BIOMASS ENERGY STRATEGY (BEST)

WOOD FUEL SUPPLY INTERVENTIONS

LESSONS LEARNED AND RECOMMENDATIONS

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“Lessons Learned and Policy Recommendations for Woodfuel Supply Interventions”

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Table of Content

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Boxes

Figures

Tables

Abbreviations

CBFM	Community-based Forest Managment
CDM	Clean Development Mechanism
CILSS	Comité Permanent Inter Etats de lutte contre la Sécheresse dans le Sahel
FAO	Food and Agriculture Organization of the United Nations
FMU	Forest Management Units
GDP	Gross Domestic Product
GHG	Greenhouse Gases
IKM	Information and Knowledge Management
LPG	Liquefied Petroleum Gas
MDG	Millenium Development Goals
MIS	Management Information Systems
NFP	National Forest Program
PES	Payments for Environmental Services
PFM	Participatory Forest Management
PPP	Public-Private Partnership
REDD	Reducing Emissions from Deforestation and Degradation
SFM	Sustainable Forest Management
ToF	Trees outside forests
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
VCM	Voluntary Carbon Market
WISDOM	Wood-fuel Integrated Supply/Demand Overview Mapping
WRI	World Resources Institute

1 Executive summary

Wood-based fuels remain the most significant energy source for the majority of developing countries. Worldwide, estimated 2.5 billion people use biofuels mainly for cooking and heating while in poverty-stricken developing countries more than 90 percent are depending on energy from biomass. Many developing countries´ energy policies so far neglected the role of wood-fuels. However, alternatives introduced by governments have often failed their purpose to overcome their peoples' overwhelming dependency on firewood and charcoal.

Biomass Energy Strategies (BEST) describe the key interventions needed to achieve sustainable biomass use, both on the supply-side and on the demand-side. The paper at hand links itself to BEST by focusing on the supply-side of wood-based solid fuels. It aims to fill information gaps and pleads for deliberate action in support of optimized, sustainable production of biomass energy. Thereby, it abstains from any attempt to "reinvent the wheel" – instead, the challenge lies in (i) transferring any applying established best practices from sustainable forest management to the production of wood-based fuels, and (ii) providing a well-structured overview of existing knowledge for the benefit of practitioners and policy makers.

It is common understanding that over-exploitation of wood-based energy sources may lead to the degradation of forests or even deforestation around agglomerations. The production of wood-fuel occurs either as a concomitant of forest management, or as an objective in itself. It can be pursued in optimizing the management of existing forests or by establishing wood-fuel plantations.

As the aim to manage existing forests sustainably sets narrow limitations on the harvesting of forest products, this solution most often cannot offer a solution for sufficient and sustainable wood-fuel supply. An obvious complementary intervention is the establishment of wood-fuel plantations. However, such plantations have faced a number of problems such as a lack of available land, insufficient tenure security and governance deficits for preventing unregulated access. Furthermore, wood fuel plantations have in many cases gradually been shifted towards production of forest products with higher market value (e.g. poles, construction timber) since wood based fuels are frequently underpriced or not commercialized at all.

In general, there are a number of current barriers to the sustainable supply of wood-based fuels. One is the discrimination of wood-based solid fuels in national energy sector policies and strategies, which is mainly due to the following factors:

- The use of biomass energy is often regarded as primitive or backwards.
- Biomass fuels are widely associated with the poorest and most disadvantaged of the society
- Firewood and charcoal has been highlighted as one of the underlying causes of forest degradation and deforestation.
- Accurate and up-to-date forest inventory data are often not available as a prerequisite for sustainable woodfuel production.

Subsequently, governments of developing countries have come under pressure with the effect that their energy policies and strategies highlight the need to shift away from ´traditional´ fuels towards LPG, solar energy, hydro-power etc.

The other barriers for more efficient and sustainable supply of wood-fuel are

- the informal and unregulated prevailing production system. This is mainly due to the fact, that charcoal and firewood are generally underpriced. Another associated problem is the lack of information and data on the resource and the stakeholders.
- The growing complexity of societal demand for forest resources: Framework conditions for a deliberate, sustainable production of wood-based solid fuels are deteriorating in the face of both mounting land-use competition, and the ever increasing complexity of societal demand for forest resources. Growth of international and domestic timber trade brought forest resources under pressure and shifted the sector's attention towards the production of valuable commercial timber. On the other hand, population growth associated with low agricultural productivity and increasing demand for food and cash crops has created strong incentives for the conversion of forests into other land uses. In addition, the growing threat to forest resources have led to the formal protection of remaining natural forests in various categories and kinds and are therefore rendered inaccessible to poverty-stricken communities dependent on wood-based fuels and other non-timber forest products. These scenarios have in common that underpriced commodities such as firewood are of low priority in land use decisions, In consequence, proponents of wood-based solid fuels face growing difficulties in identifying areas suitable for reforestation as well as for promoting sustainable wood-fuel production in forest management systems.

Based on the foregoing conditions the mainstreaming of sustainable wood-fuel production is essential in forest management and land use decisions. Approaches have to aim to (i) discourage unregulated production and use of wood-based fuels, (ii) promote technical innovation and management capacity at all levels, and (iii) improve framework conditions and business opportunities for legitimate stakeholders along the wood-fuel production chain. The ultimate goal, however, is to end the present undervaluation of wood-based fuels, and to turn them into adequately priced marketable commodities.

A shift towards a well-regulated, sustainable biomass energy sector requires a dramatic change in perception, behavior, commitment and the willingness of relevant stakeholders to participate in this process. Therefore, the present document outlines potential roles, functions and responsibilities of these stakeholders clustered into the three categories of **Shapers** (central and local governments), **Facilitators** (donor agencies, NGOs, research organizations) and **Implementers** (communities, private sector). At national level, the Department of Energy and the Forestry Department should spearhead the implementation of policy formulation and implementation, while other relevant ministries and stakeholders take over responsibilities in accordance with their mandate and function. Central governments play a key role in developing cross-cutting as well as sector-specific policies and setting development priorities, while local governments are the principal proponents of implementation-oriented planning and administration. Donor agencies, representing the second category, typically provide advisory support, capacity development, knowledge and technology transfer, and funding, while NGOs typically engage in awareness building, lobbying, and mobilizing funds for development, and advocacy. Research organizations provide information, analysis and innovation. The third category includes communities and the private sector who principally react to framework conditions and absorb support provided by the first two stakeholder categories.

Recommendations:

Promote woodfuel as a modern energy carrier: Wood-based fuels can be "modernized" all along the production chain. Wood-energy is versatile and displays a high potential for technological innovation.

Furthermore, sustainable production of wood-based fuels can serve as an engine for sustainable rural development and can create incentives for landowners and farmers to manage woodlands better, and to invest into fuelwood plantations. Therefore, a consensual vision statement for the promotion of sustainable wood energy production of all relevant government authorities is required describing the desired situation in the long term of 15-30 years. It should address four basic principles: (i) environmental and climate-friendliness, (ii) security of supply, (iii) economic efficiency and compliance as well as (iv) health and safety requirements.

Technical or financial assistance alone can neither induce nor achieve the required policy change necessary to realize such a vision. They need to be backed up with targeted policy advisory support on the national level. Furthermore, interagency cooperation must be enhanced along with the revision of policy agendas. Thus, the vision statement must be mainstreamed into the technical service culture from central to local level. Implementation of such a vision entails a stepwise process requiring a continuous refinement of respective framework conditions, organizational and procedural aspects, and technological development. The paper illustrates this process by comparing different stages of modernising the wood-fuel production chain. Practical implementation and up-scaling of this vision requires awareness raising, lobbying and PR measures to ensure that support to biomass energy production generates lasting and self-sustaining impact.

Promote informed decision making: The development of the sector towards sustainable woodfuel production requires informed decision making. Generally, efforts to improve the informational basis of policy making and subsequent implementation of wood fuel policies should focus on (i) identifying information gaps and needs of stakeholders, (ii) measures to improve information and knowledge management (IKM), and (iii) capacity development and pilot-interventions with a view to collecting supplementary data.

Implement economic policies with a view to correcting market failures: A further issue is the generally weak market position of forestry with subsequent under-valuated and underpriced products, despite growing scarcity of wood. Underpricing generally translates into wasteful and inefficient production and consumption of wood-based fuels and creates formidable disincentives for forest management and tree growing. Changing this situation implies (i) a mutually synergetic approach of adequate use regulation and enforcement (taxation), (ii) a strategic shift from open-access forests towards secure tenure and sustainable forest management (formal agreements and cutting permits), and (iii) an introduction of fuel-saving combustion technology.

Assure adequate land tenure/user rights for wood fuel production: Unregulated access to forest resources and unchecked exploitation are directly linked to forest resource tenure. It is widely recognized that security of tenure is one of the most significant framework conditions necessary for sustainable forest management. Tenure arrangements must hence be adequately reflected in wood-fuel policies. The document identifies several actions that need to be taken to support the strategic shift from demand-driven exploitation to production-oriented management. It promotes three basic types of instruments to support tenure reform and tenure security: (i) the promotion of joint management arrangements, (ii) incentive systems, and (iii) capacity development.

Improve governance capacity to reorganize the charcoal production sector: Sector administrations, prominently the forestry administration in many countries, are either weak, or themselves forced to prioritize other forest management goals over sustainable wood-fuel supply. Thus, in order to improve government capacity towards a formal and sustainable wood-fuel sector a possible solution may lie in the creation of institutions specifically assigned to cross-cutting woodfuel planning, strategy development, resource monitoring and evaluation on all levels, and operational support. In addition, capacity development also needs to reach out to the policy and legal services. Energy sector

institutions and forest sector agencies should solicit, and rely on support by authorized law enforcement agencies and the judiciary.

Assist local actors to introduce efficient production options and technologies: The sixth recommendation is concerned with the efficient production options and technologies for wood-based fuel supply and presents two basic avenues of intervention; (i) the production of wood-fuels in the narrower sense, and (ii) an introduction of improved conversion technologies for charcoal production (improved kilns).

Options for wood-fuel production in the narrower sense are demonstrated along the three production categories of (i) forest plantations, (ii) natural forests (including secondary forests) and (iii) "trees outside forests" (TOFs).

- Forest plantations on degraded land as a means of producing fuelwood can yield a wide range of benefits such as specific ecosystem services, reduced pressure on natural forests, amelioration of marginal or degraded land, employment opportunities and a contribution to rural development. They require careful development policies, full stakeholder participation and cross-sectoral coordination. Cultivation methods need to be adapted to the skills and resources of the rural people and every plantation activity should be preceded by an economic analysis. Reference is made to a village-based approach in Madagascar (GTZ) and to an outgrower scheme analyzed by FAO.

- Wood-fuel production in natural or secondary forests requires a more complex approach because it is normally only a by-product of more valuable production goals. The current document describes woodfuel productions with a particular focus on community based schemes (CBFM, CBNRM) in savannah woodlands since wood-fuel shortages generally occur in such regions. Based on experience of the World Resources Institute (WRI), a number of recommendations are presented which are particularly important when designing and implementing participatory forest management projects for wood-based fuel production.

- "Trees outside forests" (TOFs) refer to trees on non-forest and non-wooded lands. They fulfil a multipurpose function including soil and water conservation, fencing and energy supply. For the purpose of wood-fuel production, fast growing hardwood species that coppice readily, fix nitrogen and can be harvested after 4-6 years should be selected. The World Agroforestry Centre is a good source of information (database with information on tree species for this purpose and a guide on how to integrate gender issues). Another important issue is to lobby for the recognition of ToF as one of the most important fuelwood supply sources. The socio-economic and ecological advantages of wood-fuel production within agroforestry systems substantially outweigh many expensive, ill-conceived tree plantation programs with a wider diversity of goods and services for the local and national economies.

The options for wood-fuel production also include charcoal as the primary energy source in most of the cities in African countries. However, the common issues characterizing the charcoal production chain in these countries include: (i) inefficient conversion technologies, (ii) rampant and systematic corruption, and (iii) the charcoal business being dominated by a few powerful individuals.

Charcoal consumption is a very controversial issue as the transformation process from wood to charcoal results in considerable energy loss. On the other hand, charcoal burns more cleanly than wood or dried biomass, producing higher temperatures, and it is cheaper to transport and store. Therefore,

steps need to be taken to promote improved charcoal-making technologies and thus reduce the amount of raw biomass required, energy losses, and the negative impacts on health, environment and climate.

The current document, therefore, promotes for improved kiln technologies and new funding mechanisms. Since most countries' capabilities to mobilize domestic budget support for the development of a vibrant biomass energy sector are low and insufficient, the paper outlines global as well as regional initiatives to combat climate change and promote carbon-neutral energy consumption as a source for generating funding for sustainable biomass energy solutions. This includes the Clean Development Mechanism under the UNFCCC Kyoto Protocol, the new REDD mechanism agreed at the 2007 Bali Summit (UNFCCC COP 13) and the potentials of Voluntary Carbon Marketing (VCM).

2 Introduction

Supply and consumption of energy carriers are key to any development process, and the provision of energy is a pre-condition for economic growth and social advancement. While global discussions about the finiteness of fossil fuels and impending climate change have brought new and heightened attention for biomass energy even in highly industrialised societies, the issue is particularly important for developing countries. It does not seem an exaggeration to portray biomass energy solutions as a question of survival for many of the world's poorest nations, especially so on the African continent.

Notwithstanding new and emerging developments in respect of biomass-based fuels (e.g. ethanol, oil-plants etc.), biomass energy for the most part means wood-based fuels and agricultural residue. Wood-based fuels include firewood, charcoal, and various wood-industry residues (e.g. saw-dust). Agricultural residue typically includes crop-leftovers such as straw or husks, or manure from livestock. It must be noted that agricultural residue is valuable as either fodder or fertilizer, and that it is consequently used for fuel only in those circumstances were wood-based fuels are, for some reason, unavailable.

Today, it is estimated that 2.5 billion people use fuelwood, charcoal, agricultural waste and animal dung to meet their daily energy needs for cooking and heating. In many poverty-stricken developing countries more than 90 percent of the energy used is derived from biomass [1]. Most of this energy is used in households – both rural and urban – for cooking and heating purposes. For the poorest segments of society, availability of affordable energy is a matter of survival, one that directly affects their nutritional status and determines the share of income that remains available for other vital purposes, e.g. education and productive investments.

Many developing countries' energy policies and strategies thus far neglected (or deliberately downplayed) the role of wood-based fuels (for details, refer to section 2.2.1). However, many – if not most – of the suggested alternatives provide no viable answer to the respective populations' overwhelming dependency on firewood and charcoal.

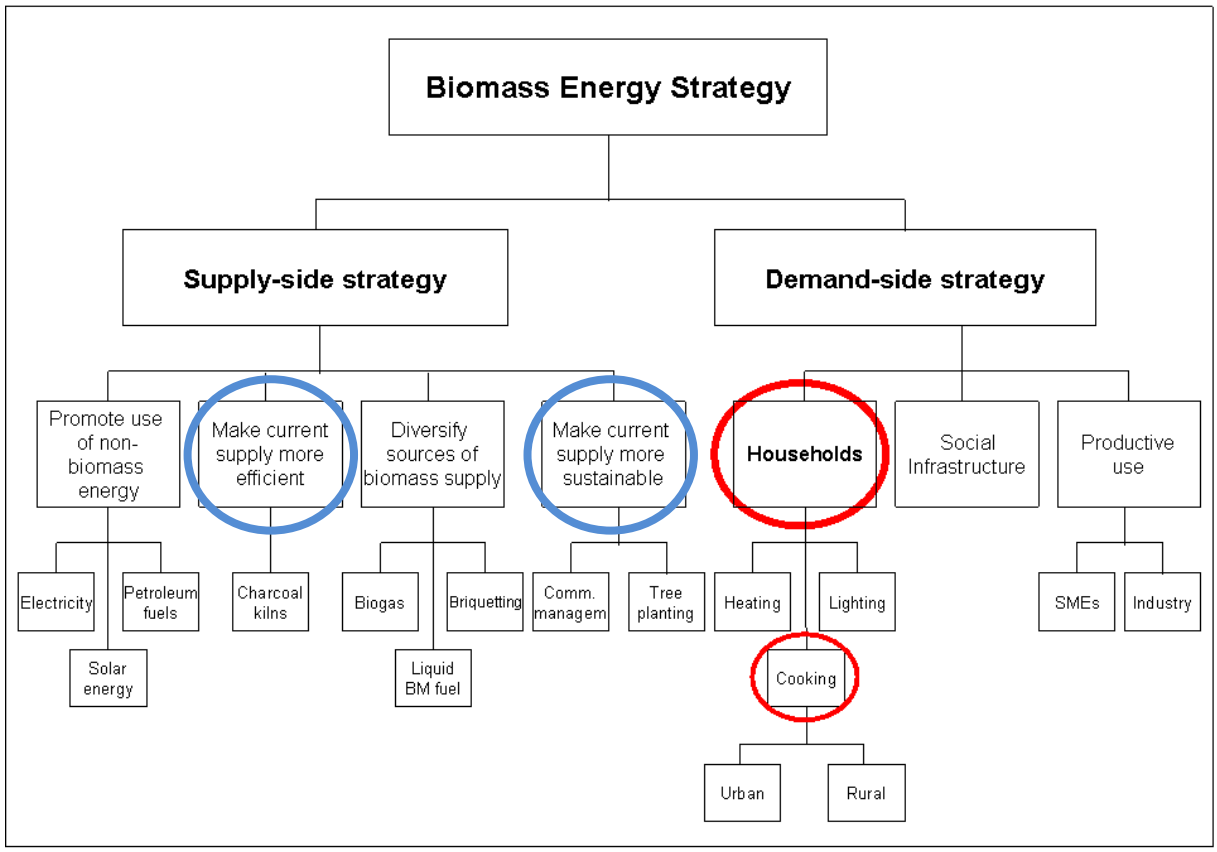
- Fossile energy carriers by definition are finite, and – notwithstanding short-lived price fluctuations – their cost can be counted on to rise in the future. For this, the drastic increase in oil-prices prior to the current financial crisis provides a vivid example. Fossile fuels are likewise problematic because (i) they increase a country's dependency on imports and negatively affect the trade-balance, (ii) they add to carbon emissions, and (iii) their use requires significant investments in technology as well as behavioural changes on the end users' part. In many countries, the introduction of LPG requires substantial government subsidies and/or donor-support. But even then, fossil fuels remain an option for better-off urban populations, rather than impoverished rural inhabitants. Fossil fuels, in consequence, do not provide a patent remedy – neither in terms of their relevance for a country's household energy problems, nor with a view to promoting social equity and helping disadvantaged segments of society ascend the energy-ladder.
- Alternative power sources such as hydro power, wind, and solar power may indeed have considerable potential as a component within a country's overall energy supply. However, their practical utility is subject to site-conditions. Besides, electricity or solar thermal energy in most cases cannot replace wood-based fuels, because it is not widely used for cooking and heating purposes.

3 Linkages to the biomass energy strategy (BEST)

Biomass energy strategies – or any energy strategy, for that matter – commonly approach their subject along two principal avenues: Supply and Demand[1]. In this context, "supply" denotes all aspects of production, utilisation, conversion, transport and marketing/distribution of biomass-based fuels, while "demand" covers all aspects of use and consumption (including provision of required technical appliances, such as stoves or similar technology).

The paper at hand aims to fill informational gaps to the extent possible, and to plead the case for deliberate action in support of optimised, sustainable production of biomass energy. In doing so, it must firstly outline its focus, and limit its purview with a view to reducing the – otherwise overwhelming – complexity of the biomass issue [see figure 1].

Figure 1: Elements of a Biomass Energy Strategy



Therefore, the focus of the present contribution shall be on the supply of ***wood-based solid fuels***, sourced through forest management, management of firewood plantations, or harvested from trees outside forests (ToF). Other biomass fuels, including novel technologies such as biogas and agro-fuels (ethanol, and other liquid biomass fuels such as plant oil) will not be covered. Neither does the paper at hand discuss renewable energy sources such as solar power, hydro power, wind power and the like. This choice of focus must by no means be understood as downplaying the significance of either "other" biomass fuels or renewable energy sources.

[1] A systematic approach to developing a biomass energy strategy is described in a recent study [2].

Notwithstanding the merit of actions to promote alternative energy sources, wood-based fuels are (and will remain so in the foreseeable future) the most significant source of energy in the majority of developing countries – especially in Africa. It is likewise justified by the fact that unregulated and non-sustainable exploitation of firewood does indeed contribute to the degradation of forest resources, thereby threatening the integrity and functional value (in terms of environmental protection, biodiversity conservation, and carbon-sequestration) of many forest eco-systems.

Therefore, the paper at hand departs from the premise that, (i) because wood-based fuels cannot be realistically replaced at short notice and (ii) because demand-side interventions alone cannot lower consumption to a sustainable level, targeted action is required to

- Replace non-sustainable and wasteful exploitation with sustainable management of existing forests and woodlands,
- Boost production of wood-based fuels on hitherto unforested areas of land.

This premise, and targeted action in its pursuit, foremost requires careful analysis of the factors that lead to the problems and/or deficits commonly associated with the use of wood-based solid fuels.

4 Specifics of the forest sector

The production of wood-based solid fuels basically occurs in two different ways: Either as a concomitant of forest management, or as an objective in itself. The following table highlights the differences between the two scenarios.

Table 1: Comparison of basic sustainable firewood production systems

Firewood as a specific management goal	Firewood as a by-product of sustainable timber production
Optimised for biomass production – single product or limited number of products	Firewood production as a low-value by-product, multi-purpose forestry
Mostly fast-growing, high-yield, short-rotation plantations, management as coppice	High-forest with varying degrees of biological and structural diversity (single species/single storey plantations vs. mixed close-to-nature forests)
Easy to integrate into agro-forestry systems	Intact high-forest (as well as undergrowth) mostly precludes agricultural cultivation (exceptions are cocoa, rubber etc.)
+/- schematic lay-out, low biological and structural diversity	Sustainable management of primary & secondary forests mostly maintains species composition and structural diversity – this does not apply to high-forest timber plantations
+/- continuous or periodical yield of easily predictable quantities of firewood; firewood production is mostly determined by area available, site properties, annual increment of selected tree species	Firewood harvesting only in conjunction with thinning/tending operations or harvesting of mature timber trees; firewood production is mainly determined by other management objectives of higher priority
Requires initial investment (clearing, planting, planting material, maintenance etc.)	May be integrated flexibly into ongoing forest management operations
Depends upon the availability of marginal land suitable for afforestation	Requires existing forest cover, including degraded forests
Management planning required, albeit on a simple scale (area/yield-based) inventory/planning tools suffice	Management planning required, complexity increases with number of species involved, structural/biological diversity
Labour intensive maintenance and production,	Tending & harvesting operations require certain

Firewood as a specific management goal	Firewood as a by-product of sustainable timber production
requiring mostly manual work	amount of silvicultural skill, transport infrastructure, heavy machinery etc.

Wood-fuel related issues (including deforestation attributed to the overexploitation of forests for fuel) are commonly discussed against the backdrop of forest sector development and sustainable forest management. However, as table 1 shows, a different, more specific focus may be required if wood-based fuels are to be produced in large quantities.

The very aim to manage existing forests and woodlands sustainably places narrow limitations on the harvesting of forest products. At present, sustainable management in most developing countries is the exception rather than the norm. Forest utilisation is widely unregulated, and responds to current market demand instead of following long-term production goals. If one is to replace exploitation with sustainable management, harvesting volumes in most cases need to be lowered substantially – even more so, if forest areas are degraded and in need of rehabilitation. Sustainable utilisation of forest resources – for commercial timber as well as for fuel – thus requires a fundamental change of the forest users' prevailing mindset. Hence, *sustainable management of extant forests alone* will often not suffice to close the (steadily widening) gap between demand and supply.

Ever since the 1992 United Nations Conference on Environment and Development (UNCED) and the adoption of the Forest Principles[2] it produced, the international forest policy dialogue (spearheaded since 2000 by the United Nations Forum on Forests – UNFF) sought to provide a canonized definition of sustainable forest management (SFM). To this end, sets of criteria and indicators (C&I) have been put forward, as a yardstick whereby forest management routines are to be judged. While no single, legally binding definition of SFM has been forwarded to this date, there is growing consensus that SFM equates **close-to-nature**, **multi-purpose forest management**. Hence the production of wood-based fuels may be regarded as one tessera within a complex mosaic of management objectives – one that is oftentimes superseded by protection and production goals of a perceived higher order. This observation provides additional backing to the argument that SFM of extant forests – however beneficial from a sustainable development viewpoint – does not provide a patent remedy for the mounting wood fuel crisis.

If the supply of wood based solid fuels is to be boosted effectively and within realistic time frames, the establishment and management of forest plantations thus appears a complementary solution. Several advantages may be cited to justify this claim:

- Wood fuel plantations can be managed for a single purpose, and can provide optimal biomass production within short rotation cycles – especially so, if fast growing, high-yield species are selected.
- Wood fuel plantations can be operated on the basis of simplified planning tools (area based or volume based) and less demanding silvicultural systems (e.g. coppicing).
- Wood fuel plantations may provide additional benefits through intercropping with agricultural crops at early stages, or grazing of livestock shortly before harvesting.

[2] Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests

- Size and weight of harvested wood enable management by a local population with little or no access to advanced harvesting, and transport technologies.
- Even though wood fuel plantations may be lacking in biological diversity (when compared to sustainably managed high forests), they nevertheless afford soil fixation and water retention services, and carbon sequestration.

Why, then, have wood fuel plantations thus far failed to achieve the prevalence, the above presentation of advantages seems to suggest?

Availability of land is a crucial factor, and land use competition oftentimes restricts the establishment of wood fuel plantations. Many developing countries are faced with high population growth rates; hence availability of land for settlement and agricultural production may be a matter of survival. Even now extant forests are at risk of being cleared and converted through encroachment, and forest plantations (whether for wood fuel production or other purposes) are generally restricted to the most marginal and unproductive sites.

Tenure security is another factor, one that may depend on legal-regulatory frameworks as well as on socio-cultural conditions and customary norms. Statutory laws oftentimes subject forest resources to state-ownership and exclusive control by public forest administrations. They likewise tend to restrict access by, and revenue sharing for the benefit of rural communities. Similarly, in many African cultures the planting of trees establishes claims to the land on which they are planted. Tree planting by households and user groups may thus be perceived as a challenge to customary authorities' control over land.

Governance deficits may likewise discourage the establishment of wood fuel plantations (or any other kind of perennial crops requiring medium to long term commitment and investment). Unless public oversight and enforcement ensures that outside users and free-riders are denied access to plantations (or communities are given full control and authority over them), there is a risk that unregulated access will occur.

Economic factors likewise tend to limit the success of wood fuel plantation schemes. As has been shown in the preceding section, wood based fuels are frequently underpriced (or not commercialised at all). Managing forest plantations for the purpose of wood fuel production must therefore seem a bad deal to investors. There are many examples where wood fuel plantations (often established with outside assistance) have gradually been shifted towards production of poles, construction timber and other forest products with a higher market value.

4.1 Current barriers to the sustainable supply of wood-based solid fuels

4.1.1 Discrimination of wood-based solid fuels in national energy sector policies and strategies

Given the obvious and undisputed significance of biomass as a source of energy it must seem all the more surprising that, in many developing countries, official energy policies and strategies either remain silent on the issue, or approach it rather critically. This observation can be attributed to a number of factors:

- Many developing countries, striving for industrialisation and modernisation, regard the use of biomass energy as “primitive” or “backward”. Instead, they pursue ambitious visions of “modern”, supposedly “cleaner” energy sources such as electricity or oil and gas.
- Biomass fuels are widely associated with the poorest, most disadvantaged and politically powerless segments of society, particularly in rural areas. Their needs and aspirations are more often than not neglected, or seriously downplayed and marginalised in offical government policies.
- Widespread use of firewood and charcoal has been highlighted as one of the underlying causes of forest degradation and deforestation. As the global forest cover continues to shrink at an alarming rate of approximately 15 millon hectares annually, multilateral policy processes and dialogues have increasingly pinpointed unsustainable use and overexploitation of forests and woodlands. Many developing countries have come under pressure to take action, and donor-organisations have consequently focused on forest protection, sustainable forest management, and options to curb the consumption of forest products – including wood-based fuels. In consequence, national energy policies and strategies in many developing countries highlight the need to shift away from “traditional” fuels, by means of introducing LPG, solar energy, hydro-power and other energy sources.
- In addition to the foregoing, government policies and strategies also frequently suffer from a significant lack of knowledge in respect of forest resources. National forest inventories are either outdated or lacking altogether, and the valuation of forest resources for their economic, environmental and social significance in most cases remains in an early state of infancy.

These observations, however snap-shot like and anything but exhaustive, provide an explanation for the fact that, in many developing countries biomass energy does not receive the attention it actually deserves.

4.1.2 Informal, unregulated and non-sustainable use of wood-based solid fuels

At present, harvesting and use of wood-based solid fuels is widely characterised by the absence of effective regulation and adequately developed value chains alike. This leads to a curious situation where (i) forest resources – including woodlands – are exploited instead of being managed, (ii) forest dependent rural communities or forest-dwellers loose control over and access to much needed forest produce, and (iii) benefits are concentrated in the hands of small numbers of intermediaries. Aside from the lack of political attention mentioned above, this situation can be attributed to the following factors:

- Wood, and firewood in particular, is generally underpriced. Depending on the circumstances in a given country or region, wood-based fuels are either gathered and consumed directly by the rural population, or commercialised by traders and freight-haulers who supply urban agglomerations. The latter scenario is frequently encountered in dry, Sahelian countries where forest resources are in short supply anyway, due to marginal soils and unfavourable climatic conditions. Towns and cities represent centres of gravity for wood-fuel demand, with concentric deforestation zones extending farther and farther from the city limits. As urban inhabitants are increasingly unable to supply their own fuelwood needs, they tend to rely on the services of commercial fuel-merchants. Owing to the fact that raw wood cannot be transported economically over large distances, charcoal in such cases replaces firewood as the fuel of choice. Adding to this effect are the general convenience of use, cleanness, and

easy storage of charcoal that provide added value to urban consumers. Wood-fuel merchants, in turn, rely on the poorest, landless and unemployed segments of urban populations for cheap labour. They maximise their benefits by deploying work-parties to the country side, to harvest wood at leisure and convert it into charcoal by means of makeshift, inefficient kilns. Charcoal is then transported to centres of consumption and sold on urban markets. Rural communities living within or close to forest areas usually hold no tenure rights to forests or woodlands and are consequently unable to check the rapid depletion of their natural resources. In consequence, charcoal prices in urban markets reflect exploitation costs only[3]. This scenario precludes investments into forest management and more efficient conversion technology alike. It likewise keeps fuel prices comparatively low for the end-users, thereby discouraging investments in fuel-efficient stove technology. Lack of transparency, inequitable distribution of benefits, adverse incentives, and resource depletion can all be traced back to governance failures; most notably the absence of conducive legal-regulatory frameworks, lack of administrative supervision, and economic framework conditions that discourage formal business and investment along adequately developed value-chains.

- Owing to the widespread lack of resource data and evidence-based management planning, the depletion of forest resources, however rampant, tends to escape detection for a considerable time. Unregulated open-access use will in most cases continue as long as transport costs do not become untenable. Forest resources within reach of consumption centres thus tend to be exhausted beyond the possibility of natural regeneration. However, even countries with substantial forests and woodlands can be affected by non-sustainable exploitation – especially so, if forest resources are unevenly distributed. Limited transport facilities, combined with unreasonably low prices for wood-based fuels lead to demand-peaks which cannot be compensated for through harvesting from more distant forest areas.

4.1.3 Growing complexity of societal demand for forest resources

The way in which forest resources are perceived and valued by society is drastically changing in many developing countries. However complex and multi-faceted this trend of development may seem at the surface, it can be summarised by a common denominator: Framework conditions for a deliberate, sustainable production of wood-based solid fuels are deteriorating in the face of both mounting land-use competition, and the ever increasing complexity of societal demand for forest resources.

- Growth of the international timber trade and development of domestic timber industries have not only brought forest resources under pressure in a general sense, but have likewise shifted the forest sector's attention towards production of valuable commercial timber. This translates into exploitation pressure on natural forests on the one hand, however, it also creates a strong incentive for timber-oriented plantation management on the other.
- Population growth – which tends to be highest particularly in the least developed countries – likewise exerts pressure on forests. Low agricultural productivity and growing needs for food and cash-crops create strong incentives for the conversion of forests into different land uses. Similar effects are caused by the quasi-industrial production of agro-fuels for the

[3] Compounded charcoal prices include (i) labour costs, (ii) transport costs, and (iii) profit margins of the wood-merchants/freight haulers - but neither production costs, nor costs for reforestation/rehabilitation of open-access forests and woodlands.

international market – a highly controversial development that can be witnessed in many parts of the world, particularly in South-East Asia. In consequence, underpriced commodities such as firewood are of low priority in land use decisions.

- Additionally, the growing threat to forest resources (and global concerns in response thereto) have led to a situation where large tracts of remaining (natural) forests are formally reserved as protected areas of various categories and kinds. This includes conservation of global public goods (biodiversity, carbon-sequestration) as well as protection of locally/regionally relevant socio-economic functions (soil and water protection etc.). Therefore, substantial tracts of forest land are rendered inaccessible to poverty-stricken communities dependent on wood-based fuels and other non-timber forest products (NTFP).

In consequence, proponents of wood-based solid fuels face growing difficulties in identifying areas suitable for reforestation, as well as in mainstreaming sustainable wood-fuel production in forest management systems.

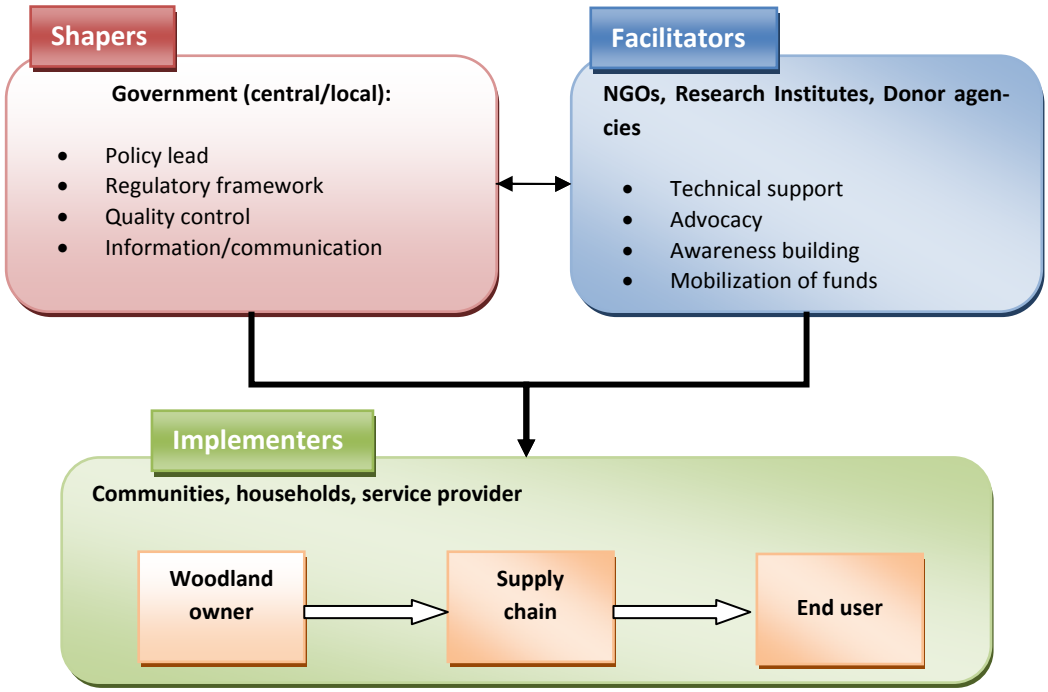
5 Roles and potentials of different stakeholders

The foregoing recommendations generally aim to (i) discourage unregulated production and use of wood-based fuels, (ii) promote technical innovation and management capacity at all levels, and (iii) improve framework conditions and business opportunities for legitimate stakeholders along the wood-fuel production chain. Their ultimate goal, however, is to end the present undervaluation of wood-based fuels, and to turn them into adequately priced marketable commodities. Simply put: to become more sustainable, wood-based fuels first need to become more expensive.

The policy, legal-regulatory, administrative, economic and technological changes suggested in the foregoing chapters have in common that they require a change in perception, behavioral changes, and – above all – commitment and willingness to bear the inevitable socioeconomic burden associated with the transition towards a well-regulated, sustainable biomass energy sector. This necessitates an integrated approach with equitable – though differentiated – participation by all relevant stakeholders.

Owing to the complexity of the issue, the range of relevant stakeholders is wide and diverse. It may be broadly clustered, however, into three main categories: (i) stakeholders who actively determine and shape the development of political, legal-regulatory, administrative and economic framework conditions (**shapers**), (ii) stakeholders who contribute to, and facilitate this development process (**facilitators**), and (iii) stakeholders who react to, and benefit from improved framework conditions (**implementers**).

Figure 2: Roles and potentials of different stakeholders



Stakeholders of the ***first category*** include **central** and **local governments**. A noticeable trend towards decentralization and devolution of central government functions can be observed in many developing countries. Consequently, the significance of local governments has grown – and continues to grow – relative to central governments. In particular, local governments have increasingly attained the authority to enact their own laws and regulations within the framework of national policies and statutory legislation, the right to levy taxes and charges for their own budgets, and to implement economic policies commensurate with their development priorities. Being closer to the realities at field level, local governments also tend to be more flexible in the up-take and application of support provided by donors and civil-society stakeholders.

Central Governments play a key role in developing cross-cutting (e.g. decentralization, privatization/land rights) as well as sector-specific policies and setting development priorities, initiating reforms, adjusting statutory frameworks, and coordinating overarching consultative processes. They typically define the entry points, priorities, and modalities for support by donors and the civil society at large. Furthermore, central governments define and shape economic policies and apply the respective instruments, notably incentive schemes, guidance taxes and innovative funding instruments such as payments for environmental services (PES, including carbon-credit marketing e.g. under the CDM, for which central government agencies are commonly appointed designated national agencies). Likewise, law enforcement and criminal proceedings are functions typically exercised by national governments.

Local governments are the principal proponents of implementation-oriented planning (e.g. woodfuel supply master-plans) and administration. They act as transmission belts for putting national policies and framework conditions into practice, providing e.g. for the establishment of decentralized coordination, capacity development, and public awareness building. However, local governments have increasingly gained leeway in defining their own development priorities and sector-programs,

backed up with the authority to levy their own taxes, charges and fees. Local governments are instrumental in promoting participatory, community-based management arrangements in respect of natural resources, e.g. by means of defining contractual relations between public services and non-state actors such as rural communities. Operating closer to the realities on the ground, local governments are in a better position to promote the self-organization and institutional development of local users, towards whom they increasingly adopt a partnership relation instead of executive control and interventions.

The ***second category*** of stakeholders includes **donor agencies** (international as well as bilateral), international as well as domestic **NGOs**, and **research organizations**. They typically assume supporting roles vis-à-vis stakeholders of both the first and third categories, subject to their respective capacities, roles and mandates.

Donor agencies typically provide advisory support, capacity development, knowledge and technology transfer, and funding support across all levels. Due to their official status as implementers of intergovernmental development cooperation, they have comparative advantages in addressing government agencies in terms of agenda setting and policy making, promoting legal-regulatory and institutional reforms, and facilitating multi-stakeholder consultative processes. In this regard, **donor coordination** must be highlighted as a crucial success factor, in terms of promoting synergies/avoiding duplications, and harmonizing/mainstreaming support instruments, e.g. incentive systems. They likewise are in a preferential position to support recipient countries' participation in international fora and processes and to facilitate the implementation of international policy frameworks and regimes (e.g. in regard to multi-lateral environmental agreements and innovative funding instruments such as PES).

NGOs typically engage in awareness building, lobbying, mobilizing funds for development, and advocacy. Depending on the prevailing circumstances of a given country, NGOs may either act as implementation partners of governments and the donor community, or else as independent watch-dogs. They likewise promote and facilitate community participation in the conservation and sustainable management of natural resources.

Research organizations provide information, analysis and innovation, especially so if they focus on applied research. With a view to promoting sustainable wood fuel supplies, research organizations have a significant role to play in providing baseline information about the status of wood resources (e.g. forest inventories, ecological monitoring), as well as in terms of technological innovation (species trials, improvement of conversion technologies etc.). They likewise facilitate information and knowledge management, and capacity development by means of education and extension services.

The ***third category*** of stakeholders includes **communities** (households) and the **private sector**, who principally react to framework conditions and absorb support provided by the first two stakeholder categories. Depending on a given country's societal setting as well as on their specific capacities, stakeholders of the third category may also engage in **consultation processes** defending their rights and voicing their needs and expectations. The private sector in particular further acts as a driving force in the modernization of wood-fuel supply chains, principally by means of investments and its contribution to market development.

The list below describes the potential role of different government agencies in wood energy interventions.

Government agency	Potential role in cooking energy interventions
Ministry of Energy (MoE)	The responsibility of the MoE is to formulating and implementing favourable policies for wood energy development. They provide guidance on energy sector development and supervise Energy Policy formulation up to implementation. MoE should spearhead the development of energy strategies and provide guidelines in regard to the prospective energy mix and the significance of wood energy in particular.
Ministry of Health (MoH)	The MoH should support strategies to reduce pollution from charcoal production. Its role could lie in issuing emission benchmarks supporting the dissemination of improved kiln technologies.
Ministry of Education/Information	The Ministry of Education is the thrust leader to enhance environmental education as well as public information on the interrelationship between people and their natural environment. Environmental education should become an important component of school curricula, playing a significant role towards the realization of sustainable development
Ministry of Finance	The Ministry of Finance is responsible for mobilising external financial resources, setting taxes and approving subsidies.
Ministry of Economic Affairs/Industry/SME Promotion	The Ministry of Economic Affairs should create an enabling environment to formalize the informal woodfuel production sector. This comprises the facilitation of procedural requirements (business start-up, registration, licensing etc.)
Ministry of Research and Technology	The Ministry of Research can support Research & Development (R&D) activities to enhance the efficient production of woodfuel (species trials, cultivation and exploitation methods, conversion technologies etc.)
Ministry of Agriculture/ Forestry/ Environment	The Ministry hosting Forestry has the prime responsibility for creating an enabling framework to enhance wood-energy production through sustainable forest management or afforestation schemes by individuals or communities. They take care that management procedures comply with the national and international body of rules and regulations and that forest services fulfil the perceived needs of the population. Jointly with the Agricultural Department the planting of trees outside forest (ToT) should be enhanced.
Local government authorities	In recent years, many countries have moved towards greater decentralisation of planning processes. This move towards decentralisation results in a more important role of local government authorities in ensuring sustainable biomass energy supply and use on local level.

Government agency	Potential role in cooking energy interventions
	Local governments are levers for the development of woodenergy sector strategy at territory level.

6 Recommendations for woodfuel supply

Summarising the above discussion of problems and deficits associated with the use of wood-based solid fuels in developing countries, the following conclusions seem pertinent:

1. The use of wood-based fuels as such does not constitute a problem in itself. Wood-based fuels have considerable potential in respect of (i) providing an environmentally friendly, renewable source of energy, (ii) promoting rural development and the empowerment of forest fringe-communities and forest dwellers, and (iii) promoting small and medium-sized businesses and pro-poor employment.
2. Where harvesting, conversion and marketing of wood-based fuels do contribute to resource depletion and inequitable socio-economic outcomes, this failure must be ascribed to governance deficits and ensuing market failures.
3. Replacing wood-based fuels through forced "modernisation" of the energy-sector does not seem a viable option for many developing countries. Neither does it provide an answer to growing concerns over deforestation and loss of the forests environmental and socio-economic functions.
4. Far from downplaying the significance and undisputed necessity of SFM being applied as a means to protect, and better utilise extant forests for the wide range of products and services they provide, the promotion of SFM *alone* does not suffice to address wood fuel supply deficits.
5. Several factors – including availability of land - limit the feasibility and performance of forest plantations as a means to produce large quantities of wood based fuels on a sustainable basis. These factors point to wider political, legal-regulatory, and institutional framework conditions that are, at least in part, non-specific to the forest sector, and thus do not lend themselves to being addressed through sector-specific interventions.
6. Significance and impact of the framework conditions discussed above underscore that bridging the wood fuel supply gap is, above all, a governance issue. If wood based fuels are to be produced in a coordinated as well as sustainable manner, structural disincentives that counteract wood fuel production must be removed. Action is required in two basic respects: Measures to dispense with unregulated access and use of forest resources, and measures to level the playing field for investments in sustainable wood fuel production. Both should result in adequate pricing of woodfuel reflecting the true costs of sustainable woodfuel production.
7. What is therefore required, are targeted policy interventions, governance support and deliberate value-chain development with a view to formalising energy business, promoting production and sustainable management of forests and woodlands, and levelling the playing field for a wider range of resource-dependent stakeholders.

The latter conclusion, in particular, sets the stage for the discussion of framework conditions required for the sustainable production of wood-based solid fuels, and concrete recommendations in the subsequent sections below.

6.1 Promote woodfuel as a modern energy carrier

As shown in the first chapter, the significance of wood-based fuels is frequently overlooked – even discriminated against – in many developing countries' official energy policies. This observation contrasts sharply not only with the manifest everyday significance of wood-based fuels for the concerned populations, but likewise with the high and obvious potential of wood-based fuels as an environmentally friendly/renewable, socially adapted, and clean/low-risk source of energy.

Box 1: Potential benefits of wood-based fuels for energy security and rural development

Wood-based fuels can be "modernized" all along the production chain. There is a variety of technologies to convert solid biomass into clean, more convenient energy carriers. Most of these technologies are commercially available today, while others are still at a stage of development and demonstration. If current wood-fuel supply chains are to be modernized and energy security enhanced, it is nevertheless imperative to formalize production, conversion and marketing of wood-based fuels, and to improve both cost-effectiveness of operations and energy efficiency.

Using firewood can create incentives for landowners and farmers to manage woodlands better, and to invest into fuelwood plantations. Sustainable production of wood-based fuels thus helps to safeguard forests and woodlands along with their multiple functions, including soil conservation, biodiversity& landscape protection, and carbon sequestration. The production of wood-based fuels is ideally suited for community-based management of forests and woodlands, and thus supports general trends towards deregulation and privatization of the energy/forest sector.

Wood-energy is versatile and displays a high potential for technological innovation in terms of enhanced conversion and combustion – Wood-based fuels lend themselves to short-term improvement of efficiency (improved stoves, kilns etc.) with modest investments involved. They nevertheless offer possibilities for more far-reaching technical innovation (chips, pellets, gasification, liquefaction), depending on the availability 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 reduce dependency on finite fossil fuels. Aside from direct efficiency gains through innovation, promotion of wood-based fuels likewise offers indirect benefits, such as foreign-currency savings and reduced economic dependency of the countries involved.

Sustainable production of wood-based fuels can serve as an engine for sustainable rural development. Forest resources are locally available and display a high potential for decentralized processing & production. Utilisation of wood-based fuels allows short transport distances with low environmental risks. Unlike other, more technologically demanding energy sources, wood-based fuels generate employment & local income especially for poor/disadvantaged and generally unskilled segments of society. Wood-based fuels are climate friendly, provided that sustainability standards are met. Production of wood-based fuels can be easily integrated with the promotion of sustainable forest management.

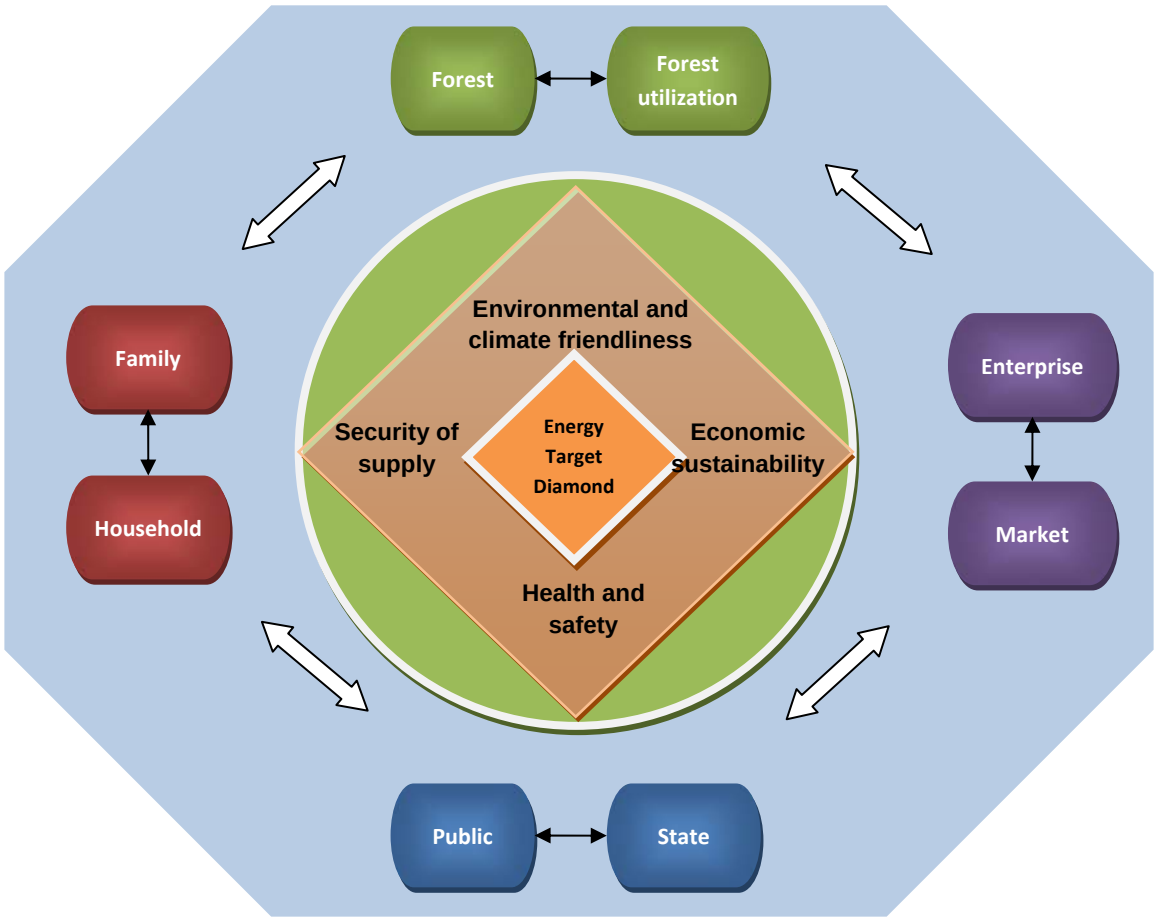
A **consensual vision statement** on promoting sustainable wood energy production of all relevant government authorities is required. The vision concentrates on the future, is a source of inspiration, and provides clear decision-making criteria. The vision statement can galvanize the people to achieve defined objectives.

A vision for sustainable wood-fuel supply describes the desired situation in the long term (15 to 30 years) [2]. It should include a qualitative statement on all involved sectors and address **four basic principles**: (i) environmental and climate-friendliness (ii) security of supply, (iii) economic efficiency and compliance, and (iv) health and safety requirements – as illustrated in the following figure X below.

These principles apply to the nexus of forest resources' availability, forest use patterns, rights and obligations existing between the different entities, and the exchange of products and services. The challenge during implementation will be to reorganize these linkages so as to comply with the principles. However, official government policies must be revised first, before implementation may commence.

The recommendation to revise and develop the (national) policy framework holds **implications for development cooperation support to the energy sector**. To begin with, technical or financial assistance on the local implementation level (regardless of whether they focus on supply or demand – e.g. interventions promoting SFM, CBFM, or dissemination of improved cook-stoves) can neither induce nor achieve the required policy change by themselves. Rather, they need to be backed up with targeted policy advisory support on the national level. Second, as energy policies tend to be cross-cutting and non-specific to a single sector, policy coherence and interagency cooperation must be enhanced along with the revision of policy agendas. Advisory support thus ought to address not merely a single sector-administration, but rather the level of ministries or inter-ministerial working groups, as appropriate.

Figure 3: The energy target diamond and its interrelationships



To be really effective (and prior to any strategy development), a vision statement must be mainstreamed into the technical service-culture from central to local level. Policy makers are responsible for communicating the vision regularly, creating pilot projects that illustrate the vision, setting short-term objectives compatible with the vision, as well as encouraging others to craft their own personal perception compatible with the overall vision.

Prudence dictates that interventions following this vision be best integrated into existing consultative fora, e.g. structures established to promote sustainable development against the backdrop of na-

tional policies or strategies to this end, or national forest programme (NFP[4]) processes (in case they exist in a given country). National processes or fora which aim to promote the biodiversity-conservation or climate-change agenda would likewise provide entry-points and opportunities for raising the policy-profile of wood-based fuels. Furthermore, they facilitate donor-coordination as an added benefit.

Implementation of such a vision entails a stepwise process requiring a continuous refinement/adaptation of respective framework conditions, organizational and procedural aspects, and technological development. Whereas political will is pivotal to the modernization of the wood-fuel sector, the shift from traditional fuel-wood consumption to a modern, "industrialized" wood based energy supply likewise depends on economic development, specifically: the per capita GDP purchasing power parity. This calls for a step-wise development as illustrated in the following chart.

Departing from a transition phase the wood-fuel supply chain is continuously formalized into a (semi-) industrial state characterised by sustainable, affordable and clean wood based energy production.

Table 2: Comparison of different stages of modernising the wood-fuel production chain

Characteristics	Traditional Phase	Transition Phase	Semi-industrial Phase	Industrial Phase
Supply chain	informal	informal/ formal	formal	formal
Planning of wood-fuel supply	no planning	Wood-fuel supply schemes	regional energy master plans	integrated energy planning
Type of management	open access	open access/ sustainable	sustainable/certified	certified
Type of exploitation	uncontrolled	semi-organized (rural wood-fuel markets)	organized (wood-fuel markets)	Out-grower scheme/ energy-contracting
Products	fuelwood/ charcoal	charcoal	charcoal, wood chips	charcoal, wood chips
Conversion technologies for thermal energy	Traditional kilns 	Improved kilns 	Semi-industrial kilns 	Industrial kilns 
Efficiency	8 to 12 %	12 to 18%	18 to 24%	>24%
Emissions (in g per kg charcoal produced)	CO2: 450 to 550 CH4: ~ 700 CO: 450 to 650			CO2:~400 CH4: ~50 CO: ~160
Woodfuel price	X	X+20%	X+40%	X +60%
Combustion technologies	3-stone fires	Improved stoves (first generation)	Improved stoves (second generation)	Stoves of high efficiency

[4] The term National Forest Programs (NFP), emanating from the International Forest Policy Dialogue, denotes a consultative multi-stakeholder consultation process which is government-led, but not government-driven. The NFP aims at providing defined elements (sector review, policy reform, legal-regulatory improvements, definition of stakeholders' roles and mandates etc.) pursuant to a set of authoritative principles.

Characteristics	Traditional Phase	Transition Phase	Semi-industrial Phase	Industrial Phase
				
Efficiency	8 to 12 %	20 to 25%	25 to 35%	>35%
Particulate matter per m3	2800 ppm	1700 ppm	<1000 ppm	< 250 ppm
Type of energy	Thermal energy	Thermal energy	Thermal energy, electric energy 	Thermal energy, electric energy, chemical energy 
Type of conversion	combustion	combustion	combustion gasification	combustion gasification liquefaction

Practical implementation and up-scaling of such a vision and thus presupposes adequate information of the public at large (producers as well as consumers), and lobbying to convince the concerned populations of the need to change their established ways of energy production and consumption.

Awareness building, lobbying and PR measures are therefore indispensable to ensure that support to biomass energy production generates lasting and self-sustaining impact. This seems advisable particularly in the following respects:

- Public education programs to sensitize the public for the harmful ecological and socioeconomic consequences of unregulated and wasteful wood fuel consumption,
- PR programs to inform concerned segments of society about ongoing programs and initiatives, and to capacitate them for equitable participation as stakeholders,
- Technical information to disseminate knowledge and innovative approaches,
- Policy and legal-regulatory information campaigns to educate concerned segments of society about legal-regulatory amendments, incentive schemes, and economic policies,
- Establishment and promotion of feedback by stakeholders, to facilitate monitoring of biomass energy support programs and interventions.

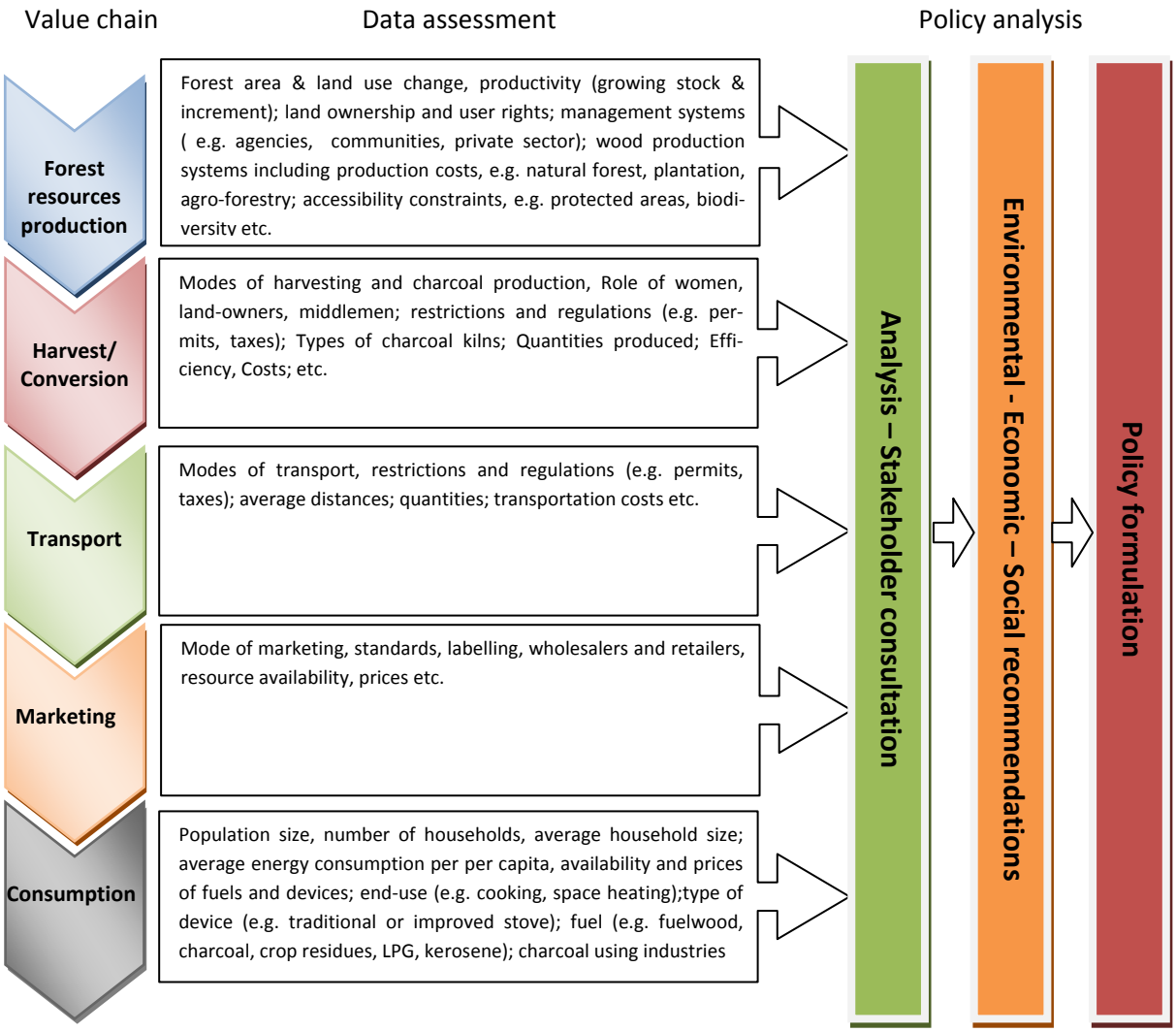
6.2 Promote informed decision making.

Shaping energy 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 have in many instances been disproven.

In the early 1980ies simple scenarios for many Sahel countries forecast near-complete deforestation within 20 years [3]. Population growth and the shift from fire-wood to charcoal were highlighted as the main driving factors. In reality, natural woody vegetation in the Sahel proved much more resilient than expected.

Wood-fuel exploitation alone clearly does not provide a summary explanation for deforestation on a national scale. It may, however, create problems locally, even though these cannot always be reduced to a simple demand and supply gap. Wood-fuel problems are increasingly regarded as being rooted in more systemic – however site-specific - deficits in land tenure, fiscal and incentive policies, urban energy markets, and misallocation of forests and crop-land.

The foregoing problems all arise along the woodfuel production chain. Therefore, precise data on the woodfuel 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 wood-fuel value chain provide the opportunity to demonstrate the regional added value of woodfuel production and thus help to sensitise policy makers for a source of energy hitherto neglected & left to the informal sector.

Examples of study projects, geared towards a comprehensive assessment and analysis of the wood-fuel production chain, include: the supra-regional Chaposa project investigating the charcoal potential for Southern Africa [4]; the National Charcoal Survey in Kenya [5], the WRI/CIRAD research project in Senegal [6], and the study initiated by the Forest Governance Learning Group (FGLG) for Malawi [7].

The above presentation is by no means intended to suggest that data-collection and subsequent analyses were to commence from scratch. A considerable part of the information required may already be in existence, however at different locations within the institutional structures of the relevant agencies and institutions. Database formats may vary, though, and governmental statistics may be outdated to some degree. Other aspects may either be missing, or may be worked on by stakeholders outside governmental structures (civil society, the private sector, or donor-supported interventions).

Among the **pitfalls frequently encountered in compiling and analyzing data** for the benefit of decision makers and practitioners is the use of **forest-specific terms and concepts**, the use of **conversion factors** for the comparison of different energy carriers, as well as misrepresentations and knowledge gaps regarding the use of wood-based fuels. Supply calculations are frequently erroneous, because the **specifics of forest management** are overlooked by stakeholders unfamiliar to the forest sector. The following paragraphs exemplify this argument further.

- Identified **forest areas** represent by no means the potential production area for woodfuel. Generally, parts of a forest are subject to legal restrictions (protected areas for nature conservation, ownership rights etc.) or are physically inaccessible or economically non-viable (e.g. too remote), and are therefore not considered for exploitation.
- Forest owners consider **woodfuel** often only as a **by-product** as they are eager to increase their profits by selling their produce as lumber or poles etc. achieving much higher prices on the market than for woodfuel.
- When estimating actual or potential wood supplies, an important distinction has to be made between (i) clear felling (often limited to plantations) and (ii) sustainable harvesting. In case of clear felling the whole stock of produced wood can be taken into account whereas sustainable harvesting presumes an annual take-off at or below the mean annual increment.
- The calorific value of wood-based fuels is subject to their density. Different tree species vary considerably in terms of their wood density, with values ranging from 100 kg/m^3 to 1200 kg/m^3. Species most commonly used for fuel display densities between 650 kg/m^3 and 750 kg/m^3.
- Forest sector statistics typically distinguish between “standing stock” (expressed in solid cubic meters), and “harvested wood-fuel” (expressed in stacked cubic meters or “steres”, containing air spaces in between). A well-piled stacked cubic meter may contain 0.65 m^3 solid wood (e.g. relatively even tree trunks harvested from plantations), whereas a poorly stacked one may hold as little as 0.33 m^3 solid wood (e.g twisted branches collected from shrubs/woodlands in the Sahel) – actually half the amount given in the first example.

With a view to harmonizing definitions facilitating knowledge exchange between forestry practitioners and development actors outside the forest sector, FAO has published a ‘Unified Bio-Energy Terminology’ [8].

Sound baseline information on forest resources is a precondition for shaping wood-fuel supply strategies on national and/or sub-national level. There are two main sources of wood-fuel informa-

tion: forestry services, and energy agencies; their approaches differ significantly. Analyzing information from these sources is challenging as there are often discrepancies in the reported values: definitions are seldom consistent; measurement units are different; conversion factors are not always available etc. Deficiencies of data, coupled with the failure to prioritise forest energy at policy level, frequently result in the absence of legislation on sectoral wood energy.

The process of collecting and verifying facts and figures is a laborious, costly and time-consuming undertaking, requiring properly trained and qualified personnel. To alleviate these constraints, FAO published a guide outlining simple rapid methods to verify existing data, to fill gaps in the information chain, and to conduct more reliable surveys [9].

FAO likewise developed and introduced the Wood-fuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology as a tool to support national wood energy planning. WISDOM is a GIS-based tool that allows the user to understand, in detail, the current spatial patterns of biomass demand and supply in a country, and to assess the sustainability of wood-fuel as a renewable and prolific energy carrier. The methodology has been expanded to investigate the scope of urban wood-fuel supply[5], which identifies the extent to which supply zones encroach into rural areas and forests [10].

Box 2: The WISDOM analysis

A **WISDOM analysis** involves five main steps: (1) selection of the spatial base, (2) development of the demand module, (3) development of the supply module, (4) development of the integration module, and (5) identification of woodfuel hot spots.

At national level, the WISDOM approach has been implemented in Mexico, Senegal and Slovenia. At the subregional level, WISDOM has been implemented over the eastern and central African countries covered by the Africover Programme (Burundi, Democratic Republic of the Congo, Egypt, Eritrea, Kenya, Rwanda, Somalia, the Sudan, United Republic of Tanzania and Uganda) and over the countries of Southeast Asia (Cambodia, Malaysia, Lao People's Democratic Republic, Thailand, Viet Nam and China, Yunnan Province

Woodfuel problems are not always simply a gap between demand and supply. They are increasingly regarded as a reflection of more systemic, and often locally site-specific, deficiencies in land tenure, in fiscal and incentive policies, in urban energy markets, and in misallocation of forests and cropland.

As a consequence, forest resource assessments have to be complemented by legal, regulatory, institutional, and socio-economic studies that analyse the framework conditions.

Therefore, efforts to improve the informational basis of policy making and subsequent implementation should focus on

- Identifying information gaps as well as the specific needs and potential contributions of relevant stakeholders (stakeholder analysis, needs assessment)
- Measures to improve information and knowledge management (IKM), including harmonization of statistics and management information systems (MIS), documentation and up-scaling of experience and lessons learnt, and information sharing among stakeholders
- Capacity development and pilot-interventions with a view to collecting supplementary data (e.g. introduction and dissemination of forest inventory protocols and instruments), and targeted supply of novel/advanced methods and technologies (e.g. GIS applications, resource monitoring etc.).

[5] The term "urban woodsheds" is analogous with the familiar geographic concept of watersheds

6.3 Implement economic policies with a view to correcting market failures

The weak market position of forestry – worldwide – is characterised by an undervaluation of wood as a raw material and by the low price elasticity of all forest products. Despite growing scarcity of wood, charcoal generally remains underpriced by up to 50 percent, relative to its "true" economic value. This is because the exploitation cost of wood-based fuels reflects only the cost of labour (which is marginal) and capital required for production and transport. Market prices thus express opportunity costs and expected profits of freight haulers and retailers involved in the wood-fuel business, with no regard for replacement costs or the legitimate claims of people living within or adjacent to forests and woodlands. Underpricing 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 [11] 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 superiorly efficient Casamance kiln has been disseminated since 20 years throughout Africa without success.
- Tree growing approaches remain ineffective when competing with open access resources. Costs for planting and maintenance in this case are prohibitively high, and significant subsidies (e.g. Madagascar: 200 to 300 €/ha) are necessary to provide enough incentive [11]. This holds also true for any investments in natural forest management.
- Substitute fuels such as kerosene must be highly subsidized to become 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, no subsidies 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 [12]:

- 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.

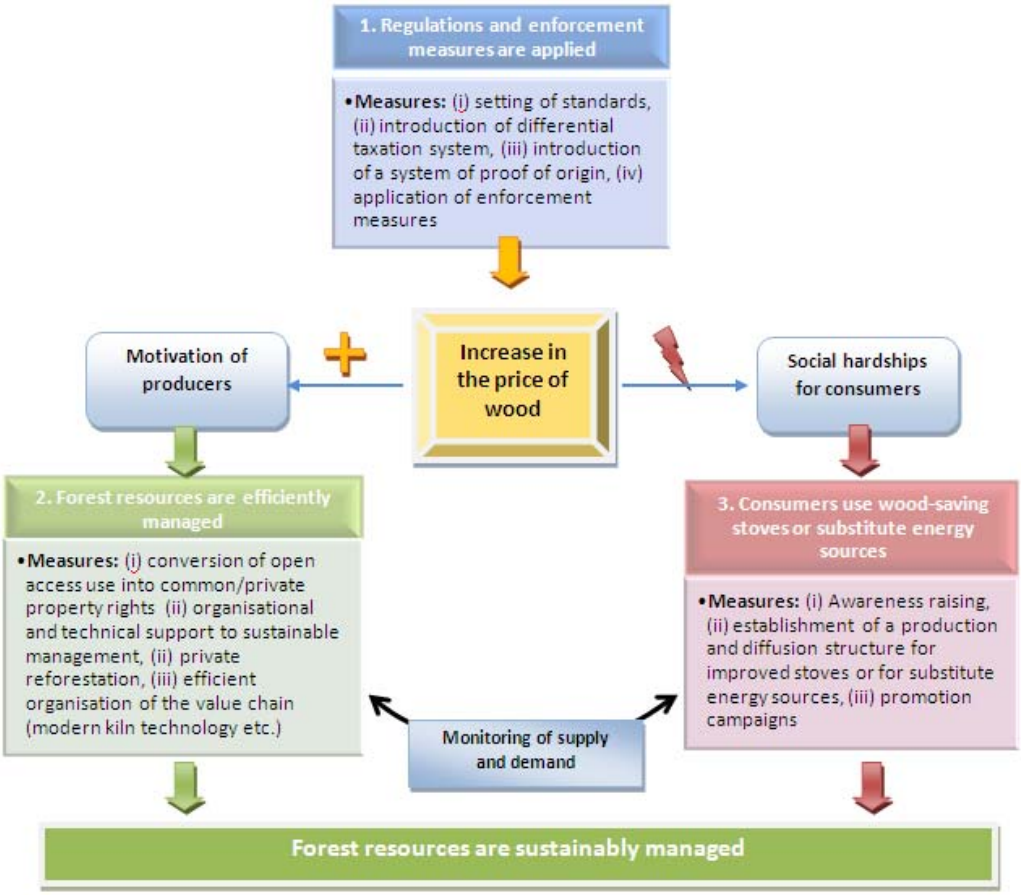
Cutting the Gordian knot of underpriced wood-fuel resources calls for a mutually synergetic three-pronged approach (see figure):

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 sourced 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.

Figure 4: Measures and impact structure to switch from exploitative to sustainable forest management



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 [11].

Introduction of fuel-saving combustion technology

As measures 1 and 2 are designed to *deliberately raise 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 1990ies in Niger, Mali and Chad under the title "rural firewood market system", albeit with different, country-specific approaches. To date, Niger and Mali may be regarded as the most advanced examples. 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 [13].

6.4 Assure adequate land tenure/user rights for woodfuel production

Unregulated access to forest resources and unchecked exploitation are directly linked to **forest resource tenure**. Tenure arrangements are highly specific to a country's political and legal system, social order and historic development, and must hence be adequately reflected in wood-fuel policies. In many cases, forest resource tenure does not equate full-fledged land ownership[6]. While (forest) land ownership frequently rests with the state, rural households or communities may lay claim to a wide range of rights of access, management and use (both statutory and customary). It is widely recognized that security of tenure is one of the most significant framework conditions necessary for sustainable forest management [14]. Recent comparative studies show clearly the relationship between insecure tenure, poor economic performance, social instability, degradation of natural resources, and critical biodiversity losses [15].

Wood-based fuels are no exception to this rule. Open access and unregulated use allow the growing scarcity of wood resources to go unnoticed until overexploitation has exhausted forest resources to the point of deforestation and economic non-feasibility.

Firewood is typically harvested from woodlands and degraded secondary forests adjacent to settlement areas. Despite this, forest fringe communities rarely hold title to the forest resources they depend on for their daily subsistence. Unlike timber plantations, valuable high forests, or protected

[6] Ownership is defined as the *exclusive legal right to a thing*: (i) the right to possess, (ii) the right to exclusive use, (iii) the right to manage and / or dispose of the property, (iv) the right to income, (v) the right to security, (vi) the absence of term, and (vii) the liability to execution.

forests, areas of this kind are neither privately owned, nor do they attract the high level attention of local governments, forest authorities or civil society.

This situation creates a formidable disincentive for investments in sustainable production of wood-based fuels. It explains why unchecked exploitation and informal production and marketing are difficult to replace with more transparent and equitable arrangements. Several **actions** need to be taken **to support the strategic shift from demand-driven exploitation to production-oriented management**:

- Identification, documentation and subsequent reconciliation of claims to forest areas,
- Mapping, demarcation and cadastral[7] registration of forest areas, including those dedicated to sustainable production of wood-fuel,
- Clear assignation of rights, obligations and responsibilities (including decision-making authority) in respect of forest resources, both within communities (for both men and women), and pertaining to third parties,
- Establishment/empowerment and capacity development for community-based institutions in charge of forest resources,
- Agreed and documented approaches to conflict-resolution and enforcement mechanisms.

No blueprint approaches or patent remedies are available to solve tenure related problems and challenges. In each case, **tailored solutions** must be designed through careful analysis of the prevailing political, legal-regulatory, administrative, socio-economic, socio-cultural, and historical contexts. Multi-stakeholder consultations can help foster ownership, and reduce the potential for land-use conflicts. There are **three basic types of instruments** to support tenure reform and to promote tenure security are highlighted below:

- **Promotion of joint management arrangements** to foster good relations on fragmented forest areas, and establishment of Forest Management Units (FMUs) sufficiently large to enable Sustainable Forest Management (SFM) through forest owners' associations, cooperative arrangements, Public-Private Partnerships (PPP)
- **Incentive systems** (regulatory as well as financial), and gaining public support through advisory and assistance schemes, credit schemes, tax-holidays, payments for environmental services (PES)
- **Capacity development** through a diverse range of measures, ranging from community empowerment and advocacy to practical management training and organisational / marketing support (e.g. through design and promotion of value chains etc.).

It must be noted that in many developing countries, **wood-based solid fuels – despite their obvious significance for the domestic energy supply – are either traded informally, or fail to be regarded as marketable goods outright**. Charcoal, in most cases, is the only type of wood-based fuels for which markets (though informal) exist – this being due to the fact that charcoal, unlike raw wood, more easily lends itself to transport between centres of supply and consumption.

[7] Documenting land ownership, by producing documents, diagrams, sketches, plans, charts, and maps

6.5 Improve governance capacity to reorganize the charcoal production sector

Following up on the foregoing observation that targeted modernization of the wood-fuel supply chain and establishment of vibrant wood-fuel markets foremost are governance challenges, the issue of **governance capacity** comes into focus. Governance, in this context, must be understood in the broadest possible sense, i.e. definition of frameworks for planning and monitoring, education and training, cross-sectoral coordination and inter-agency collaboration, law enforcement, provision of targeted public support, and encouragement of civil society participation and private entrepreneurship. These aspects reflect an **integrated and comprehensive approach**, one that would probably overtax the capabilities of a single sector-administration.

The above statement reflects back on the first, cross-cutting recommendation presented in section 1, i.e. to end the discrimination against wood-based fuels, and promote them as a modern energy carrier & contribution to the partner countries' energy-mix. Achievement of this goal would already provide a crucial measure of horizontal as well as vertical policy coherence and inter-agency collaboration.

One obvious example would be the more prominent inclusion of forest sector administrations and stakeholders in energy-policy making and strategic programming. On the other hand, however, forest sector administrations in many countries are either weak, or themselves forced to prioritize other forest management goals (specifically timber production) over sustainable wood-fuel supply. This holds true particularly in those cases, where forest administrations have been reorganized into semi-independent "agencies" or state-owned enterprises which must recover their operational expenses through maximized forest revenue generation.

A possible solution to the currently weak and dispersed governance capacities and mandates may lie in the **creation of institutions** – e.g. in the form of para-statal bodies – specifically tasked with cross-cutting wood-fuel planning, strategy development, resource monitoring and evaluation on all levels, and operational support. The latter function would further include a wide range of public relations/awareness building, training and extension, and lobbying for policy support and high level attention to the goal of sustainable wood-fuel production.

Box 3: Example of a para-statal body combining the responsibilities for managing the domestic energy sub-sector

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.

While improved governance is indispensable in promoting sustainable wood-fuel supplies, **multi-stakeholder participation and involvement of the private sector** likewise is a crucial precondition. Institutions of the aforementioned kind would thus face the task of catering to the various stakeholders' needs, e.g. by means of coordinating their respective contributions and activities, administrating public support schemes, and providing information & knowledge management (IKM) services. Capacity building to these ends must ensure that public institutions are properly prepared to assume their specific relay function and increasingly act as service providers.

The foregoing observations underscore that enhanced governance support needs to emphasize participation, partnership and cross-cutting interaction/coordination over centralized planning, command-and-control approaches, and single-sector administration. However, this shift of focus does by no means imply that law enforcement and public supervision were insignificant or dispensable. To the contrary, **law enforcement** must be stepped up in parallel, so as to safeguard the rights of legitimate resource users, and end the undervaluation of wood-based fuels. In this context, the challenge is not only to prevent and detect/suppress actions that are outright illegal, but also to discourage – by way of differentiated taxation systems – unregulated and therefore unsustainable exploitation of open-access areas.

Transparency and accountability are key to promoting legal security, and to raise the overall credibility of agencies involved in administrating the wood-fuel sector. To this end, administrative support functions and law enforcement/supervisory mandates need to be carefully coordinated. However, they ought to be kept separate, with a view to minimizing risks of abuse and corruption. Energy sector institutions and forest sector agencies should therefore solicit, and rely on support by authorized law enforcement agencies and the judiciary. These, however, in many cases lack the means as well as the problem-awareness required for coordinated action. Capacity development therefore needs to reach out to the police and legal services, with targeted support in the following respects:

- Awareness building, so as to sensitise law enforcement agencies for the risks and potential damage associated with unregulated exploitation of forests and woodlands,
- Training and extension in regard to land rights, forest laws, detection of violations etc.,
- Improvement/simplification of penal procedures, so as to speed up prosecution and punishment of violators,
- Clarification of roles and mandates in the exercise of legal authority (rights of arrest, search and seizure, collection of fines etc.), so as to enhance transparency and accountability of law enforcement,
- Clarification and subsequent institution of proof of origin systems for sustainably sourced wood-based fuels, as well as differentiated taxation schemes to levy surcharges on wood-fuel produced from unregulated open-access areas.

6.6 Assist local actors to introduce efficient production options and technologies

The sixth recommendation refers to two basic avenues of intervention: (i) production of wood-based fuels in the narrower sense, and (ii) introduction of improved conversion technologies for charcoal-production (i.e. by means of improved kilns). In the following discussion below, both aspects shall be treated separately.

Assisting local actors to introduce efficient production options and technologies calls for two basic modes of support: **knowledge transfer** and **technology transfer**. However, it must be noted that these two issues will only deploy significant impact when the above mentioned recommendations are fulfilled. This is specifically true for measures correcting market failures and securing land tenure. Neglecting these issues leads to the need of additional incentives which have been often provided by donor institutions in form of subsidies.

It must be noted that nothing presented herein is in any way novel or revolutionary. There is, in fact, a wealth of experience and lessons learnt to draw on. The paper at hand thus deliberately abstains from any attempt to “reinvent the wheel” – instead, the challenge lies in (i) transferring any applying

established best practices from sustainable forest management to the production of wood-based fuels, and (ii) providing a well-structured overview of existing knowledge for the benefit of practitioners.

Finally, some options shall be explored with a view to promoting the actual impact of knowledge/technology transfer, by means of promoting adequate funding for the dissemination of best practices as well as assistance to stakeholders for a smooth integration into formalized and well-regulated market structures.

Options for woodfuel production

Forest plantations (i.e. artificially established forests) on degraded land are a chief means of providing a renewable and environmentally friendly energy source. At present, there are approximately 109 million hectares of forest plantations world-wide. Surprisingly, Africa accounts for as little as 10 percent of the global total [16]. If managed sustainably, forest plantations can yield a wide range of benefits, e.g.

- Ecosystem services, such as soil fixation, water protection, carbon-sequestration,
- Reduced pressure on natural forests,
- Amelioration/rehabilitation of marginal or degraded lands,
- Employment opportunities and a contribution to rural development at large.

Despite their obvious potential, forest plantations in the past oftentimes failed to perform for various reasons, chiefly among them inadequate design (site-selection, species-site matching) and management. Poor health/stability and vitality/growth thus translated into low productivity and lacking return on investment. Owing to deficiencies in design (site-selection, lack of participation), large-scale plantations by either public forest services or private investors are also frequently prone to land right disputes and social conflicts. Many plantation programs likewise faced heated criticism by environmentalists – especially in those cases, where secondary forests had been cleared to make room for even-aged, single-species plantations.

To function properly and to effectively ease pressure on existing natural (including secondary) forests by providing substantial supplies of wood-based fuels, plantations require careful development policies, full stakeholder participation, and cross-sector coordination. The United Nations' Food and Agriculture Organization (FAO) coordinated a multi-stakeholder process to balance the social, cultural, environmental and economic dimensions of planted forest management and to support their contribution towards sustainable livelihoods and land use through voluntary guidelines for planted forests [17]. These guidelines are tailored primarily to governments, public- and private-sector investors, policymakers and planners.

Generally, the establishment of plantations on pristine or almost pristine forest lands is not recommended. Hardwood species have the greatest potential for wood-fuel, and the types selected should preferably coppice readily. Varieties should be chosen that fix nitrogen, and serve multiple purposes. Actual selection depends on what can be grown easily on the site, and can be acceptable to the users. Cultivation methods should be adapted to the skills and resources of the rural people. Care in the establishment phase is very important. Every plantation activity should be preceded by an economic analysis. Sustainability can only be assured when the returns on investment are significant for the plantation owner, as well as having positive social and ecological potential.

German technical cooperation (GTZ) adopted a village-based approach in Madagascar, which focuses on local people the centre of planning and implementation of wood-fuel plantations. Individuals receive property rights over degraded community land earmarked for reforestation. The project provides institutional and technical support, including soil preparation with tractors. The owner then assumes full responsibility for raising seedlings, and maintaining the plantation. An overall GIS based monitoring system gives data on each plantation plot, including productivity figures, income generation etc. To date (2008), more than 4,000 hectares have been planted, providing an increase in income of more than 20% for more than 1500 rural households. The approach is described in a brochure [11].

Out-grower schemes are a relatively trend on the African continent, where private sector investors increasingly enter into long-term agreements with small-holders. Investors provide financing (loans), and inputs such as seedlings and extension support for the establishment and maintenance of the woodlots, while small-holders ensure continuous protection and management of their woodlots. For the companies, these schemes address the need to develop long-term timber/woodfuel supplies without tying up large amounts of capital in land holdings when all they require is wood. The out-grower scheme has been analyzed by FAO in a detailed report [18].

Natural forests (including secondary forests) require a more complex approach, owing to the fact that wood-based fuels typically are a by-product of more valuable production goals such as timber, poles etc. On the other hand, wood-fuel shortages generally occur in regions where savannah-type vegetation is predominant due to low and erratic rainfall patterns. These savannah woodlands are not suited to high-value timber production, although they may contribute substantially to non-timber forest product supplies such as fodder, gums, resins, etc.

Savannah woodlands easily lend themselves to sustainable management approaches known as Participatory Forest Management (PFM) or Community based forest (natural resources) management (CBFM/CBNRM). PFM is a forest management system in which communities (forest users and managers) and government services (forest departments) work together to define rights of forest resource use, identify and develop forest management responsibilities, and agree on how forest benefits will be shared. The key challenge is to establish a sustainable forest management commensurate with the increasing resource demand and land use competition. PFM approaches have gained considerable momentum against the backdrop of decentralization programs devolving management responsibility over (formerly) state-owned forests to the local communities. To create a sustainable structure using a PFM approach, and to encourage investment in sustainable forest management by local people, land tenure issues and the orderly transfer of decision-making powers from central government to local institutions have to be resolved.

Manuals on Participatory Forest Management:

The CILSS-based project PREDAS published a manual on community based forest management for wood-fuel production for energy. [30]

A field manual explaining the key steps of establishing Participatory Forest Management in Ethiopia has been put together as the result of ten years' practical experience. [31].

UNHCR published a guide on forest management practices to react on some degree of forest degradation and deforestation in the refugee and returnee context. [32]

Recommendations and potential pitfalls regarding decentralization of natural resources management are described in a World Resources Institute (WRI) publication [19]. The following aspects have been

found to be particularly important when designing and implementing PFM projects for wood-based fuel production:

- PFM activities should take place after stakeholder consultation to enhance awareness of the causes and consequences of uncontrolled exploitation and the benefits of available techniques for forest rehabilitation.
- Baseline studies are fundamental tools for assessing success or failure of intended PFM activities.
- The extent to which administrative authority and responsibility should be transferred from government agencies to rural communities requires critical analysis and informed public debate. In this respect, (forest) land ownership is a crucial determinant. Equitable sharing of costs and benefits within the communities, and between the communities and the government, needs to be clearly defined. The results should be recorded as an agreement, providing the basis for PFM activities.
- Functional institutional frameworks at village level must be developed to oversee planning, implementation and monitoring. Such a local management structure should be governed by the Community or Village Assembly. Clear guidelines have to be developed to specify the responsibilities of each and every member within the local management structure.
- Forest management plans must be simple and short and should be developed through participatory action in a way that is accessible for communities with low literacy levels. To foster local 'ownership' of such a management plan, the contents of the plan must include the knowledge, experience and expectations of the local community about their forest.
- By harvesting woodfuel, people exert complex impacts on their forest resources. These impacts are hard to predict, particularly in regard to their long-term ecological aspects. Ecological monitoring is more and more recognized as a helpful method in natural resource management.

Box 4: Examples of PFM approaches for wood-fuel production

A good example of successful PFM for wood-fuel production is the introduction of **rural wood-fuel markets (RWM)** in West-Africa. A RWM is a place where wood-fuel dealers can buy firewood and charcoal sourced from a designated woodland area managed by villagers under an agreement with local authorities. This woodland area is managed using a simple plan agreed between village associations and the local forestry service. It includes: (i) an annual wood-fuel quota that stays below the annual production rate (safety margin); and (ii) a set of very simple silvicultural and wood-fuel cutting rules. Rural wood-fuel markets are run by a local management structure. Experience and best practices from the CILSS-based EU-supported project PREDAS have been documented within a publication on how to create wood-fuel markets [20].

In Ethiopia, a PFM approach called **WAJIB** has been developed with GTZ support in which a binding agreement is made between the local forest user groups and the district forest office. There are clearly defined rights, duties and obligations for both partners. This approach differs from many other PFM approaches in Africa as the number of participating households is limited by the forest carrying capacity and the economic potential. The underlying assumption is that households will only invest in forestry operations if they can make a living out of sustainable forest management. Thus, the forest in a given village is subdivided into forest blocks with an average size of 360 hectares. Based on the forest carrying capacity of 12 hectares per household, each block is managed by a WAJIB group of not more than 30 households. Each WAJIB group has its own internal regulations (by-laws), which govern the use, protection, rights and responsibilities of each household within the block. The main duty of the forest administration is to provide technical advice to the WAJIB groups on how to develop and utilize the forest on a sustainable basis [21].

In Southern Africa, the miombo woodlands[8] are the major sources of fuel. These woodlands provide a wide range of products (including timber) and services to rural households, so the forest management approaches need to be quite diverse and is often embedded into an integrated land use approach [22].

Trees outside forests (TOFs) include all trees found on non-forest and non-wooded lands, such as agricultural lands, in urban and settlement areas, along roads, in home gardens, in hedgerows, scattered in the landscape and on pasture and rangelands. Most knowledge on TOFs comes from experience in agroforestry[9]. Agroforestry helps farmers create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems.

Although TOFs fulfill a multipurpose function, and are part of an integrated land-use system, woodfuel can be a principal product. The FAO (2001) cites references where in the Asia-Pacific area, over two-thirds of the energy demand of around two billion people is supplied by wood-based fuels from non-forest sources.

Trees for fuel wood can be planted dispersed, in rows, on crop land (alley cropping), in homegardens, as replacement, or by the introduction of selected trees or shrubs to enhance natural fallow vegetation. To control soil and water erosion, trees and shrubs are planted as living barriers along the contour lines of a slope or terrace. Living fences planted as tree-lines on farm boundaries or on pasture plots, animal enclosures, or around agricultural fields can contribute to the energy supply of local households. The Agroforestry Extension Manual for Kenya provides an excellent overview of the different approaches, illustrated by a number of case reports [23].

As with forest energy plantations, hardwood species that coppice readily and fix nitrogen should be selected. Furthermore, species selection should likewise reflect socioeconomic parameters including return on investment (fast growing hardwoods which can be harvested after 4-6 years are preferable), resilience against grazing damage, and ease of planting and maintenance. The World Agroforestry Centre maintains a freely accessible database providing information on the management, use and ecology of a wide range of tree species that can be used for fuelwood in agroforestry[10].

Lack of accessible wood fuel supplies mainly affects women, and it is important to integrate their concerns when designing agro-forestry projects. The World Agroforestry Centre published a guide on how to integrate gender issues when programming agroforestry initiatives in the Sahel [24].

Box 5: Examples of ToF initiatives

The **Sahel Eco-Farm (SEF)** approach has been developed with the support of ICRISAT. It is a good example of an agroforestry-based system combining ecological advantages (such as improving the microclimate) and soil conditions, with income generation. This approach improves the livelihoods of the rural poor in vulnerable regions such as the Sahel. The SEF is based on an alley cropping system, in which trees and/or shrubs are intercropped with annual crops [25].

Production of wood-based fuels can also be promoted as part of systems to **rehabilitate fallow land** by means of nitrogen-fixing trees. Experience shows that wood can be harvested already after 3-4 years, depending on the circumstances prevailing at a given site. Enough wood can be obtained from from one hectare of improved fallow to supply the fuelwood needs of a typical rural household with 6–7 members for 6–8 months [26].

Another key initiative is to promote agro-forestry approaches at policy level so that they are recognized as one of the most important fuel wood supply sources, besides natural forests and planta-

[8] Tropical and subtropical grasslands, savannas, and shrublands

[9] Agroforestry is the practice of growing trees and agricultural products on the same piece of ground, and at the same time.

[10] http://www.worldagroforestry.org/Sites/TreeDBS/TreeDatabases.asp

tions. The socio-economic and ecological advantages of agro-forestry substantially outweigh many expensive, ill-conceived tree plantation programs. Agro-forestry can be developed at a fraction of the cost of large-scale plantations, and the approach encourages greater local participation and a wider diversity of goods and services for the local and national economies[11].

Sustainable wood-production aside, technical assistance to promote sustainable wood-fuel supplies must also address conversion technologies, i.e. means and modalities of turning solid wood into charcoal.

Conversion technologies

Charcoal is a prime source of energy in most African countries, and is a driving force in their economies. Worldwide charcoal production has increased, rising by an annual 3.7 percent from 1990 to reach 44 million tons in 2000 [27]. Surprisingly, policy makers pay little attention to the ways in which charcoal is produced and sold; including whether wood used for charcoal burning is harvested in a sustainable fashion. For lack of coherent strategies, oversight, production capacity and marketing arrangements, the charcoal business typically remains **informal and unregulated** – leading to inefficient and risky production methods. The common issues characterizing the charcoal production chain in many African countries include: (i) unregulated/illegal resource use (ii) rampant and systemic corruption, (iii) inefficient conversion technologies, (iv) a perception that it is a poor man's business considered 'dirty' and economically unattractive, (v) the charcoal business being dominated by a few powerful individuals.

Problems arise at all stages of the charcoal value chain, so a precise understanding of the charcoal value chain provides an excellent entry-point for shaping sound policy frameworks. It offers an opportunity to the various stakeholders to add knowledge, innovation, capital, and technology at each step or link in the value chain. Sound policy can provide checks and balances, creating more balance within and between the sectors, and supporting the intended overarching goals, such as the Millennium Development Goals (MDGs). The National Charcoal Survey of Kenya provides a good example of how the different links in the chain have been investigated to inform clear policy decisions [5].

Charcoal consumption is a very controversial issue, as the transformation process from wood to charcoal results in considerable energy loss, requiring significantly more wood to produce the same amount of energy. This has led many countries to impose bans (Kenya, Tanzania, Gambia etc), however, with little practical success. Charcoal use continues to increase with the pressures of growing urbanization. On the other hand, charcoal burns more cleanly than wood or dried biomass, producing higher temperatures, and it is cheaper to transport and store. For these reasons, interest in charcoal is growing, and steps need to be taken to promote improved charcoal-making technologies and thus reduce the amount of raw biomass required.

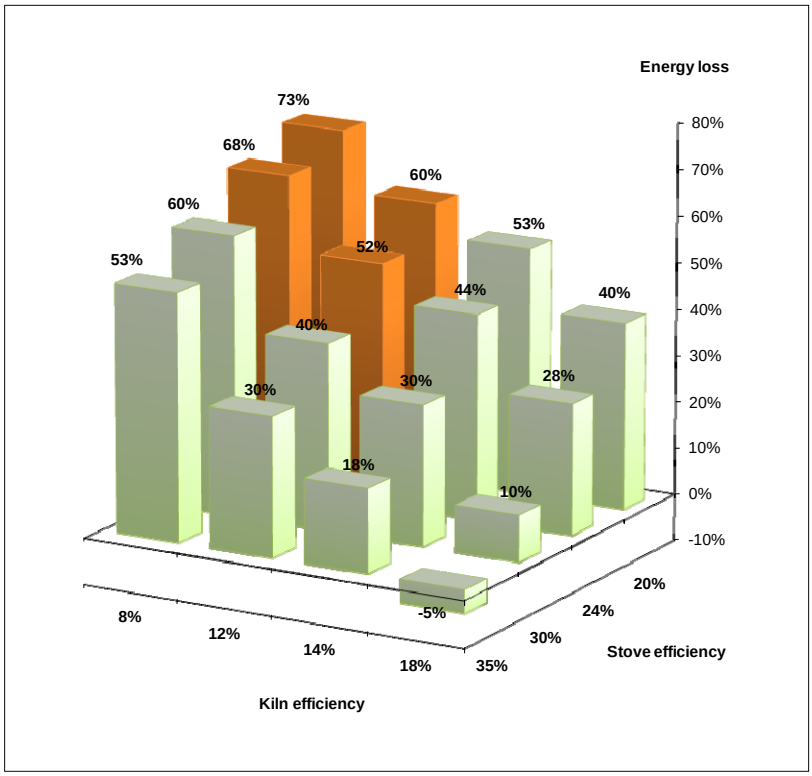
The most common types of traditional kilns are earth or pit kilns with efficiencies ranging between 8% and 12 %. Because parameters like the humidity of the wood used, kiln size, and process control play an important role, the relative gain of an improved technology ranges from 5% to 50% [28].

Part of the energy losses during charcoal making are compensated for during end use, as charcoal stoves have higher efficiencies than wood stoves (30% - charcoal stoves versus 10%-15% untended open fire or tripod).

[11] http://www.fao.org/forestry/tof/en/

Figure 5 gives information on the amount of energy loss in % when introducing improved kilns and/or improved stoves in comparison to the usage of firewood (e.g. there is an energy loss of 73% when charcoal is converted by traditional kilns (efficiency of only 8%) and consumer use stoves with an efficiency of 20%).

Figure 5: Energy loss during conversion as a function of technologies used compared to firewood usage



Charcoal production creates substantial greenhouse gases (GHG) through wood-pyrolysis, with the gaseous products vented into the air. For charcoal production to become carbon-neutral, wood must be produced in a sustainable manner, and combustion efficiencies need to be close to 100% (most small scale applications do not reach this standard).

Charcoal production is a labour-intensive process, employing a large number of people at different phases of the process and distribution. It is estimated that charcoal production generates between 200-350 person days of employment per Terajoule of energy, compared to 10 person days per Terajoule for kerosene. Sustainable production of wood-based fuels (particularly charcoal) can support rural development through decentralized processing & production, short transport distances with low risks, potential for short-term efficiency improvements (improved stoves, kilns etc.). It can yield a health-dividend, due to reduced levels of smoke, cleaner combustion and easy handling. To be environmentally beneficial, highly efficient kilns and renewably-sourced fuels are required.

Different types of improved kilns have been tested and disseminated, and a wealth of experience and lessons learnt is available for practitioners to draw on. Improved models include stationary brick kilns and semi-industrial high-efficiency/low emission appliances, as well as transportable metal kilns for more flexible and decentralized charcoal production. Selection of the best suited technologies (or combinations thereof) must, in all cases, reflect ecological as well as socioeconomic site conditions, including availability of investment capital, transport infrastructure, and market access [29].

New funding mechanisms

Whichever ways and means of knowledge and technology transfer are chosen to support sustainable production of wood-based fuels in a given country, practical implementation and up-scaling of best practices foremost depends on the **availability of funding**, and **adequate management capacities** on all levels. This includes targeted support to market development, investment, and commercialization

/ formalization of businesses, in sync with the modernization of wood-based fuel production chains. Most countries' capabilities to mobilize domestic budget-support for the development of a vibrant biomass energy sector are low and insufficient, and donor support in most cases cannot maintain development processes past the initiation/demonstration stage. Therefore, innovative funding mechanisms are needed to sustain the lasting transition from unregulated wasteful exploitation of wood-based fuels towards their sustainable management and production.

Various global as well as regional initiatives to combat climate change and promote carbon-neutral energy consumption offer considerable potential for the generation of funding for sustainable biomass energy solutions.

- The Clean Development Mechanism under the UNFCCC Kyoto Protocol provides for the establishment of forest plantations with a view to promoting carbon-sequestration and safeguarding sustainable supplies of forest products (CDM-A/R). However, afforestation and reforestation measures under the CDM are procedurally challenging, time-consuming and costly, and do not easily lend themselves to small-scale application and flexible integration into integrated rural development approaches. Thus far, only one CDM forest-project has gained official recognition, while several others are under review and consideration. CDM-A/R, being exclusively focused on plantation establishment on hitherto unforested lands, also excludes existing forests (natural or secondary) from its purview.
- Agreed at the 2007 Bali Summit (UNFCCC COP 13), a new instrument is emerging for the post-Kyoto period (past 2012) which expressly promotes protection and sustainable management of existing forests. Designed to combat GHG emissions from deforestation and forest degradation, REDD will provide a more flexible framework for compensating carbon-sequestration services of existing forests. It likewise promises significant synergies with other forest-related processes and initiatives, e.g. biodiversity conservation. Funds generated under the REDD mechanism would likely provide a useful means for promoting sustainable biomass production in existing forests.
- Voluntary carbon marketing (VCM) operates outside the Kyoto/compliance context. Numerous initiatives, global as well as regional, are emerging in this context. Even though basic verification and registration requirements are similar to requirements stipulated under CDM-A/R (e.g. the Gold Standard), VCM is widely regarded as a more flexible instrument, one that is also more accessible to decentralized/small-scale implementation.

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