal may turn out to be more expensive than many of the modern fuels for household use).

1.2 Poverty

Poverty has been defined to include not just lack of financial resources but also access to education, basic human freedoms, participation in decisions that affect the person, ownership and access to natural resources. In this paper, issues of access, decision-making and participation are discussed but basically, lack of financial resources is considered to be underpinning most of these.

² FAO (1993): A decade of wood energy activities within the Nairobi Programme of Action. FAO Forestry Paper No. 108.

³ Ibid

In general, gathering of woodfuel in rural areas in the developing world is exclusively by women, sometimes assisted by children. With increasing scarcity, the collection time increases, resulting in less time for the woman's other important functions such as agriculture, cooking and child caring. This in turn, may affect the nutrition and health of the entire family, both of which are crucial aspects of poverty.

In Ghana, more than one third of the population is unable to meet their basic nutritional needs, even if they devoted their entire budget to food⁴; this situation has been made worse with the current high oil prices and rising food costs. Poverty is predominantly rural, much of it occurring among the small-scale farmers and the self-employed, including many of the actors in the charcoal trade. The percentage of the population living on less than one dollar a day is quite high; many people in the informal sector make less than the daily minimum wage of above US\$ 2.

1.3 Poverty Reduction

Poverty reduction may be defined as any process which seeks to reduce the level of poverty in a community, or amongst a group of people. Poverty reduction programmes may be aimed at economic or non-economic poverty. Some of the popular methods used are education, economic development and income redistribution. Measures to remove social and legal barriers to income growth among the poor are also crucial to poverty reduction.

Poverty may thus be reduced through improving access to natural resources and involvement of people in the making of decisions that go to affect their lives. Again poverty may be reduced by addressing issues related to tree and land tenure. Moreover, paying realistic prices for assets over which the poor have control can put money in the pockets of the poor, thereby reducing poverty.

In Ghana, the contribution of charcoal (and woodfuels for that matter) to poverty reduction has not been optimal for various reasons. We will briefly discuss the role of charcoal in the national economy, factors that have accounted for the suboptimal contribution of charcoal to poverty reduction and explore the available options for increasing the prospects of the charcoal trade contributing to poverty reduction.

2.0 Charcoal and the Ghanaian Economy

The woodfuel business is a major source of employment (and cash income) for many rural and the urban poor people. It has been estimated that about 0.45 million people are directly involved in the production, transportation and marketing of woodfuels in the country as a primary occupation, whilst over 2 million people engage in the trade as secondary occupation. Woodfuels indirectly support the livelihood of over three million Ghanaians, mostly small-scale commercial and household enterprises. It has been estimated that more than 84% of all people engaged in the woodfuel business are women. The contribution of the sub-sector to GDP is put at 1.81%. The use of woodfuels results in foreign currency savings of about US\$560 million; Charcoal exports to Europe and Asia are also valued at US\$400,000 annually. Woodfuels are also a source of fiscal revenue for the Forest Services Division, traditional authorities and some district assemblies⁵.

Charcoal is the predominant domestic fuel for 69% of urban households. Per capita consumption is about 181 kg per annum and an estimated 476.8 thousand metric tonnes are consumed annually in urban Ghana. Yet charcoal is very expensive. In 1988, it was the most expensive domestic fuel, constituting about 10% of the daily household budget⁶. (With the rapid increases in the price of crude oil of late, this situation may be a bit different now).

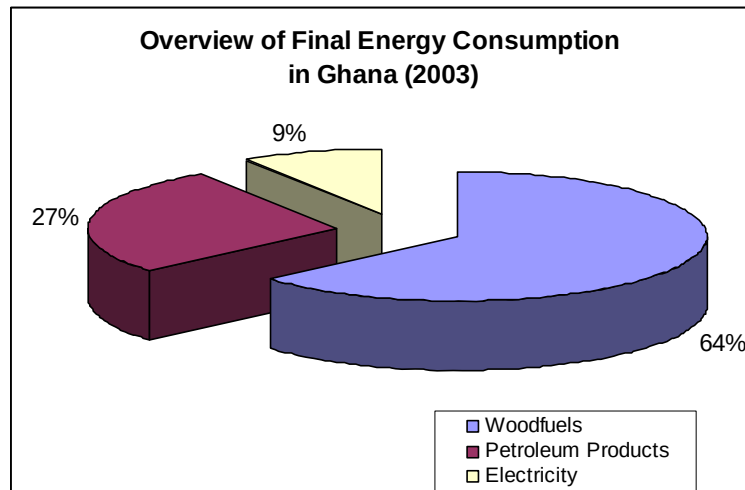
Figure 1 below shows the contribution of woodfuels to the total national energy consumption mix in 2003.

Figure 1: Contribution of Woodfuel in National Energy Consumption

⁴ Ministry for Lands, Forestry and Mines (2008): Paper presented at ITTC meeting in Ghana in June 2008.

⁵ Ministry of Energy (2006): The Revised Draft National Woodfuels Policy

⁶ Nketiah, K.S. *et al* (1988): The charcoal cycle in Ghana – A baseline study.



Source: Energy Commission – SNEP 2006-2020

Notwithstanding all the economic importance and the environmental impacts of woodfuels, policies on energy have tended to focus mainly on the production and use of modern energy forms to the neglect of woodfuel.

3.0 Charcoal Production in Ghana

3.1 Resource Base

Close to 80% of the total national charcoal production comes from the dryer forest between the northern Savannah woodlands and the southern Moist Semi-deciduous Forest, mainly from poorly stocked natural wood stands. The tree species used are of medium to high density and increasingly, have included high density trees of economic importance like the Shea butter tree (*Butyrospermum parkii*) with a density of about 700kg/m³. The producers complain that the usually preferred tree species are now more difficult to come by. In cities and towns where wood processing (saw milling and ply milling) takes place, charcoal is produced from sawmill residues: off-cuts, edgings and slabs. This however, has gone down with increasing demand for the mill residues, particularly for small scale processing enterprises. At the same time, there has been a slump in wood processing in Ghana for various reasons. Nevertheless, one company now produces charcoal from its forest and mill residues for export, mainly to Europe. Production from the Moist Semi-deciduous Forest has also gone up to meet the increasing demand. Not much charcoal is produced from plantation or bamboo or other resources.

3.2 Production Methods

Attempts have been made to promote different charcoal production methods, specifically, the Casamance from Senegal, the Metal Kiln (TDRI) and half metal and half pit. The brick kiln and the retort have also been tried. But still the bulk of the charcoal produced is by the traditional earth mound method. In the north western part of the country, charcoal is produced on a relatively small scale by several women (farmers); it is produced in bits from twigs and saplings; the product is head-loaded in pans to the local market and roadsides for sale. In the forest zone, some charcoal is produced from medium to high density forest tree species by mainly male farmers as an off – season activity. Here, essentially the earth mound method is used, using soil and turf as the covering material. Charcoal production from mill residues is mainly by women and children. Even though here too the earth mound method is used, the covering is essentially sawdust which itself is combustible. This therefore results in poor charcoal yields and quality.

In the dryer forests, production is by gangs ranging from two to seven men who produce on commercial basis. They use chainsaw mainly (and to a limited extent, the axe) to fell and cross-cut the trees which are then stacked for carbonisation. A production cycle may take up to three weeks (10-21 days) and yield up to ten maxi bags of 25-45 kg each of charcoal. The production gangs operate on informal cooperative basis in a kind of mutual self-help scheme known as ‘nnoboa’. Individual producers acquire the woodland and do the felling and wood preparation, often with hired labour. But in the stacking of the wood and the mound preparation (ready for carbonization) help is sought from other producers who operate in a loose association which takes turns to

assist the members at the critical stages of the production process. Charcoal production under this system is more professional and yields are reasonably high. The retort is also used for the production of an annual average of 800 tonnes of high quality charcoal for export.

3.3 Distribution and Marketing

Charcoal is transported by various means; from the bush to the road side or loading bays, head-loading is mainly used. Trucks are the main means of transport between production centres and markets in towns and cities. In a few situations tractors are also used where accessibility is poor, especially in the rainy season. Bicycles, canoes and pull (or donkey-drawn) carts are also used depending on the situation. One study⁷ reports that specialised transporters always exceed their licensed weights by as much as 200%. As a consequence, charcoal trucks often fall over where the road is not good enough. Transportation charges are reported to be high and are positively related to distance, with about 20% of haulage expenses going into fuel costs. One study⁸ reported that transport cost could be as high as 60% of the final selling price of a bag of charcoal.

Bags of charcoal are delivered directly to households and retailers in urban centres; but a good proportion of the product is also retailed in bags by roadsides of high ways. Sole wholesalers are rather limited. Most of the big time wholesalers also retail in smaller bits; and there are also small retailers who may purchase a bag or two to retail in small amounts in their neighbourhoods.

3.4 Consumption and Utilisation

The bulk of the production goes into household cooking and heating. In a few cases, charcoal has been used in space heating for poultry farms with young chicks. Industrial uses of charcoal are not very well developed yet. The export market is also limited; on average, only some 800 tonnes are exported on an annual basis.

3.5 Actors in the Charcoal Trade and Poverty

There are two main kinds of charcoal producers: farmers who do it as an off-season activity, and people who do it on a full-time basis. It is estimated that 84% of the actors in the trade are women and children. In some cases, it involves whole families with babies straddled on the backs of their mothers, with other children helping to harvest freshly produced charcoal or headloading the produce to marketing points. This is particularly so with people who produce at the subsistence level or from mill residues. The part-time producers are made up of both men and women farmers.

The full time producers fall into two categories: the 'elite' producers or financiers, who negotiate with landlords to acquire the land, and those who only sell their labour. At the main producing areas, the full-time producers follow the trees and therefore live very rough, with little water and food as well as poor shelter, whilst spending much time (including nights) on the job. Proper reckoning of their time input would reveal that they make very little income. Often teenagers are also engaged as loading boys; they load the produce on the trucks and travel with the truck to the towns and cities where they offload the produce to the rather dispersed retailers. Most often, these teenagers who could otherwise be in school are not paid, rather, they sacrifice education and all only for a pittance of an allowance for their labour.

The only actors in the trade who seem to be making reasonable gains are the financiers; these are rich enough to acquire tracts of land for charcoal production. They then engage strong young men to undertake the actual production. They often have the links to the urban centres; they hire the trucks and also arrange for the sale of the produce. In some cases, their wives serve as wholesalers in the urban centres. Truck drivers too seem to be making reasonable gains; besides the hiring cost of the truck, they also purchase a few extra bags of the product at the bush price (which is usually fairly low) and carry these as additional load to whatever they have been hired to cart. This in a way would explain the frequent overloading of charcoal trucks. Once in the urban centres, the drivers sell the commodity at almost double the bush price, making some good profit, since in effect they do not pay any fares for transport.

⁷ Nketiah *et al* (1988): The Charcoal Cycle in Ghana – A baseline study

⁸ Appiah, S.K. (1986): Charcoal supply to urban markets in Ghana (Project report)

The charcoal retail trade has very few full timers; most people do it on part time basis, with their main job being with the public or civil service. The part-time retailers hardly make any profits. Due to financial limitations, they take only a few bags at a time and in many cases, their profit is in kind, as they use part of the charcoal for their own domestic need. Even though charcoal is used to some extent in many homes in Ghana, the major users of charcoal are the urban poor and rural elite. Due to affordability, and in some cases, storage space, most of the consumers buy charcoal in bits, when and as needed. Even though this may appear cheaper, it turns out to be rather more expensive than buying a bag at a time.

4.0 Woodfuels Policy Development in Ghana

In the mid 1980s, the woodfuel sector in Ghana received a lot of attention. Under the UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), a series of studies and assessments were carried out. These included a nationwide study of the charcoal cycle, attempts to introduce improved technologies for both the production and end-use devices. Separate assessments were carried out on the possibility of using logging and mill residues for charcoal production; technical and financial feasibility of producing charcoal and briquettes from sawdust. At the time, there was a lot of interest in woodfuel research, focusing on production methods, physico-chemical analysis of charcoal and fuelwood and the silviculture of fuelwood crops.

About the same time, there was an increased interest in the export of charcoal. Most of the production was however from the natural woodlands. Government thus became alarmed and imposed a ban on the export of charcoal. Some districts that heavily depended on charcoal both as a source of employment and revenue for the local government structures also instituted a total ban on charcoal production from those areas. These measures however, turned out to be knee-jerk reactions; no long term strategies were put in place to appropriately respond to the needs in a sustainable manner. As can be expected, neither of the measures could really hold. Nevertheless, all these circumstances culminated in the realisation of the need for a comprehensive woodfuels policy, but it was not until the year 2000, when a draft policy was prepared with support from DANIDA.

Unfortunately however, the policy process which started very well with multi-stakeholder participation could not be carried to its logical conclusion; the draft policy document was not finalised and could not be given effect. In 2006 and 2007, when the Government received support from the UNDP to ensure access to sustainable energy services for cooking, the finalisation of the national woodfuel policy was made one of the key outputs of this new initiative.

The draft woodfuels policy has the laudable intention of promoting ‘the woodfuel business as a sustainable enterprise to address poverty, redistribute wealth and ensure that the exploitation of the nation’s wood resources for energy purposes is done in an environmentally friendly, renewable and sustainable manner’⁹. The policy aims at an integrated management of the country’s forest resources for sustainable supply of woodfuel to support efficient marketing of woodfuels at fair prices, equitable distribution of woodfuel revenues, and efficient utilization of the woodfuel to enhance the socio-economic well-being of the people who own and use these resources and the maintenance of ecological quality.

5.0 Key Issues From the Current Charcoal Cycle Set-Up

1. Charcoal plays a crucial role in the economy of Ghana but its contribution to poverty reduction has been sub-optimal. Dependence on it is high and likely to increase with population growth, urbanisation and increasing prices of fossil fuels. Nevertheless, the sub-sector has been a neglected area for policy and assistance.

2. Currently, there is even no desk for woodfuels at the Ministry of Energy. Wood fuel issues still remain informal and unregulated. There is therefore very little, if any, public/ government support to the sub-sector. It is often some unclear as to which ministry should deal with woodfuel issues. The conventional forestry ministry is often more concerned with timber than any other products or services. The Ministry of Energy is also preoccupied with electricity and crude oil-based fuels. Woodfuel experts have advocated the setting up of a ‘Woodfuels Development Authority’ but cautions have been drawn. As at now, woodfuels are everybody’s business, and therefore nobody’s business.

⁹ Ministry of Energy (2006): Draft National Woodfuel Policy

3. The bulk of the production comes from areas with rather fragile ecosystem. Essentially all the producers depend on natural stocks of trees in the fallow/farm lands. Production therefore follows the trees and is thus very dispersed in any given area. Even though some preferred charcoal tree species can coppice after cutting, some farming practices including maize production and over cultivation of same piece of land do not allow for the regeneration and tree coppicing. Sustainability of the resource base is therefore in serious doubt. There is very little use of other raw material sources, including plantation wood, bamboo and coconut shells.
4. Supply distances are long and increasing, with the cost of transportation taking a good proportion of the selling price of charcoal.
5. Demand for charcoal is price-inelastic, even though the relative prices of alternative fuels greatly influence the degree of substitution.
6. Current practices are such that most actors in the trade only make small margins; the bulk of the profit goes to the financiers.
7. The charcoal trade has been seen only in a rather parochial sense, starting with the production and its use by households.
8. The efficiency of the methods of carbonisation is generally low.
9. With the increasing environmental concerns, there has been more public criticism or condemnation of charcoal production in favour of alternatives that are perceived to be more environmentally friendly.
10. Most of the current production practices follow the wood source; producers therefore have little interest in the long term or sustainable use of the resource.
11. The absence of reliable and up-to-date data on the charcoal trade also does not make for easy planning.

All these factors have hampered the contribution of charcoal to poverty reduction in Ghana.

6.0 Optimizing the Contribution of Charcoal to Poverty Reduction in Ghana

6.1 Holistic View of the Charcoal Industry

There is the need to integrate backwards to cover the development and use of other raw materials and also look at the forward integration of the charcoal trade through the development of industrial uses of charcoal, particularly its use in purification processes for water, edible oils and gold processing (such as the carbon in pulp process), as well as air cleaning operations. Examples also exist in the large-scale use of charcoal in the metallurgical (Brazil) and cement industries. Promoting the industrial use of charcoal for both small and medium enterprises could have great implications for economic (income generation) and social (job creation) aspects for rural areas.

6.2 Land Tenure System

Traditional land tenure arrangements usually do not cover trees. To have right of access to the trees, producers often have to deal directly with landowners who are often different from the tillers of the land and are also far removed from the land. The incentive for producers to protect the land from soil erosion is therefore low; on the other hand, farmers who may have no stake in the trees on the land have little incentive to protect trees from excessive cutting or may even destroy the trees before they are given out or poached by the charcoal producer. A tenure system that also gives the migrant farmer (who is usually closer to the land than the landowner) greater influence or interest in the trees would ensure greater protection of trees and even promote the planting of trees.

6.3. Real Economic Value of Trees

Studies have shown that in many places, the production cost of charcoal does not take into account the real value of the wood raw material. In many cases, this value is equated to the token amount paid to access the wood either in the form of land rent or 'drinks' money for the landowner or landlord. Whilst failure to capture the real economic value of the tree may appear to favour the poor urban consumer who may be paying less for the charcoal now, in real terms, the cost may be much higher if issues of environmental services and cost of replacement could be adequately captured. Again failure to capture the real economic value of trees has made wood rather cheap and not worth investing in over time. Against this background, investment in woodlots and wood plantations in general has made very little impact on the wood resource base for charcoal production. Reckoning the true economic value of trees could give better return on investment and therefore attract more investors into woodlots and plantation development, especially for short rotation fuelwood crops.

6.4 Access to financial resources

Beyond the issues of land and tree tenure, poor access to financial resources may be improved through micro-financing schemes that offer easier and cheaper long term financing which is necessary for the development of tree plantation or woodlot. The relatively long gestation period for trees generally, makes investment in the sector unattractive and uncompetitive. Micro-financing schemes at concessionary interest rates would therefore be necessary to make investment in the subsector more competitive. With improved access to credit, retailers could take more stocks at a time and thereby increase their returns.

6.5 Market Development

Development of the charcoal market, including developing and promoting industrial uses of charcoal could give more value to the product and make the trade more profitable

6.6 Policy support

Comprehensive and effective policies with the necessary legal backing (legislation) in place will provide the necessary environment for the charcoal trade to flourish and enhance its prospects to contributing to poverty reduction.

6.7 Institutions

Good and effective institutional arrangement in place to mainstream wood fuel generally and charcoal in particular is very essential. If charcoal (and woodfuel for that matter) is to contribute to poverty reduction, then there will be the need to make a body responsible for wood fuel so as to be able to champion its course - mainstreaming wood fuels. Better organized production and distribution with a uniform taxation system that returns a good part of the revenue to the producers will greatly improve the prospects of the trade enhancing poverty reduction.

7.0 The Current Situation in Ghana

7.1 Draft Policy

Ghana's draft woodfuels policy is quite comprehensive, but has been on the drawing board for rather too long. It also fails to capture charcoal in a holistic manner. It treats charcoal purely from the domestic energy point of view and also makes no mention of the need to harness or develop

alternative resources for charcoal production. The draft document rightly lays much emphasis on the management of existing resources, but the guiding principles and the strategies could have given a lot more attention to plantation development.

7.2 Initiatives on Plantation Development

Ghana currently has several initiatives on plantation development; advantage could be taken of some of these to promote woodlots for charcoal production. In particular, the government has since 2001, launched a presidential initiative on plantation development. The programme is aimed at restoring forest cover, addressing the wood deficit situation, creating jobs and alleviating poverty within forest fringe communities. The

programme is designed to use the Modified Taungya System (MTS) in which farmers are co-owners of the plantations with Government. Farmers are guaranteed a 40% share in the plantations and 100% of the agricultural crop proceeds. The remaining benefits from the tree plantations are to be shared among the Government (40%), the land owners (15%), and the forest fringe communities (5%). It is reported that 200,000 persons are actively engaged in this scheme. Laudable as this may seem, a system that allows the farmer full ownership of the trees would even better reduce poverty. This however would require some land reforms to give forest fringe communities greater access to and ownership of the land.

7.3 Land Administration Reforms

Ghana has embarked on land administrative reforms. The objective is to lay the foundation for a self-sustaining, land administration system that is fair, transparent and cost-effective and which guarantees security of tenure. The reforms are also meant to simplify procedures for land acquisition and give security of tenure. This however does not address community tenure and ownership rights. Civil society organisations have been championing the call for comprehensive reform that addresses community tenure and ownership rights. Such reforms will give greater incentive for investing in plantation or woodlot development.

7.4 Community Mobilization, Organisation and Participation

As pointed out in Section 1.3, the course of poverty reduction would be greatly served if people get access to education. Education for most of the actors in the charcoal trade may require mobilising and organising them into trade associations. This will make it easier to reach them for purposes of awareness raising and capacity building, in terms of equipping them for meaningful engagement with politicians and the powers that be to negotiate for their interests, and to participate in taking decisions that affect them.

In Ghana today, there are a few initiatives that have provided the platform for multi-stakeholder dialogue on forestry issues in particular. These include the on-going Voluntary Partnership Agreement process and two projects, 'Forest voices' and 'Strengthening voices for better choices' funded by DFID and the EU respectively. These projects worked with communities to build their capacity for meaningful engagement with duty bearers on issues of relevance to them. Another initiative that has helped in this direction is the concept of forest forums, piloted by the Forestry Commission and some NGOs. This was started at the district level some five years back; over the last couple of years support was received from the FAO for upscaling to Regional and National Forest Forums. Again, this affords the citizenry, particularly forest fringe communities space to participate in forestry sector debates.

8.0 Conclusions

The charcoal trade has a great potential to contribute to poverty reduction, but currently, its contribution is only suboptimal. There are interesting and worthwhile initiatives in place to increase these prospects, but a lot more needs to be done. Specifically, the comprehensive draft woodfuels policy has to be finalised and promulgated; the necessary legislation must also be passed to give effect to its laudable intentions. Education and awareness creation must be carried out about the status of the resource and the need to diversify the production base, looking especially at bamboo, coconut shells and planted resources. Actors in the trade must also be trained in sound business practises including book keeping. To promote investment in woodlots, legal reforms to address the issues of ownership, tree and land tenure have to be carried out, and access to micro-finance improved. Product development beyond the household use of charcoal has to be pursued, e.g for export, purification and refining processes at the industrial level. An effective institutional arrangement would be necessary if all these are to be hat enhances the work of the sub-sector.

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Analysis of charcoal value chains - general considerations

Steve Sepp – Eco Consulting Group - Germany

On behalf of GTZ

Introduction

Charcoal is a prime source of energy in most African country, as well as a driving force of their economies with estimated annual growth rates of around 3.7 percent [0]. Surprisingly enough, policy makers pay little attention to the ways in which charcoal is produced and sold – e.g. the question as to whether wood used for charcoal burning is harvested in a sustainable fashion. For lack of coherent policies, charcoal production, transportation and distribution remain, above all, informal and unregulated – rendering them inefficient and risky [0]. Besides, various stages of the charcoal supply chain impact in multiple ways on the economic, social, and environmental aspects of the MDG agenda. The observation that charcoal does not receive the policy attention it deserves may in part be explained with a crucial lack of baseline data, and structural governance deficits. Investigating the sequence of charcoal production and marketing in all its facets – including research and development, the regulatory framework, raw material supplies – is a key to any systematic improvement. The value chain approach¹⁰ provides a convenient means to this end, adding, as it were, knowledge, innovative insights and technology to each link. It enables policy makers to create favourable framework conditions which promote competitive enterprises, sustainable jobs and income for local people. Furthermore, it allows impact-oriented monitoring of initiated policy actions.

Numerous development projects dealing with wood-based fuels focused narrowly on individual links of the supply chain, often with mixed results. For instance, projects which promote improved kilns for charcoal burning have to compete against low-priced wood-fuels from open-access forest areas – in effect, investments necessary for the adoption of improved technology do not pay off, and dissemination falters. In a similar manner, dissemination rates of improved stoves usually level out at 20-30 percent, owing to the fact that reduced consumption lowers the price of wood-fuel (and thus discourages further investment). Unregulated logging in open access forest areas contributes to the problem of underpriced wood-fuels, and at the same time hampers projects which promote sustainable forest management (which likewise requires considerable investment).

If charcoal production and its use are to contribute to sustainable development and poverty alleviation, the entire charcoal value chain needs to be addressed in a holistic manner. That includes full and formal recognition of wood-based fuels as a future-oriented source of energy – a prerequisite for deliberate change from informal energy supply towards modern, locally-based energy industries. Wood-energy is versatile and displays a high potential for technological innovation (e.g. pellets, gasification, liquefaction) in terms of enhanced conversion and combustion – depending, of course, on the availability and targeted allocation of investment capital. Strategic interventions geared towards promoting enabling framework conditions thus create business opportunities for a wide range of service providers, and foster local employment and income. Additionally, sustainably sourced wood-based fuels contribute to carbon-neutral energy supplies, promote environmental protection and the conservation of biodiversity, and help to relieve dependency on finite fossil fuels.

Importance of promoting the charcoal value chain

Charcoal burning and marketing at present requires only minimal financial and human resources. Wood is mostly obtained for free. Charcoal production therefore is a business of choice for the rural poor; it contributes to their household income and provides a safeguard against food-shortages, unemployment and similar poverty-related risks.

¹⁰ The basic concept of a supply chain is similar to the value chain. As the terms are contradictorily discussed we prefer to use the term value chain approach, taking into account the overall efficiency and the costs of performing the key activities of the charcoal supply chain providing more conclusive statements on development opportunities.

The number of people engaged in the charcoal business is remarkable. For example, the estimated number of charcoal producers in Kenya (ca. 200,000) is as high as the number of people working in the educational sector. Approximately 500,000 people engage in downstream-processing and trade. With the number of dependents added, the charcoal business supports as many as 2.5 million Kenyans [0]. Their annual income nearly equals that of Kenya's tea industry. Similar figures are reported by other countries (e.g. Malawi [0], Niger [0]). Such figures vividly underscore that promoting sustainable charcoal industries provides a first-rate means of poverty alleviation. The value-chain approach aims to bring out the charcoal business from the shady realm of the informal sector and to harness its potential for sustainable development. This necessitates a comprehensive analysis of existing constraints, from ecological parameters to property/user rights to market access. Response strategies need to be streamlined, combining approaches such as sustainable natural resource management, policy & legal-regulatory reform, SME promotion etc.

There are numerous examples and guidelines to value chain analyses [0],[8],[9], albeit with a decidedly agricultural focus. Adaptation to the specifics of the charcoal business is therefore necessary.

Common issues characterizing the charcoal value chain

Specific analyses aside, a number of common characteristics shall be presented upfront. They apply to most African countries.

- **Unregulated/illegal setting:** Wood harvesting, charcoal burning, transport and trade are in most cases unregulated. However, where legal restrictions apply, they are frequently ignored – due to many countries' lack of legal-regulatory coherence and enforcement capacities.
- **Corruption** is rampant and systemic in many cases, which hinders adequate governance and enforcement. This problem further diminishes the legitimacy of the charcoal business, and leaves many producers vulnerable to economic exploitation.
- **Inefficient conversion technologies** are the logical consequence of the unregulated & insecure setting, clandestine operation and overall capacity deficits.
- **Charcoal production is a poor man's business.** Landless, uneducated or otherwise disadvantaged people provide a cheap source of labour. For lack of other options, they can be easily exploited. Poverty forces them to sacrifice long-term considerations (health, livelihood security etc.) for meagre short-term income. The poor are also powerless in the sense that they cannot defend their vital interests vis-à-vis more powerful stakeholders of the charcoal supply chain. They are not organised in most cases, and thus avail of little – if any – bargaining power, and virtually no access to investment capital.
- **In the public perception, charcoal is discriminated against** as “dirty” and economically unattractive. This hinders strategic planning as well as mobilisation of investment capital.
- **Free access to raw material** leads to deforestation and degradation. Adding to the widespread perception that wood-based fuels are “technically backward”, this further discredits charcoal as a source of energy.
- **The charcoal business displays a decidedly oligopolistic structure:** Profits are usually concentrated in the hands of a few intermediaries, engaged as transport agents or wholesalers. Furthermore, this setting is heavily biased against women, who often bear the heaviest workloads (wood harvesting/collection, kiln operation, small-scale retailers). Instead of equitable revenue-sharing along the entire value chain, revenue circulates in a loop between traders and consumers – a short circuit, so to speak. Marginal cash flows to the charcoal burners – and virtually none to those communities, whose forest areas are being depleted in the process.
- **Charcoal operators are reluctant to formalize their businesses** as they cannot perceive the benefits. The reasons are: (i) transaction and other costs of formalization are high and arbitrary; (ii) procedures are complicated and time consuming; (iii) contact with local and central government officials (many of whom are suspected of corruption) is generally frustrating and humiliating.

Analyzing the charcoal value chain

Any targeted response to the problems observed requires that knowledge gaps are filled, and relevant baseline data obtained for a specific setting. The value chain approach has already been introduced in the preceding sections. Now, therefore, systematic value chain analyses shall be advocated and outlined in broad conceptual terms as an instrument of choice. They yield insights immediately relevant to policy-makers, civil-society stakeholders and development agencies alike.

The exercise consists of a sequence of four mutually related steps. From each step to the next, facets are added to the picture, and the degree of resolution increases. Each stage of the analysis can be illustrated in a map-like fashion, a multi-layered “atlas” of the charcoal supply chain in a specific context being the eventual end-result [0]:



1. Reconstructing the value chain. This marks the point of departure for subsequent stages of the analysis and serves to visualise the links of a given charcoal supply chain. The result is a map which identifies both chain links (i.e. elements, or stages/functions of the charcoal supply process) and corresponding categories of stakeholders. Value chain maps are the core of any value chain analysis and therefore indispensable. The following figure provides an - admittedly generic – example; in a given case, some elements or stakeholder-categories may be missing.

Figure 1: Generic elements of a basic linear charcoal value chain map



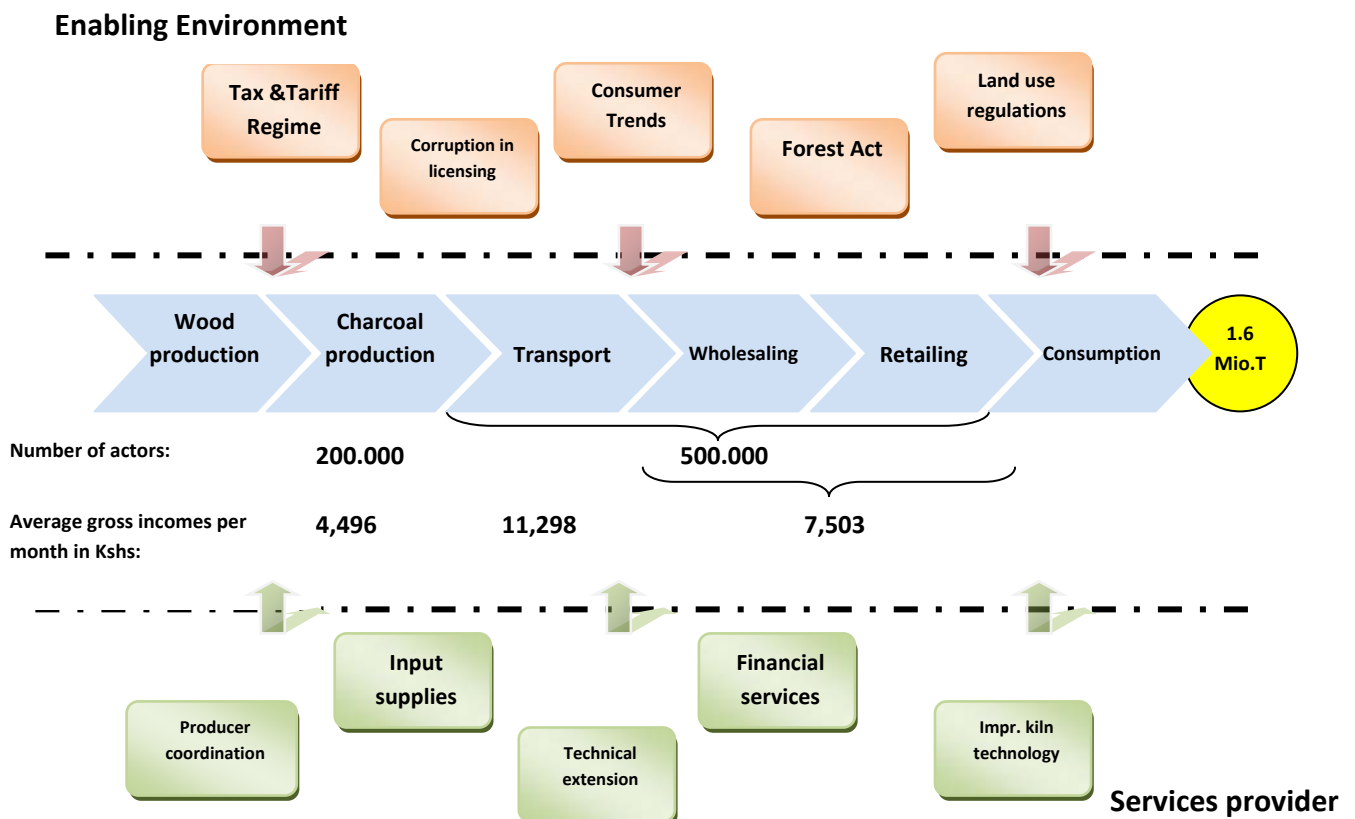
Chain mapping is not only analytical, but also a communicative exercise – one that benefits from stakeholder participation in workshops, interviews etc. Participatory value chain mapping provides the added value of stakeholder dialogue and may thus serve to build trust, correct misconceptions, and broaden the insight & awareness of policy makers.

2. Quantifying the value chain in detail. Once elements and stakeholder categories are agreed upon, quantifiable data are added so as to (i) better understand the overall economic significance, (ii) identify and gauge trends of development, and (iii) provisionally identify intervention priorities and opportunities.

Quantifiable data typically include the number of stakeholders in each category, product volumes and their market shares, amounts of revenue accruing at different stages of the value chain etc.

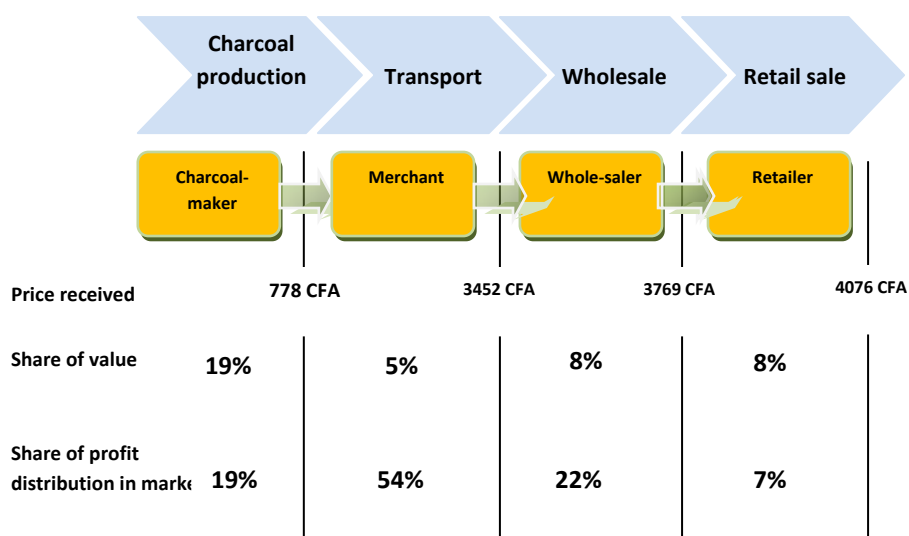
Figure 2 outlines a charcoal value chain on a highly aggregated level, drawing on data obtained through the National Charcoal Survey in Kenya [5]. Additionally, political, legal-regulatory, administrative and societal framework conditions are added for the purpose of subsequent observation and analysis, as together constitute the wider context and “environment” of the charcoal business.

Figure 2: Quantified value chain illustrating the enabling environment as well as the services provider



3. **Preparing an economic analysis of value chains.** This stage complements and deepens the quantification, with a distinct focus on economic efficiency. To this end, the flow of revenues accruing at various stages of the value chain is analysed in regard to (i) income and profit, prices, and quantities of the goods handled by the different actors; (ii) distribution of income and profit within and among the groups along the value chain; and (iii) the mechanisms which determine revenue generation and revenue sharing in a given setting (see Fig.3).

Figure 3: Charted economic analysis of a charcoal value chain in Senegal [10]



4. **In-depth analyses of selected factors.** Following reconstruction and quantification of the value chain, identification of relevant framework conditions and economic analysis, each link must be scrutinised for the underlying causes and mechanisms which promote or inhibit sustainable development and poverty alleviation. Zooming in on individual parameters adds qualitative detail and provides explanations for the quantifiable facts observed. The selection of parameters for further analysis is guided by the dimensions of sustainability, i.e. ecological, economic and social aspects. Once again, such findings can be visualised in the form of thematic maps (cf. Fig. 4).

Given the degree of resolution and the amount of detail at this stage, it seems advisable not to include the respective findings directly in the visualisation of the value chain (the overall “map”), but to produce supplementary thematic maps for each parameter. An easily accessible structure is paramount.

For example, poverty and the relative weakness of certain stakeholder categories may require a detailed “stakeholder analysis”. It allows for a differentiated investigation of matters such as household size and structure, educational histories including technical/entrepreneurial capacities and skills, gender-relations, market access, social networks, perception of needs and problems etc. (see Figure 4).

Numerous studies of the charcoal sector point to various regulatory and operational constraints hindering business development in an informal setting. For instance, regulatory constraints may include aspects of resource tenure and management rights (e.g. land tenure, forest management, environmental laws, etc.) as well as procedural requirements (registration, licensing, taxes and duties, property rights, etc.), factors such as labour legislation (e.g. employee benefits and rights) etc. Typical operational constraints include access to public services and infrastructure (communication, roads, power); access to information and information services (availability of rules and regulations, market information, advice on investment opportunities), and access to capital and credit.

Figure 4: Charted stakeholder analysis depicted from the National Charcoal Survey Kenya [5]

	Charcoal Producer	Transporter	Vendor
Average Age	39	35	34
Share of women	16%	14 %	57%
Marital status	78% married	75 married	66% married
Owning business	95%	88%	67%
Formal education		Primary 58% Secondary 30 % Tertiary 3.8%	Primary 50% Secondary 36 % Tertiary 4 %
Business affected by HIV	26%	30%	27%
Av. gross income per month	Kshs. 4,496	Kshs. 11,298	Kshs. 7,503
Full time business	51%	43%	74%
Main problems faced	Lack of raw material (21%) Corruption/harassments (19%) Lack of finances (13%) etc.		Scarcity in high quality charcoal (20%), Harassment by govt. authorities (18%), Low profitability (12.5%),etc.

Building a roadmap for charcoal value chain upgrading

Findings and conclusions from the systematic analysis of a given value chain must be put to practical use. They inform the drafting of coherent response strategies, geared towards promoting a regionally focused private sector of robust and dynamic small firms, delivering tens of thousands of decent jobs, and optimising the output of environmentally friendly, socially acceptable and economically viable energy services. Strategic development in this context allows for flexible, implementation-oriented consideration of global public goods & policy goals, including environmental services such as carbon sequestration and adaptation to climate change.

The envisaged approach does not stop short at strategy development, however, but includes the design of operational action-plans with clearly assigned roles and mandates, impact-oriented results and corresponding provisions for monitoring and evaluation, and resource allocation – a **roadmap** being the intended result.

While individual roadmaps may vary according to a given setting, some common aspects may be discussed at this point. In most cases, optimising a value chain means to **promote stakeholder equity**, and to empower disadvantaged and hitherto marginalised groups. The aim is to involve stakeholders more evenly in policy formulation, strategic planning, implementation and monitoring. Educating stakeholders about their rights and responsibilities is just as important as the targeted improvement of the political, legal-regulatory and administrative framework.

Furthermore, it is necessary to enhance stakeholder relations. If **conflicts** are to be prevented, mutual trust has to be built particularly between (regional) government agencies and private operators engaged in the charcoal business. A market economy operates on the premise that the roles and mandates of government agencies and private operators are clearly separated and complementary. Government is expected to create an enabling, business friendly environment which ensures that private operators - willing to bear risks and adequately skilled – may run profitable and reasonable secure businesses. In return, private operators are expected to abide by the effective rules and regulations, to pay taxes, and to help maintain those enabling framework conditions, on which their businesses depend.

Another common feature in many contexts is **decentralisation**, meaning the deliberate, strategic devolution of executive power from the central government to regional or local self-governing entities. Given that charcoal production is, by definition, a local/regional business it is advisable to draw a roadmap on **the regional level**. Any centralised planning – from the national level downwards – would remain too abstract, too time-consuming, and less efficient besides.

Building a roadmap above all is a process of consultation and learning. It benefits greatly from institutionalised stakeholder participation in terms of more cost-effective and less conflict-prone implementation, and more sustainable impact.

Building a roadmap involves a sequence of steps [0]: (i) agreeing on a vision and strategy for upgrading a given value chain (ii) analyzing opportunities and constraints (iii) setting operational objectives, (iv) drafting actions plans which prescribe certain measure in detail, ensure adequate coordination within and among thematic clusters (“fields of action”), and clearly attribute responsibility to certain stakeholders. In any case, all activities must be monitored – either continuously, or periodically, as required – with a view to verifying the realisation of lasting impact over time.

• Agreeing on a vision and strategy for value chain upgrading

A commonly shared “vision” or strategy is a key-requirement for the optimisation of any value chain. It requires transparent, multi-stakeholder participation (including by policy makers charged with shaping economic policies). Because many stakeholder groups tend to have different perceptions of reality, a first step is to achieve a common understanding and baseline knowledge among the stakeholders involved. This can be most conveniently achieved by jointly reviewing and discussing results of the value chain analyses.

Many policy makers and development organisations focus on poverty alleviation and the empowerment of hitherto marginalised groups of stakeholders. Those stakeholders, on the other hand, as thus far profited most from the status quo (transport operators and wholesalers) will most likely be very reluctant to consent to any redistribution of economic benefits. To avoid conflict, process facilitation/moderation is recommended. The aim must be to create a win-win situation which makes necessary redistributions of revenue along the value chain more palatable for the hitherto most powerful and privileged parties. For instance, one may point out more reliable and predictable supplies of high-quality charcoal, less opportunity costs arising from the harassment by public authorities, less corruption etc.

Determining a vision or strategy for the charcoal business requires answering the question “how should the value chain look like five years from now”. One obvious aim is to balance charcoal prices with at least the cost of forest rehabilitation/reforestation and sustainable forest management. Currently in most cases, informally produced charcoal is seriously underpriced, causing wasteful use of charcoal and discriminating against sustainable management of forest resources. This situation calls for four basic shifts: (i) charcoal needs to get more expensive, so as to generate a more substantial revenue flow, (ii) revenues from charcoal production must

be distributed more equitably, so as to give marginalized groups a stronger incentive for sustainable management and production, (iii) to achieve this goal, the legal-regulatory framework must be deliberately adapted, and (iv) disproportionate economic hardships must be relieved for poverty-stricken end-users, by way of promoting and disseminating fuel efficient stoves among vulnerable segments of society. Adequate monitoring and enforcement at each level eventually decide the success of improving a value chain.

• **Analyzing opportunities and constraints to upgrading the value chain**

At this stage, operational detail is added to the strategic vision. The roles, mandates, rights and responsibilities of the concerned stakeholders are systematized, and their respective capacities and weaknesses considered. The overall goal is to pinpoint specific weaknesses of the current setting, and to devise technically as well as socially adapted responses. To this end, three basic guiding questions may prove useful [0]:

- What are the reasons for the chain to stagnate?
- Which gaps exist between the requirements on a value chain derived from the vision and its current structure and performance?
- Which constraints reduce the competitiveness of poverty groups (target groups) and prevent their integration into the value chain?

Once again, the value chain analysis prepared at the outset provides the most important source of information. It further enables the design of indicators to measure the success of planned activities. Answering the above mentioned guiding questions amounts to a SWOT analysis.

• **Setting operational objectives and planning specific action**

Following the conclusion and evaluation of the SWOT analysis, most of the necessary improvements will readily suggest themselves. The challenge now is to involve stakeholders in implementation, according to their respective roles and mandates, and commensurate with their management capacity. Where stakeholders lack the capacities necessary for the implementation of planned activities, they must be supported by government services or donor-funded development cooperation, as appropriate. A clear schedule for implementation must be agreed at this stage, and milestones defined for the purpose of monitoring.

• **Monitoring the impact of value chain upgrading**

Impact-oriented monitoring is an indispensable component of value chain development. Without it, success cannot be observed, required adaptations cannot be effected, and the cost efficiency of planned measures remains uncertain. Adequate monitoring foremost depends upon the prior definition of indicators, each with clear and easily measurable baseline, and benchmark values. Wherever possible, monitoring should be conducted in the form of a participatory process, enabling stakeholders to add their experience and specific observations, and to capitalise on the experience of others, and lessons learnt.

Conclusions

As the previous discussion has shown, the value chain approach provides a useful and convenient tool for problem analysis, strategic planning, operational planning, implementation and monitoring. The paper at hand may only outline the process in general terms, and draw the reader's attention to the most important elements. In practice, circumstances may vary from case to case, and call for a carefully adapted approach. No blueprint exists, and no uniform operational guidance can be presented at this point.

However, some aspects clearly deserve to be highlighted:

- The need for systematic, multi-faceted analysis, as a precondition for any activity to promote the charcoal business,
- The conflict prone nature of measures intended to redistribute benefits and formalise various stakeholders' roles and responsibilities – careful moderation and mediation is required to promote equity among the groups concerned,

- The inseparable interdependency between political/legal-regulatory/institutional framework conditions on the one hand, and technical/practical issues on the other – ensuring sustainability of the charcoal business as a cornerstone of environmentally and socially friendly energy supplies is – above all – a governance issue,
- The need to regard the promotion of charcoal value chains as a mutual learning process of the concerned stakeholders,
- The need to foster ownership by means of a commonly agreed strategic vision,
- The need for operational planning using the road-map approach,
- The need for impact-oriented monitoring as an indispensable factor of success.

Finally, readers should bear in mind that, while ingenuity is called upon in promoting charcoal value chains, the simplest, most straightforward course of action in most cases will be the best and most successful.

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Charcoal Supply Chain Study in Ethiopia

Yisehak Seboka

Senior Energy Expert

Ethiopian Rural Energy Development and Promotion Centre (EREDPC)

Jeevanandhan Duraisamy,

INBAR Consultant

1. Abstract

Charcoal is among the most important household fuels in Ethiopia, used in the traditional coffee ceremony and for cooking by the urban poor. Agricultural residues which are abundantly available and usually wasted can play a major role in easing up the critical energy situation of the country. The Ethiopian Rural Energy Development and Promotion Centre (EREDPC) has a number of programmes to utilize the agricultural and process residues. Among these is the production of charcoal briquettes from cotton stalk, coffee husk, chat stem, *Prosopis*, branches and bamboo waste.

The paper provides some background on charcoal in Ethiopia, briefly describes the types of charcoal production technologies and mainly focuses on the charcoal supply chain study in Ethiopia. The study addresses: charcoal production (illegal and legal production), charcoal transportation (middle man and transporters), wholesale and retail traders, household consumers and charcoal inflow to Addis Ababa city. The study had the following main objectives: (i) to better understand the charcoal supply chain (production-transport-wholesale-retail) and (ii) to identify barriers and opportunities for improvement.

The paper also describes some of the research and project activities pursued with the objective of improving biomass conversion technologies. In particular, focus is given to the trial and the findings on improved earth mound charcoal kiln (the Casamance), portable metal kiln, production of agglomerated charcoal and beehive briquettes from agri-residue.

2. Introduction

About 90% of Ethiopia's energy needs are supplied by biomass in the form of wood and charcoal. Charcoal makers use traditional practices to produce charcoal, where the average conversion ratio from wood to charcoal has ranged from about 10-15%. Charcoal production is an extremely important economic safety net as it provides readily available cash for food and livelihood security. Ethiopia is the second largest charcoal producer on the African continent. According to FAO STAT (Forest STAT), the 1995 - 2005 estimate for charcoal production is 3,320,535 tones. At least 19 million tons of wood are consumed each year to produce charcoal by thousands of traditional charcoal producers. Charcoal production is thus considered as one of the major activities contributing to loss of forest resources.

3. Types of Biomass Resources and Estimated Availability for Charcoal Production

In Ethiopia, bamboo, *Prosopis*, agricultural residues such as cotton stalk, chat stalk, and coffee husk have shown promising initial results to satisfy demand in the short term and, if seriously promoted, to become possible alternates to wood charcoal. This paper attempts to compile the research results obtained with the objective of improving the charcoal supply chain from producer to consumer.

Table 1. Estimation of biomass resource potential in Ethiopia for charcoal production

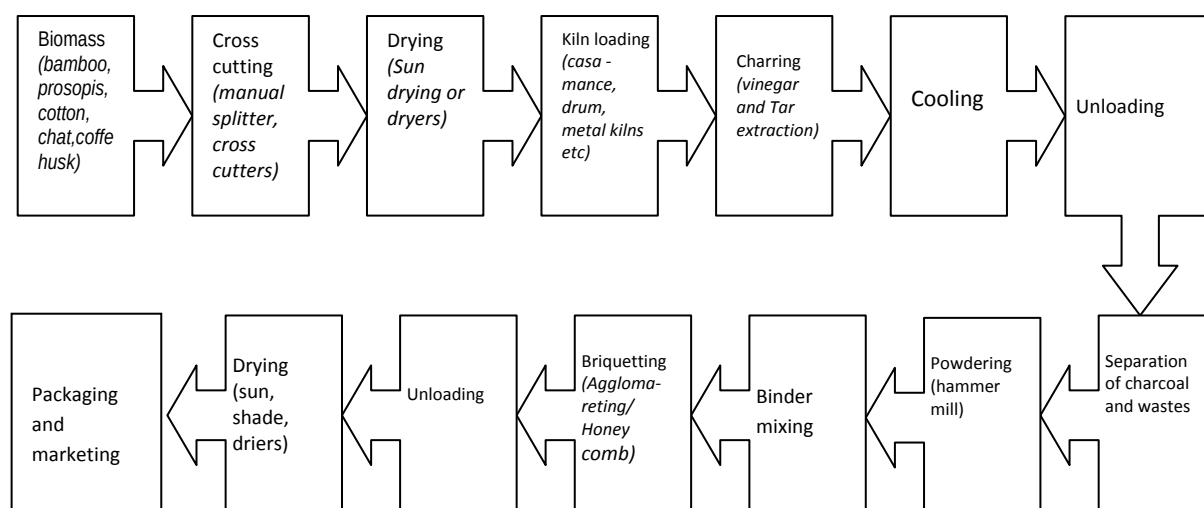
No	Resources	Estimated area of cover (ha)	Dry Yield (Tones)	Improved Yield 20% (Tons/ yr)	Charcoal production 50% (Ton/yr	Bags of 40 kg	Projected annual out put bags / yr
	Bamboo	1,000,000	15 – 20 / ha	3.0 - 4.0/ ha	1.5 - 2.0 / ha	37.5 – 50	37,500,000- 50,000,000
	<i>Prosopis</i>	100,000	4– 6/ ha	0.8– 1.2 ha	0.4 -0.6/ha	10-15	1,000,000 - 1,500,000
	Cotton	89,000	3.8 / ha	0.76	0.38	9.5	845,500
	Coffee	NA	214,299 t/yr	42859.8	21429.9	535747	535,747
	Chat*	25,000	5116 t / yr	1032 t	511.6	12790	12,790

*Addis Ababa dry chat residue

4. Charcoal Production and Briquette Technologies

The overall charcoal production process involves the following steps: the upper part of the chain is similar to the traditional process; the lower part of the chain is the process which is being developed by EREDPC for converting any hardy biomass into charcoal and to make briquettes.

Figure 1. Charcoal production and briquette making technology process chain



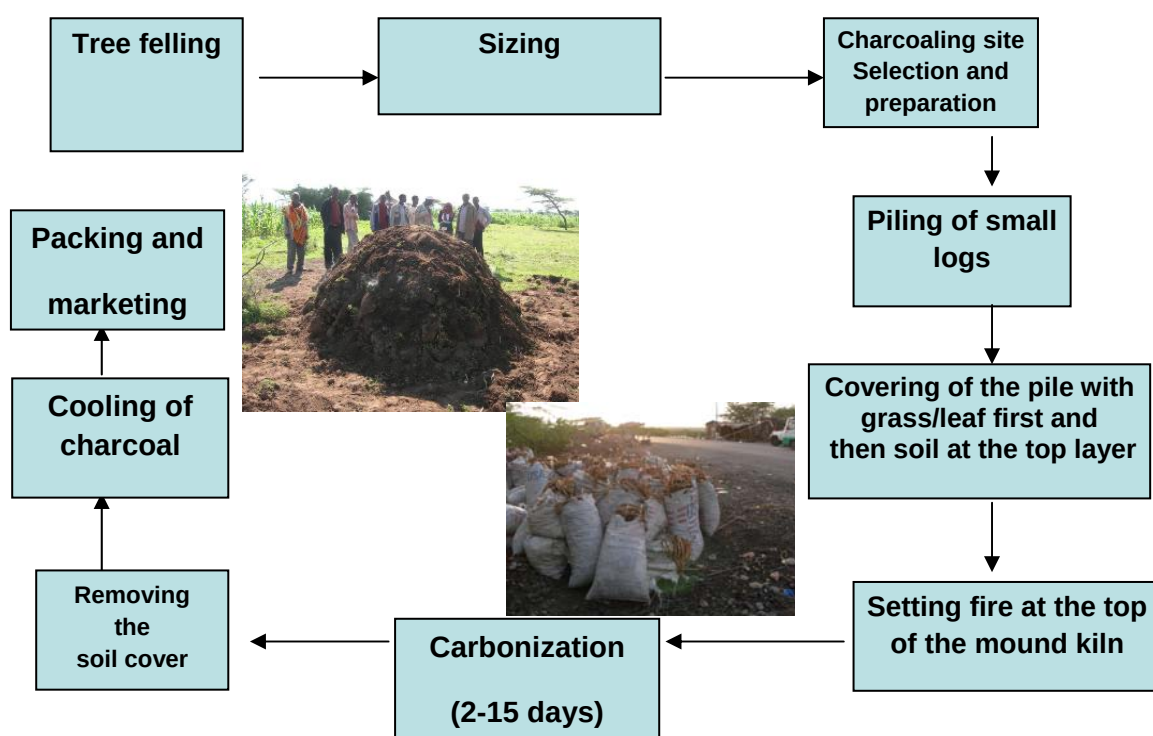
4.1. Charcoal production technologies used in Ethiopia

Depending on the type and quantity of residue available for charcoal production, and among others market price of wood charcoal, various types of charring technologies could be employed. Available charcoal making technologies tested in Ethiopia are: earth mound, Casamance, metal kiln and drum charring units.

4.1.1. Traditional Earth Mound Kiln

Charcoal is produced in traditional Earth mound kilns in Ethiopia with an efficiency of 10-15% (wet weight basis). It is the most frequent method of charcoal production. Earth mound is the least efficient and charcoal produced by this type of kiln could also be easily contaminated with soil and other foreign particles. Total carbonization period depending on the size of the mound ranges from a few days to a month.

Steps of Charcoal production



4.1.2 Improved Earth Mound (Casamance)

Casamance is an improved version of earth mound kiln. It is covered with earth and leaf material with holes at the base and a chimney made from 3 oil drums (200 litres) is introduced. The fourth drum is welded into this piece at a right angle. The fifth barrel is used to collect tar at the bottom of the chimney. Opposite the direction of the wind a chimney is inserted into the triangular duct of the kiln.



Figure 2. Casamance kiln prepared for testing

4.1.3. Portable Metal Kiln

These types of metal kilns are made from metal sheets or manufactured from used 200 litre oil drums. It has a diameter of 1.70 meter and height of 0.90 meter. It has a capacity of about 2 m³ of raw material per charge. The efficiency of these kilns was found to vary from 28 -33% depending on operator skill and experience.



Carbonization of Prosopis using metal kiln

4.2 Production of charcoal briquettes

Charcoal briquettes are products intended to substitute lump charcoal. They are either made from charcoal residues left over at charcoal lump production sites or they are made from biomass that are not suitable for the manufacture of lump charcoal. The latter are mainly agricultural residues, for example, coffee husks, cotton stalks, chat stem, etc.

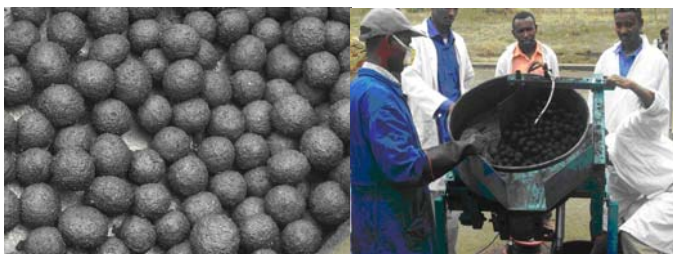
4.2.1. Beehive Briquetting



Beehive briquettes are cylindrical in shape (13 cm in diameter and 8 cm long) and have a number of holes (usually 19 longitudinal holes of 13 mm diameter). A single beehive char-briquette will weigh about 400 to 500 grams. Beehive briquettes require a specially made beehive briquette-burning stove and are suitable for activities that require continuous heat for relatively longer hours than is required from common charcoal stoves.

4.2.2. Agglomeration

This is a method of size enlargement by gluing powder particles together using binder in a rotating pan agglomerator. Agglomerated charcoal briquettes are spherical and have a diameter which varies between 20 and 30 mm. The charcoal powder is shaped into briquettes by using a binder such as molasses (a by-product from sugar manufacturing). Production capacity of the agglomerator is 30-50 kg/hr.



Production of agglobriquettes from bamboo waste

5. Charcoal Quality Tests

The quality of charcoal varies widely depending on the wood species and carbonization process. It is therefore important to define charcoal properties when we talk of charcoal production from different wood species and agricultural residues. The charcoal briquettes from agro-industrial wastes need quality determination analysis

(physical, chemical & combustion test). Charcoal briquettes will be accepted and used if they meet minimum quality requirement.

Table 2. Approximate composition of some different charcoal types

Type of charcoal	Moisture (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)	Calorific value (cal/gm)
Acacia Spp. charcoal	3.67	22.90	3.64	69.79	7780
Bamboo charcoal	9.31 ¹¹	15.03	14.80	60.86	6959
Prosopis charcoal	3.90	25.90	3.50	66.80	6256
Cotton stalk charcoal briquette	4.10	17.20	20.30	58.40	4588
Chat stalk charcoal briquette	8.04	28.58	16.54	46.84	5100

*Source : EREDPC laboratory

6. Charcoal Supply Chain Study

Ethiopian Rural Energy Development and Promotion Center (EREDPC) in cooperation with INBAR carried out a charcoal supply chain analysis from production to consumption in Addis Ababa and its hinterlands from 14 July 2007 – August 15, 2007.

The supply chain study looked into the legal and illegal charcoal production processes of major charcoal producing areas in Afar and Oromia regions. The study used participatory approaches to collect data among producers, middle men, transporters, traders and consumers (household). The study addressed: charcoal production, charcoal transportation, whole-sale and retail traders, household consumers and charcoal inflow to Addis Ababa.

6.1 Study area and methodology

The two selected regions of charcoal production are located in the Afar region state with predominately with Prosopis spp., acacia spp. and in Oromia regional state with acacia spp. where a charcoal production ban is in place. The field study covered all stakeholders in the supply chain for Addis Ababa. A combination of Participatory Rapid Rural Appraisals, survey questionnaires, informal and formal interviews were carried out to get a comprehensive picture of the situation.

The Afar community consisting mostly of semi settled nomadic pastoralists in Afar Regional State is using mostly Prosopis spp. for legal charcoal production to supply the markets in Addis. This place is around 300 kms from Addis Ababa and the Prosopis spp. is an invasive weed which is dominating the natural vegetation forcing the Afar communities who depend on cattle for their livelihoods to depend on charcoal for income. The charcoal is mainly being produced by settlers from other regions who came to work in cotton farms and also in land leased from Afar communities for cotton farming and charcoal to arrest the spread. It is a well functioning informal symbiotic relationship where the settlers pay a small leasing fee (around 0.15 US \$ per bag of charcoal produced and sold using the Prosopis). The charcoal is produced using traditional kilns in a very inefficient way (around 10 - 12% conversion rate) leading to large-scale carbon emissions, leakages and wood wastages. At times the settlers / Afar community log natural acacia trees to produce charcoal and this has led at times to a temporary ban on charcoal. However, government bans do not usually stop charcoal production but lead to rising prices due to problems in demand and supply. The analysis revealed that charcoal production is becoming a major source of income overtaking pastoralism and agriculture. It is expected to grow and lead to a change of livelihoods in the Afar community to become charcoal producers in the medium to long term.

Oromia regional state is the biggest and one of the most degraded areas of the country. Two adjoining villages in East Shewa zone around Bulbula were studied. Charcoal production has been banned and declared illegal because of the use of natural acacia woodlands which have shrunk to a great extent. Even trees along the rivers are being now targeted for charcoal production. Almost all interviewees stated that they know to produce charcoal and are producing it from time to time illegally. However, charcoal is produced regularly and supplied to the market and almost all rural farmers in Oromio and most of the settled labourers and some Afar families are engaged in charcoal making during the study period. Despite the local peasant associations taking actions such as confiscation of the charcoal, imposing fines, imprisonment etc., rural households take risk of producing charcoal on a regular basis. However, large-scale kilns are being discontinued or continued only in remote mountainous areas as they require more days to char and also there is a higher risk of punishments. Farmers have admitted to illegally felling medium or small size trees within the farm, along the rivers in the early mornings or in the evenings to char them in the maize fields. Small kilns ranging between 2 -5 bags are mostly being used now as charring can be done overnight / in a couple of days thus minimizing the risk of legal actions. Also the Kebele leaders expressed that it is not easy to regulate as it is a very sensitive and delicate matter for them to take action against their own family/relatives/ neighbours. They also mentioned that they are themselves at times engaged in charcoal production to meet unexpected expenses thus using charcoal as income generator as well as a livelihood insurance.

6.2 Result of the Charcoal Supply Chain Survey

Producer survey

In both production areas it was clearly stated that firewood was used for own use and charcoal was produced for income generation, which shows that charcoal is an urban energy source not used in rural areas at household level. Rural energy programmes which have been promoting charcoal stoves have not been adopted. In Oromio region even firewood is considered a valuable and tradable commodity so poor households prefer to use agro-residues such as maize and bean stalks for firewood. Almost all producers have some type of health risk in the form of injury or burns and malaria is one of the major diseases as they got infected while managing the kilns. Charcoal is also considered a sure means of income and it is becoming a year round activity providing employment in rural areas.

As charcoal trade and transportation is illegal, the local middlemen and the transporters were not forthcoming for the study. However informal interviews were held with some traffic police and some truck drivers. To compensate this gap and to accurately estimate the inflow of charcoal by different means (head loads, donkey loads, private car, public bus, trucks etc) to the city a 24 hour (2 shifts day and night) 7 day long observation was conducted at all the entry gates of Addis Ababa. Compilation of the data collected shows that on a monthly basis 230,919 bags (mixed sizes) enter the city, which comes to almost 3 million bags a year with an increasing trend.

A random but well distributed survey in all the charcoal selling markets and shops revealed that most urban customers prefer to pay premium prices for hardwood, heavy and big pieces of charcoal. This market preference was reflected at the producer level leading to the use of big and aged acacia spp. followed by Prosopis. Well networked, coordinated and established supply links help them to overcome legal barriers. In spite of the constant rise in the price of charcoal the demand is growing due to the fact that prices for fossil fuels are rising. This leads to an increase in transportation of charcoal from rural producers to urban areas. A large section of the traders are selling mostly piles and bags to suit the middle class. Charcoal waste is only partly used. Many small girls and boys are also seen selling small charcoal piles to support the family. Many charcoal sellers stated that they make marginal profits and that most of the profit goes to the big traders who take the risk of legal actions for transporting and trading. Many were unaware of the legal status but stated that charcoal should be legalized. Some of the households in and around middle class and poor habitations of the city also sell charcoal in front of their houses. The sellers were neither aware of nor have they seen any new forms of charcoal showing that the technologies which are disseminated to produce new forms of charcoal such as briquettes and alternate charcoal from other woody biomass were never adopted nor reached the market from the projects/enterprises which produced them in the past/recent years.

Charcoal Inflow Survey in Addis

The study was conducted from august 9 to 15, 2007 in order to know the complete weekly inflow of charcoal to Addis Ababa city. Within the seven days and nights 7697.29 sacks of charcoal were recorded. From this result

also it can be concluded that the annual inflow is estimated at 2,809,510.85 sacks of charcoal. [Note from the Editor: this does not take into account seasonal fluctuations, e.g., there would be higher inflows during the cold season when space heating requirements are higher].

Table 3. Charcoal inflow to Addis Ababa city through five main gates Aug. 9-15, 2007

	Name of checkpoints (gates)					Av./day	Total for 7 days (Sacks)	Estimated monthly flow (Sacks)	Estimated Annual flow (Sacks)
	Kaliti	Jimma	Wolega (Tatek)	Gojam	Dessie				
Charcoal (sacks)	19,386	4,108	3,807	15,879	10,701	7,697.29	53,881	230,918.7	2,809,510.85

Household Survey in Addis

The consumer survey covered all zones and all the income classes of the city. All respondents stated that they use charcoal in the coffee ceremony followed by the 'wot' cooking. The upper, upper middle and middle class prefer to use charcoal for cooking because it results in tastier food. Many have maids / relatives / older people living in the household who have time to cook slowly on charcoal stoves. Most of the consumers stated that hard, heavy and bulky charcoal is preferred and they are willing to pay higher prices as charcoal provides more energy (calories) and burns longer. Most consumers also prefer to buy charcoal in piles and only some bought charcoal in bags. Many of the households stated that their charcoal consumption has gone up in last 3 years and also charcoal use during weekends and festivals is high as they had more time to cook and wanted to have tastier food. Many of the consumers have adopted new improved stoves.

Institutional stakeholders

The institutional stakeholder meeting engaged participants from government institutions – EREDPC, Ministry of Agriculture – Forest Research Centre, Environment Protection authorities, local NGO's and international agencies – FAO, GTZ, World Vision and FARM Africa. Currently only EREDPC and GTZ are engaged in an improved stove project related to energy and there are no other current programs focusing on charcoal or firewood related to domestic fuel. However EREDPC is continuing to do some small follow up of technology demonstration of bamboo, cotton stalk and chat residue to make honey comb briquettes through its own funds and limited funds from INBAR. All institutional stakeholders agreed that the present policy and legal measures are not sustainable or effective in regulating the charcoal production. On the contrary it has led to an increase in charcoal use and prices. They were aware of the problems related to inefficient charcoal production using traditional methods, carbon emission due to leakages, lack of effective transfer and adoption of technologies, absence of formal incentives/promotional programmes for improved charcoal production enterprises. The sector is well organised and provides valuable employment along the supply chain but remains informal due to policy gaps. The group acknowledged that charcoal is the biggest forest use in the country and the well established biomass fuel sector has the potential to be sustainable and carbon neutral if suitable policy measures are complemented with appropriate technology actions. Research, technology transfer and adoption into alternate and sustainable biomass resources such as branch, bamboo, cotton stalk, bean stalk, chat stalk etc. should be taken up urgently. Charcoal projects should take advantage of the Clean Development Mechanism (CDM), Carbon Neutral projects, Global Environment Facility projects and carbon sink projects which permit afforestation activities should be developed for energy plantations to arrest deforestation in a comprehensive manner. Being the only country in the region with rich water and favourable climate condition the existing ecosystems to be preserved and degraded lands should be rejuvenated. A special policy on charcoal should be charted for Ethiopia similar to the policy on Gum Arabic / Coffee. Countries like Sudan for production systems, Mozambique for charcoal production licensing and management plans could serve as a model for Ethiopia. The Ministry of Energy and the Environmental Protection Authority were willing to work on these issues but requested technical support from the international stakeholders.

7. Conclusions and Recommendations

7.1. Conclusions

Charcoal is an indispensable renewable, clean, employment generating cheap urban energy source and the biggest biofuel sector in the country. Charcoal production to consumption provides valuable employment and income to poorest of the poor and the middle class. It is emerging as a year round activity for rural farmers and as a insurance to livelihoods. Current production systems for charcoal production are unsustainable, and the technology and incentives are insufficient. The present prohibitive policy and regulatory mechanisms only aggravate the situation and a comprehensive policy combined with adequate actions should be adopted immediately.

Wood charcoal could be substituted with charcoal briquettes made from agricultural and process residues or short rotation wood. The technical viability of char-briquettes production from bamboo, prosopis and agricultural residues such as chat residue cotton stalk, coffee husk is mature. It has been demonstrated that charcoal production and production of charcoal briquettes of acceptable quality is technically viable. The agro-industrial residue briquettes have exhibited comparable physical and combustion characteristics in tests conducted both at EREDPC laboratory as well as in household charcoal stoves. And, the production and marketing of agro-industrial waste charcoal briquettes could be a viable business opportunity. However, the financial viability of producing and marketing of residue char-briquettes would be highly dependent on many factors including, the location of charcoaling and briquetting plant, volume of production and the price of wood charcoal.

7.2. Recommendations

- Register all traditional charcoal producers and train them in improved carbonization process.
- Legalization of wood charcoal production and trading. Illegal charcoal trading in the towns and cities has to be stopped and permit issued to those who want to make their business legal.
- Imposition of stumpage fees on wood charcoal production
- Imposition of charcoal production license which will be used in product transport to markets
- Effective management and control of forest resources through participation of local communities. Enhance the forest resources utilization based on the social and economic well-being for local communities; the local community has to have power to control and give forest products business.
- Establishment of checkpoints that make sure that marketed charcoal is locally produced.
- Introduction of efficient, cheap, and simple charcoal kilns and training to charcoal producers and entrepreneurs.
- Organize the charcoal makers in to working groups in order to facilitate training and stacking large volume kilns.
- Demarcations of charcoal production area.
- Alternative resources through introduction and promotion of short rotation species like- bamboo, Prosopis and using agro-industrial residues to produce a substitute for hard wood charcoal is important.
- Charcoal production needs due attention in the policy arena.

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CHARCOAL SUPPLY CHAIN STUDY in Mozambique

Nilza Hassane Puná

(INBAR Consultant)

1. Introduction

At least 80% of the African populations continue to rely upon traditional sources of biomass fuels mainly charcoal and firewood to meet their energy needs. This situation is expected to remain unchanged; in particular, the demand for charcoal in most countries in the region continues to grow at high rates owing to the ever-increasing rural-urban migration. These trends coupled with inefficient charcoal production and consumption practices, and inaccessibility by most households to other reliable and affordable commercial energy forms indicates the continued and probably growing dependence on the already dwindling biomass resource for energy.

Charcoal is one of the most important commodities produced by the rural poor across Africa which is largely used in urban areas. It is an important and simple means of income generation and in rural areas its production can be the more important than other activities such as agriculture. Charcoal also contributes to a reliable, convenient and accessible energy for cooking at all times and at a stable cost. Additionally, charcoal trade offers income generation opportunities for many people in the urban areas, through small scale retail businesses mostly run by women who sell it in the urban roads.

Most of Africa's charcoal energy use occurs in sub-Saharan Africa. In Mozambique alone, a study has shown that over \$200 million of charcoal is sold in the town and cities where it is primarily used for cooking. Production of traditional fuels is often insufficient to satisfy rising demand and the availability to the poorest communities is expected to decline, which will intensify environmental degradation in those communities.

The bulk of charcoal wood is clear-cut from secondary, and in some cases, from primary forests. Hence, charcoal leads to considerable deforestation, which is now one of the most pressing environmental problems faced by most African nations. Deforestation has negative implications both for the local environment and the global environment. Also deforestation leads to reduction of natural resources on which the poor depend, and land degradation, contributing to the downward spiral of poverty.

1.1. Objectives

The present report summarizes the main findings of the Maputo charcoal supply chain study. Specifically the study aims were to:

- describe the charcoal supply chain for Maputo;
- understand how the production and sales of charcoal affect or are affected by communities livelihoods
- document institutional and socio-economic aspects related to production, trade and consumption of charcoal
- analyze implementation of legal instruments by local communities, and
- estimate the demand and supply scenario;

The study provides a glimpse of the charcoal supply chain to help in understanding the severity of dependence of local communities in relation to wood for energy needs, the charcoal flows, specifically the trends in deforestation due to charcoal production and how the problems caused by charcoal production can be effectively addressed to curb deforestation and global warming, including the promotion of bamboo for bio-energy.

2. METHODOLOGY

The study was carried out between April and June 2008 in Maputo and Gaza Provinces which are the main supply areas for Maputo markets. In these provinces, the Districts of Magude, Massingir and Mabalane were purposefully selected as these are the main charcoal supply areas. Participant observations along the supply chain from the resource base up to the consumer in Maputo and interviews were used, complemented by the use of questionnaires for all the stakeholders involved in the supply chain.

A total of 60 producers were selected randomly and interviewed, 30 in Magude (Maputo province) and the remaining 30 in Mabalane and Massingir districts (Gaza province). Transporters were interviewed both in the production areas as well as in the markets. Additional information regarding the charcoal transportation quantities was collected at the train stations of Mabalane and “Gare de Mercadorias”. The vendors both retailers and wholesalers were interviewed at Maputo main markets located in the various urban districts. Interviews to consumers at household level were also taken in the houses and markets. A total of 25 households were interviewed in Maputo city. Twenty five big consumers (often called “barracas”) were also interviewed around the same Urban Districts (DUs).

3. RESULTS

3.1 The charcoal supply chain

Besides the government authorities, the main stakeholders involved in the charcoal supply chain are: Producers, middlemen, transporters, wholesalers, retailers and consumers (Figure 1).

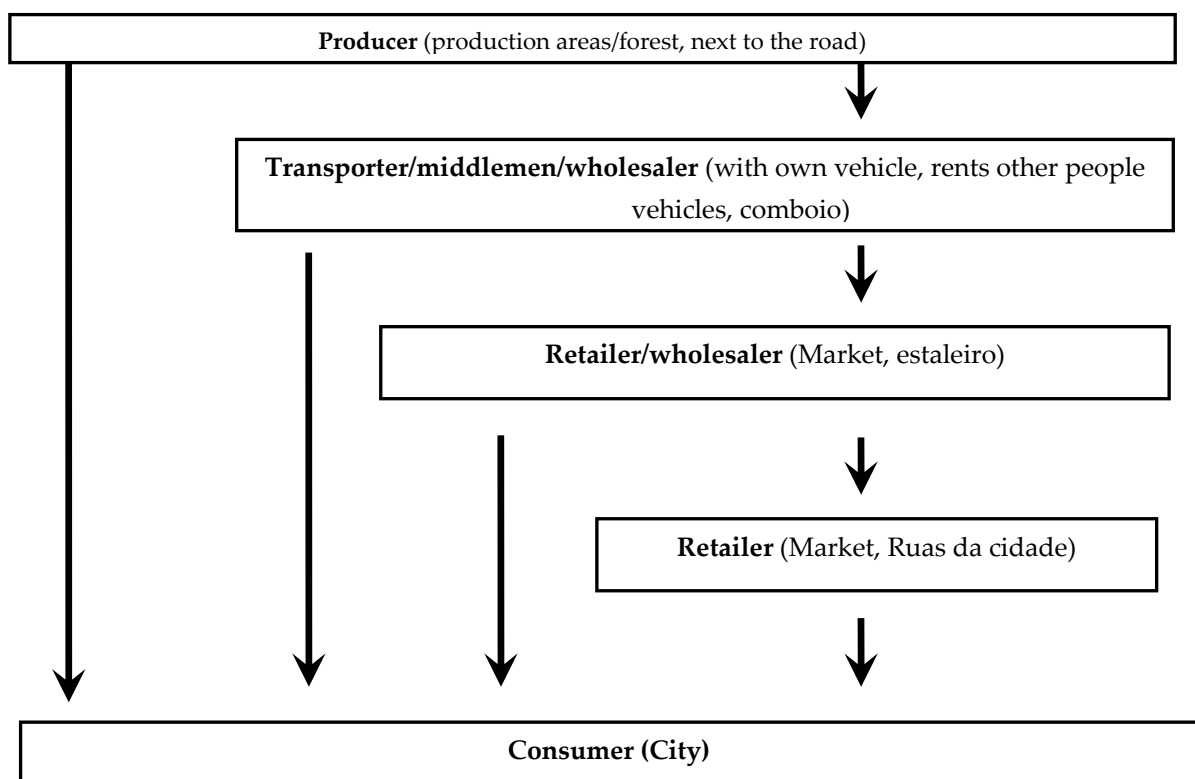


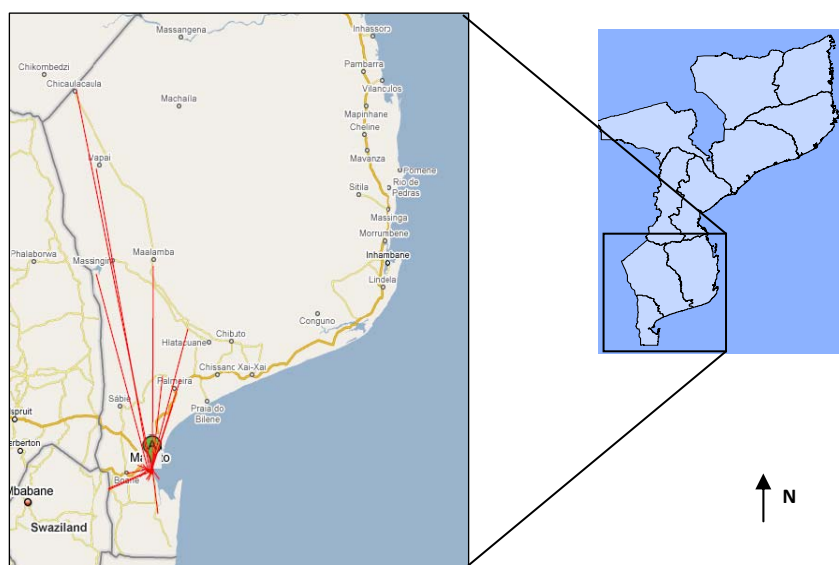
Figure 1- Maputo charcoal supply chain

3.2. Producers

Producers are individuals that burn the firewood to produce charcoal. Most of them live in remote areas, in temporary camping sites with precarious living conditions, close to the resources because there is little wood left around the main cities. In some cases they are locals from the production areas but there is a growing trend

for producers to migrate from one area to another seeking for the resources availability. Also there is an increased trend of getting “outsiders” working as full time producers, being paid by third persons who hold the charcoal production license for the volume produced. Two different scenarios can be observed, i) those who receive a monthly payment and ii) those who receive a payment according to their productivity i.e., producers are paid per bag produced (e.g. 100Mt/bag produced). The second kind of arrangement incentivizes the increased production and may pose a threat to the environment as there is little attachment from these producers to the resources.

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



As result of the distance to the markets, charcoal transportation costs are increasingly becoming higher and may at a certain point in time become prohibitive for the majority of the consumers who depend on them to meet their energy needs.

The licensing process

Only a few producers are currently licensed. Mainly the transporters or the wholesalers who normally buy from the local people hold licenses. Although the forest law and its respective regulations state that the producers should be the licensed ones, the licensing process is a clear attempt at having some control over the charcoal production which is difficult due to the limited capacity the Government has to control the vast forest areas.

Producers are mainly licensed where there is a community/producers association organized in the area (e.g. Mabalane area, Mahel, Massingir) or in the case where the individual, mostly from outside, is involved in all the supply chain stages from production to selling to the final consumer in the city markets. As most producers are not licensed, this gives them less leverage to negotiate the charcoal prices.

There is uniformity in the charcoal prices in the production areas mainly where there are producers' associations, because the charcoal price is decided jointly by all producers. However, a limitation is the lack of clear procedures for the price definition. Also, although there is uniformity in the prices of charcoal within the same area, there is still lack of uniformity on the sizes used for the charcoal packaging which are decided by the transporters who decide on the quantities that are fed into the bags (figure 3).



Figure 3 - Size of the charcoal bags used in Maputo and Gaza (~1.5m height and 100Kg weight)

Charcoal bag sizes varied between and within the provinces. Gaza province presents bags that weigh more, between 70 and 100kg, which represents losses to both the producer and the government because the transporter pays the same price for a higher quantity of charcoal. Therefore, the Government should take adequate steps to ensure uniformity of the rules applied in all the provinces. An option would be the licensing of the charcoal based on its weight together with an improvement of the law enforcement capacity and systems.

Production process

The production process normally involves 4 stages namely: the preparation of material, kiln preparation, carbonization and packaging and sales.

Charcoal producers use mainly the traditional methods of charcoal production, with earth mounded kilns covered with soil being the most common. These kilns are made using different species and sizes of firewood having therefore, varied but normally low production efficiencies (around 10 to 15%), which implies more wood is cleared to produce charcoal and therefore causing more deforestation. The commonly found shape in Maputo is the Boat type (figure 4) while in Gaza there is no standard shape being the majority of kilns shaped in a rectangular format.



Figure 4 - Traditional charcoal production kiln (boat type)

Most of the producers learned the activity through friends or seeing others doing it and have never benefited from any training which can be seen as a limitation because they have some problems with the kilns' failures (due to unburned wood or conversion of wood into ashes). For instances some producers have stated that they have lost the production of 5 kilns /year, which is equivalent to over 100 bags of charcoal a year per producer. This problem can be solved if the carbonization process is more controlled, therefore small kilns are advisable. However, even with small kilns, producers should be able to decide how big or widespread the chimneys must be to ensure a good carbonization hence producers should be trained in the charcoal production which currently does not occur.

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

The biggest kilns were observed in Massingir district with sizes of 10 to 30m long, 2 to 3m wide and 1.5m height. These kilns produce between 140 and 150 bags of charcoal and take approximately 1 month to burn. However the most frequent sizes of kilns is small (9m x 3m x 1.5m) which lasts around 30 days to produce charcoal using the chainsaw and around 45 days using the ax.

On average a producer is able to produce 1 kiln/month or the equivalent of roughly 20 bags of charcoal/month.

Producers normally use the whole tree and the species used are dependent on the availability in the area. Figure 5 below shows the frequency of use of different species for charcoal production.

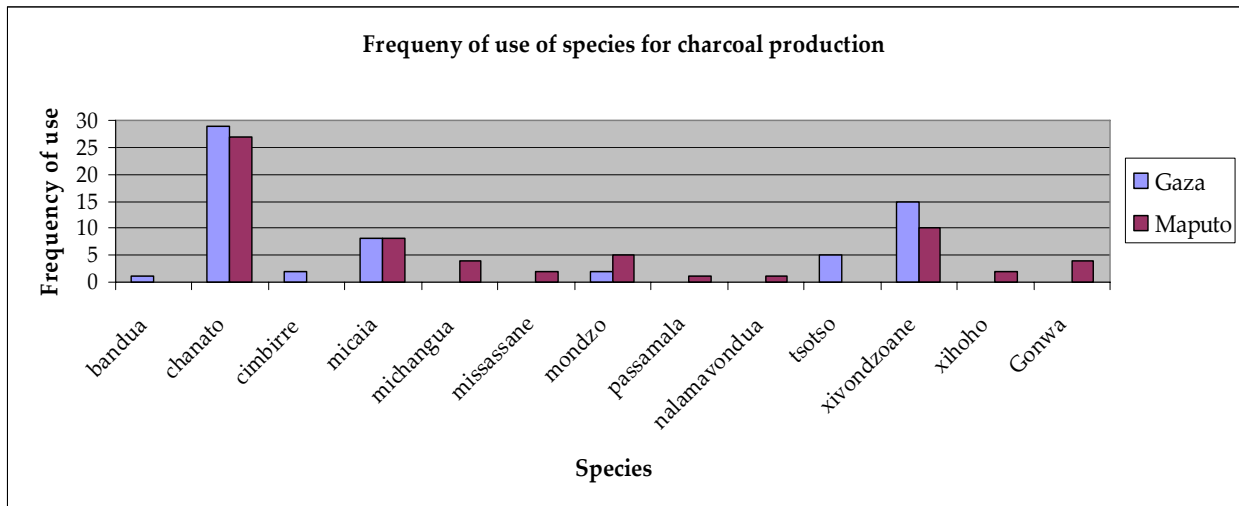


Figure 5 - Frequency of use of species for charcoal production in Maputo and Gaza

The main species used are chanato (*Colophospermum mopane*), Xivondzuane (*Combretum sp*) and micaias (*Acacia sp.*) because they are readily available. In Maputo more species used due to absence of the preferred species (figure 6 below).

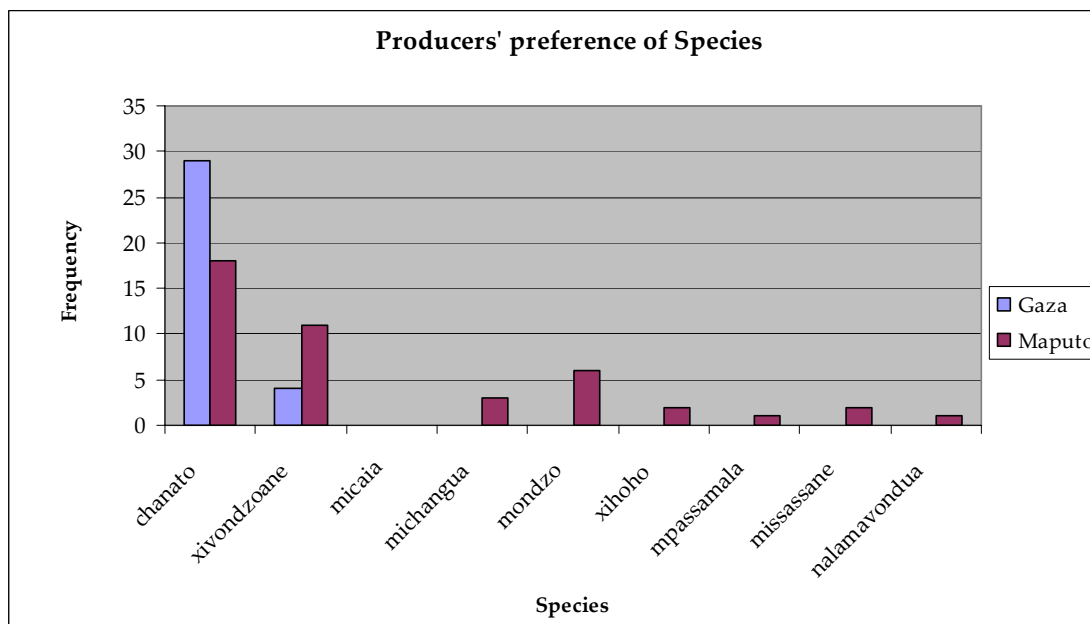


Figure 6 - Frequency of producers' preferences for the charcoal producing species

The most preferred species is chanato followed by xivondzwane. Most of these species belong to the 4th class of the RLFFB but there are some species that are not part of the 4th class and currently being used for charcoal production namely: *Lonchocarpus capassa*, *Ornithogalum sp.* *Androstachys johnsonii*, *Terminalia sericea*, *Combretum imberbe*, *Ziziphus mucronata*, *Guibourtia conjugata* and *Combretum molle*.

1st, 3rd class species and even precious woods are currently being used illegally for charcoal production but after the charcoal is produced and packed only a few people are capable of identifying the species that have been used to produce it. This reflects the lack of capacity for the law enforcement that the Forest and wildlife sector is currently facing as well as the low levels of awareness of local communities regarding what can be used for charcoal production or the little option producers have in Maputo due to the scarcity of charcoal producing species.

The major reasons for the use of such species are the quality of charcoal produced and the abundance of the species in the area. Other reasons, cited less frequently, were the clients' preference and the long lasting characteristics of the charcoal produced using the species. In Maputo, the abundance of the species is the second major reason, while in Gaza there are still more options. Therefore, producers can select the species that produce good quality charcoal.

There is an increasing tendency of using more motorized equipment such as the chainsaws for cutting the trees which increase the productivity of the operations allowing the operators to cut more trees in less time and therefore contributing to accelerated deforestation.

Another problem noticed was the disregard of the height recommended as the best for species regeneration, i.e., 30cm from the floor (Figure 7).



Figure 7 - Trees cut above the recommended height - 30cm.

There are no specific management techniques being applied to the charcoal production process. Also, though the legislation allows it, there are still no charcoal concessions in the country and charcoal production takes place under the simple license exploitation regime.

Additionally, there are no replacements of the trees cut for charcoal. Moreover, despite all producers stating they use big trees and use the entire tree for the production process, it was possible to see there is little observance of the sizes in the trees being cut which, according to the RLFFB, should be trees with a DBH equal or above 30cm for most of the species in the 4th class. All these can also be problematic and threaten the sustainability of the species.

One option to tackle this problem would be the definition of areas suitable for charcoal production alone and manage them as charcoal concessions. People that are currently operating as enterprises for profit making and operating under the simple license regime should be compelled to get a concession because this would oblige them to present a management plan for the area and manage it sustainably.

Due to the continuous demand, charcoal production occurs all around the year particularly when it is a paid work. If done as alternative activity, the production is seasonal as during the rainy season producers normally abandon the charcoal production in favour of agriculture which is regarded as the most important activity.

On average, producers may be able to burn one kiln producing 20 to 30 bags of charcoal per month. The average price of charcoal is 120Mt/bag, therefore, producers' income can be between 2.400 and 3,600Mt/month (~ 100 and 150 USD/month) per person which is almost two times above the minimum wage¹² in the country. Even in those cases where producers consider agriculture as the major activity, it was possible to see that the contribution of charcoal for these communities' livelihoods is of crucial importance with regard to buying food and clothes, getting medical aid and paying school fees for the family. Hence, sustainable charcoal production is required to ensure these producers have a long lasting source of income.

¹² Minimum wage in 2008 for Mozambique is 1.315Mt for the Agrarian Sector and goes up to 2.345Mt for the Defense & Security Sectors

Most of the producers are not making any savings or investing in other income generating activities which would help improving their livelihoods. Also, there are no banks in these areas.

Except for the producers involved in the whole supply chain, most of the producers have little information about markets.

Dimension of activity

Based on calculations, using the registers from the SPFFBs, is estimated that 149.760 trees are currently being cut officially every year to supply charcoal to urban markets in Maputo. Taking the average value of 93.7 trees/ha¹³, officially 1,598.29 ha are being cut yearly to supply charcoal for Maputo markets. This is only a small part of the volume involved in the supply chain as Pereira (2001) reported that only 1% of the charcoal that entered Maputo City was licensed and the remaining 99% entered through illegal ways. Considering this, a close estimation of the real situation would come to a number of 159,829 ha being cut every year to supply Maputo markets.

There is no definite information on the contribution of charcoal production to deforestation, however, a study done in 2005 by FAO consultants has estimated an annual area of 100.000 ha being cut for the whole country for fuelwood production which corresponds to a volume of 10million m³ of trees. For charcoal alone the study estimated that around 5 million m³ of wood are being cut every year and this accounts for a business volume of about 180 million USD (FAO, 2005).

3.3 Transporters

Transporters normally function as middlemen and wholesalers. This category includes individuals that carry the charcoal from the production areas to the district headquarters using donkeys, tractors, trucks and pushing trolleys or that transport charcoal from the district headquarters to the main markets in Maputo city. Transporters can be divided into different groups:

- People who own one or more vehicles and transport their own products - normally licensed and having their own employees or buying from producers to resell in Maputo.
- People who own one or more vehicles and transport third person products mostly from women that dedicate to the buying and reselling business. Not all of these vehicle owners have a license being in these cases the responsibility of having all documents with the owners of the products.
- People who dedicate themselves to buying the charcoal in the rural areas and reselling it in the city of Maputo. They don't have their own transport and can use either rented trucks or train carriages for the charcoal transportation. Individuals that transport the charcoal from the inner production areas to the collection areas (e.g. for the train station), using trucks, tractor or animals.
- People who transport the charcoal from the wholesalers to the retail outlets/ places.

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

Majority of transporters are "outsiders" from the production areas being most of them living in Maputo, Chòckwé and some exceptions from Xai-xai.

Main reasons engaging in the transportation are: subsistence (32%), unemployment (21%) and the profitability of the business (21%). Consequently, if the problems associated with charcoal production are to be tackled by reducing the amount of charcoal that is currently produced, then alternative means of subsistence and employment opportunities should be given to the individuals involved in the transportation activity as well.

There are different transportation means being used for the charcoal. Except for Chicualacuala, Mabalane and Magude, where there are train stations, majority of Charcoal that is brought to Maputo city is being brought by

¹³ Marzoli *et al.* (2007)

either small or big trucks. Animals and pushing cars are only used for transporting charcoal within small distances such as from production areas to the main road or from the market in the city to the retailing place.

The amount of charcoal currently being brought by train is twice that of 2007. This increase can be attributed to the increases in petrol prices that led to a shift from the usage of trucks to trains. Trains are cheaper costing 20.5 Mt/bag and 44.5Mt/bag for the cargo and passenger trains respectively while the truck costs may reach up to 260Mt/bag depending on the area and the truck capacity. Train allows for bigger quantities of charcoal (around 350 bags/carriage) to be brought to Maputo at one time but has the inconvenience of only being available twice a month or in small loads using the passenger train.

Most transporters prefer species such as Chanato (*Colophospermum mopane*) and Xivondzuana (*Combretum molle*). Other species also transported with less frequency are: Micaias (*Acacia sp*) and Mondzo (*Combretum imberbe*). The main reason for the species preference is the quality of charcoal produced in terms of calorific content. Other reasons are the long lasting characteristic of the charcoal produced and consumers' preference.

Charcoal is being transported all over the year but the rainy season (December-March) is the period with little quantities being transported due to the unavailability of charcoal and difficulty of trucks to access the production areas leading to increased prices in the city markets.

Benefits from the charcoal transport may be stated as the incomes that transporters get. Some transporters may get monthly net incomes between 150.000 and 220.000Mt¹⁴ per vehicle. Hence, charcoal transportation is more profitable for the transporters who are earning over 20 times more than what producers get. Some of the transporters may have more than one vehicle (some had 2 or 3 vehicles). If nothing is done to revert the situation the Government aspirations of reducing the rural poverty through sustainable use of natural resources may be difficult to achieve in the case of the charcoal production areas as we will keep enriching the urban people who do not re-invest in the rural areas. Consequently, these rural areas that are still "rich" in resources are likely to remain with the current high poverty levels.

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

Truck owners are generally outsiders who do not belong to the production areas and are mainly driven by the incomes generated by these activities. So, when there are little revenues generated through this activity they are likely to switch to other profitable activities.

Quantities of charcoal that enter using the passenger train are small compared to the loading train.

The majority of charcoal is coming from Mpunzi followed by Combomune and Chicualacuala. Mabalane has a community association which helps to control what is coming from there but it is impossible to ascertain about the charcoal that is coming from other places.

There is a big chunk of charcoal entering Maputo city by train. In one week, it was possible to observe 2,914 bags of charcoal entering using the passenger train (equal to 23,312 bags/month) and 7,735 bags entering using the loading train (amounting 15,470 bags/month). A rough estimation suggests an amount of around 38,782 bags/month of charcoal entering Maputo city by train. However, to get more realistic numbers observations should be done over a longer period of time.

Assuming an average size of bags of 85Kg, one would come up with an estimation of 39,558tons of charcoal entering by train every year to supply Maputo markets. Considering a wood density of 0.8tons/m³¹⁵ for the

¹⁴ This still includes the costs related to payment of salaries (5000Mt/mont) and vehicle maintenance costs

¹⁵ Siteo, 2007

charcoal producing species and a conversion efficiency of 15%¹⁶ we would come to an amount of 263,717m³ of firewood used to produce this quantity of charcoal. Taking an average volume of 31.9m³/ha¹⁷, then approximately, 10,333Ha of forests are being cut to supply the charcoal that enters Maputo by train yearly. However, besides the train, a lot of charcoal is being brought by small (3-5 tons) and big (above 5 tons) trucks.

Due to the informal characteristic of the business there are no statistics that relate the number of transporters involved in this supply chain. Assuming that except for the cases of community associations the majority of licenses are issued for transporters, then we can come to a figure of around 96 transporters for Maputo province and around 216 for Gaza. This is only the number of transporters that are currently registered and there is still a large portion of charcoal that is being brought unregistered/illegally.

Gaza is requiring 11 times more charcoal than Maputo and most of this charcoal is being produced to supply Maputo markets. Also, the number of licensed individuals from Gaza is twice the number of transporters from Maputo. Currently in Maputo there are 2 main supply areas namely the Matutuine (42%) and Magude (41%) districts, while in Gaza majority of licenses are being issued to Massingir (45%) and Mabalane (35%) districts.

Based on producers' production capacity a total of 5,098,553m³ or equivalent to 4,078,842tons of wood are currently being exploited to supply the urban demand of Maputo city. This figure does not differ greatly from the one estimated using the transportation data which estimates an equivalent volume of 4,395,293tons or 5,494,116m³ of firewood used for charcoal production. The exploited area is slightly higher in this case estimating around 172,229Ha currently being cut every year to supply Maputo markets.

The recent forest inventory estimated, for Maputo and Gaza provinces, an annual change of forest cover of around 17,000 and 13,000ha, respectively, between 1990 and 2002 (Marzoli, 20007). It is known that the charcoal production is amongst the main reasons for the changes in the forest cover. As this data seems to be outdated it is important to assess how these figures of forest cover changes have altered between 2002 and 2008.

In 2005, an FAO study estimated that around 211,994 tons of charcoal was consumed per year in Maputo City representing 29% of the total consumption in the country. A more recent study carried out by Siteo in 2007, estimated a total consumption of 5 million tons of charcoal for the whole country which compared to the estimated value of 659,294tons means that Maputo city alone is currently consuming almost 13% of the charcoal consumed in the country.

Comparing the current estimations, which can only be used as rough indicators, given the little rigor used in their estimation, with that of FAO (2005), one wonders about the reasons that led to the increase of around 210% in the quantities of charcoal being consumed in Maputo city. Current quantities of charcoal that enter Maputo city have tripled in four years while the population size did not increase greatly¹⁸. One explanation is the continuous increase in fossil fuels' prices which may have motivated some to switch from the usage of these fuels to charcoal which is considered cheaper than gas.

3.4 Wholesalers

Wholesalers normally receive the charcoal from transporters with whom they have already made arrangements to sell the charcoal and pay them afterwards. Some of the wholesaling places belong to the transporters or the producers that are involved in the whole supply chain.

Mainly women are engaged in wholesaling business, mostly in the age range of 40-60years.

Wholesaling places are widespread along Maputo city markets but the main are: Xiquelene (Mucoriane), Malanga, Adelino, Inhagoi, Janet. Other markets may have wholesaling places but the quantities of charcoal currently being traded appear to be lower than in the above-mentioned markets.

Main reasons for engaging in the activity are subsistence and poor employment opportunities. As long as consumers demand charcoal and producers still produce it, this activity is likely to continue. It is important to

¹⁶ Average efficiency of charcoal production in Mozambique (Siteo, 2007)

¹⁷ Average volume of trees for all forests and woody formations in the Mozambique (Marzoli, 2007)

¹⁸ According to INE, 2008, Maputo city population growth was 11.3% (from 987,943 to 1,099,102 inhabitants) between 1997 and 2007

note that wholesalers would have little alternatives if the charcoal business was to be closed because of their age, educational level and lack of preparedness for formal jobs except informal sales.

Market trends normally follow the production trends; during the summer/rainy season, charcoal becomes scarce thus, the charcoal prices tend to rise. Also, charcoal prices vary, among others, depending on the area where the charcoal is being sold, and the origin of the charcoal as well as the species used.

Main costs involved in the wholesaling are the market fee the charcoal purchase prices that are being paid to the transporters (350Mt/bag). On average, wholesalers may get monthly net incomes between 3,650 and 12,200Mt which is still over the minimum wages in the country and more than the producers' net income.

3.5. Retailers/resellers

Retailers buy the charcoal in bags from the transporters or wholesalers and resell it in small cans or piles. They can be found in all markets and along the roads in the city (Figure 8).



Figure 8 - charcoal retailing

Due to the informality of the activity, it is difficult to estimate the numbers of people that are involved in it. But one may assume there are large numbers of individuals involved in this activity.

As with other stakeholders in the supply chain, the main reasons for entering in this business are subsistence mean and unemployment.

Retailers sell the charcoal all year as there is always demand for this source of energy. One bag may be divided into 4 (four) cans of 25L plus other small cans and piles. Retail prices vary between 100 and 130 Mt for the 25L can, 10 to 15 Mt per can of 1800gr, 8 to 10Mt of 900gr cans and 5 to 7Mt for the small piles. Retailers may sell 4 to 9 bags of charcoal per month. They buy the charcoal at 350Mt/bag and sell it at 470 to 500Mt/bag therefore getting an income that varies between 480 and 1350 Mt (~19 to 54USD/month).

3.6. Consumers

Charcoal consumers are normally located in the urban and peri-urban areas and may be divided into two different groups (Siteo, 2007): i) Domestic - those who use it for cooking and heating the houses and ii) large/industrial consumers - those who use charcoal to cook or generate heat for industrial processes such as collective kitchens (e.g. hospitals, schools, prisons, army base, restaurants and fast food outlets).

It is estimated that around 70-80% of the urban population consume charcoal in their houses (Sitoé, 2007) mainly because it is considered accessible and cheaper than other sources of energy. The National census estimated the urban population at 1.099.102 inhabitants for Maputo city. Therefore one may assume that almost 880,000 inhabitants currently using charcoal.

Main reasons for the usage of charcoal are the accessibility and the absence of affordable alternative sources of energy. Mozambique has a huge potential in terms of energy. However, only a small portion of this potential is currently being explored (DNERN, 2006).

When compared to the use of gas or electric energy, the use of charcoal is more expensive to the user. However, low income levels make charcoal a good alternative for a great part of the population as the user can buy it in small quantities for daily consumption. Also, charcoal doesn't have initial costs associated with its usage

except for the stoves which are simple but less efficient and normally cost less than 150 Mt each (~6 USD) (Figure 9).



Figure 9 - charcoal stoves

The costs of using alternative energies such as the gas or electricity are prohibitive to the majority of the population. Initial investments needed to acquire the stove are at least 500Mt (~25 USD) and the other necessary equipment is estimated at an amount of 2,700Mt (equivalent to (~107USD), which is two times above the minimum wage in Mozambique.

Another important issue is related to the cultural aspects, such as the belief that the food prepared using charcoal tastes better than the one done using electric or gas stoves, may also hinder the replacement of charcoal by other sources of energy.

The increase in urban population is leading to increased consumption of charcoal which increases the rate of deforestation. Hence, to alter this situation, the Government should put some effort in providing alternative and affordable sources of energy to urban populations.

Estimates of market size

There are no exact figures related to the number of people and the quantity of charcoal being consumed in Maputo. In 2005, FAO estimated that 150,000 are employed in the fuelwood sector in Mozambique, the value of charcoal in the market amounted at 180 millions USD and approximately 10 millions m³ of wood are being removed from the forests in the country every year to supply energy for urban populations.

Sitoe (2007) estimated a per capita consumption of 0.9 ton/year. Current demand is around 14.8 million tons/year and the current production capacity is 22 million ton/year. This means that the total balance for the country is still positive (Sitoé, 2007). However, it is important to note that the consumption and demand are not equally distributed in the country and therefore some provinces currently have a negative balance (Drigo *et al*, 2008).

Maputo is no longer a viable source of charcoal as there is little biomass left but there are still some areas with low forest potential that should be managed for sustainable charcoal production in the southern part of the country (Figure 10).

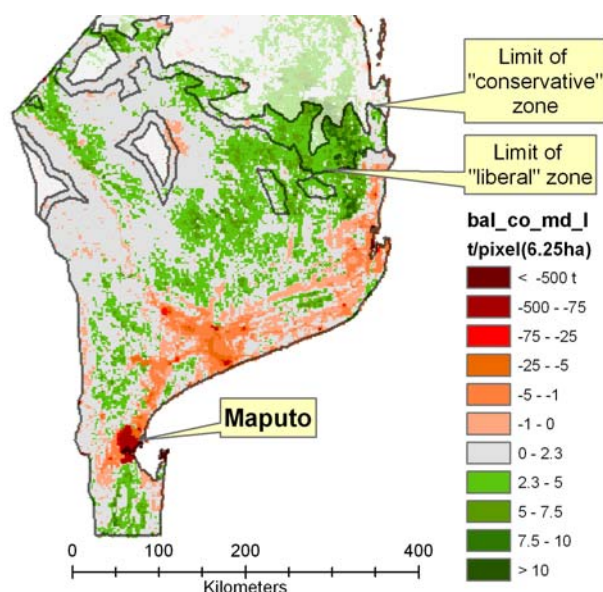


Figure 10 - Map of WISDOM analysis for Southern Mozambique (Drigo et al, 2008).

Around the coastal areas where the main urban and peri-urban areas are located, the woodfuels balance is negative. Areas that still hold a positive balance in the southern region of Mozambique are mainly located in the hinterlands of Inhambane and Gaza provinces (Drigo *et al*, 2008). Gaza still has a positive balance and the same is the case in Inhambane but it is crucial to introduce management programmes for areas that are currently suffering from the pressure of Maputo market demand and may in a short while lose the vegetation cover as has happened in Maputo.

Most of the people interviewed were not aware of the linkages between the charcoal production and the global environment. Besides reducing the carbon stored in the forests and releasing emissions during the burning process, charcoal production and consumption also causes reduction of the forest cover, biodiversity and environmental services threatening the resources' sustainability as well as causing health problems. Looking at current consumption patterns, it is important that the different stakeholders take actions to solve the problem and avoid future environmental problems. Options to tackle this problem include: i) dissemination of improved production technologies such as the drum kilns, ii) introduction of stoves with improved efficiency, iii) provision of affordable alternative energy sources and iv) the introduction of fast growing species and agricultural wastes for charcoal production. Further, awareness raising campaigns for all stakeholders involved in the supply chain are needed.

3.7 Institutions involved in the supply chain

Government institutions work at different levels and play different roles to ensure that the Government objectives of sustainably managing the forests are achieved. The Ministry of Agriculture is responsible for the sustainable usage of the forest and wildlife resources. Other Government agencies include: Provincial Services of Forest and Wildlife (SPFFBs), District Services of Economic Activities (SDAEs) and Local Administrations who implement the policies and legislation pertaining to the use of these resources including the issuing of licenses and permits for charcoal production as well as law enforcement.

The Ministry of Energy is responsible for the energy sector. These Ministry's interventions have been focused on the consumption aiming at reducing the consumption through introduction of improved technologies (e.g Casamance kiln). However, it is important to note that after the introduction of new technologies there has been follow up on their implementation.

There is little cooperation between these two Ministries which should in fact be working together if the sustainable usage of forest resources is to be achieved. Moreover, it would be more effective and beneficial for forest sustainable management if the biomass energy sector was taken care of by a single institution rather than divided between different institutions.

Apart from the Government institutions there are also some NGOs working in the forest sector and these NGOs also play an important role in disseminating good practices for the management of the forest resources. They are mainly involved in advocacy and raise awareness for the consequences of over-exploitation of resources for the charcoal production. However, NGO's efforts may sometimes contribute little if not backed by the Government institution which should carry on with their initiatives after the projects are finished. Hence it would be good if all projects implemented by NGOs could at the same time build capacity in the government sector to follow up and sustain activities beyond the lifetime of the projects.

4. Conclusions

The Maputo charcoal supply chain involves producers, transporters that act as middlemen and/or wholesalers, retailers and consumers.

Apparently a large number of people are involved in the supply chain, however, the informal character of the business make it difficult to have accurate statistics of the sector and its real contribution to people's livelihoods.

Many reasons determine the entrance of the people in the supply chain. On the producers' side, the main reason is the high unemployment rates.

Different entities are involved in the supply chain, however, there is still little interaction and coordination between them which reduces the probability of success of their interventions.

Mozambique Government is willing to manage the forest and wildlife resources sustainably and contribute to the poverty reduction. Also there is a good policy and legislative systems providing directives that would enable the sustainability of the sector while ensuring the sector is contributing to poverty reduction in the country. However, some problems persist in the charcoal supply chain namely:

- Lack of capacity to enforce the legislation particularly at the exploitation areas (there is little control over species, sizes and techniques being used)
- Weak production systems which lead to wasting more resources
- Absence of specific fees for charcoal production, hence the usage of fee system based on the firewood fees which are cheap
- Unrealistic conversion of firewood to charcoal bags reducing the charcoal price to unrealistic levels.

The existence of producer associations and units at provincial level that work with communities is actually helping to improve the control over the production areas. But there is little compliance with the law at the production levels which is associated with the lack of Government capacity to enforce the law, which in turn may in the long run threaten the sustainability of the resources.

Based on the study estimates, currently more than 5 million m³ of wood are being cut corresponding to an area of over 100,000Ha of forests being cleared to supply charcoal for Maputo city¹⁹.

Although the total supply/demand scenario for the country is positive, there are some areas, such as Maputo province where this balance is currently negative. This means interventions to revert the situation should prioritize the supply for this areas.

5. Recommendations

To address some of the problems identified in the study, the following is recommended:

- Carry out detailed studies to estimate the real dimension of the charcoal supply chain and ensure better visualization of the charcoal production impacts

¹⁹ Indicative figures that need further verification

- Carry out studies to determine the efficiency of the conversion of firewood to charcoal and define a standard conversion rate that would enable a realistic pricing of the charcoal using the firewood price
- Redefine the exploitation fees for charcoal production or introduce a system of licensing based on the bags and at the same time standardize the size of the bags
- Promote the establishment of forest concessions for charcoal production
- Promote the licensing of producers associations rather than the transporters and middlemen so that producers have better leverage when negotiating charcoal prices and therefore increasing their levels of incomes. This would also improve the control over the licensing process. Follow up with reforestation activities and better control on the areas, techniques and species being used
- Define areas for charcoal production and ensure their management follows an approved management plan. Charcoal produced in these areas could be certified and the area could probably be eligible for the CDM.
- Introduce improved charcoal production and consumption technologies to reduce the current exploitation levels

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Woodfuels Integrated Supply Demand Overview Mapping (WISDOM) for Mozambique

C. Cuambe²⁰

National Directorate of Land and Forests

1. Introduction

The main objective of the Wood Energy Component of the Consolidation Phase of the Integrated Assessment of Mozambican Forests (AIFM) was to enhance the capacity of the country for the formulation of sound wood energy policies and the sustainable management of biomass resources through the development of a wood energy information system for the production of geostatistical data and thematic maps describing and quantifying the national bioenergy production and consumption and its potentialities.

In this regard, a consultancy was carried out to assist the implementation of a woodfuel demand and supply analysis for using the WISDOM methodology to support the sustainable management of woody biomass resources and wood energy development planning in Mozambique.

Wood energy is not a self contained and delimited sector and does not have a well defined institutional structure responsible for its planning and control. It rather sits at the intersection of many different sectors (forestry, energy, agriculture and rural development), disciplines (silviculture and forest management, agronomy, physics, chemistry, engineering, etc.) and institutional competences, each of which has its specific portfolio of responsibilities and planning tools but none of which perceives a direct responsibility towards the development and monitoring of sustainable wood energy systems (FAO, 2008). Consequently, wood energy systems sound policy and planning can only be achieved if these different “souls” are integrated. Thus, a critical challenge in wood energy planning is to overcome the fragmentation of competences and responsibilities that characterize the sector and to achieve an adequate level of integration and collaboration among the sectors involved.

Sometimes, the energy sector uses planning tools that include wood energy elements, but these are analyzed mainly from consumption perspectives, leaving out most of the issues related to woodfuels supply sources and production sustainability.

Forest management tools, on the other hand, deal with production sustainability (FAO, 2002b), but focus mainly on timber concessions and industrial roundwood production rather than woodfuel production, in spite of the paramount importance of woodfuels among forest products. Moreover, forest management is limited to forest formations, while a significant fraction of all consumed woodfuels is produced outside forests and other wooded lands (i.e., shifting cultivation areas, land use conversions, agroforestry, farmlands, etc.) or from harvesting and industrial forestry residues.

Specific wood energy problems are commonly dealt with by means of detailed local studies whose results support local planning or are expanded at national level to guide energy action and interventions. However, many local studies and projects, if not most, were focused on specific cities and on their fuelwood and charcoal supply zones, with the specific scope of supporting sustainable resource management and the continued supply of woodfuels (Bertrand et al, 1990; ESMAP, 1993; Chaposa, 1999). These studies provide adequate information and effectively support the formulation of sound policies, but they are expensive and time consuming. Their cost makes them limited in coverage and sporadic, thus failing to provide the national overview that is necessary for the formulation of national policies in respect of renewable energy potentials, forestry and energy planning, inventories of greenhouse gases, etc.

Moreover, the local studies confirmed the local heterogeneity of wood energy situations and helped to mark out the fundamental characteristics of wood energy systems; wood energy systems which comprise the production, distribution and consumption of woodfuels are complex and site specific. Woodfuels may involve trade aspects, may be transported far from their production sites, or may be gathered and consumed locally. Consumption patterns may change rapidly in favour of “higher” fuels such as gas and kerosene, or “lower” fuels such as agricultural residues or cow dung, in response to varying market conditions or levels of accessibility to wood resources.

²⁰ Paper adapted from Drigo R. (2008)

Demand and supply patterns influence each other and tend to adapt to varying supply patterns and resource availability. This means that quantitative estimations of the impacts that a given demand pattern has on the environment are very uncertain, and should be avoided (Leach and Mearns, 1988; Arnold et al., 2003). Hence, successful planning requires a thorough understanding of the entire context, which encompasses the whole supply chain, including non-forest supply sources, the consumption patterns and trends, and its social, economic and institutional stakeholders.

2. WISDOM overview

To cope with the various dimensions of wood energy systems, the Wood Energy Programme of FAO developed and implemented the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology, a spatially-explicit planning tool for highlighting and determining woodfuel priority areas or woodfuel hot spots (Drigo *et al.*, 2002; FAO, 2003). At national level, the WISDOM approach has been implemented in Mexico (FAO, 2005; Masera *et al.*, 2006), Slovenia (FAO, 2006a), and Senegal (FAO, 2004). At subregional level, WISDOM was implemented over the eastern and central Africa countries covered by the Africover Programme (FAO, 2006b) and over the countries of SE Asia (FAO, 2007).

The WISDOM methodology is characterized by its thematic specificity and by its open framework, which allows a high degree of flexibility and adaptability in the heterogeneity and fragmentation of the data related to the production and consumption of woodfuels. WISDOM approach has the advantage of considering the entire demand and supply context, which supports a consistent and objective definition of the sustainable supply zones of the major cities (Urban Woodsheds).

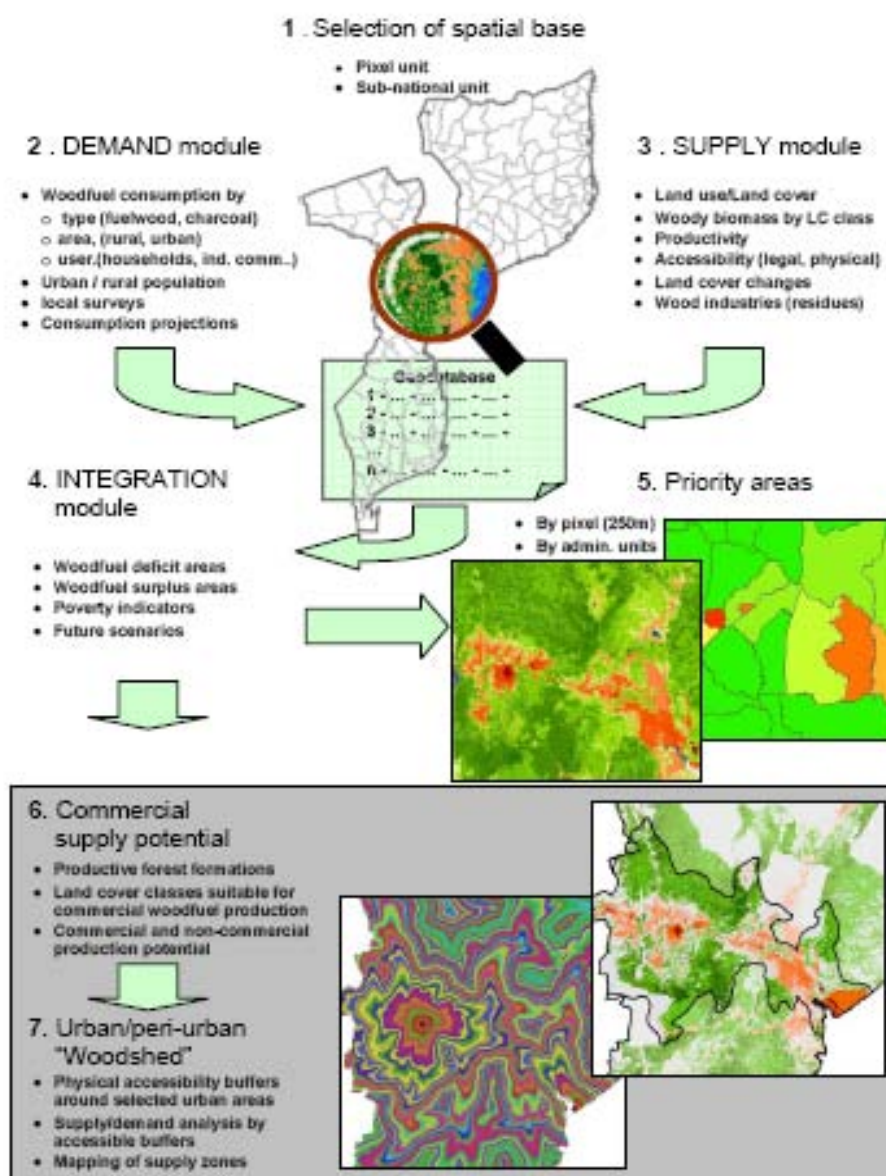
A national-level WISDOM analysis does not replace detailed local-level analyses for operational planning, but rather it is oriented to support a higher level of planning, i.e. strategic planning and policy formulation, through the integration and analysis of existing demand and supply-related information and indicators. More than absolute and quantitative data, WISDOM is meant to provide relative or qualitative valuations, such as risk zoning or criticality ranking, highlighting, at the highest possible spatial detail, the areas deserving urgent attention and, if needed, additional data collection. In other words, WISDOM should serve as an assessing and strategic planning tool to identify sites for priority action.

WISDOM is based on: a) the use of geo-referenced socio-demographic and natural resource databases integrated within a geographical information system; b) a minimum spatial unit of analysis at sub-national level; c) a modular, open, and adaptable framework which integrates information of relevance to wood energy from multiple sources; and d) a comprehensive coverage of woodfuel resources and demand.

3. Methodology

An overview of the analytical steps and main thematic layers of WISDOM Mozambique is shown in Figure 1. In consideration of the acquisition dates the satellite images used for the interpretation of land cover and the stratification of the national forest inventory, it was agreed to set the reference year of the WISDOM analysis at year 2004.

Figure 1: WISDOM Mozambique: main analytical steps and thematic layers



To implement the WISDOM analysis, the following activities were carried out: i) review data and maps produced by AIFM and provided by institutional partners for the development of the supply and demand modules, ii) Define and initiate the procedure for developing a geostatistical dataset on the distribution and pattern of actual and potential biomass productivity available for energy use and of current consumption; iii) Conduct the analysis to the extent possible with the available dataset; iv) Define and implement a step-by-step analytical procedures to clarify the processes and allow revision, updating of the specific data layers, v) Discuss with partners (Universities, Forestry and energy agencies) about the overall WISDOM approach and on the specific parameters to be assessed concerning biomass stocking, productivity and consumption patterns to obtain additional advise and reference material.

4. Data, estimation procedures and main results

The study involved the use of a variety of datasets namely:

i) Administrative maps provided by INE,

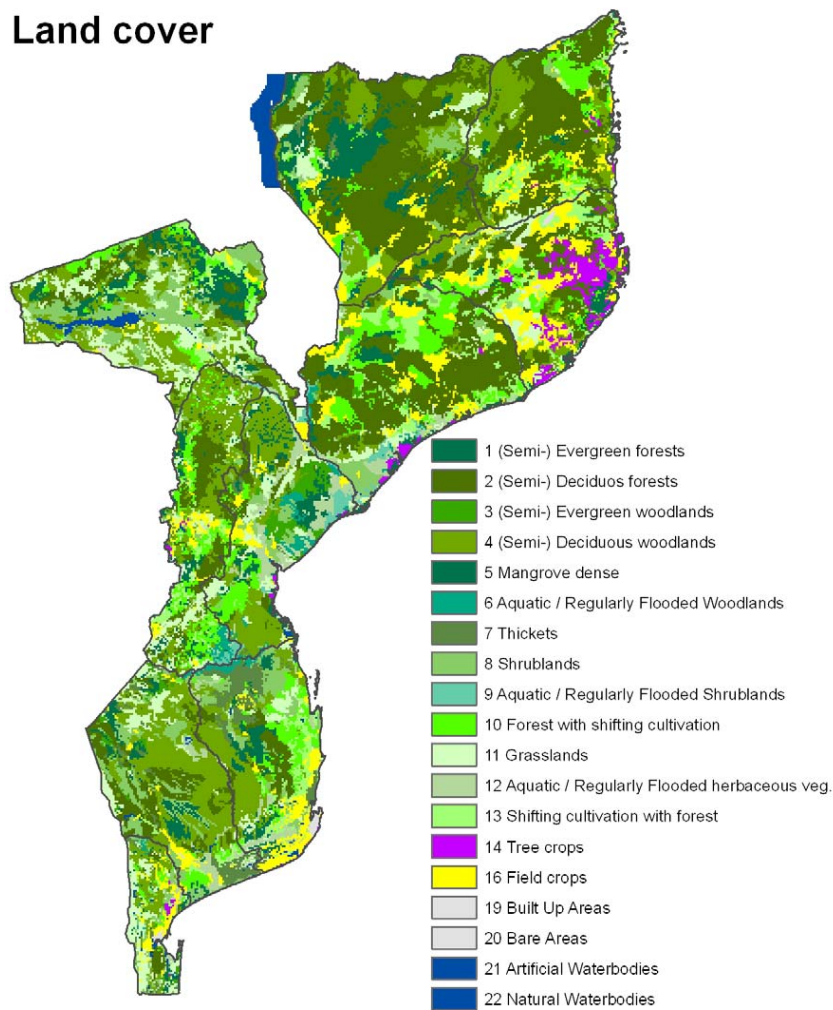
ii) National Land Cover map of Mozambique used as main reference created in the framework of the AIFM Programme and used as basis for the National Forest Inventory, used for mapping of biomass stock and increment, mapping of physical accessibility and the rural population probability model, etc.). Figure 2 shows a “summary” of this map by displaying the principal land cover class.

iii) Tree Cover Percent map based on MODIS 500m (Hansen et al. 2003), resampled at 250m.

iv) Map of urban areas created purposely for the WISDOM analysis

v) Road network based on the available maps of communication infrastructure that are limited to major motorable roads.

Figure 2: Land Cover Map of Mozambique

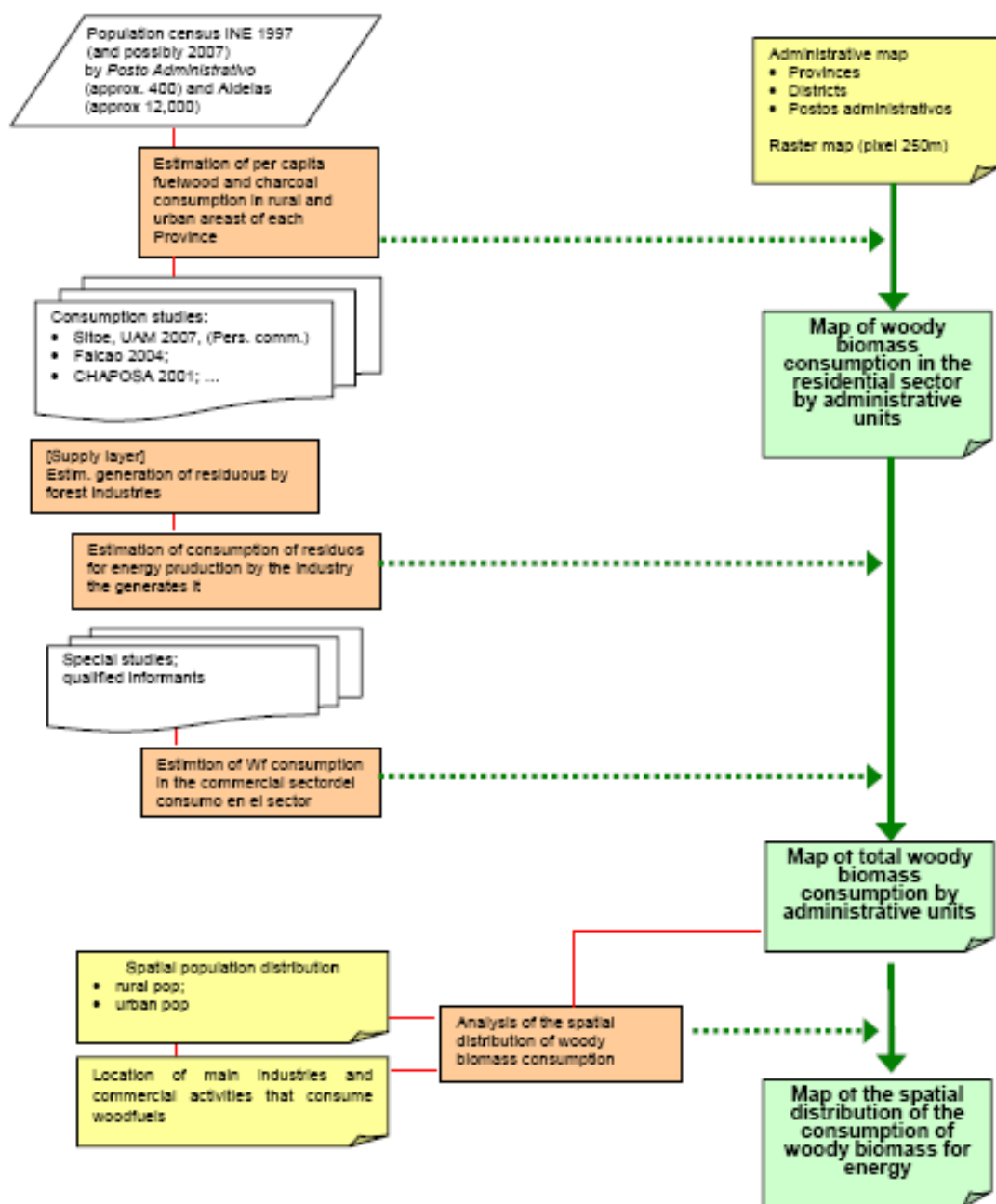


A Raster cell size of 250m was adopted for the study.

4.1. Demand module

The flowchart in Figure 3 provides a simplified description of the main thematic layers and processing steps required to complete the Demand Module.

Figure 3: WISDOM Mozambique: Demand Module. Flowchart of main analytical steps



Additionally, the study used the most recent and detailed references on fuelwood and charcoal consumption in the rural and urban areas of Mozambique namely: Sitoe (2007), Mirasse and Brouwer (2004), and Brower and Falcão (2001). Estimates on the fraction of urban and rural population that uses fuelwood and or charcoal for cooking and for lighting were taken from INE's surveys of households (IAF 2002/3) and from INE's survey of basic wellbeing indicators (QUIBB 2000/1).

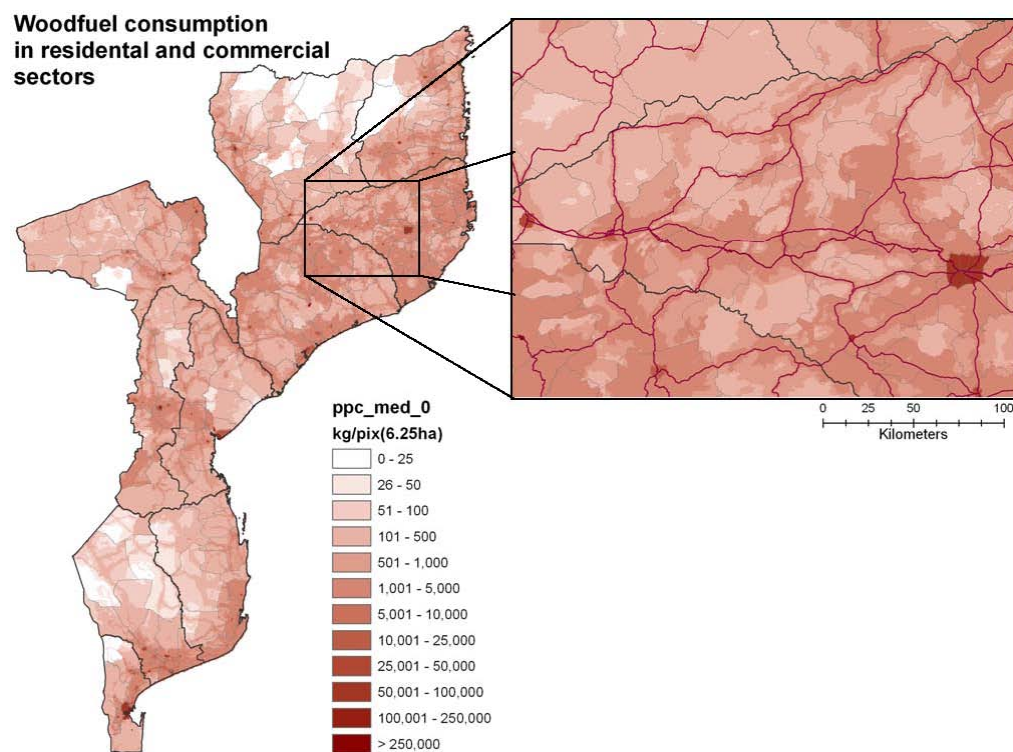
The spatial distribution algorithm of rural population (defined by PA statistics) was based on land cover characteristics, road proximity and river proximity and terrain model. In order to evaluate the significance of certain variables (i.e. the influence of river proximity on patterns of population distribution) factorial analysis was carried out over the Province of Manica as well as over the entire country using PA population as function of relevant land features (land cover classes, proximity from roads and other populated places).

Population statistics to be spatially distributed referred to the situation at year 2004, which is the reference date of WISDOM analysis. The reference demographic statistics that were used to assess 2004 urban and rural populations were: INE 1997, Projection to 2004 based on INE 1997 and successive projections revisions, Preliminary District-level results of the INE Census 2007. The best approach to estimate 2004 population appeared to be using 1997 – 2007 total population growth rates by district with inference of urban/rural fractions based on the growth rates of the cities reported in the 2007 Census results.

Missing any reference data on fuelwood and charcoal consumption in commercial activities in all urban areas of the country, the same proportion to residential consumption found for Maputo (Brower and Falcão, 2001) was assumed. The map of the spatial distribution of woodfuel consumption in the residential and commercial sectors is shown in Figure 4.

Reference studies on the consumption in the industrial sector (tea and tobacco drying, fish smoking; ceramics; brick making; blacksmith): Statistics on the location and production levels of these industries could not be found. Thus, estimation and mapping of industrial woodfuel consumption was the weakest component of the entire study.

Figure 4: Spatial representation of woodfuel consumption in Mozambique



4.2. Supply module

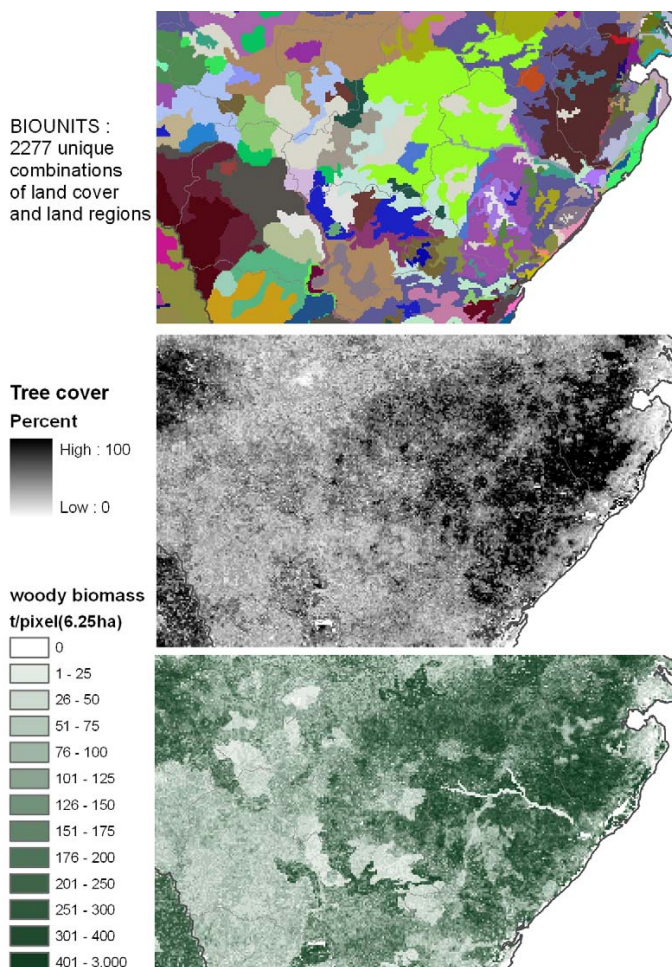
The flowchart in Figure 5 provides a simplified description of the main thematic layers and processing steps required to complete the Supply Module. Direct supply sources refer to the land cover classes and relevant stock and productivities. Main source data used in the estimation process were: i) the National forest inventory data, ii) Land cover/ecological class groupings iii) Biomass expansion factors, wood density factors and chosen increment estimation equations and iv) Stock and sustainable productivity of surveyed land cover classes.

The estimation of biomass stocks per hectare and productivity was done considering the individual land cover classes, the ecological regions where they occur and the class combinations that are actually represented in the final land cover map. This resulted in 2277 individual “biounits” (multi-polygon entities) each of which carrying a certain biomass stock (t/ha) value. The spatial distribution of woody biomass stock and sustainable biomass productivity was done using the MODIS Tree Cover Percent values as proxy of spatialization to represent the stock and productivity variance within the entire “biounit” category, according to the following formulation:

$$\text{value in cell of biounit} = \text{tree cover} / \text{average tree cover of biounit} * \text{average value of bb}$$

Example of biounits, Modis tree cover data and resulting stock map are shown in figure 6.

Figure 6: Cartographic “ingredients” of the supply module (Biounits based on land cover and ecological zones; Tree Cover Percent map based on MODIS 500m) and woody biomass stock map.

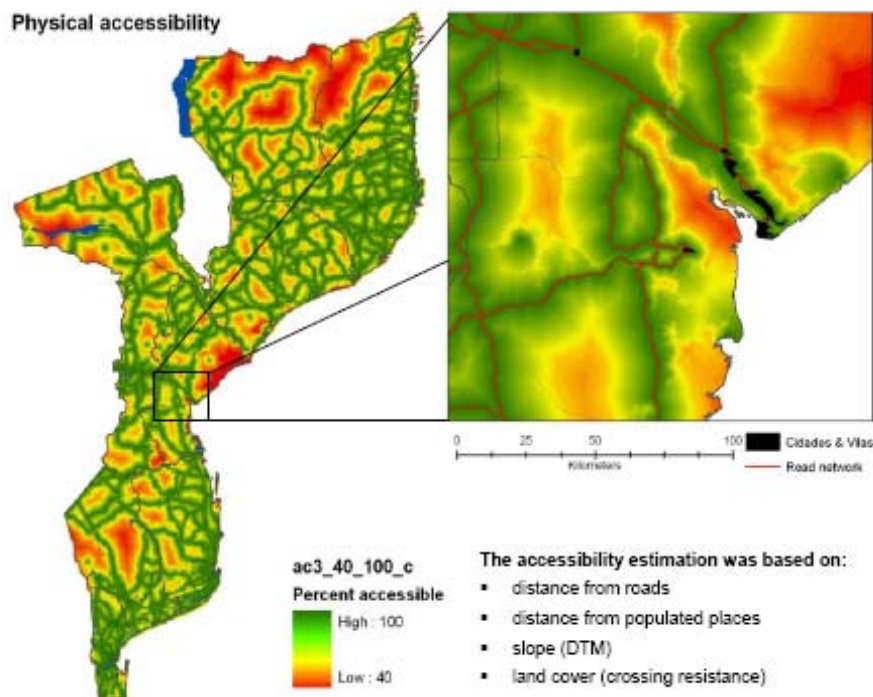


On long term planning, the amount available for energy use is limited to the non industrial assortments, including the branches and defective stems of the commercial species. For a shorter term planning it should be considered that the non-commercial fraction of commercial trees is not really available until the commercial assortment is actually extracted. In this respect the statistics of extracted industrial volumes may be used to improve the estimation of currently available woody biomass.

Deduction of non-industrial assortments used for uses other than energy, such as construction poles and fraction of trees/shrubs that provide non-wood forest product and that are thus protected by villagers, was estimated on the basis of the average amount of wood used in the building of rural hats, the average duration of the construction and the average number of inhabitants, parameters derived from a research conducted in the Province of Inhambane (Cuambe, 2004). Thereafter, the poles volume demand was distributed as a direct factor of the map of spatial distribution of the rural population (where the constructions are located) and then deducted from the non-industrial productivity mapped during the previous step.

Physical accessibility - is the spatial parameter that defines the accessibility of a given biomass resource in relation to the distance of the nearest road and populated place and to a “cost” factor based on the slope and on the characteristics of the terrain to be crossed. The continuous value resulting from the cost-distance analysis was then converted into segments on quantiles and an accessibility factor (% accessible) was associated to each segment. Considering that the available road map is incomplete since it does not report smaller tracts and that the location of rural villages below the “vilas” level are also not known, the influence of the cost-distance analysis was not overemphasized in the accessibility ranking. In fact, the highest cost areas were not considered as totally inaccessible but only partially accessible. Quantitatively, it was set that to the highest cost areas was given a factor of 0.4 (40 % of the resources being considered physically accessible) and that such factor was progressively increased to reach 1 in the lowest cost zone (100% of resources accessible). The map of physical accessibility resulting from the process is shown in Figure 7.

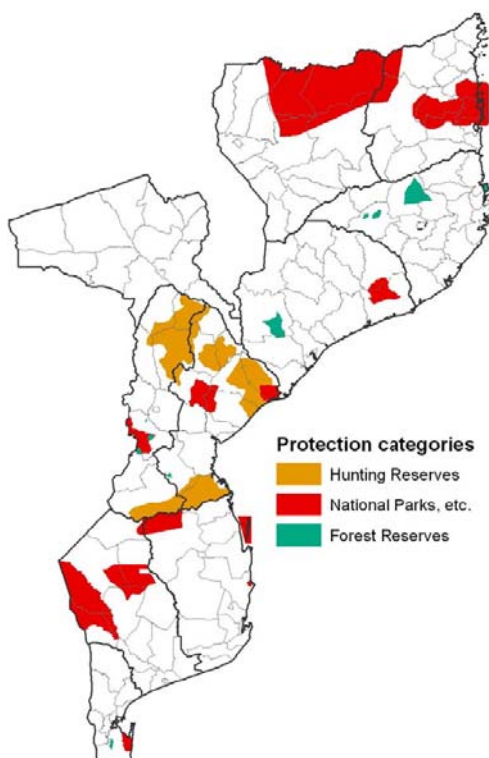
Figure 7: Physical accessibility map.



Legal accessibility - Accessibility restrictions to forest exploitation within protected areas are limited to commercial operations, leaving virtually untouched the rights of local populations to gather the fuelwood and construction material needed for own use. This means that legal accessibility was used only in the definition of the “commercial” productivity, while it was not considered in the calculation of the local supply/demand balance. In practice, the legal accessibility factor was applied only to the surplus biomass resulting from local balance, and thus reducing the resource available for commercial charcoal and fuelwood production for distant urban markets and exports.

Main protection categories considered are shown in Figure 8 namely: Protected areas under Ministry of Tourism, Hunting Reserves and Forest Reserves. Fazendas de Bravio. This dataset is only partially digitized and the inclusion in the analysis of accessible resources is therefore incomplete.

Figure 8: Protected areas categories used to map legal accessibility constraints. (Fazendas do Bravio are not displayed due to incomplete data)



4.3. Indirect supply potential

The procedure to create a geostatistical database of forest industries' residues potentially available for energy uses involved two main steps, the first aiming at the geographic distribution of the industries and the second one to assess residue generation according to the industrial processes and material used and/or produced: i) Harmonization of the three main databases reporting the names, locations, concession areas (for the industries that have concessions) and other forest industries' and ii) Estimate residues production on the basis of existing national and international references. In the first assessment, the residues production was estimated as 50% of the raw material processed, considering sawmill residues and the subsequent residues produces in the following processing phases. It's recommended to further pursue this item in collaboration with the Department of Forest Engineering of the University Eduardo Mondlane.

It was impossible to assess the amount of recovered wood, such as dismissed construction material, furniture, pallets etc. because there are no formal or even slightly related statistics. For instance, there is no pallet factory in the country from which some product lifecycle information could be obtained. Some additional investigation is recommended but it is unlikely that this component becomes significant in the woody biomass supply demand scenario.

The various categories of biomass productivity that constitute the woody biomass potentially available for bioenergy from direct and indirect sources may be summarized as follows:

i) Total productivity: This defines the biological sustainable capacity to produce woody biomass in current land cover/land use conditions. It does not include leaves, twigs and roots but includes all species, and vegetation formations and land cover/uses. This category is mainly theoretical as it includes inaccessible resources as well as products that pertain to other uses and/or industrial processes.

ii) Non-industrial productivity: This category refers to the fraction of total productivity that has no industrial interest in terms of species and assortments and that is not used for other purposes. From this productivity are excluded the stems of the precious species of quality 1, 2 and 3, as clearly indicated by the national regulations that rule forest exploitation in Mozambique (Art. 19, LFFB). In addition to the woody biomass from other non-precious species, the non-industrial biomass productivity does include the branches as well as the defective stems of the precious species since they have no use in wood industries. The industrial wood is deducted, as a fraction, only from the forest land cover classes defined by the National Forest Inventory.

iii) Physically accessible non-industrial productivity: This category defines the fraction of the total non-industrial biomass productivity that may be considered accessible, after deduction of the areas and fractions of productivity that are inaccessible due to physical constraints (i.e., slope, distance from roads and populated places, crossing resistance of land cover classes).

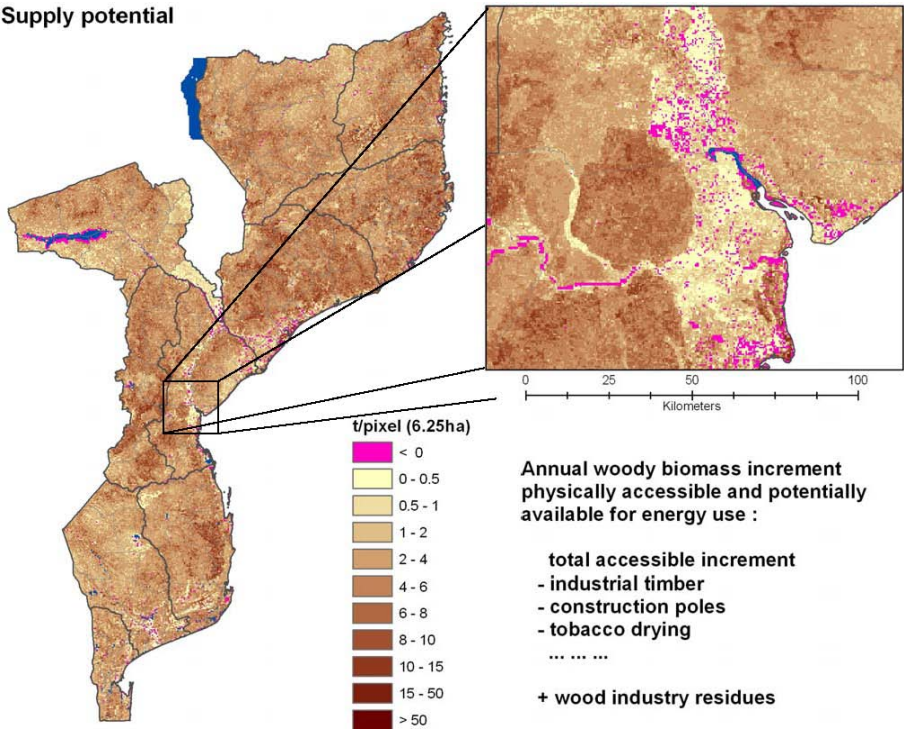
iv) Available productivity: This category defines the fraction of the accessible non-industrial productivity that remains available for energy uses after deduction of the woody biomass annually consumed for other purposes. This implies the estimation and exclusion, of the material used as construction material by rural dwellers as well as that used for tobacco drying. The construction poles' biomass is not deducted from the productivity map directly but rather mapped as an additional demand component associated to the rural population map (a sort of "biomass debt"). This is the supply resources considered for the estimation of local supply/demand balance.

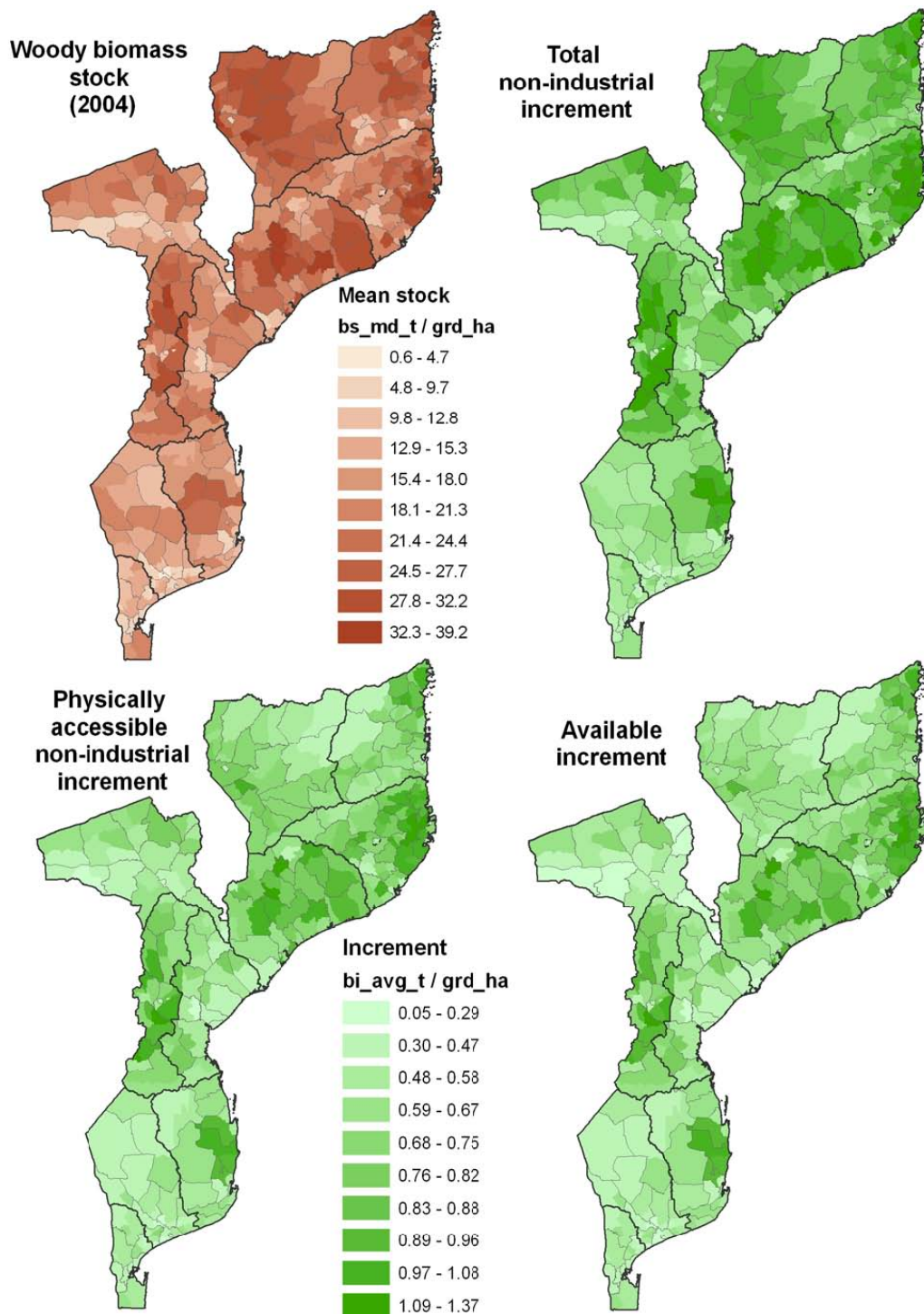
v) "Commercial" productivity: This category does not refer to the productivity per se but rather defines the fraction of the surplus, determined by the local supply/demand balance and hence after satisfaction of local demands, which may be suitable to sustain commercial fuelwood and charcoal production to feed urban markets and export. The sources included are those with higher sustainable production capacities and that are free from legal restrictions that allow for local non-commercial exploitation only (i.e., national parks, other protected areas, *fazendas do brávia*, reserved forests, hunting reserves, etc. ...). This category refers to the fraction of the surplus resulting from local supply/demand balance analysis that may be considered as available and suitable for commercial bioenergy planning.

Province-level summary WISDOM statistics reporting also stock and available productivity data are given in Table 2 further below.

Figure 9: Supply potentially available for energy use from direct and indirect sources.

Supply potential





4.4. Integration module

The first and most important result of the integration module is the balance between supply potential and current consumption. This analysis was carried out at two subsequent levels: firstly at local level, to assess the supply/demand balance for each pixel or within a limited radius and secondly at commercial level, considering local surplus suitable for commercial woodfuel production and local deficit areas.

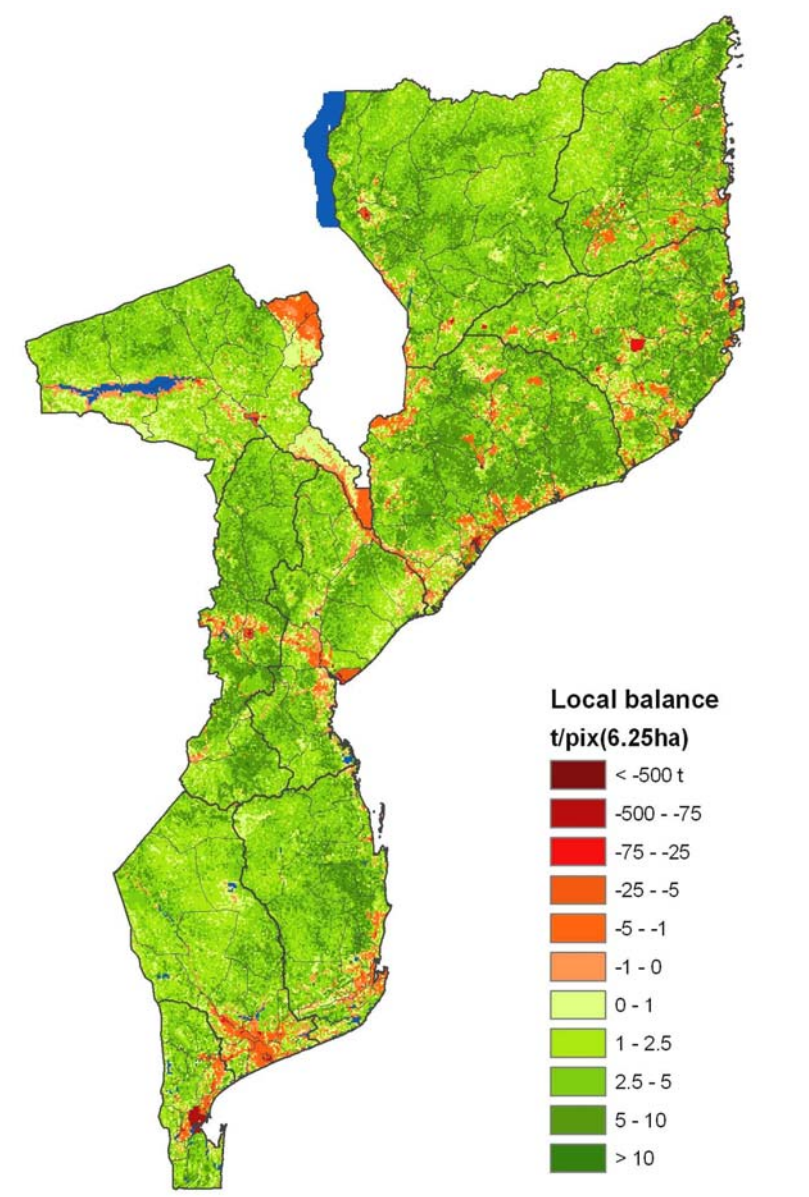
Integration of supply, demand and balance data with other thematic layers, i.e. socio-economic parameters, poverty indicators, infrastructures, services, etc., is possible and highly recommended. The combination at geographic levels of wood energy and other aspects will produce new and additional insight on the multifaceted wood energy issue that will certainly increase the understanding and the capacity to formulate sound policies and plans well adapted to true local conditions. This additional level could not be carried out in the study but it's strongly recommended to expand the range of integration analysis on priority themes as soon as clear interests are expressed.

4.5. Local balance

Pixel-level balance

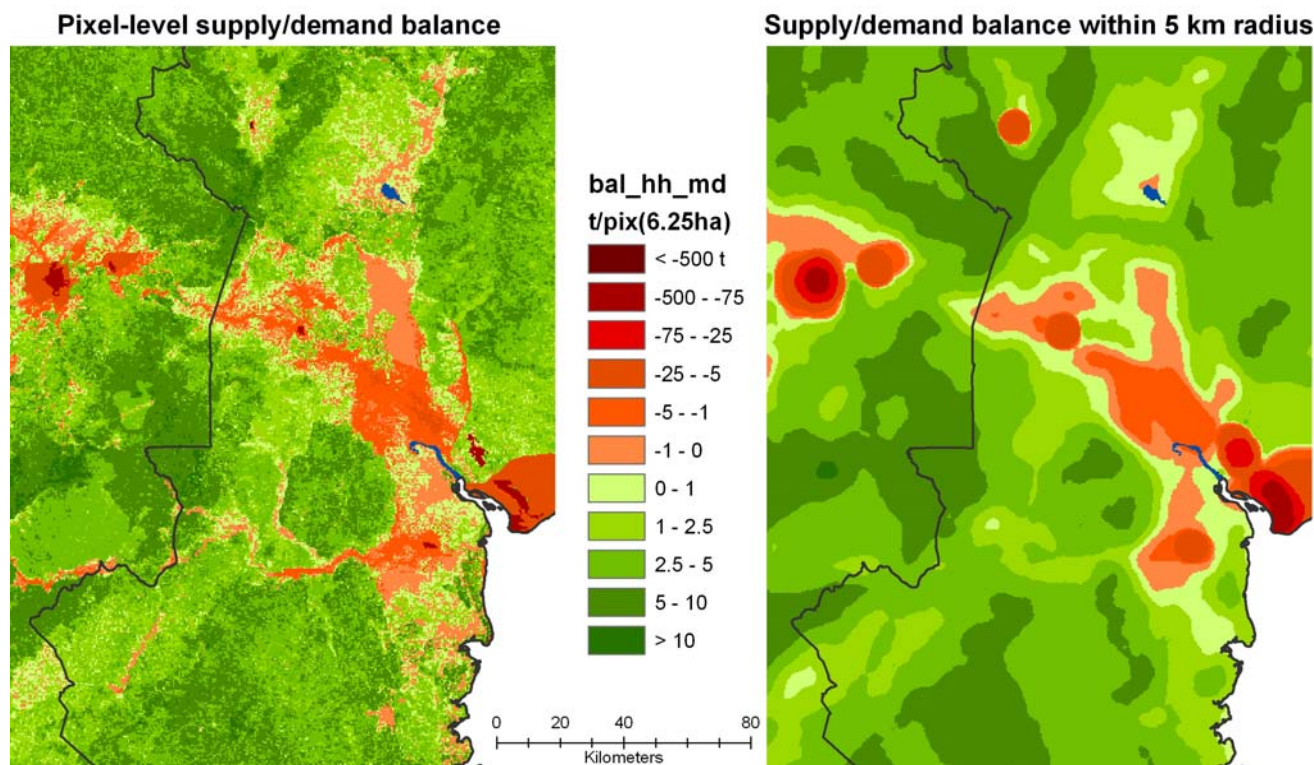
The supply/demand balance at pixel level is calculated by deducting the pixel-level consumption from the pixel-level available productivity. The pixel-level local balance map is shown in Figure 11.

Figure 11: Local supply/demand balance



Another higher resolution example of the pixel-level map is in Figure 12 (left side). Provincial summary of local balance statistics are given in Table 1.

Figure 12: Local supply/demand balance assessed at pixel level and within a 5-km radius



Local neighborhood balance

The calculation of supply/demand balance by pixel has a useful accounting function but represents a somewhat virtual balance since individual cells are usually either a production or a consumption site. More meaningful is to represent the relation between the consumption and the supply potential within a surface somewhat related to the real supply context. In case of local household consumption in rural areas such horizon is represented by the distance that household's members are prepared to go to fetch fuelwood, on foot or by local transport mean. In order to visualize this factor, through the FOCALMEAN function, the balance of each cell was calculated as the balance between the mean supply and consumption values within a 5 km circle around each cell. An example of pixel and neighborhood balance covering the Beira-Chimoio area is shown in Figure 12.

Comparing the two maps it's evident how some deficit areas (at pixel-level) reach surplus conditions when analyzed in a 5 km radius (bottom-left and top-right of the maps). At the same time, deficit areas of few pixels may remain negative even on the 5 km horizon, thus better revealing the consumption site (top-center of the maps).

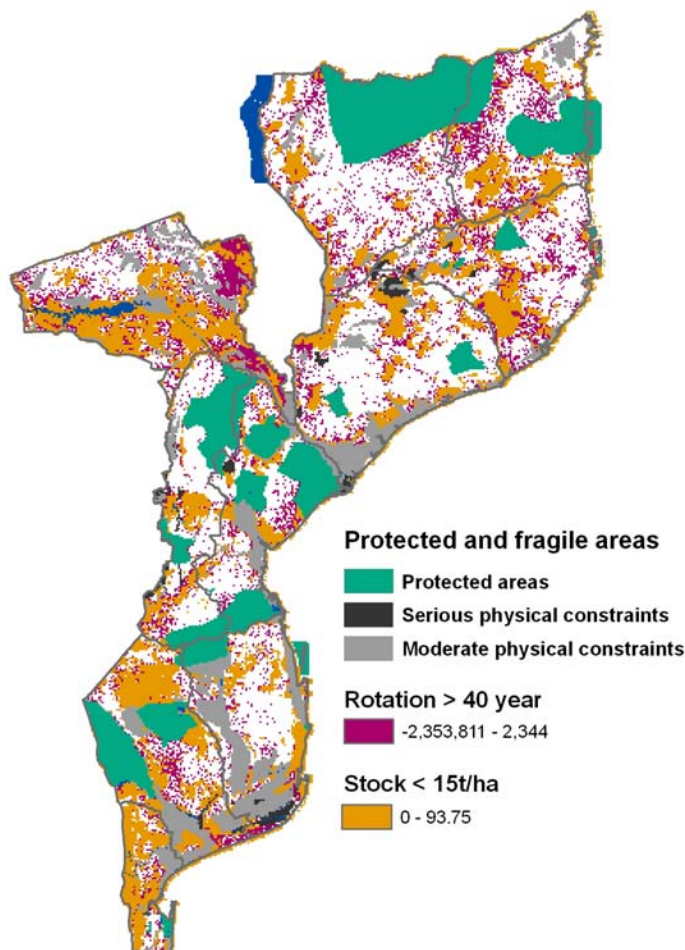
Commercial balance

The commercial balance was analyzed with the purpose of determining the realistic sustainable supply zone of major woodfuel markets such as those of urban areas, bioenergy planning and future biomass power plants as well as for export purposes.

In the definition of the "commercial" balance the supply side considered only the fraction of the surplus that may be regarded as available and suitable for market-oriented production systems, while the demand side considered the deficit resulting from the local supply/demand balance. This implied the accounting of deficit conditions of the local balance as such and the estimation of the commercial share of local surpluses, excluding protected areas, unproductive areas as well as low-productivity areas.

Completely excluded are the sources that are under legal restrictions for commercial exploitation (while allowing access for local non-commercial needs). These areas include national parks, other protected areas, *fazendas do brávio*, reserved forests, hunting reserves, etc. (see Figure 8 and Figure 13).

Figure 13: Main constraints to the utilization of local woody biomass surplus for commercial woodfuel markets



Besides legal constraints, the areas considered accessible should not present the physical characteristics that were used in the Land Unit study to map protective (i.e. non-productive) forest areas (Wolf and Lorenzini 2007). Two levels of protective constraints were considered, one more “conservative” and one more “liberal” as defined in Table 1.

Table 1: Protective forest areas under physical constraints to be excluded from the commercial supply potential. “Conservative” and “liberal” scenarios.

Steepness Geomorphic hazard

moderately steep (15÷30%)

“Conservative” steep (30÷60%) ponding (temporary water-covered)

very steep ($\geq 60\%$)

“Liberal” steep (30÷60%)

very steep ($\geq 60\%$)

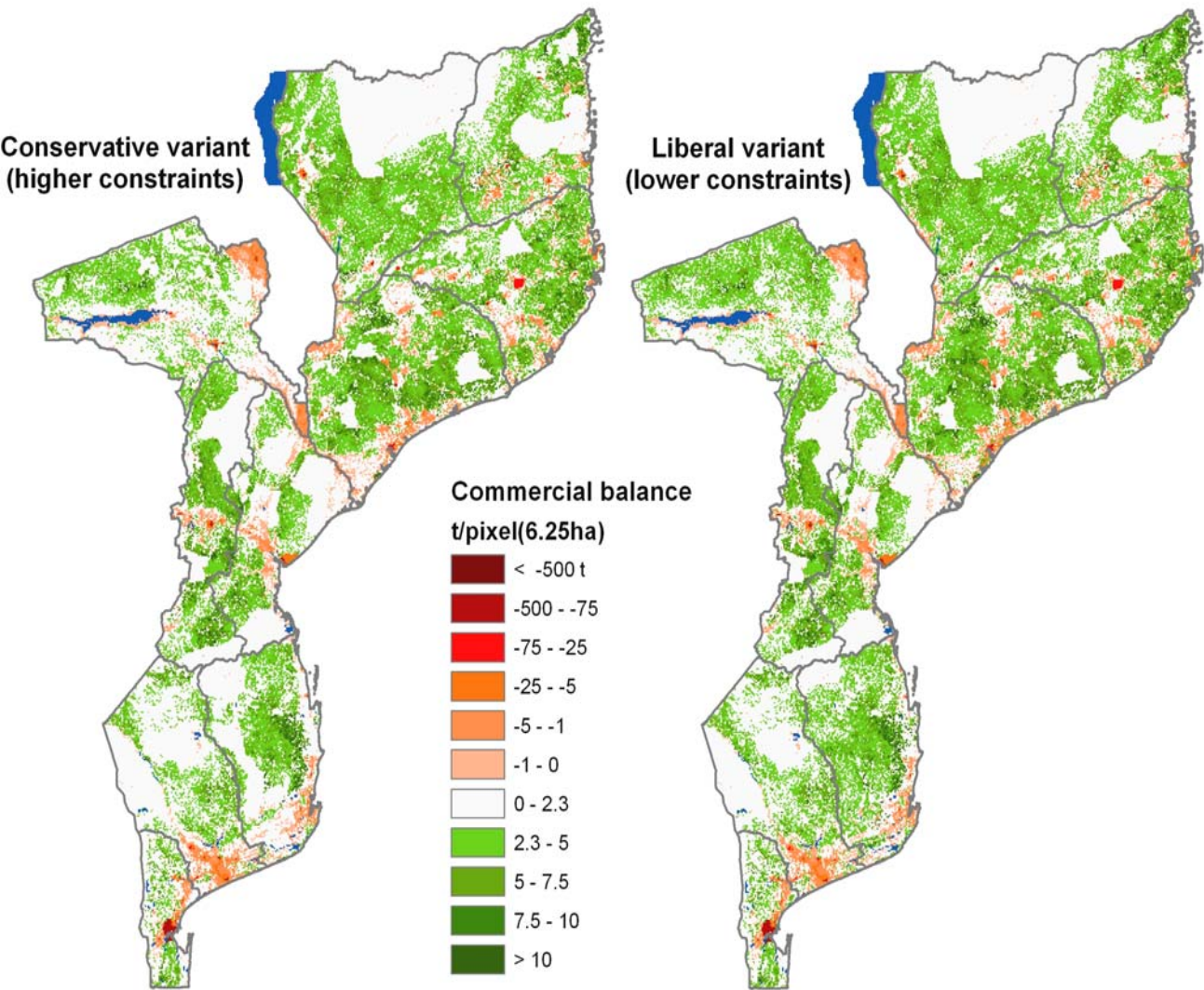
In addition, where legally accessible, the commercial supply potential is limited to the formations that guarantee an adequate sustainable production of wood for energy that justify transport and management costs. To assess potentially commercial sources some basic quantitative thresholds related to charcoal making were defined:

One threshold concerned the minimum stocking required for profitable charcoal production considering average kiln size and collection distance (Mancini *et al.*, 2007). Such stock threshold was set at 15 t/ha considering that below such level the cost of kiln preparation would be unprofitable.

The second threshold concerned the rotation period determined by the estimated annual surplus of the local supply/demand balance: only the areas with surplus levels that guarantee rotation periods lower than 40 years were considered eligible. To reach such condition the available surplus must be above 0.375 ad t/ha/year.

Consequently, only the areas with a stock above 15 adt/ha, a surplus above 0.375 adt/ha/year and “productive” vocation were considered as potential commercial sources. The geographic coverage of the various constraints that limit the commercial exploitation of local surplus are shown in Figure 13 and the commercial balance maps relative to the “conservative” and “liberal” definition of physical constraints are shown in Figure 14.

Figure 14: Commercial balance represented by local deficit areas and “commercial” surplus. Two situations are considered: a more conservative and a slightly more liberal definition of exploitation constraints.



Administrative-level summary results

Maps of consumption and local/commercial balances by Posto Administrativo are shown in Figure 15. Provincial summary of commercial balance statistics for the conservative and liberal variants are given in Table 2.

Figure 15: Woodfuel consumption and local/commercial balance by administrative unit (Posto Administrativo)

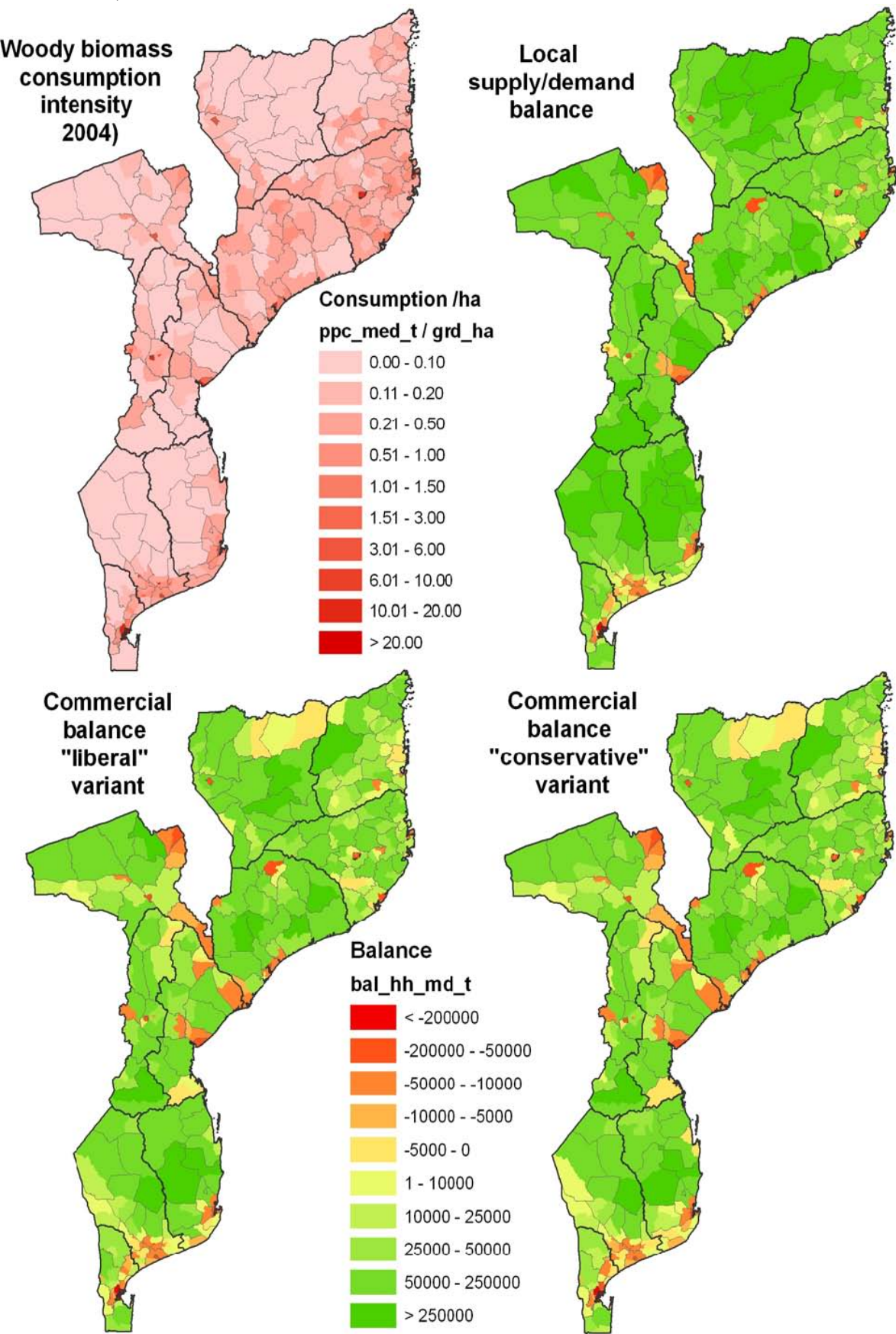


Table 2: Summary of WISDOM statistics by Province

Province	total		available	residential			
	total Woody biomass stock	non industrial increment	increment physically accessible	and commercial consumption	local balance	commercial balance "liberal"	commercial balance "conservative"
	000 t	000 t	000 t	000 t	000 t	000 t	000 t
Niassa	308,447	10,607	6,977	749	6,228	3,757	3,600
Cabo Delgado	178,505	6,502	4,851	1,079	3,772	2,087	1,935
Nampula	169,033	6,868	5,885	2,755	3,131	2,226	2,095
Zambézia	248,529	9,745	7,862	2,526	5,336	3,988	3,635
Tete	169,455	6,876	4,188	1,114	3,074	1,921	1,425
Manica	144,755	5,843	4,594	937	3,657	1,997	1,885
Sofala	126,496	4,866	3,753	1,184	2,569	973	889
Inhambane	125,461	5,127	4,294	890	3,405	2,326	1,697
Gaza	112,708	4,345	3,382	863	2,519	977	821
Maputo	31,464	1,267	1,124	924	201	-204	-263
Maputo Capital	238	11	11	982	-971	-971	-971

4.6. Woodshed analysis

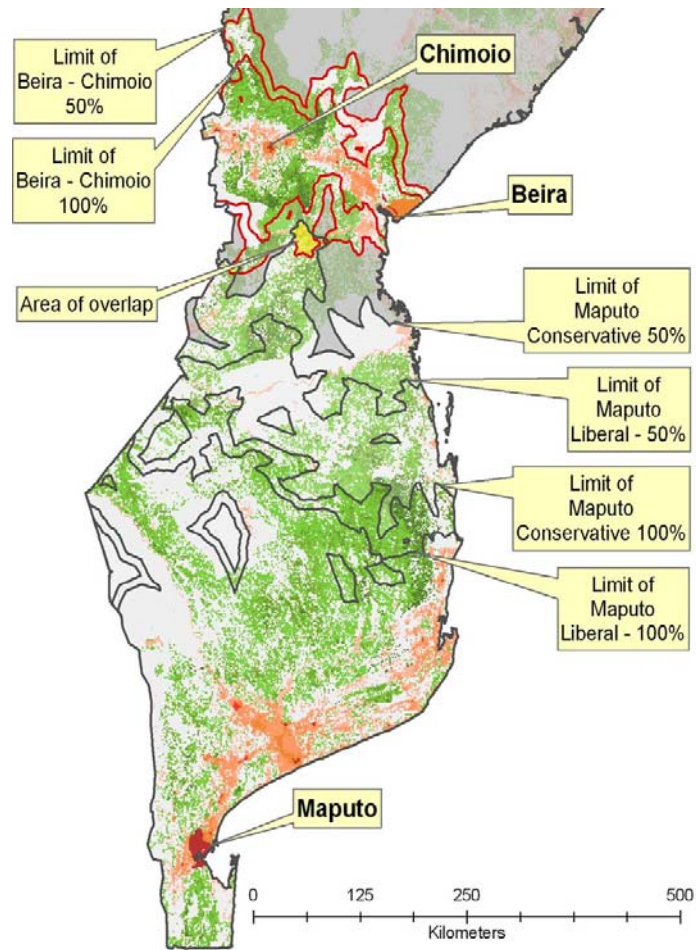
Based on the commercial balance it is possible to outline the potential sustainable woodfuel supply zones of major cities and their area of influence, keeping into account the consumption of surrounding urban and rural areas as well as the resources realistically available. These zones are termed “woodsheds” in analogy with the familiar geographical concept of *watersheds* (FAO, in press).

The urban woodshed of a given city may be defined as the area around the city in which the balance between total woodfuel demand and the commercial surplus achieves stability (i.e., non-negative value). Consumption outside the city is taken into account entirely as local deficit areas (local consumption higher than local productivity) but the surplus woody biomass (local productivity higher than local consumption) is limited to the “commercial” share, as discussed before while defining the commercial balance.

The estimation procedure for determining the woodshed of a selected city is to progressively expand the area around the city until the cumulative value of the commercial balance reaches positive value, which indicates that within such territory the supply potential matches the demand. This means that we assume that the entire surplus is managed to produce the requested amount of woodfuels. This is obviously a theoretical situation. It may be advisable, in fact, to assume different “management intensities” referring to the share of the resources that can be put under sustainable production regime within the area and a given time period. This means that actual supply will represent a fraction only of the entire potential supply. Accordingly, in order to achieve a balance condition the woodshed will increase its surface until a new balanced condition is reached.

An example of woodshed analysis for Maputo and for Beira-Chimoio is given in Figure 16. In this analysis, both “conservative” and “liberal” commercial balances were considered, which produced a significant impact on the size of the supply zone for Maputo but not for Beira-Chimoio. In addition, two different management regimes were assumed: a 100% regime, in which the entire commercial surplus was considered, and a 50% regime in which only half was considered. The regime intensity obviously produced a dramatic impact on the supply zones’ size. With the lower management regime and the more conservative commercial balance the necessary supply zones of Maputo and Beira-Chimoio come to overlap slightly.

Figure 16: Woodshed analysis for Maputo and Beira-Chimoio. Sustainable supply zones based on conservative/liberal constraints assumptions and on 100%-50% management regimes.



The socio-economic woodshed

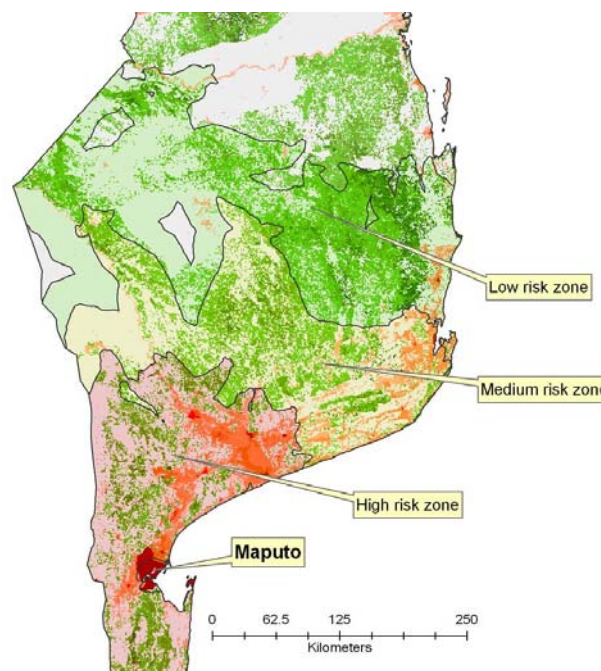
Beyond “simple” biomass accounting, the urban woodshed helps to visualize and understand the complex and far-reaching urban/rural interface in both geographic and socio-economic terms. In fact, a clear vision of the territory concerned allows to identify the communities involved, in good or in bad, at present or in the future, in producing the woodfuels that the cities demand. The identification of the rural communities, the administrative units and their political entities, both urban and rural, constitutes the first essential step towards the development of sustainable wood energy systems in which environmental and socio-economic sustainability can be integrated. In fact, urban demand, usually seen as a threat on the surrounding forest resources can convert into an important and lasting opportunity for decentralized rural and forest communities if the sustainability is respected and the urban/rural relationship is formally recognized and based on principles of equity.

Degradation/deforestation risk zoning

The cause-effect mechanisms that lead to the loss of forest area are complex and rarely induced by a single cause. It's rather easy to see a relation between unsustainable fuelwood and charcoal production and forest degradation but, in spite of a common perception, it's not easy to prove a direct relation between woodfuel production and deforestation. On one hand it's indubitable that intense and unsustainable charcoal making can lead to heavy degradation or even complete loss of forest cover but, on the other hand, it's also true that fuelwood and charcoal production are very often simple byproducts of the expansion of cropland and shifting cultivation into previous forested lands. In the second case, for instance, a reduction of fuelwood and charcoal demand would do little to reduce the deforestation rate.

The WISDOM analysis does not assess loss or degradation of forest resources, for which a proper monitoring programme is required, nor can it tell where and to which extent fuelwood and charcoal production may be directly responsible of the ongoing processes of deforestation and degradation. It may, however, define varying intensities of risk of forest degradation and/or deforestation by segmenting the nominal sustainable supply zone of a city (urban woodshed) into risk zones along a gradient of accessibility. Figure 17 shows an example of risk zoning within the Maputo woodshed in which the risk level is set to be inversely proportional to the distance from the city and within the estimated sustainable supply zone.

Figure 17: Degradation risk zoning within the Maputo's sustainable supply zone.



5. Conclusions and recommendations

5.1 Conclusions

WISDOM Mozambique is conceived as a strategic planning tool to be maintained, deepened and, most important, used by forestry and energy and rural development planners concerned with wood energy. In this respect, the analytical conclusions, thematic maps and tables here presented should be considered as the first step in the analysis of this sector and not the conclusion of a process.

In fact, the main result of the activity is the WISDOM geodatabase, more than the single table and map that have been produced in the process and the possibility of to “refresh” the system with new reliable parameters as they become available.

From the analysis carried out, limited to medium productivity and consumption levels, a wide variety of results were produced, ranging from stock and productivity estimates, consumption estimates and several local and commercial supply/demand balances, spatially (at 250m pixel level) as well as by administrative units of all levels. Based on this data and findings, the following aspects may be highlighted:

- i) The total non-industrial productivity of woody biomass annually available for the entire country is estimated at 62 Mt (t*10, air dry) from which some 46.9 Mt are physically accessible and potentially available for energy use.
- ii) The total consumption in the residential and commercial sector is estimated at 14 million t.
- iii) At national level, there is a consistent surplus potential of woody biomass for both local and commercial exploitations. At sub-national and local levels, however, there is a marked variability and there are many areas of deficit:
 - At provincial level only the province of Maputo and Maputo capital show deficit conditions, with a cumulative “debit” of some 1.2 million t.
 - Niassa and Zambézia are the provinces with higher surplus, which is estimated at approximately half of the entire available potential.
 - At District level, 31 out of 148 Districts (21%) present a deficit condition at local balance level, fraction that rises to 41 (28%) for the “liberal” variant of the commercial balance, and to 46 (31%) for the “conservative” variant.
- iv) Maputo’s woodshed, which represents the territory necessary to provide a sustainable supply of woody biomass (as charcoal, mainly) to satisfy the consumers of Maputo and of all other enclosed cities and rural communities, is very big indeed, reaching as far as 450 km from the Capital and covering the entire Provinces of Maputo, Gaza and more than half of Inhambane (assuming that the whole available resource is managed).
- v) Still concerning Maputo woodshed, if we assume to put under sustainable production regime only half of the potential productivity, the distance from Maputo would reach over 600 km including, beyond Inhambane, the southern parts of Manica and Sofala.
- vi) Within Maputo’s woodshed we can define areas and resources under various levels of pressure and consequently under different levels of risk of degradation and of triggering processes of permanent deforestation. Considering the level of demand and the distribution of resources, it is estimated that the high risk zone reaches approximately 200 km from Maputo, while the medium risk zone covers a buffer of some 150 km beyond, reaching a distance of some 350 km.

On a more general perspective, the WISDOM analysis already produced or is expected to produce, in the near future, the following benefits:

- Holistic vision - For the first time the wood energy issue can be visualized and analyzed over the entire country maintaining at the same time a local perspective.

- Priority areas definition - The local perspective and national consistency of analysis and parameters permits the identification of priority areas of intervention and/or further analysis.
- Valorization of existing data/knowledge - The need to feed the WISDOM modules with the best available information on supply and consumption aspects implied the review and use of every piece of information, study, survey etc. ever done over these subjects in the country, thus attributing value and function to information otherwise fragmented.
- Critical data gaps definition - A thorough review of the information available allowed the identification of data gaps that are really critical for a good understanding and for the formulation of sound policies.
- Optimize available resources - The identification of priority areas of intervention, in geographic as well as thematic terms, allows circumscribing and focusing future actions (resource management, additional data collection, etc.) and thus enhancing the efficiency and reducing the costs of such actions.
- Promote cooperation and synergies - The inter-sectoral and interdisciplinary character of WISDOM implies the exchange of information among agencies and it favors the discussion about the multifaceted wood energy “sector” over a common shared ground built with the contribution of each party. It is hoped that the use and maintenance of the WISDOM geodatabase will further strengthen these liaisons and inter-agency collaboration in the future. The role that WISDOM will play in the inter-institutional Advisory Group that supports the formulation of the National Biomass Plan will certainly promote further synergies among the DNTF, the University, energy agencies and other parties of the advisory group.
- Enhance visibility and political recognition - The integration of various aspects and the cartographic representation of result makes WISDOM easy-to-visualize and to some extents it makes a complex issue simple and, to some extent, attractive. This makes it more accessible to non technical readers and simplifies the task to policy makers, who will be less reluctant towards a subject often considered “intractable”.

Data limitations:

Reference data, such as the total woodfuel consumption in Cidades, Vilas and rural areas, are estimates rather than objective measurements since systematic consumption data was never collected and the availability of survey data was strongly unbalanced between Maputo, the other major and minor cities, and rural areas.

The estimation of woody biomass stocking and productivity was based on AIFM’s National Forest Inventory data and Land Cover maps that provided solid information on forest classes but only indicative values for most non-forest classes. This means that for these classes the estimates cannot be more than “best approximations” based largely on poor references and inference.

In general, however, as may be explained by fuzzy logic, the maps integrating many parameters acquire a reliability of their own thanks to the concurrence of so many factors and in spite of the weakness of individual quantitative parameters. Field action may therefore be implemented with good confidence within the core priority areas, while additional data may be collected in order to build up more reliable quantitative estimates where the situation is less clear and investment appears justified.

It is not possible to estimate with precision the error associated with the results of the study, since the quantitative results were not based on a uniform statistical approach but rather on a mosaic of extremely heterogeneous statistical and cartographic data sources. An idea of the possible margin of error associated with biomass stocking and productivity might be derived from the statistical confidence interval of inventory data for the forest strata used in the analysis. The values for stocking ranged around the mean, with a factor of between 0.76 and 1.24, and a similar factor range was assumed for the mean annual increment.

The results presented in this document refer exclusively to average productivity and consumption values, which produced average balance values. The forthcoming analysis based on minimum and maximum productivity and consumption values will allow visualizing the range of incertitude associate to current reference data and to determine and differentiate the “core” priority areas that are confirmed in all variants from the situations that are less certain.

Data layers needed:

In order to provide a reliable analysis of woodfuel supply and demand it's important to refresh regularly the reference data with accurate and up-to-date parameters as they become available. One important updating that will soon be available concerns demographic data from the census of 2007, which will hopefully provide a new map of *localidades* and *aldeias* that will enhance rural population mapping. According to INE, the final results of the *3 Censo Geral de População e Habitação 2007* will be released within June 2009 at province level and by November 2009 at national level.

In addition to the regular system maintenance, it's recommended to upgrade the information concerning the following:

- Secondary road network -the available road map reports primary roads only and excludes the system of secondary roads and *pistas* that play an important role on the accessibility of forest resources.
- Woodfuel consumption in sectors other than residential and their distribution within the country (tobacco drying, fish smoking, brick making, etc..).
- Consumption and distribution of electricity and other energy carriers (gas, kerosene). Spatially discrete information on the penetration of alternative fuels for residential and industrial use will allow a better understanding of the substitution trends and potentials within the country.
- Profitable/non profitable woodfuels' sources. The distinction between the "commercial / non-commercial" sources of woody biomass was made on productive/protective aspects and not, so far, on economic aspects. It's therefore important to undertake investigations on this in order to develop a realistic assessment of the true commercial potential of woody biomass resources and their distribution.

5.2 Recommendations

The importance of woodfuels as energy source for the majority of Mozambicans and its dominant role as forest product were well known even before the WISDOM analysis but now, it's possible to discriminate deficit and surplus areas with objectivity. It is therefore possible, and strongly recommended, to develop on such basis sustainable forest-energy strategies able to profit from the opportunities that the wood energy sector offers, where they exist, mitigating at the same time the negative impacts that unsustainable exploitation practices are producing in so many forest areas of the country. Among others, the following management options may be considered:

- A system of forest concessions specifically oriented to fuelwood and charcoal production.
- Definition of clear and formal urban-rural partnerships aiming at the satisfaction of urban needs respecting at the same time environmental sustainability and equity in the distribution of economic benefits.
- Promote the creation of rural woodfuel markets and/or other forms of woodfuel producers associations and consortia oriented to secure a more sustainable use of the resources securing at the same time the perpetuity of the benefits.

The WISDOM geodatabase integrates data derived from the National Forest Inventory carried out by AIFM with data coming from several institutions and research centers on a variety of topics dealing, mainly with woodfuel consumption aspects. The integration of inter-sectoral and interdisciplinary competences is essential for the efficiency of WISDOM and therefore, it is strongly recommended to maintain and further develop WISDOM Mozambique as a shared inter-sectoral and inter-disciplinary tool for bioenergy planning. To ensure the integration it is recommended to strengthen the linkages with energy, agriculture and other planning agencies and to share the WISDOM geodatabase with the specific scope of verifying the underlying assumptions and sharing the responsibility of maintaining the reference information up-to-date.

Complete the WISDOM analysis along the minimum and maximum productivity and consumption variants, in order to represent the variability induced by available data and to highlight the margin of confidence of the conclusions that the analysis suggests.

Further integrate the analysis with socio-economic aspects that will help to understand the fuel substitution dynamics and develop realistic scenarios and forecasts. As a useful step in this direction it is recommended to use WISDOM data and the priority areas therein identified to conduct socioeconomic analyses of sustainability, substitution trends.

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CHARCOAL PRODUCTION AND SUSTAINABLE FOREST MANAGEMENT: THE EXAMPLE OF GHANA

Michael Kwaku,

INBAR Regional Coordinator - West Africa

Abstract

Urbanization and economic development are bringing about changes in consumption patterns and increases in household income in developing countries, which in turn are leading to major changes in the household energy sector. A pronounced shift from fuelwood to charcoal, especially in Africa has raised concerns among environmentalists and those responsible for forest development and management. (Girard, 2002)

In Ghana, charcoal is the predominant domestic fuel for about 69% of urban households, per capita consumption is about 180kg per annum and an estimated 476.8 thousand metric tonnes are consumed annually in urban Ghana.

In general energy consumption in Ghana, as in many African countries is still low and limited almost exclusively to fuelwood especially in rural areas. However, energy consumption and the type of fuel used by households evolve as countries develop. A survey carried out for World Bank's Energy Sector Management Assistance Programme (ESMAP) in 45 cities in 12 countries between 1984 and 1993 (Price, 2000) showed that a decrease in the use of woodfuel shift to petroleum products is clearly related to improvement in income, as well as to new policies and programmes established by governments. Yet charcoal is the most expensive domestic fuel in Ghana taking a high percentage of the daily wage. It constitutes about 10% of the daily household budget (Nketiah, 1992).

Production of charcoal in Ghana is essentially by the traditional earth mound method; the major cost components of production by this method, using live tress, are labour 50%; chain saw hiring 35%; wood cost 7-12%. A few steel kilns, however, are in use by private companies in the Western and Ashanti regions.

Transportation of the charcoal often involves head-loading, use of canoes where stream and rivers exist; tractors, pull carts and trucks. However, trucks are the main means of charcoal transport to the urban centers.

Over the years there seemed to be very little concern regarding tree planting and reforestation programmes, especially in the savannah zones to replenish the large numbers of trees which have been felled for charcoal burning. Most of the charcoal producers in these areas often migrate to new areas after near-depletion of the suitable trees species and have little interest in setting up tree plantations for their future wood supplies.

In the light of the rapid depletion of the preferred wood species for charcoal production, more work needs to be done on the properties of charcoal from different wood species. This would help establish the suitability of a lot more wood species for charcoal production.

Technological interventions are also urgently needed in areas of charcoal production and household usage, plantation establishment and instituting effective policies and legislations in the production to consumption systems to balance wood-fuel supply and demand for charcoal, thus ensuring that a sustainable development of the wood-fuel sub-sector is maintained.

Keywords: development, charcoal, sustainable, reforestation, industry, Ghana

1.0 Ghana Profile

Ghana is an independent sovereign state in West Africa lying between latitudes 4° 44' and 11° 11' north and longitudes 3° 15' and 1° 11' west. It extends over a total land area 23 million hectares or 239000 km². The

population in 2004 was 20 million with an estimated growth rate of 2.5% and a population density of about 84 persons per km². The topography is undulating and gentle with only few areas above 700m. The prominent relief feature is the voltaian escarpment which rises to 635m and runs virtually unbroken from East around Koforidua to Mampong-Ashanti in the North West. The principal land use groups are forest reserves (11%), unreserved forest (2%), wildlife (5%), savanna woodlands (30%), bush fallow (25%) and tree and annual crops (12%) and unimproved pasture (15%). Agriculture industry is extensive but on a smallholder basis using hoe and cutlass with mechanized farming. The traditional economy is principally based on agriculture, forestry and mining with ecotourism recently being a major contributor. The Gross National Product is currently estimated to be 600 USD per capita. The forestry sector contributes about 8% of the GDP with non-timber forest products (NTFP) contributing about 1.2% of the forestry GDP.

2.0 Overview of charcoal production in Ghana

2.1 Product Description

In Ghana, wood fuels forms the bulk of energy used by majority of the population. This comes in the forms of charcoal, firewood and to a limited extends crop residues. Currently, the total annual wood fuel consumption is estimated at between 14-16 million tones coming from 25-28 million cubic meters of wood. It is estimated that 50% of the wood fuel supply is used for the production of charcoal and the remaining is used as firewood. Whilst charcoal produced is consumed mainly in the urban areas, firewood is the main fuel consumed in the rural areas.

Charcoal production in Ghana is usually produced from logging residue; sawmill waste and wood from the forests. Major producing areas are concentrated in the Dry Savannah Forest where the wood is usually dense, slow-growing and highly lignified. Carbonization of wood from these areas gives good yield of charcoal. High Forest Zones also do have charcoal production centers, although, production in these areas takes longer and gives lower yields. The charcoal produced is also of lower density and production costs are high. Often the bad terrain and weather conditions at these areas make charcoal production unattractive to the major and professional charcoal burners.

Charcoal processing is carried out mainly by the informal sector including women and children. The competition among women and children during wood collection, for the production of charcoal, has no respect for age or size; it is survival of the fittest. Often, the site is seriously polluted by smoke from the open burning of sawdust from the sawmill. Women and children work at the site without protective clothing. The fumes from the sawdust mix with the smoke from both the burning sawdust heap and the charcoal processing smoke together with the black soot from the sifting of charcoal.

Environmental concerns about using wood for charcoal have prompted producers to look for alternative sources of materials and more environmentally-friendly production facilities for charcoal in Ghana. These include wood wool, coconut shell and cocoa waste using steel kilns and gasification plants. According to a source from the Energy Commission in Ghana, the waste materials from logging and saw mill for example, would have gone waste to cause environmental problems if they were not carbonized into charcoal.

Almost all the charcoal in Ghana is produced by the traditional earth mound method, which requires no capital investment. The primary disadvantages are that earth mound kilns are hard to control, susceptible to the elements and have generally very low yields with unpredictable charcoal quality. Several improved charcoal production methods with resulting higher yields are available, but have one factor in common in that they require some capital investment in equipment and some training of operators to utilize the kilns efficiently.

In Ghana, certification is often required from Ghana Energy Commission, to ensure that wood for the charcoal is from saw-mill waste, lumber residue or obtained from licensed sustainable sources and owned by the exporter. Another regulatory body, Ghana Timber Industry Development Division of the Forestry Commission also certifies that the lumber company has used sustainable wood. The environmental Protection Agency then inspects the production facilities to certify that they conform to acceptable environmental standards. These regulations have been enacted to ensure that the forest is not degraded by indiscriminate cutting of good quality logs for charcoal.

2.2 Uses and Characteristics

Charcoal has diverse uses, such as for cooking, heating, and in pharmaceutical, metal smelting and filtration industries etc. In Ghana charcoal is mainly used for cooking.

Good quality charcoal should be quick and easy to ignite, clean and free from tar, excess moisture and gaseous material. Additionally it must be free from heavy metals such as cadmium, copper, zinc.

2.3 Production Areas

Commercial production of charcoal in Ghana is concentrated in the following areas: Savannah Woodland Vegetation Zone in the Brong Ahafo, Ashanti, Eastern and Volta Regions.



Figure 1: Commercial Charcoal producing areas in Ghana (Brong Ahafo, Ashanti, Eastern and Volta Regions)

2.4 Distribution Channels

A high percentage of internal distribution of charcoal is from remote and mostly inaccessible areas in Ghana. Tractors normally transport the charcoal from these areas to bulk storage deposits where the product is finally conveyed by road vehicle to middlemen in Accra, Kumasi, Takoradi, Tema, and Ashiaman. The producers usually transport the product to the ports for exporters.

2.5 Nature of Producers

The majority of producers in Ghana are illiterate and located in small villages often difficult to access. Producers in major production areas usually organize themselves into registered associations. A high percentage of charcoal from these sources is consumed in the local market.

In the dry forest (transition) zone, charcoal production is mainly done by Sisaalas, an ethnic group from the upper west region of Ghana. They produce charcoal on a full time basis; but may undertake subsistence farming alongside to sustain themselves. This group is migratory and tends to follow wood availability and usually operate in gangs.

Another group of producers are the exporters, who either have cultivated special woodlots which they carbonize in their own charcoal kiln, usually steel kiln or those who use very modern production facilities. One such company in the Western Region of Ghana obtains supply of waste wood from a parent company lumber and carbonizes them into charcoal. The waste wood is in the form of forest logging residue and saw mill waste from a parent lumber company. The company makes use of modern gasification plant for charcoal production. This modern kiln which has an efficiency of 25-35% seems to have taken the lead in the introduction of an efficient technology in charcoal production in Ghana.

The type of charcoal produced from this type of plant is clean and free from tar, excess moisture and gaseous material and is therefore suitable for indoor use. However, the cost of production is very high therefore all of the charcoal produced by this company is exported.

2.6 Price Determination and Export Markets

The price of charcoal is highly dependent on the following factors;

- i) Moisture content of the charcoal
- ii) Volatility
- iii) Packaging
- iv) Heating value
- v) Burning time

Ghana's main exporting markets countries are;

Share in Ghana's export

UK..... 73%

Belgium 8%

Netherlands..... 7%

Italy..... 6%

Germany..... 5%

In, 2003 when the world average price of charcoal was \$215 per ton, Ghana supplies the United Kingdom (U.K) market at \$208 and the Netherlands at \$337.

2.7 Packaging and Labelling

The shipment of charcoal for export in Ghana is dependent on the mode of packaging. There are two main forms of presentation. Usually, it is not packaged, put into 40ft containers and shipped directly to the buyers in the Netherlands, Italy, the UK, Germany and Belgium.

Recently, some charcoal exporters have added value to charcoal from Ghana by bagging it in 3kg, 5kg and 10kg bags for export usually to the UK market. This type is labelled already and sold to supermarkets.

3.0 Charcoal Production and Use

In Ghana, charcoal is often traditionally made from species that yield a dense and slow-burning. Because these species are slow growing and are therefore particularly vulnerable to over-exploitation, there is a need to encourage diversification and the use of plantation species or species producing less dense charcoal. However,

where the use of alternative species for charcoal making is promoted, it is necessary to re-evaluate the processes involved in the charcoal supply chain.

Charcoal production in Ghana is still largely based on the rudimentary earth mound technology which is low yielding and consuming about 4-6 tonnes of wood per every tonne of charcoal produced. Market forces regulate the trade and uncontrolled demand could pose a high environmental risk to the resource base. The production of charcoal in this manner releases a lot of methane and other greenhouse gases.

In the late 80's two major programmes were instituted in Ghana to address the issue of inefficient end-use devices used for cooking, including the nationwide promotion of the Ahibenso improved charcoal cooking stove, which was meant to replace the traditional "coal-pot".

One necessary adaptation is the design of energy-efficient charcoal stoves as most of the stoves currently used are not really suitable for charcoal from light-weight species, burning it too quickly and vigorously for consumers' needs. The Ahibenso improved stove for instance saves between 35-40% of charcoal compared to the traditional coal-pot. Hence, the promotion and use of the Ahibenso stove will help reduce the high demand for charcoal for household needs.

When charcoal is used as cooking fuel as in the case of Ghana, there is the need to introduce procedures which will encourage the use of light charcoal (sale by weight, quality-based prices, control over species used, etc). This could limit over-exploitation and encourage production from plantation species to the considerable benefit of the environment and consumers.

Professional training and supervisory measures could also help reduce the current pressure on species that yield dense charcoal.

Total charcoal export from Ghana in 2001 was about 2,770 tonnes, increasing to almost 4,600 tonnes in 2003. However, some of the charcoal exported used to come from the natural forest, but with regulations and administrative order affected by Ghana Energy Commission, charcoal export from natural forest has officially been stopped. Only charcoal produced from wood-wastes and from owned plantations are permitted. As a result, the quantity of charcoal exported in 2004 fell to 2,900 tonnes (Energy Commission Strategic National Energy Plan 2006-2020, Ghana, 2006, p. 7)

Promoting the cultivation of energy forest plantations, re-introduction of improved charcoal production stove programme and improved charcoal production kiln will create massive jobs for rural communities involved in the plantations. It will also create jobs for artisans involved in the manufacture of charcoal stoves. In other words such a programme promotes sustainable development and will stand a greater chance of attracting climate change related funding to the country.

The sustainable production and use of charcoal through proper management and planning of supply sources, together with rational trade and marketing infrastructure and efficient use, can have significant positive impact by helping to conserve resources, reducing migration from rural or forested areas and improving people's income. However, the necessary interventions for long-term solutions may not be easy to implement, especially for poor countries that may lack the necessary financial resources, institutional capacity and skilled personnel.

4.0 Production Concerns

The gradual economic improvement in many African countries that has brought about increases in household incomes, is leading to major changes in the household energy sector. A shift from fuel wood to charcoal could have a major ecological consequence if it is not kept under control and this has raised concerns among environmentalists and those responsible for forest development and management.

One great concern is that charcoal, unlike fuelwood, is most often produced from forest resources. Thus the use of forest biomass for charcoal making could still represent a threat to the future of the resources in local terms, especially in certain situations with high demand (for instance, the periphery of large urban zones with low resources) and lack of proper forest management practices and regulations.

With the introduction of charcoal stoves for instance as more efficient means than wood stoves, the ratio of primary energy to useable energy is almost the same as with firewood. Hence, the government of Ghana like

other African countries is concerned about the potential threat of charcoal to forest resources and has therefore launched programmes in the past two decades to encourage substitution of charcoal with other fuels (particularly LPG) through subsidies and provision of equipment to households. However, substitution programmes have also had the negative effect of creating unemployment in forest areas when charcoal production was discouraged. The lack of employment led to increased migration towards urban and peri-urban areas and accentuated the demand for fuel and even more charcoal, as these are the main sources of affordable energy for poor people.

Banning the production and marketing of charcoal production, as is being advocated by many environmentalists could prove counterproductive. A ban may not necessarily reduce production, but simply drive producers underground, thereby precluding proper control of production procedures.

5.0 Need-Based Approach for Sustainable Production and Management

Unlike in the industrialized countries where a large number of more efficient and rational technical solutions are being developed to enable carbonization processes to conform to environmental and energy norms and to improve carbonization yield because of increased wood prices. The basic goal of Ghana and other charcoal producing countries in Africa is to produce more charcoal using less wood.

Many sawmills produce great amounts of waste, which is often simply burned for disposal or very roughly carbonized. Semi-industrial charcoal making process with incineration of pyrolysis gases and heat recovery could provide a satisfactory way of optimizing sawmill by-products, since mills have the necessary technical and human resources (FAO, 1985).

Though traditional charcoal production may be labour intensive, an improved production technique will result in a good yield with relatively low capital investment, if the techniques are efficiently used.

Although globally charcoal consumption could be expected to decrease in the near future, locally or in some countries such as Ghana it may still increase as a result of new industrial “green energy” market opportunities under development (Unasylva 211, Vol. 53, 2002). Therefore forest services and energy commissions/agencies should give particular attention to charcoal and its sustainable production and use. Effective interventions might include among others:

- establishment of forest management programmes to avoid deforestation by over- harvesting of species suitable for charcoal production
- providing charcoal makers with a range of suitable technical methods from which to choose from, rather than a single ‘best’ technical solution
- promotion of charcoal from residues and forest plantation timber, through pricing and appropriate policies

6.0 Conclusion and Recommendations

6.1 Conclusion

Socio-economic studies and reports on the charcoal sector in Ghana identified strengths and weaknesses, potential and opportunities, problems and constraints that pose a threat to sustainable growth of the charcoal industry in Ghana.

Woodfuel being the most important energy source for Ghana can not be left in the hands of inefficient charcoal producers if Ghana wishes to see a sustainable production and consumption in the foreseeable future.

The industry will only see modernization when regulations and professionalism is introduced. In this regard, tertiary institutions can be assisted to run courses and programmes in woodfuel technology.

To ensure a sustainable management of Ghana's forest vis-à-vis charcoal production it is necessary to identify best practices for charcoal production in Ghana and design an appropriate programme for the adaptation and promotion with cost effective charcoal production technologies.

With adequate forest management, supervision and control practices, the growth of charcoal use may not have a serious impact on forested areas that supply consumption centers.

6.2 Recommendations

- i) It is recommended that government support promotion and development of sustainable management of the country's natural forest and woodlands for sustainable supply of wood for charcoal production. This can be achieved through the following measures;
 - Survey, map, register and gazette all sustainable managed wood-fuel areas outside the forest reserves.
 - Governments through public and private agencies encourage and assist local community groups or individual entrepreneurs to establish woodlots or plantations to ensure sustainable supply of wood.
 - Introduce woodfuel production contracts, which allow the utilization of timber off-cuts from the forest reserves for the production of charcoal.
 - Establish standards and registration requirements for charcoal producers and registration of all commercial charcoal producers to be given trading rights.
 - Standardize woodfuel trading. Trade in charcoal should be done in bags with official seals.
- ii) It is recommended that government establish a National Woodfuel Office within the Energy Commission so that such institutional frameworks will help enhance and coordinate woodfuel (charcoal) related activities as an integral part of national energy development. It is suggested that such offices will
 - Involve all institutional agencies associated in the woodfuel industry in the planning, implementation and monitoring of activities in the sub-sector.
 - Have a working linkage with the Ghana Forestry Commission, the local government institutions and other identifiable stakeholders.
- iii) It is recommended that Government regulate the woodfuel industry, such as transportation, marketing and export systems to encourage more sustainable practices. Through this measure:
 - All commercial charcoal transporters should be in possession of an information sheet specifying the origin of the load, the destination of the load with due signatures of for example, the Local Government Revenue Collectors and Wood-fuel Transporters Association at all destination point where they exist.
 - Energy Commission as in the case of Ghana will have to strengthen its licensing framework for exporters of charcoal. As part of the licensing requirement all exporters will be obliged to submit shipping documents indicating the quantity, source and origin of the charcoal and destination to the Energy Commission for endorsement. Exports of the charcoal will only be allowed from Waste wood and wood from planted energy forests.
- iv) It is recommended that, Government supports the development and introduction of improved technologies and higher levels of efficiency in the production and consumption of charcoal. To achieve such a policy;
 - All traditional and commercial charcoal producers can be registered and train in improved carbonization process and
 - Monitor the health impact charcoal production and use especially, on women and children and feed the information to stove designers and for policy formulation

- Finally, charcoal is part of a range of fuels for domestic use that needs to be incorporated into any programme to rationalize energy resource use in tropical countries. Rather than seeing it as the forester's public enemy. All stakeholders, especially, planners need to understand the problems and implement suitable solutions to make the best possible production and use of charcoal to the benefit of all.

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Health Aspects of Charcoal Production and Use

André Seidel

On behalf of GTZ

Charcoal as a Household Fuel

Biomass is the main fuel for more than 2 billion people in developing countries. Especially poorer families rely on this fuel, which frequently is available without cash. In rural areas, biomass fuels may be the only available energy source and in most Sub-Saharan countries, more than 80 per cent of the population depend on it for cooking. The different types of biomass used by households comprise dung, agricultural/forestry residues, fuelwood and charcoal. Frequently, biomass is used in traditional stoves and fireplaces, which are highly inefficient. Therefore, large scale use of biomass fuel can have a number of adverse effects on the environment such as overuse of forest resources, which contributes to deforestation. This is especially true for charcoal, because during its production in inefficient kilns most of the wood is squandered.

Nevertheless, in many parts of Africa charcoal is a highly preferred fuel especially in urban areas. There are several reasons for this:

- it has double the energy content of fuelwood;
- it is lightweight and thus easy to transport;
- it is easy to store over a long period of time;
- it produces less fumes and noxious compounds when burned;
- in most cities it is cheaper compared to kerosene, LPG or electricity;
- it has the image of “modern” energy.

Currently, the demand for charcoal is so high that it will not be covered in the foreseeable future. This has made charcoal production an important economic factor in many African countries. However, it should be kept in mind that most charcoal is produced in the informal sector using traditional production methods and rather inefficient kilns. In addition, in many countries part of the charcoal is produced by farmers during the dry season only or by part-time workers. This makes it difficult to assess the health effects of charcoal production and at present little is known about the health status of African charcoal workers. In contrast, the health effects of biomass use have been studied in detail. To assess the impact charcoal can have on health the effects of the use of traditional biomass fuels like fuelwood will briefly be outlined in the following.

Health Effects of Biomass Use

Using dung, agricultural residues and fuelwood in traditional stoves is not only inefficient but there is also incomplete combustion of the fuel. This produces large amounts of noxious gases and particles. When cooking is done inside, these pollutants lead to Indoor Air Pollution (IAP). IAP mainly consists of two components:

- **Carbon monoxide (CO)**, which is a colour- and odourless but highly toxic gas;
- **Particulate Matter (PM)**, which consists of small, organic particles (also called soot). Especially the smaller particles (diameter less than 10 µm, PM₁₀) can deeply penetrate into the respiratory tract and cause irritation and illnesses as shown below.

High levels of IAP are the cause of a variety of health problems such as infections of the lower respiratory tract (Acute Respiratory Infection, ARI), chronic obstructive pulmonary disease and eye irritation (see table 1). In addition, ARI is also suspected to facilitate the development of asthmatic condition.

Table 1: Health Effects of IAP (from WHO 2006, modified)

HEALTH OUTCOME	POPULATION	EVIDENCE
ARI	CHILDREN LESS THAN 5 YEARS	STRONG
CHRONIC OBSTRUCTIVE PULMONARY DISEASE	WOMEN AGED ≥ 30 YEARS	STRONG
	MEN AGED ≥ 30 YEARS	MODERATE
LUNG CANCER (COAL)	WOMEN AGED ≥ 30 YEARS	STRONG
	MEN AGED ≥ 30 YEARS	MODERATE



ARI is especially prevalent in children less than five years old. (Picture 1 WHO, with permission) This age group includes infants carried on the back of their mother during cooking and thus they are especially exposed to the smoke when the mother bends over the open fire. As a consequence ARI is one of the main causes of death in both boys and girls of this age group. In contrast, in older age groups girls and women are affected about twice as much as boys and men, which is due the longer exposure of females during cooking (Ezzati et al. 2000). It is estimated, that about 1.5 million children and women are killed every year by the smoke of open fires, in Africa about 1,000 children each day (WHO 2006). In addition to ARI, long-term exposure to smoke causes chronic obstructive pulmonary diseases mainly in women, which causes several million deaths in Africa every year.

Health Effects of Charcoal Use

More than 80 % of charcoal is used in urban areas, making it the most important source of household energy in many African cities. Since charcoal must usually be purchased, the introduction of energy-efficient stoves has frequently been more successful than the dissemination of improved fuelwood stoves. Besides saving up to 40 % of charcoal, improved charcoal stoves equipped with a ceramic liner also emit less PM, making charcoal a rather clean fuel.

In addition, cooking behaviour also contributes to reduction of IAP because charcoal is usually lit outside. During the ignition process a large portion of the pollutants is released, whereas the subsequent burning is almost pollutant-free. Thus, this practice enhances the health benefits of charcoal use further.



Traditional charcoal stove (Photo: A. Seidel)

Improved charcoal stove (Photo: M. Kees)

Whereas little PM is produced by combustion of charcoal, the high levels of CO emitted even by improved charcoal stoves are a serious problem. The American research institute Aprovecho reports, that during laboratory tests an improved charcoal stove emits only 85 mg PM, whereas fuelwood stoves emit between 1290 and 1500 mg. However, this reduction of about 95 % is contrasted by higher CO levels emitted from charcoal stoves compared to fuelwood (74 g vs. 15 – 20 g for fuelwood). A solution to the problem could be a recently developed charcoal stove, which is based on the “Rocket-Stove-Principle”. It emits very low levels of both PM (81 mg) and CO (15 g) while retaining the high energy efficiency.

It should be noted however, that besides using efficient charcoal stoves, behavioural changes, such as ventilation of the kitchen or lighting the charcoal outside, can greatly reduce IAP. The use of a hood also very efficiently brings down IAP, but it is more expensive to install.

The relationship between daily exposure to PM and the occurrence of ARI in farm worker’s families has been studied by Ezzati et al. (2000) in central Kenya. Since the authors have measured the emissions of the three-stone fire, ceramic wood stoves and charcoal stoves in the same population during an earlier study, it was possible to compare the stove emissions with the incidence and severity of ARI. Exposure to PM₁₀ varied between about 150 to 800 µg/m³ in charcoal stove users compared to about 1,800 to 3,800 µg/m³ found for ceramic wood stoves. The traditional three-stone-fire had the highest emissions ranging from about 1,800 to 8,500 µg/m³. The burden of ARI increased in households using the three-stone-fire, whereas it was reduced in families using charcoal and ceramic wood stoves, charcoal providing the greater health benefit.

Health Effects of Charcoal Production

The Carbonisation Process

Charcoal is produced from wood by a complex process called carbonization, which occurs at temperatures between 450 to 600 °C in the absence of air. Under these conditions organic vapours and gases are lost and part of the organic substances polymerizes, all of which increase the carbon content of the product. After the process is finished, charcoal is the final remains. One of the factors affecting quality as well as the yield is temperature. At relatively low temperatures around 300 °C a high yield of charcoal is obtained. However, this charcoal still has a high content of volatile material, which is undesirable because it produces noxious fumes during use. Temperatures around 600 °C give lower yields but the charcoal has a low content of volatiles making it a preferred fuel. Table 2 shows that besides methane (CH₄) and carbon dioxide (CO₂) especially the emissions of potentially harmful Non Methane Volatile Organic Compounds (NMVOC) are greatly reduced during carbonisation, whereas nitrogen oxides (NO_x) are not.

TABLE 2: EMISSION FACTORS FOR WOODFUELS USE AND PRODUCTION
(1000 MT GHG / 1000 MT) (FROM FAO 1999 MODIFIED)

CHARCOAL	CO ₂	CO	NO ₂	NO _x	CH ₄	NMVOC*
CONSUMPTION	2.567	0.2156	0.0000308	0.00308	0.00616	0.00308
PROCESS						

PRODUCTION PROCESS	6.511	0.2156		0.000308	0.0308	0.05236
TOTAL	9.078	0.431	0.0000308	0.0034	0.037	0.055
FUELWOOD	1.513	0.069	0.0000552	0.00138	0.00414	0.00828

* Non-Methane Volatile Organic Compounds

Health Effects

In Africa very little is known about the health impact of charcoal production compared to the use of this fuel. Ellgård (1993/2001) has studied the effects of charcoal burning in the Chisamba District in Zambia. Charcoal is produced in an informal way during certain times of the year only. To assess the health effects the author used a questionnaire and analyzed the different steps of production with regard to their health hazards. In addition, he measured the concentration of CO and PM at the kilns. Urban housewives using charcoal as a fuel were studied to compare the effects of charcoal production and use.

From the work the following health risks during production can be identified:

Table 3: Potential Health Risks during Charcoal Production (after Ellgård 1993/2001, modified)

STAGE OF PRODUCTION	POTENTIAL HAZARDS	HEALTH RISKS
CUTTING THE WOOD	ACCIDENTS DURING CUTTING, HEAVY PHYSICAL LABOUR	INJURIES
COMPILING THE WOOD	HEAVY PHYSICAL LABOUR	BACK PROBLEMS
COVERING THE KILN	LOW RISK	LITTLE OR NONE
IGNITING THE KILN	LOW RISK	LITTLE OR NONE
TENDING THE KILN DURING CARBONISATION	BREAKING OF THE KILN SURFACE	BURNS, EXPOSURE TO FUMES AND SMOKE
OPENING THE KILN, UNLOADING CHARCOAL	NOXIOUS FUMES AND SMOKE, DUST, TAR, HOT CHARCOAL	CO-POISONING, IRRITATION OF EYES AND RESPIRATORY TRACT, BURNS,

Regarding the different steps of production the risks from heavy physical labour seem to outweigh the other hazards. Exposure to noxious fumes may be limited by the fact that charcoal production is done in the open, which reduces the concentrations of CO and NMVOCs considerably. However, without doubt, the most dangerous task is the opening of the kiln, when workers are exposed to a variety of health hazards (heat, tar, smoke). It has been reported, that CO-poisoning and even fatal accidents occur, if the kiln is not completely extinguished when opened (Karlsson and Bachs 1988, c.f. Ellgård 1993/2001). The other tasks which bear major health hazards are assembling of the logs and cutting of the wood.

The results of the interviews were in line with the health problems outlined above. When asked about their complaints, the workers mentioned backache as the biggest problem, followed by heat, cough and chest pain. In comparison to urban housewives as charcoal users, the workers showed more excessive sweating at night but less breathing problems. In general, indicators of bronchitis (cough, chest pain) were more prevalent, whereas symptoms of asthmatic condition were less than in housewives. An explanation for the latter is that charcoal workers may change occupation if an asthmatic condition worsens, whereas housewives usually can not.

The smoke generated during carbonisation is a complex mixture of liquid, solid and gaseous compounds. Many are noxious such as nitrogen and sulphur oxides, benzene, aldehydes, organic acids and polycyclic aromatic hydrocarbons (PAH), just to mention a few of them. Most of them irritate the respiratory tract and especially PAH are known to be carcinogenic and exposure to wood smoke increases the risk of certain types of cancer of the upper respiratory tract and the oral cavity (Pintos et al. 1998). Measurements of respiratory suspended matter at kilns in Zambia have shown that concentrations are about fourfold of the level housewives are exposed to (Ellgård 1993/2001), whereas CO-concentrations are the same. However, during charcoal production the health effects may be reduced by the fact that tending the kiln can be done in a rather short time, which reduces exposure time. However, the incidence of lung cancer in African charcoal workers is unknown.

Likewise wood smoke, the liquid tar produced during carbonisation, contains a variety of organic compounds, which are carcinogenic (e.g. PAH). During charcoal production workers are exposed to smoke during tending and possibly also to tar during opening of the kiln. However, in African charcoal workers the degree of exposure to and the health effects of tar compounds are presently unknown.

In summary, the findings by Ellgård suggest, that, although some of the tasks connected with charcoal production can be harmful, they seem not to be alarming from an occupational health perspective.

However, in African charcoal workers, the health effects may be difficult to detect for a number of reasons. First, since charcoal is made in the informal sector many workers produce it part-time or only during a certain season. Second, it can be assumed that workers change occupation when health problems aggravate. Third, charcoal workers frequently smoke, which may obscure or interfere with possible effects of charcoal production.

A study by Tsunakis *et al.* (2001) investigated the effect of short term charcoal production among traditional charcoal workers in Crete. Like in many African countries charcoal production is a seasonal activity using traditional earth mound kilns. However, the authors focused on respiratory function only and used clinical measurements to detect possible effects. The 22 worker studied had produced charcoal in average for about 24 days and during this period of time they were exposed to wood smoke for about 14 days. Workers were tested before and after charcoal burning. Male residents not involved in charcoal production served as a control group. Both groups included smokers and non-smokers. Charcoal workers showed increased respiratory symptoms like coughing, sputum production, wheezing and dyspnoea. Furthermore, three workers had blood in their sputum, but none of the control group. Measurement of lung function revealed a decrease in charcoal workers compared the levels measured before charcoal production and to the control group. Although the authors could not detect the underlying mechanism for these changes the results call for additional studies.

It is likely that the health condition of Greek charcoal burners is different from that of Zambian workers. Nevertheless, the changes found in the above study probably also occur in latter, but they may be masked by the effects of heavy labour. Although more studies are needed, the results indicate, that seasonal charcoal production may adversely affect the respiratory system, too.

Charcoal Production in Brazil: Health Effects of an Industrial Production System

Currently Brazil is the largest charcoal producer in the world, the industry being a major consumer. Unlike in Africa, where most of the charcoal is used by households, the iron industry is the major charcoal consumer in Brazil. Very large amounts are produced in an industrial way at large production sites with hundreds of stationary kilns. In general, the production is much more organised compared to the African system. Means of assistance (like power saws) as well as means of occupational health and safety are available. Workers are hired by companies and frequently work all year, which makes them more suitable for studying the health effects of charcoal production than African workers, who frequently work part time.

The charcoal workers specialise on different steps of the production process. There are

- Loggers, who cut the wood,
- truck drivers, who load/unload the truck and transport the wood,
- kiln workers, who load the kiln, start the fire, burn the charcoal, and finally unload the kiln,
- kiln burners, who inspect the burning kiln and

- charcoal carriers, who load the charcoal on trucks.

Kato and co-workers (2004, 2005) have studied the health effects in different groups of workers. They conducted interviews and measured urinary content of metabolites of 2-naphthol and 1-pyrenol. Both substances are metabolites of carcinogenic PAH occurring in wood smoke. The data should provide information about the possible biological significance of smoke exposure.

The workers' main complaints were similar to those of African workers and also other results confirmed the study by Ellgård (1993/2001). However, in Brazilian charcoal workers biological effects of exposure to wood smoke compounds could be demonstrated for the first time. The authors took urine samples from kiln workers and determined the content of the 2-naphthol and 1-pyrenol. Urine samples of wood cutters, which are not exposed to smoke, served as a control group. The measurements showed that in urine samples taken from kiln workers the level of both 2-naphthol and 1-pyrenol was more than 4 to 5 times higher than in samples of woodcutting workers. Furthermore, when tested in an in-vitro system the urine of kiln workers proved to be more mutagenic. This indicates that the substances are biologically active and could also damage human cells causing cancer. However, the increase of urinary PAH-metabolites and the enhanced mutagenicity were found in non-smokers only and did not exceed the levels found in smoking workers.

Although the working conditions studied in Brazil differ from those prevalent in Africa and Crete, the results indicate potential health hazards, which could become significant if charcoal production is intensified and workers produce full-time and / or specialise on tasks, which particularly expose them to smoke.

Taken together the use of charcoal can provide considerable health benefits and has the potential to avoid millions of premature deaths (Bailis et al. 2005). However, our knowledge about the health risks of charcoal burning is still insufficient. Although it might be possible, that in Africa no major health problems are associated with the current informal way of production, they could become more important if the system would be changed to an industrial type.

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Shaping charcoal policies: context, process and instruments as exemplified by country cases

Steve Sepp – Eco Consulting Group - Germany

On behalf of GTZ

Development policy background – basic premises

This paper builds on the observation that, particularly in Africa, charcoal policies are hard to come by. But what actually are “charcoal policies”? The term “charcoal policy”, as used in this context, denotes an integrated public policy approach which addresses charcoal utilization in a comprehensive manner.

Given that charcoal is a marketable and highly commercialized commodity, one may conveniently regard charcoal utilization as a value chain – including wood supply, processing, transport, and various stages of marketing up to the individual end-user. Viewed from this angle, charcoal policies are – above all – **cross-sectoral policies** (or, rather, sets of sector-policies) which involve (and impact on) a particularly wide range of stakeholders. As most of the sectors relevant to charcoal utilization are exclusively controlled or dominated by government bodies (forestry, land administration, energy, etc.) “*Shaping charcoal policies*” must be primarily regarded as a **governance issue**. Charcoal policies reflect government objectives and development priorities.

As with all public policies, the effective & efficient implementation of charcoal policies depends not only on whether they are factually appropriate, but also on their legitimacy. One obvious means to enhance legitimacy is **multi-stakeholder participation**. Another is to demonstrate **coherence with globally recognized principles**, goals and relevant international regimes.

The Millennium Development Goals (MDGs) adopted by 191 member states of the United Nations, stipulate a globally shared responsibility to achieve sustainable development. Governments may thus enhance the overall legitimacy of public policies by aligning them demonstrably with the MDGs.

This provides a basic yardstick whereby charcoal policies may be measured. They need to maximize social and economic benefits, and to improve economic sustainability through efficient and productive use of forest energy [1]. Charcoal burning is a source of additional income and one of the survival strategies adopted by many households in arid and semi-arid zones all over Africa. Revenue from charcoal production may buy food, improve homes, and pay for children’s tuition fees & school material. Viewed from this angle, sound, comprehensive (and thus legitimate) charcoal policies may contribute to MDG 1 (eradicating extreme poverty and hunger), MDG 2 (achieving universal primary education), MDG 3 (promoting gender equality and empowering women), and MDG 7 (ensuring environmental sustainability).

The charcoal value chain is complex and may, on the surface, be regarded as principally related to energy-sector policies. However, charcoal production and use are interlinked with many more sectors, including forestry, agriculture, health, transport etc. Hence, shaping a charcoal policy is no isolated exercise, but requires **inter-agency communication** and **cross-sector coordination**. This does not happen spontaneously, but requires an adequate institutional setting. In this regard, shaping a charcoal policy also means to promote conducive procedural and administrative frameworks.

Measurable impact on the ground depends just as much on how a charcoal policy is implemented, as it depends on the issues raised above. In this sense, shaping charcoal policies means to deliberately promote adequate selection and use of governance instruments (laws and regulations, incentives, planning and information).

As policies change over time, shaping charcoal policies must be regarded as a **learning process**. This calls for flexibility in implementation, continuous observation of changing circumstances, and impact-monitoring. It likewise requires capitalizing on past experience and lessons learnt.

This observation highlights the inherent characteristics of a policy: it is formulated and implemented, but also modified, repelled, interpreted, contested and resisted. It likewise draws attention towards the various actors involved in policy at different levels, the roles they play, the ways they relate to each other, and their networks of information exchange and learning.

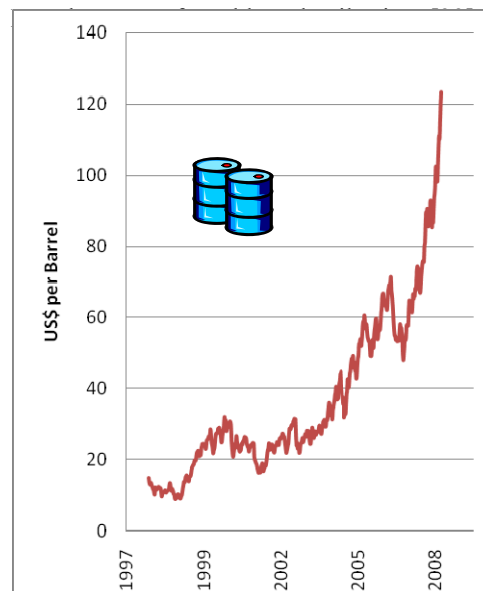
Consideration of facts and trends

A charcoal policy cannot be designed without considering internal and external effects of the national and international energy development. Some of the most striking facts and trends influencing the formulation of a charcoal policy are cited hereafter:

a. Boost of the oil price

The oil price has tripled in the last 18 months and exceeded the symbolic 100 dollar threshold. Demand essentially from China and India is still expected to grow in the coming years. On the supply side it is difficult to keep up as oil and gas are finite resources.

In most developing countries the poor will be kept from ascending the “energy ladder” – a metaphor for the fact that, with rising income, consumers switch from firewood to charcoal to fossil fuels (Kerosene, LPG) and, eventually, to electricity. Rising fuel prices may even cause wealthier parts of society to revert to lower ranking sources of energy. In Madagascar, for example, people of the upper middle class return to charcoal, as they can no longer afford the high costs for LPG.



b. Climate change

In their fourth assessment report, known as AR4, the Intergovernmental Panel on Climate Change (IPCC) forecasts an average rise of global temperatures of 2.0 – 4.5°C. The actual magnitude of global warming is said to depend largely on the development of greenhouse gas emissions in coming decades. Deforestation and forest degradation account for 18% of global carbon dioxide emissions and thus spur climate change, as they release carbon stored in woody vegetation and impair the forests' sink-capacity (FAO 2007).

Many studies argue that wood-fuels are carbon-neutral in that they do not alter natural carbon cycles. Replacing fossil fuels with wood-based fuels is therefore regarded as a means to mitigate climate change (IEA, 2004). However, when wood is harvested in an unsustainable manner and inefficient conversion/combustion technologies are used, a negative impact on the GHG emission is certain, often exceeding that of fossil fuels (Kammen, Bailis 2003). This obviously calls for improved ways of harvesting and production. Sustainable forest management, improved charcoal kilns and efficient stoves combined can lower GHG emissions and make wood-based fuels a carbon-neutral energy source.

In Europe, fuelwood received a boost due to efficient combustion technologies, record high oil prices, and government-policies that promote renewable energy to mitigate climate change. The 2007 Warsaw resolution of the fifth Ministerial Conference on the Protection of Forests in Europe explicitly recognizes forests as a major renewable energy resource.

In Finland, Sweden and Austria wood-based fuels already account for up to 17 % of the national energy consumption. For example, heating with CO₂-neutral wooden pellets has become a cost-effective alternative to conventional fuels. The European Union has put limits on the overall energy consumption, aiming for a 20% decrease by 2020 (EC 2005). Consequently, EU Member States are beginning to adopt their national strategies to achieve this goal.

c. Agrofuels compete with food and biodiversity

With skyrocketing oil prices and growing recognition of the need for cleaner energy sources, ‘agro-fuels’ are increasingly regarded as a viable alternative to fossil fuels. Agro-fuel production and use have markedly increased. By now, side-effects of the agro-fuel boom become apparent. Agro-fuels have been identified as one of the driving factors behind rising agricultural commodity prices and food shortages world-wide. According to FAO, the wheat price rose by 80% within a year, and global cereal stocks have been depleted to a 25-year low. The World Food Program faces difficulties to feed 73 million people this year. Agro-fuels are also held responsible for distorting rural development in many of the countries concerned. Experience from Latin America and Asia reveals that smallholders are expelled from their land to make room for high-capital, low-labour agro-fuel industries which create serious rural conflicts [4]. It is also acknowledged that forests are being cleared to provide land for vast oil-palm plantations, with the inevitable consequence of shrinking wildlife habitats, loss of biodiversity, and declining livelihoods of forest-dependent rural communities. Such unintended, negative impacts cause many governments to reconsider their agro-fuel policies (including subsidies).

What future role will charcoal play?

Bio-fuels account for almost 80 percent of the total renewable energy consumption world-wide. They supply more energy than nuclear power-plants, and about four times as much as hydropower, wind, solar and geothermal energy combined. Wood is the most important biofuel [5]. Presently, half of the annually harvested round-wood (about 1.8 billion cubic metres per year) is used for fuel, as noted in a forests & energy report to the

People Relying on Traditional Biomass (Mtoe); World Energy Outlook 2006

	2004	2015	2030
Sub-Saharan Africa	575	627	720
North Africa	4	5	5
India	740	777	782
China	480	453	394
Indonesia	156	171	180
Rest of Asia	489	521	561
Brazil	23	26	27
Rest of Latin America	60	60	58
Total	2 528	2 640	2 727

FAO Conference [6]. Wood-based fuels provide upwards of 70 % of the total energy consumption in Sub-Saharan Africa. The International Energy Agency predicts that by 2030, biomass energy in Africa will still account for an estimated three quarters of total residential energy.

In light of the rising costs for fossil fuels, and growing disenchantment over the negative side-effects of agro-fuels, forest energy will for several decades remain an important pillar in the energy mix of African countries struggling to meet an ever growing demand. Consequently, there is a need for official recognition of wood-based fuels in national energy policies.

Challenges and barriers to sustainable charcoal production - country examples

Uganda: Main foci of the National Energy Plan [8]

1. Increase power generation
2. Diversify power generation sources to ensure security of supply
3. Increase access to modern energy in rural areas
4. Increase operational efficiency in the utility companies and connect more customers to the grid
5. Determine the petroleum potential of the country
6. Create a competitive petroleum supply market in the country
7. Promote the use of renewable energy and energy efficient technologies (geothermal, solar, wind, mini and micro hydro, etc)
8. Manage energy related environment impact
9. Improving energy governance and administration

The following examples illustrate the major challenges and barriers to a sustainable charcoal production. They are subjectively selected by the author and in no way intended to be exhaustive.

It must further be acknowledged that many countries try to reform and to reorganize their wood-energy sector. Respective examples are cited. Most efforts, however, remain isolated measures, oblivious of the need for a comprehensive and holistic overhaul of the wood-energy sector.

Governments ignore charcoal as main source of energy and leave it to the informal sector

Many partner countries’ national policies and energy-sector programmes tend to consider wood-based fuels (chiefly fuel-wood and charcoal) a “backward” and

ecologically risky energy-source, and seek to discourage its use / mitigate its prevalence. Consequently they call for replacing the so called “traditional fuels” with “modern fuels” in the near future. For this, the Ugandan National Energy Policy 2002-2012 provides a case in point [7].

Despite the candid acknowledgement that biomass (firewood, charcoal and crop residues) accounts for up to 90 % to the total energy consumption, Uganda’s short and medium-term policy priorities (2002-2012 years) are entirely focused on promoting fossil fuels or other substitute energy sources (see box).

Similar observations apply to the National Energy Policies of Sierra Leone and Chad, where political efforts centred on electrification to absorb the lion’s share of financial allocations to the energy sector. By contrast, studies in South-Africa revealed that even one decade past the introduction of electricity, 90% of the households continued to use wood-based fuels as a major source of energy for cooking [21].

So called “traditional energies” are deliberately shunned and left for the informal sector, especially women. Hence the dominance of small-scale self-help approaches over strategic and concerted efforts. Not surprisingly, most energy policies bent on “modernisation” do not even mention gender-related issues. An analysis of 22 country energy policies and strategies revealed that only in two documents gender issues are mentioned: Tanzania, Zambia [9].

This attitude should be thoroughly revised, and policy support provided for the development of advanced, decentralised/community-based, integrated rural energy industries. These are key to bringing about the comparative advantages of forest energy, as well as to promoting the achievement of MDG targets. The following characteristics predestine wood-based fuels (particularly charcoal) to become a motor for rural development:

- Locally available and renewable resource,
- Potential for decentralised processing & production,
- Short transport distances with low risks,
- Generation of employment & local income,
- High potential for short-term improvement of efficiency (improved stoves, kilns etc.)
- High potential for technological innovation (chips, pellets, gasification, liquefaction)
- Climate friendly energy source (provided that sustainability standards are met),
- Charcoal yields a health-dividend, due to reduced levels of smoke, cleaner combustion and easy handling.

Progressive policies are required to these potentials for poverty alleviation and sustainable rural development. In Ghana’s “Strategic National Energy Plan (2006-2020)” the decade-long disregard for wood-based fuels is openly recognised, and recommendations are made to institutionalise the wood-energy sector as a sub-sector in its own right. It is proposed to establish National Wood-fuel Office as a coordinating body, so as to improve management efficiency, promote charcoal-industries, and ensure a sustainable wood supply [10]. Sudan and, recently, Kenya have adopted specific legislation to govern their charcoal industries. Sudan in particular is praised for having created encouraging framework conditions. The lessons learnt from the Sudan example may be summarized as follows [11]:

- Charcoal is recognized as a key source of energy.
- There is a specific institution, a government para-statal, to implement wood energy policies.
- Production of charcoal from plantations and natural woodlands is well planned.
- Resources are allocated on a yearly basis for plantation establishment.
- There is strong public and private sector participation.

- Charcoal is a formal and lucrative industry.
- There are clear marketing arrangements and rules.
- Traders are organized into a formal association recognized by the government.
- The government raises royalties and taxes, which are reinvested in establishing plantations.

Weak policy coherence

Common goals can only be achieved by making sure that policies are not fragmented, that they do not overlap, and that they do not result in unnecessary or additional transaction costs. This calls for thorough inter-ministerial policy coordination.

However, policy coherence, consensus, and commitment in the wood-fuel sector suffer from insufficient open discussion of policy options. Additionally, the authority and jurisdiction of several ministries, agencies and associations lack clarity, with the result that some encroach on others' terrains.

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

For example, it is difficult to comprehend why energy policy in Kenya on the one hand favours the dissemination of improved charcoal stoves, while on the other hand charcoal making remained for a long time illegal in the country. The same holds true for ad-hoc presidential charcoal bans designed to halt deforestation, which are at odds with other policies or effective legislation. Ethiopia, Kenya, Uganda, Chad, and Niger are pertinent examples – despite the fact that selling charcoal in all cases remained a perfectly legitimate business.

After having experienced substantial efficiency losses in managing the domestic energy sector by various stakeholders, the Government of Mali decided in 2003 to create a rural energy services agency (AMADER) with the mandate to promote household energy nation-wide. The main responsibilities comprise: (i) to expand rural markets for wood-based fuels; (ii) to improve the regulatory and fiscal framework as well as enforcement; (iii) to encourage the manufacture, promotion, and use of low cost equipment for wood-based fuels; (iv) to encourage fuel substitution where appropriate; (v) to consolidate planning, monitoring, and evaluation tools in the sector.

The principal means of fostering policy coherence are a national energy policy and a strategy designed to implement it, with roles and responsibilities assigned clearly to the various institutions (**institutional coherence**). Additionally, policies at each level (national, regional and local) ought to be streamlined *before* actions are implemented (**horizontal coherence**), and coherent implementation from national level downwards must be guaranteed (**vertical coherence**).

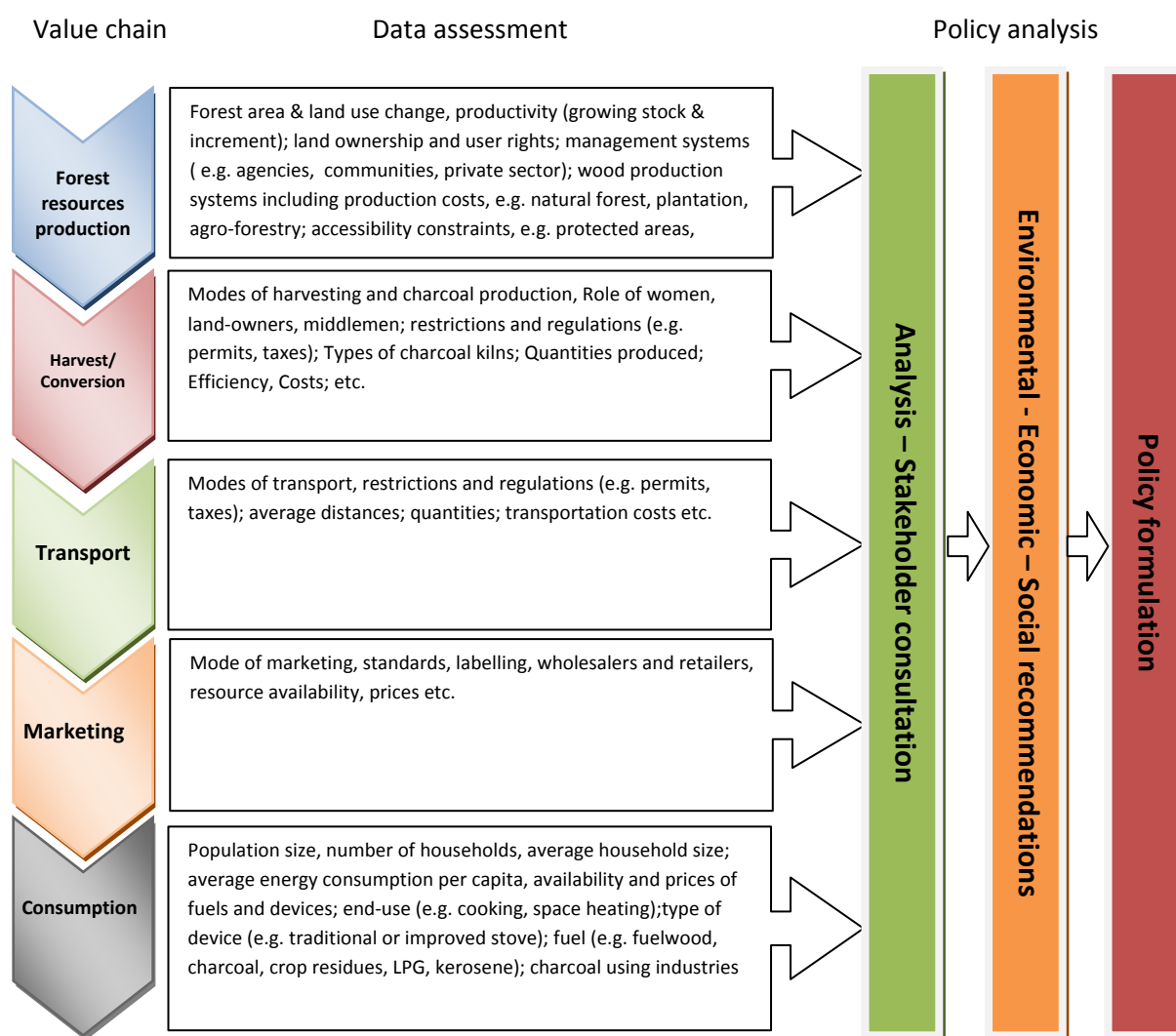
Kenya: Conflicts in sectoral policy and legislation [17]

Specific policies and statutes on water, wildlife, and agriculture also have provisions for forest management. Some of these are contradictory, for example, policies for agriculture, forestry, and wildlife. The Wildlife (Conservation and Management) Act prohibits extractive uses of the forest, which the Forests Act permits. The Agriculture Act promotes putting more land under agriculture. In Kenya, agricultural land is restricted to high potential areas that are settled, most of them around high mountain forests that the Forests Act seeks to protect.

Lack of baseline information for policy formulation

Shaping charcoal policies (or any kind of policy, for that matter) presupposes reliable baseline information as a precondition for rational decisions. Past assumptions and predictions by national and international organizations regarding wood-based fuels were proven wrong in many cases. In the early 80s simple scenarios for many Sahel countries forecast near-complete deforestation within 20 years [12]. Population growth and the shift from

firewood to charcoal were highlighted as the main driving factors. In reality, natural woody vegetation in the Sahel proved much more resilient than expected. Woodfuel exploitation alone clearly does not provide a summary explanation for ongoing deforestation on a national scale. It does, however, create problems locally which cannot always be reduced to a simple demand and supply gap. Wood-fuel problems are increasingly regarded as being rooted in more systemic – however locally site-specific - deficits in land tenure, fiscal and incentive policies, urban energy markets, and misallocation of forests and crop-land. All problems arise along the charcoal production chain. Therefore, precise data on the charcoal value chain provide an excellent entry-point for shaping sound policy frameworks. They offer an opportunity to the various stakeholders to add knowledge, innovation capital and technology at each step or link in the value chain. On this basis checks and balances may be introduced to assure a more balanced development within and between the sectors, with a view to achieving the intended overarching goals (e.g. MDGs).



Furthermore, evidence-based analyses of the charcoal value chain provide the opportunity to demonstrate the regional added value of charcoal production and thus help to sensitise policy makers for a source of energy hitherto neglected and left to the informal sector. Examples of study projects, geared towards a comprehensive assessment and analysis of the charcoal production chain, include: the supra-regional Chaposa project investigating the charcoal potential for Southern Africa [13]; the National Charcoal Survey in Kenya [14], the WRI/CIRAD research project in Senegal [0], and the study initiated by the Forest Governance Learning Group (FGLG) for Malawi [20].

Limited will/ governance capacity to reorganize the charcoal production sector

In many countries, the forest-sector's contribution to the national economy is marginal (2 to 4%), due to the fact that production and use of wood-based fuels are informal and thus escape official statistics (e.g. Uganda: formal sector 11% against 89 % in the informal sector [16]). Consequently, forest governance receives little attention and meagre budgetary allocations. For this reason, national funding often fails to adequately reflect local governments' needs and sources of revenue. In consequence, local branches of the forest service display low human, technical, and enforcement capacities. This problem is often exacerbated by half-hearted or arbitrary decentralization of forest governance which leaves local administrators ill prepared for the challenge of promoting community involvement or investment by the private sector. Such institutional weaknesses lower the morale of local staff, and invite corruption. Corruption coupled with unclear policy, and legal frameworks is seen as a major cause of unregulated or even illegal charcoal businesses.

Charcoal as an underpriced energy resource

Despite growing scarcity of wood, charcoal generally remains underpriced by more than 20 to 50%, relative to its economic cost in most African countries. This is mainly caused by insecure land-tenure, which leaves many forest areas open to free and unregulated access and use. In consequence, market prices of wood-based fuels reflect only the opportunity cost of labour and capital required for production and transport. Undervaluation translates into wasteful and inefficient production and consumption and creates a formidable disincentive for forest management and tree growing. The following examples illustrate the consequences:

- Investment costs for improved kilns (metal chimneys etc.) do not pay off [17] as long as wood remains a free resource. Despite training support, charcoal burners eventually abandon the improved technology. This is the main reason why the improved and more efficient Casamance kiln has been disseminated for 20 years throughout Africa without success.
- Tree growing approaches stay ineffective as planting and maintenance costs must be taken into account, when competing with open access resources. Significant subsidies (e.g. Madagascar: 200 to 300 €/ha) [17] are necessary to provide enough incentive. This holds true also for any investments in natural forest management.
- Substitute fuels such as kerosene must be highly subsidized to be competitive, as is the case in a number of countries (e.g. Senegal, Chad). On the one hand, the need for substantial subsidies creates a long-term foreign exchange burden and tilts a country's trade balance. On the other hand, no subsidy can ever be high enough to benefit poor households – in consequence, only the wealthier segments of society benefit. Furthermore, state subsidies for substitute fuels send wrong market signals, further discouraging investment into tree planting or forest management by communities or the private sector.

By contrast, charging market rates for wood-based fuels would yield the following benefits [18]:

- more responsible and efficient resource use,
- revenue generation that creates leeway for strategic investment (e.g. in the forest sector),
- market incentives for tree planting and forest management by a wide range of stakeholders,
- highlighting the status of tree resources as a renewable resource,
- (rural) employment, and
- foreign exchange savings.

Cutting the Gordian knot of underpriced woodfuel resources calls for a mutually synergetic three-pronged approach (see figure):

1. Adequate use regulation & enforcement

This requires introduction of a differentiated taxation scheme, and presupposes efficient tax collection. Differentiated taxation in this context means that *only* wood-based fuels stemming from open access areas are

taxed. By contrast, communities/farmers who engage in sustainable management on their own properties would remain exempt from taxation (or similar disincentives). This needs to be certified by proof of origin (coupon system on the basis of sustainable exploitation quota). By taxing transport of cut firewood only, the system is comparatively easy to control and promotes efficient administration – as opposed to more extensive and highly decentralised systems based on the granting of firewood cutting permits.

2. Strategic shift from open-access forests towards secure tenure & sustainable forest management

Open access to natural resources carries the risk of unsustainable overexploitation (the “tragedy of the commons”). By contrast, sustainable forest management presupposes clear and secure long-term forest tenure (“property rights”). By example, a community may be granted exclusive control over natural woodlands growing on their territory, and the exclusive right to sell wood-based fuels harvested/produced thereon. In return, the community would be bound to enter into a formal agreement with the forest service to manage the woodland sustainably and to use improved kiln technologies (e.g. Village VERT approach in Chad). Private-sector operators are encouraged to help communities establish rural firewood markets. Once a community is registered as a Rural Firewood Market, outsiders are barred from obtaining local cutting permits.

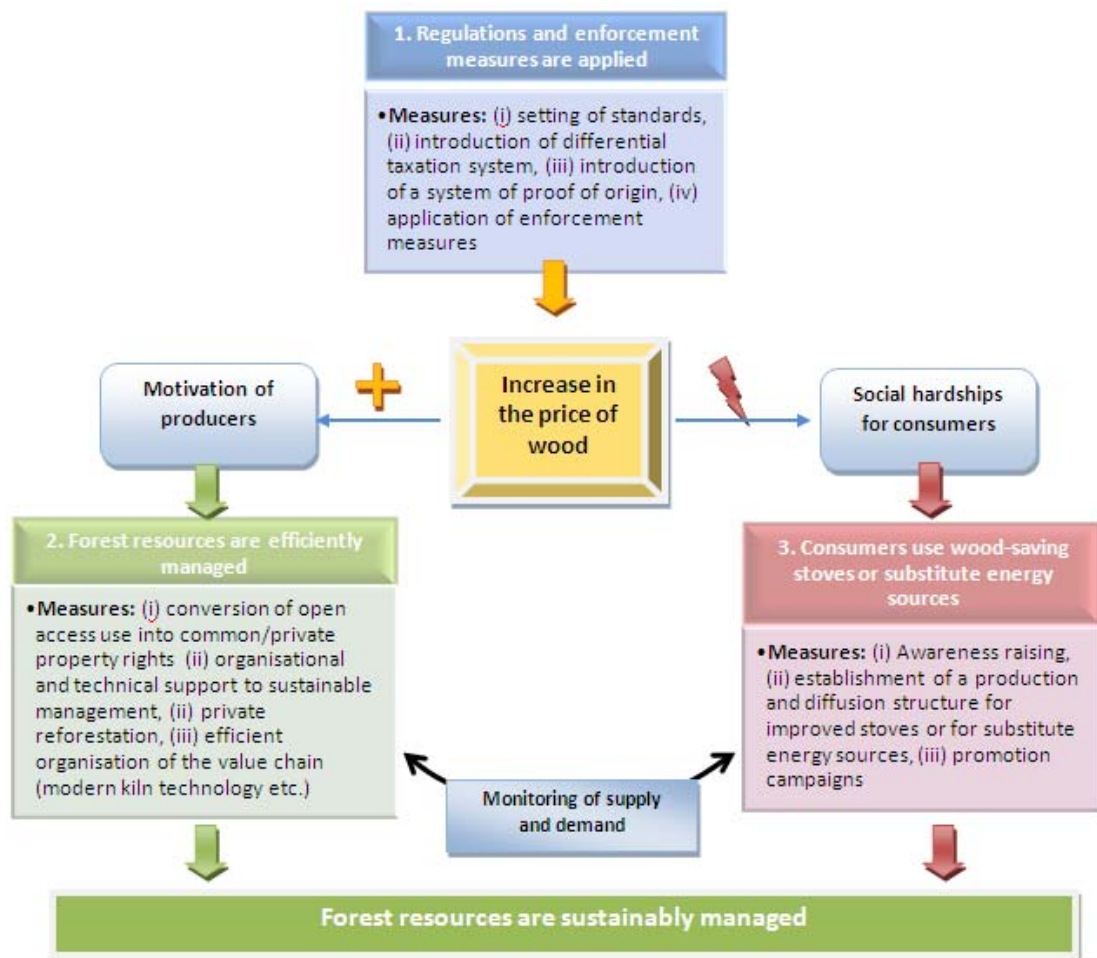
In countries with significant areas of marginal and/or degraded public land, privatisation of land for the purpose of tree-farming may be an option. Such schemes have the potential to preserve/ameliorate land and to augment wood-fuel supplies at the same time. The case of Madagascar may be cited as a particularly promising example, where tenure rights in respect of marginal public lands have been granted to individuals of local communities for the purpose of creating energy plantations [17].

3. Introduction of improved combustion technology

As measures 1 and 2 are designed to deliberately increase wood-fuel prices, they create market-incentives to use wood-based fuels more efficiently. However, poverty-stricken segments of society may be unduly and additionally burdened. This calls for targeted dissemination of fuel-efficient technology (i.e. fuel saving stoves) with the aim of mitigating disproportionate and unintended social hardships. At the same time, fuel substitution becomes more attractive for those who can afford it – without the need for costly long-term state subsidies.

In any case, continuous monitoring is a key-factor of success. To make the system work, the impact of market demand for wood-based fuels on forest resources must be observed, and timely responses devised to ensure sustainability under changing framework conditions.

This system was first introduced in the late 1990s in Niger, Mali and Chad under the title “rural firewood market system”, albeit with different, country-specific approaches. To date, Mali may be regarded as the most advanced example. Notwithstanding persistent weaknesses in the fiscal, administrative and technical frameworks and lingering corruption, the system is widely regarded as a significant contribution to responsible resource management and pro-poor empowerment, decentralisation & good governance [18].



Conclusions

Energy consumption will continue to grow and, despite concerns about climate change and energy security, wood-based fuels will remain a major energy resource in Africa for decades to come. National energy strategies need to reflect, and capitalise on the comparative advantages and efficiency gains from using forests as energy source. Synergies between energy generation and regional forest industries must be fostered so as to reduce risks, increase profitability and promote participatory, sustainable forest management.

Charcoal problems and related response strategies are, of necessity, highly specific to framework conditions on national, regional and local levels. This precludes “blueprints” and panacea, and calls for careful adaptation to the prevailing circumstances on the ground. “Shaping charcoal policies” thus means to address two intervention levels: policy formulation and enforcement/practical implementation. In order to promote strong, substantial and sustainable growth in the wood-fuel sector, any policy must be predictable in the long term, have the potential to account for locally specific circumstances, and promote concrete, local-level projects. To this end, wood-fuel policies need to be designed within the context of a sustainable (rural) development approach, and principles of local control and participation adhered to in the planning process. Comparative advantages of locally produced/managed energy sources must be fully exploited, so as to assign wood-fuel production a pace-maker role for regional economic growth. To this end, hitherto exclusive mandates and responsibilities of national-level public agencies (e.g. the national forest service) should be transferred to private operators, non-governmental organizations and legitimate local governments. Quasi-monopolies enjoyed by urban-based charcoal traders should be replaced with more competitive and equitable market settings.

Regional charcoal strategies must address the entire supply chain and set out targets for clearly defined & verifiable quantities or percentages of wood-based fuels. The bureaucratic and administrative barriers e.g. overcomplicated forest management planning requirements, complex fiscal systems and land tenure procedures may inhibit development and thus warrant critical reflection. The regulatory framework needs to integrate externalities in order to promote adequate pricing of wood-fuel, and thus enhance regional economies.

In summary, the paper at hand advocates a combination of clear rules, transparent enforcement, strong incentives and awareness-creation/capacity development. Key stakeholders and the general public need guidance by way of information campaigns, training, and demonstration projects to ensure that awareness-deficits or false perceptions do not curtail policy implementation.

Last but not least, it will be decisive to improve networking and the exchange of expertise. The pool of regional experience and expertise is rapidly growing and should be better exploited in light of sounder policies. Reservations to learn and exchange knowledge and experience must be set aside in the pursuit of common goals. This holds true especially for the relationship between Anglophone and Francophone African countries.

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Brief Information on the Biomass Energy Policies in Mozambique

Marta Suzana Penicela

National Directorate of New and Renewable Energies - Ministry of Energy, Mozambique

1. INTRODUCTION

Mozambique has a population of around 20 million of with 80% living in rural areas and depending on wood biomass to meet their energy needs. Almost 80% of the energy in the country is used in the form of wood biomass. According to the Forest and Wildlife Policy and Strategy document (1997), the demand for this energy is around 16million cubic meters per year.

In Mozambique, only 10% of the population has access to electricity. It is estimated that the deforestation rate between 1972 and 1990 is around 4.27% and the Forest and wildlife policy state that the fuelwood demand is one of the main causes of deforestation in the country. Therefore it is important to develop sustainable technologies for the biomass energy consumption as a way to reduce the deforestation rate.

2. MINISTRY OF ENERGY VISION

The Ministry of Energy is responsible for the study, conception and execution of policies related to the energy sector. Under this ministry, the National Directorate of New and Renewable Energies (DNER) is the entity responsible for the conception, promotion, evaluation, and execution and monitoring of policies for the sector of new and renewable energies seeking the aiming at achieving the sustainable developments.

3. ENERGY RESOURCES IN THE COUNTRY

- Hydroelectric Potential
- Natural gas reserves
- Coal reserves
- Biomass energy
- High Insulation levels
- Eolic energy (in study)

4. ENERGETIC POTENTIAL IN THE COUNTRY

- Hydropower: 12.500 MW,
- Natural Gas: 2,5 TCF, (Pande and Temane)
- Coal: more than 10 million tons
- Around 70% of the country covered by woody formations (65,3 million hectares currently covered by forests and other woody formations) (national Inventory, 2007)

5. LEGAL INSTRUMENTS THAT GUIDE THE SECTOR

- Energy Policy (1998)

- Energy strategy (2000)
- Electricity Law decree 21/97
- Fuels regulation (Decree 63/2006)
- Energy strategy (being revised)
- New and Renewable energies policy (in development)
- Electricity Regulation
- Action Plan for Poverty Reduction (PARPA II)
- Government 5th year plan (2005-2009)
- Socio-economic Plan (PES 2008)
- Millenium Development Goals (MDG)

6. ENERGY POLICY (BIOMASS SECTION)

In the formulation and consolidation of biomass policy, the Government of Mozambique will carry on with the development of initiatives to improve the information on the following areas:

- Biomass resources
- Consumption levels of biomass energy on the domestic sector
- Firewood and charcoal markets
- Land and Forest Management systems in the household agrarian sector

7. ENERGY POLICY COMPONENTS

- Gradual reduction of fuelwood consumption promoting the usage of biogas;
- Sustainable management of fuelwood through cooperation with rural communities, NGOs and big biomass consumers
- Introduction of measures for the conservative consumption of fuelwood through improvements on the carbonization and combustion techniques;
- Promotion of trainings and dissemination of information related new stoves that have been proven to be more efficient and low cost;
- Research and promote technologies that ensure a more efficient usage of biomass resources.

8 MAIN CHALLENGES IN THE USAGE OF RENEWABLE ENERGIES

- Develop mechanisms for the conservation of forest resources that are becoming scarce resulting in unbalances in the domestic sector as well as in the environment.

9. ACTIONS CARRIED OUT IN THE BIOENERGY SECTOR

- Training of charcoal producers in charcoal sustainable production techniques (improved kilns)

- Introduction of improved stoves for domestic and industrial usage
- Pilot project for introduction of briquettes and
- Pilot Project for biogas production

10. FINAL CONSIDERATIONS

- There is an energy policy that guides all the sector activities
- There is also a strategy being revised and updated
- The Policy of New and Renewable Energies sector is in pipeline that will soon be disseminated

Annex 1 - Results of working group

Group 1 - Charcoal and Communities' livelihoods

1. Participants/Group members:

- Michael Kwaku
- Aniceto Matias
- Teresa Nube
- Sandra Mucavele
- Vasco Acha
- Antonio Muronha
- Alferes Tomas Simbe

2. Project Title: Establishment of charcoal production systems through improved Technologies

3. Project Description

3.1. Target Group: Charcoal Producers

3.2. Problems to be addressed

- Low incomes;
- Use of inefficient technologies;
- Forest devastation;
- Lack of alternative sources of income in the communities;

3.3. General Objective

To introduce and promote efficient charcoal production methods to improve the standard of living of local communities

Specific Objectives

- Increase charcoal producers' income;
- Introduce improved charcoal production kilns (casamance);
- Develop plans for the forest sustainable use;

Potential Donors: Government, GTZ, FAO, IUCN, GEF

Expected Results

- Adopted improved charcoal production techniques by producers;

- Target group aware and capable of using charcoal production improved technologies;
- Increased producers income;
- Developed strategies for the charcoal sustainable production;

Action Plan

- Raise awareness and introduction of new techniques for charcoal production
- Establish a forest management plan;
- Organize a workshop to train the producers on new charcoal production techniques and development of business management skills;
- Training of charcoal producers' groups;
- Develop partnerships with other Organizations such as GTZ, Forests and Lands Department, Ministry of Energy (Department of New and Renewable energies), ADEL;
- Market analysis (SWOT) ;
- Establish a transport chain and market;

Policy Recommendations:

For the government:

- Development of policies for protection and development of the charcoal sector;
- Control charcoal prices;
- Provide subsidies for the acquisition of improved kilns;
- Involvement in the dissemination of new technologies (community leaders, Chiefs of Post and locality);
- Organize fairs for charcoal sales where the improved kilns can be shown and charcoal production technologies can be demonstrated;
- Disseminate the production of “poupa lenha” stoves to reduce charcoal consumption;
- Invest in micro credit banks in the communities to help the producer;

For the Communities

- Establish demonstration fields for the forest exploitation;
- Involvement in the discussion of legislation pertaining the conservation of forest resources;

Group 2 - Protection of Environment and Health

1. Participants/Group members:

2. SWOT analysis

2.1. Problems/Weaknesses

Deforestation;

- Biodiversity reduction;
- Soil erosion and degradation;
- Increased desertification;

Climate change;**Release of gases/noxious substances;****Diseases: cataracts, breathing problems,****Headaches, back problems;****Inadequate charcoal production technologies;****Malaria risks during charcoal production;****Risks of forest fires****Environment laws not being implemented;****Forest resources are common goods and open access;****Land belongs to the Government and no one is responsible for them;****2.2. Strengths**

- Existence of natural forest resources;
- Existence of environmental laws and regulations;
- There is a certain level of awareness at social and government regarding environmental protection;
- Charcoal burns cleaner than firewood;

2.3. Opportunities

- Existence of improved technologies (kilns and stoves);
- Existence of raw materials for charcoal production such as forest and sawmill wastes;
- Existence of alternative raw materials (agriculture products, animal wastes) for energy production;
- Existence of carbon sequestration initiatives;
- Existence of agroforestry initiatives;
- Afforestation programs;
- Existence of alternative energies (electricity and gas)

2.4. Threats

- Few investments in afforestation programs for wood energy production;

- Donors may change their focus/priorities in relation to the biomass energy programs;
- Government priorities may change;
- Increased price of petrol barrel;
- Preference for charcoal in relation to other energy sources

3. Project Title:	Afforestation for firewood and charcoal production	Production of improved kilns and stoves	Plantations for carbon sequestration
4. Project Description			
4.1. Target Group	Private Sector	Private Sector and Communities/Associations.	Implementing agency: • Government • Executing agency: • Communities; • NGOs; • Private Sector
4.2. Problems to be addressed	• Supply raw materials for charcoal production; • Reduction of native forests	• Reduce the demand for charcoal and firewood; • Reduce the incidence of diseases caused by gases inhalation	• To compensate the CO2 emissions and have a cleaner and healthy environment
4.3. Implementation Area/Place	areas where the resources are scarce, close to urban centers (Maputo, Beira, Nampula)	• Improved stoves – Urban centers • Improved kilns- charcoal producers' communities	• TBD preferably: • Risk zones (prone to floods) • Water retention and conservation areas

4.4. Government, WB, GEF, African Development Bank (ADB)

Main activities

- Awareness campaigns and incentives will be given for the private sector;
- Intensify law enforcement at national level in open access areas

4.5. Action Plan

- Formalize the informal sector of charcoal production and sales;
- Include in the school curricula environment and health aspects related to charcoal production;
- Promote use of improved kilns and stoves;
- Demarcate charcoal producing areas

4.6. Policy Recommendations:

- Biomass should be a priority for the renewable energies' policy;
- Ensure the sustainable supply of fuelwood energy;

- Ensure coherence in definitions of biomass policies;
- Government should set up policies to incentive/promote the use of alternative energies;
- Law enforcement should be improved

Group 3 - Policies (Fuelwood Legal Framework)

1. Participants/Group members:

- Alima Issufo
- Kwabena Samuel Nketiah
- Michael Kwaku
- Marta Susana Penicela
- Maria Augusta
- Francisco Geje
- Steve Sepp
- Osvaldo Manso
- Olivia Da Silva Amosse
- Pedro Vicente

2. SWOT analysis

2.1. Problems/Weaknesses

- Lack of policy and strategies, weak implementation of existing policies and sometimes these are not clear or easily understandable,
- Weak institutional capacity (human resources, finance),
- Weak inter and intra-institutional coordination,
- Weak database and information system,
- Inadequate system of licensing fees and incentives in the sector,
- Weak land use plan that contribute to inadequate use of resources.

2.2. Strengths

- Active supply chain,
- Large part of population involved in the supply chain,
- Charcoal is a local renewable resource,
- Existence of different institutions working on alternative energies,
- Existence of legal instruments such as the land, forests and LOLE regulation, etc.

2.3. Opportunities

- Sustainable biomass management may contribute for carbon sequestration,

- Increased price of fossil fuels may favour demand for charcoal,
- Growing interest of donors for supporting alternative energies,
- Existence of a favourable framework for access to carbon credits

2.4. Threats

- Political instability,
- Food insecurity may favour charcoal production,
- Frequent changes of politics makes difficult implementation of policies,
- Politic and social environment difficult policy implementation,
- High level of illiteracy
- High levels of unemployment
- Natural disasters and high levels of poverty

3. Project Title	Unit for coordination, harmonization, institutional support and information exchange	Creation of a national database and implementation of a national survey on fuelwoods.	Fuelwoods and Governance.
3.1. Ambit	Regional	National	National

4. Project Description

4.1. Logical framework

Project 1 - Unit for coordination, harmonization, institutional support and information exchange

	Objectives Indicators	Verification Means (MOV)	Risks
General Objective To strengthen institutions and improve policies and practices in the charcoal trade at national and sub-regional levels			Willingness of countries to provide information Availability of resources to carry out project activities
Specific Objectives Share best practices in the charcoal trade, Build on each others' experiences Strengthen national and sub-regional institutions	Best practices duplicated in other countries Strong national institutions		Willingness to share information and experiences Availability of financial resources
Expected Results Improved charcoal trade in the sub-region Strong national institutions	Higher yields from the production methods Sustainable harvesting of wood resources Greater compliance with laws; fewer cases	Field reports; observation from field visits, reports from the Forestry Department	Willingness to apply lessons learnt

	of illegal activities		
Activities Exchange of visits: 12 people in cross-visits Establish national focal points Training, seminars, workshops, Technical assistance, etc Produce sub-regional newsletter	Needs Reports on visits; National focal points established Reports on activities Quarterly newsletter published		

Project 2: Creation of a national database and implementation of a national survey on fuelwoods

	Verifiable indicators	Means of verification (MOV)	Risks
General Objectives Create a database for policy development and implementation	Database created and functioning	reports, Webpage	
Specific objectives Provide information regarding the biomass (Biodiversity, available areas, access to resources), production methods, efficiency, stakeholders, supply areas, distribution and commercialization forms	Disseminated results of fuelwood survey, Disseminated study results	Brochures, webpage	
Expected Results Established the database to support policy implementation	Developed the biomass policy		
Activities Create a focal point to coordinate activities, Verify/ visit existing information about the topic and develop TORs Hire services to carry out the study and develop the database	Needs Usd 50.000 Usd 20.000 Usd 500.000 for 10 provinces		Lack of funding

Project 3: Fuelwood and Governance

	Verifiable indicators	Means of verification (MOV)	Risks
General Objectives: Improve the governance on fuelwood sector	Reduced deforestation	Satellite imagery, inventories and reports	

Specific objectives: - Promote participatory management at all levels: Communities, Private Sector, SDAE, SPE, schools, health, etc. - Promote coordination/ harmonization/ implementation of legislation at various levels related to biomass energy, - Enhance the law enforcement in the fuelwood supply chain, - Promote transparency and accountability of various stakeholders in the fuelwood supply chain	Decentralized management of fuelwood, Adopted legislation at various levels, Management of resources and more benefits to communities	Number and type of stakeholders managing the resources, Number of management committees and other organised stakeholders, Number of communities operating at community level as community management, Reduced Number infractions, Number of communities benefiting from the dos 20%	High level of illiteracy and unemployment, may contribute to legislation breaches, Corruption may be an impediment to law enforcement strengthening
Expected Results: - Stakeholders involved in decision making, - Effective and uniform application of law, - Improved law enforcement, scope and quality of services, - Higher access to information, accountability and more efficient use of resources			

Action Plan

Activity	Time frame	Responsible Agency
Bring policy recommendations to attention of government	end of June, 2008	Conference Organisers/Secretariat
Constitute inter-ministerial body (IMB)	By 20th June, 2008	Conference Secretariat / MoA/MoF/MoE/MoPD
Elaborate the project ideas/concept notes	End of July, 2008	IMB/INBAR
Identify possible donors	Mid July, 2008	IMB/INBAR
Organise producers at Provincial levels	End of 2008	All provincial staff
Educate concessionaires and producers about provisions of the law/policy	By Mid 2009	DNTF and provincial staff of FD
Promote energy concessions	End of 2008	Min of Agric/IMB
Establish licensing differentiated fees,	End of 2009	Min of Agric/Min of Fin/IMB

Policy Recommendations:

- Implement a national survey for fuelwood,
- Develop a policy and strategy specific for biomass,
- Creation of a multi sector entity to coordinate and supervise all issues related to the biomass which nature and mandate need to be decided
- Establish differentiated license fees,
- Promote energy concessions

Group 4 - Information and technology transfer/adaptation/adoption

1. Participants/Group members:

- Dulcidio Khombe,
- Joao Machel,
- David Makodzo,
- Antonio Malalane,
- Ermelinda Michonga,
- Nicolau Moises,
- Horacia Mula,
- Nilza Puna,

2. SWOT analysis

2.1. Problems/Weaknesses

- Detailed inventory
- Lack of inter and intra institutional cooperation;
- Inexistence of cooperation mechanisms
- Existing technologies not known
- Insufficient follow up after projects
- Insufficient dissemination of information
- Little research and adaptation at local level

2.2. Strengths

Experience in improved charcoal production kilns etc

Capable personnel

2.3. Opportunities

- Available information about technologies;
- Investment
- WISDOM Tool
- Existence of clear policies
- Availability of resources
- Awareness about resources protection

2.4. Threats

- Inexistence of a policy and strategies oriented for biomass energy
- Open access to raw materials

3. Project Title: Dissemination of technologies for production and use of fuelwood

4. Project Description

4.1. Problems to be addressed

Forest Devastation/sustainability of resources used for fuelwoods;

4.2. General Objective

To improve the levels of adoption of fuelwoods production and consumption technologies

Potential Donors: GTZ, OVE, GERENA, IFAD, FUNAE, FDA, FNI

4.4. Target Group	Government and non-Government Institutions and	Producers & Consumers
4.5. Specific Objectives	• Operationalize the inter/intra-institutional coordination	• Incentive adoption/adaptation of improved technologies
Expected Results	• Improved the inter/intra-institutional coordination • Basic legislation known	• Adopted improved fuelwood production technologies; • Disseminated the knowledge
Activities	• Identify actors involved in the fuelwood sector • Create a forum for discussion of fuelwood related issues • Develop mechanisms for articulation of the stakeholders involved in the fuelwood sector	• Survey/inventory of the existing information and technology regarding the production and use of fuelwood; • Evaluate the fuelwood production and use technologies; • Identify improved practices, “best practices” and produce technical notes about fuelwood production and use; • Disseminate best practices; • Monitor the adoption of disseminated technologies
Strategies		• Existence of resources • Afforestation • Consumer level • Improved stoves • Use of briquettes • Alternative sources of energy (gas, biogas, electricity, etc) • Producers level • Improved kilns • Briquetting production

4.6 Policy Recommendations:

- Approve rapidly mechanisms of inter/intra-sectoral coordination;
- Evaluate the adoption level and impact of disseminated technologies;

- Organize producers associations and establish concessions for charcoal production;
- Train associations in business management to ensure their growth;
- Correct and adapt disseminated technologies;
- Define clear policy orientation lines for the biomass energy with emphasis on the rural areas.

Annex 2 - List of participants of the conference on charcoal and Communities in Africa

Nr.	Name	Institution	E-mail	Telephone
1	Imaculada dos Santos	GTZ-Probec	imaculadamz@gmail.com	827858460
2	Osvaldo Manso	DNTF	omanso@yahoo.com.br	823032890
3	Yolanda Goncalves	DNTF	yogoncalves@yahoo.com.br	824707000
4	Eugenio Manhica	DNTF	eugenioamanhica@yahoo.com	823989520
5	Reinaldo Luis	UEM- FAEF	reinaldosiba@yahoo.com.br	828708643
6	Dulcidio luis Khombe	SPFFB NIASSA	khombe@yahoo.com.br	828488800
7	Ermelinda Estefania Michonga	INBAR- West Africa	emichonga@yahoo.com.br	823895532
8	Aniceto Matias	ADEL - Sofala	mkwaku@inbar.int	233(24)8727 783
9	Antonio Malalane	GTZ-Probec	adelsofala@tdm.co.mz	825749160
10	Fabiao Suaze	Simultaneous translation services	fabiao_jopaquim@yahoo.com.br	21486211
11	Sandra Mucavele	SPFFB Maputo	sandra.mucavele@gmail.com	828034270
12	Ralf Kwaschik	INBAR- NTFP	rkwaschik@inbar.int	+91 11 2433 4801
13	Maria Augusta Magaia	SPFFB Sofala	jojoca3mz@yahoo.com.br	
14	Maria Angareni	Italy embassy	maria.angareni@italcoop.org.mz	
15	Samiro Magane	FAO	samiro.magane@fao.org	823093050
16	Paulo Deves	Jornal Raio X	paulodeves@tvcabo.co.mz	827256216
17	Vasco Acha	GTA	vascoacha@gmail.com	823232320
18	Paulino Djamba	Denmark embassy		842943961
19	Antonio Muronha	DPA/SPFFB Nampula	muronha@yahoo.com.br	826920870
20	Kwabena S Nketiah	Tropenbos International Ghana	ksnketiah@yahoo.com	233 (20)8152148
21	Steve Sepp	Eco-Consulting Group	steve.sepp@eco-	4928837366

Nr.	Name	Institution	E-mail	Telephone
			consult.com	
22	Jose Carlos F Maduela	SPFFB Inhambane		823829456
23	Dania Falcao	FDA	danialfalcao@ffa.org.mz	21302814
24	Yisehak Seboka	Rural Energy	yseboka@yahoo.com	911955889
25	Muhamud Matsinhe	AIM	mmatsinhe@gmail.com	825977804
26	Simiao Nhassengo	Mediafax	nhassengo2004@yahoo.com	848408377
27	Mandrate Nakala	DNTF	mnakala@tdm.co.mz	823828788
28	Rucali Aly Dauto	DNTF	rucaidauto@yahoo.com.br	824873460
29	Catarina Pajume	MINAG		
30	Raimundo Cossa	DNTF		21312072
31	Ines Acacio	DNTF		21312072
32	Helena Eduardo Mabulambe	DNTF	helenamabulambe@hotmail.com	21302555
33	Nilza Hassane Puna	INBAR	nhp411@gmail.com	824163590
34	Sara Tembe	DNTF		21302555
35	Pedro Mangué	DNTF		827838010
36	Irene de Souza	USAID	isouza@usaid.gov	21352059
37	Francisco A. Geje	UEM- FAEF	fgeje@uem.mz	824536230
38	Lourenco R. Tsambe	DPA/SPFFB Gaza	cocoloane@yahoo.com.br	825702549
39	Ana Laura Ribeiro	PRODEZA	ana.prodeza@tdm.co.mz	843845690
40	David Makodzo	SPFFB Sofala	makodzodavid@yahoo.com.br	825873120
41	Nicolau Oscar Moises	SPFFB Cabo Delgado	nicola@teledata.mz	826887250
42	Marta Susana Penicela	Ministerio da Energia	msp@me.gov.mz	827656400
43	Pedro Vicente	DNTF	pbalo@yahoo.com.br	824846100
44	Teresa Nube	DNTF	teresanube@yahoo.com.br	825445502
45	Carla Cuambe	DNTF	carlacuambe@hotmail.com	827340380
46	Horacia Mula	IIAM	horaciachelina@yahoo.com.br	824605520

Nr.	Name	Institution	E-mail	Telephone
47	Esperanca Chamba	IIAM	erechamba@hotmail.com	846129450
48	Olivia Susana da Silva Amosse	SPFFB Maputo	olisuzysilva@yahoo.com.br	824857190
49	Imede Falume	DNTF	imede.falume@yahoo.com.br	824692190
50	Andre Hebeler	USAID	ahebeler@usaid.gov	825394433
51	Marjaana Pekkoh	Finland Embassy	marjaana.pekkoh@turmin.fi	823107360
52	Rauno Laitalainen	NDF / DNTF	raunolainen@gmail.com	825290404
53	Almeida A. Siteo	UEM- FAEF	asitoe@uem.mz	823195410
54	Joao Machel	SPFFB Zambezia	chizambane@yahoo.com.br	825810990
55	Alferes Tomas Simbe	SPFFB Tete		825132596
56	Salvador Jossias	DNTF	sjossando@yahoo.com	825815180
57	Andre Seidel	GTZ-Hera	drseidel@aol.com	49 5554477042
58	Eugenio da Camara	BBC	eugeniodacamara@yahoo.com.br	824157145
59	Amelia Macie	DNTF		
60	Alima Issufo	DNTF	aissufo@yahoo.com	823099160
61	Inacio Muianga	DNTF		
62	Aguinelio Gualagreiro	GM-Noticias	ayencios@yahoo.com.br	824403650
63	Wibke Thies	GTZ-SADC	wibke.thies@gtz.de	843983319