

Wood – A source of supply for sustainable energy

Examples of best practice from project experience

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Examples of best practice from project experience

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Abstract

Wood is globally the most widely used renewable energy source, and accounts for a large part of energy consumption in developing countries. However, unsustainable production and conversion regimes (e.g. lack of land-use management, corruption) have led to a negative perception of woodfuel. Today, the use of fuelwood or charcoal is often blamed as a major driver in deforestation. When woodfuel is produced sustainably, it is seen in a different light. Experience from many projects shows how sustainable fuelwood or charcoal production positively contributes to energy supply, economical development, environmental protection and social issues. An analysis of six projects, working on sustainable woodfuel production in developing countries, highlights the positive effects of a modern woodfuel value chain with qualitative and quantitative impact data. Almost every project is reporting an increase in local income generation and improved energy supply. Furthermore, every project clearly shows that its activities are creating a positive impact on the environment, such as the rehabilitation of degraded land or forest protection.
Besides these positive effects on national and local development, there are specific advantages that should promote its political promotion: it can be renewable, easily accessible and has huge potential as a source of modern energy.

1 Introduction

Energy provides the basis for modern economies. Today, wood with a worldwide share of nearly 80%, is globally the most widely used renewable energy source (IEA 2007) and accounts for an estimated 7% of the world's total energy supply (FAO 2000). Most global wood energy consumption (90%) takes place in developing countries (FAO 2008), where it is mainly used for cooking, but also in production processes or in generating electricity. In developing countries, woodfuel is used in two ways: either directly as fuelwood, or processed in the form of charcoal. In most cases, it is harvested from forests (direct woodfuels), sometimes it comes as a residue from other wood processing activities such as timber industry (indirect woodfuels).
The use of wood energy has been, and still is, often blamed as a major driver in deforestation in developing countries. This debate on the problems – described as the 'Woodfuel Crisis' (ESMAP 2001) – has been spurred on by serious levels of deforestation in the tropical dryland forests, and around urban areas, where wood energy consumption is often higher than regrowth rates. These unsustainable woodfuel production and conversion regimes are not only characterised to the imbalance between extraction and regrowth, but have the following features:

- **unregulated/illegal settings** - unregulated wood harvesting, charcoal burning, transport and trade
- **corruption** - bad governance, economical exploitation
- **inefficient conversion technologies -** no incentives to make production more efficient
- **'poor man's business'** - non-organized and easily exploitable charcoal producers
- **negative public perception** - charcoal is commonly discriminated against as 'dirty' and economically unattractive
- **free access** - lack of land ownership or land-use regulation leading to deforestation and degradation
- **oligopolistic structures** - profits from the charcoal value chain are usually concentrated in the hands of a few intermediaries (Sepp 2009).

Large parts of the wood energy production patterns and consumption patterns in developing countries are still unsustainable due to these factors (BMU 2009), and this reinforces the bad image of wood energy as a threat to natural forest resources, causing soil erosion and energy poverty.

Current experience from projects that are working in the field of sustainable woodfuel production show a different perspective on wood energy: a modernization of the woodfuel value chain (Figure 1) and the establishment of a sustainable production regime has significant positive effects on economic, ecological, social and energy issues.

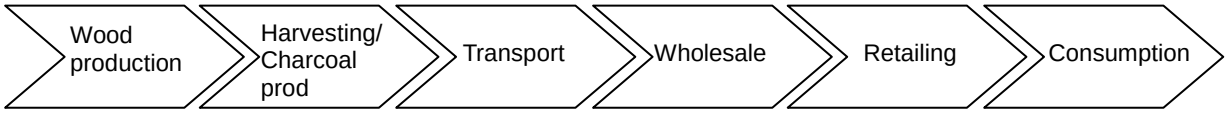

Figure 1: The woodfuel value chain (source: Sepp 2009)

A modern, sustainable wood energy production chain can be characterized as follows:

- **Regulated and formalized setting** - legal restrictions and enforced legal capacities for wood harvesting, charcoal burning, transport and trade,
- **Transparency** - adequate governance and enforcement
- Highly efficient conversion technologies - this is possible, where it is regulated and within a secure setting
- **Lucrative revenue rates** - organization of local woodfuel/charcoal producer societies for better bargaining power
- **Regulated land-use and land ownership** - provides incentive for long term investments and resource protection,
- **Decentralized business structures** - equitable/appropriate distribution of benefits along the woodfuel value chain
- **Efficient cooperation with local/central government officials** – non-bureaucratic organizational structures

Wood is a source of energy with several key advantages: it is renewable, easily accessible and holds huge potential for modern energy solutions.

This report is based on project experiences from different countries that were able to establish sustainable woodfuel production patterns with remarkable impacts on energy supply, economical development, environmental protection and social issues. The aim of this paper is to provide arguments for improved promotion of wood energy and the sustainable modernization of woodfuel value chains.

These issues are presented within two chapters: the first gives a general overview on the different land-use systems from which wood energy is sourced. It provides an insight into the issues of land ownership and land-use rights, which represent the most important political frameworks for sustainable woodfuel production. In the subsequent chapter the impacts of sustainable woodfuel production are presented to demonstrate selected project experiences. These two chapters provide qualitative and quantitative arguments to promote and lobby for wood energy and a modernization of the whole woodfuel value chain.

2 Origins of Woodfuel

Wood as energy is used in different forms (fuelwood or charcoal) and is supplied directly from the forest or indirectly from other wood processing activities, such as timber production. Fuelwood is the cheapest form of energy in areas where wood is easily available. Charcoal is more convenient as it provides more heat for a longer time and is easier to transport, but it usually costs more. It is mainly used in urban areas, whereas fuelwood is more common in rural settings.
Woodfuel originates from a wide range of land-use systems. The manner in which wood for energy use is produced depends on climate conditions, vegetation cover, local demand, infrastructure, and also crucially on land ownership and land-use rights (Figure 2).
Section 2.1 provides an overview and a definition for the different land-use systems from which wood energy originates. Sections 2.2 and 2.3 discuss the issues of land-use rights and land ownership. These represent the major frameworks for the establishment of sustainable production patterns.

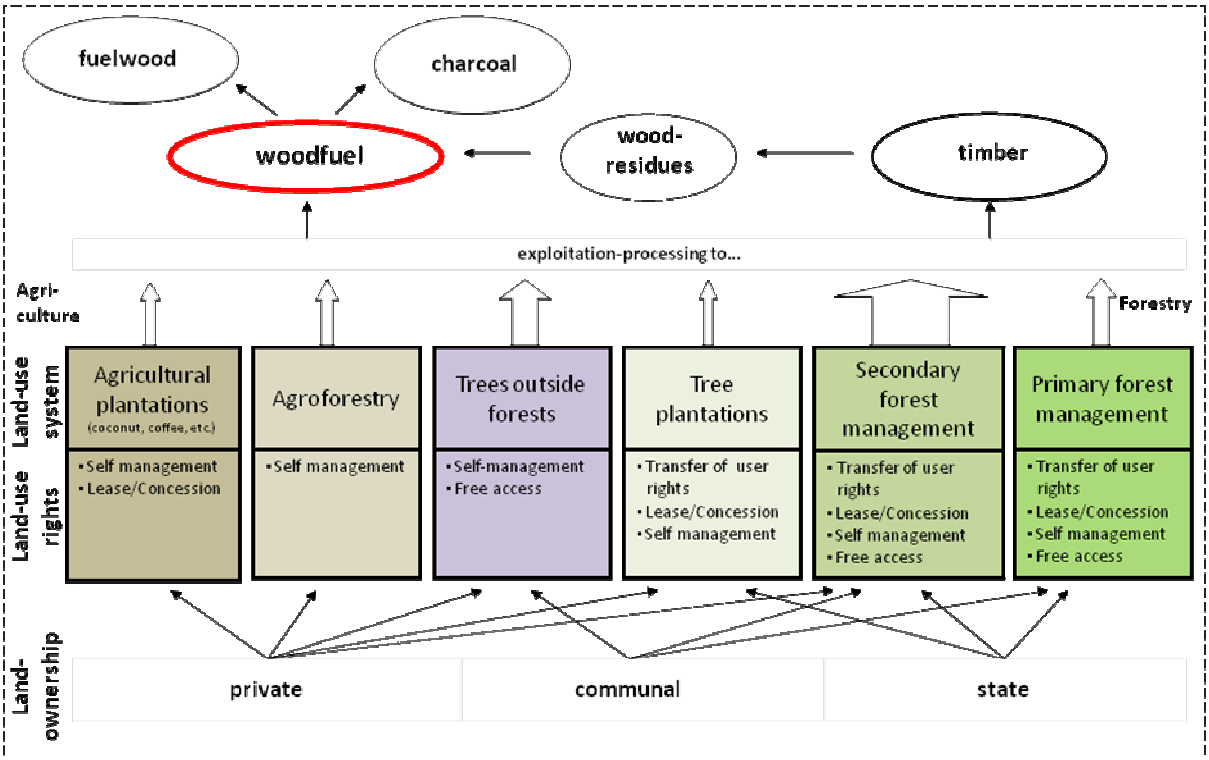

Figure 2: Origins of woodfuel (source: S. Sylla (GTZ HERA), S. Sepp (Eco Consult))

2.1 Land-use systems

The land-use systems from which woodfuel originates can be broadly divided into the areas of agriculture and forestry. These consist of agricultural plantations, agro-forestry, trees outside forests, tree plantations, secondary forest management and primary forest management (Figure 1).

Agricultural plantations represent cropping systems whose main objective is producing fruit, for example coconuts, coffee, bananas, etc. These plantations leave wood residues that can be used for energy purposes.

Agro-foresty systems represent a collective of land use methods, where woody perennials and crops and/or animals are deliberately integrated (e.g. silvopasture, forest farming). With this method, the productivity of land can be increased, environmental benefits arise due to better soil protection, biodiversity and micro-climate, and the agricultural crops are protected by the surrounding trees. The species mostly used for woodfuel production are fast growing hardwoods which can be harvested as coppice after 4-6 years. Woodfuel can also be a by-product from other trees that are grown for different purposes in the agro-forestry system.

Trees outside forests (TOF) comprises all the trees that are located outside forest areas. Forests are defined as areas of more than 0.5 hectare and a canopy cover of more than 10% (FAO 2005a). Consequently, not every tree will be part of a 'forest', in terms of the definition. TOF are found on agricultural land, on fruit-tree plantations, in home gardens, along roads and on public places in cities and villages. They represent an important source of woodfuel, particularly in areas with low forest cover (FAO 2000). The contribution of TOF to energy

supply still remains underestimated in many countries, even though a large proportion of rural households cover their woodfuel-demand from TOF.

Even though the planting of trees and forests takes place at increasing rates worldwide, **tree plantations** account for only 4% of the total forested area (FAO 2005a). Nevertheless, in the year 2000 they were estimated to supply about 35% of global roundwood, and their potential to meet the demand from natural forests for wood and fibre is increasing (FAO 2000). Plantations that are grown exclusively for energy purposes are becoming increasingly common in some countries, and plantations for other end-uses like timber can also provide woodfuels as by-products (FAO 2008).

Secondary forests are also known as degraded forests. These are 'forests and forest lands that have been altered beyond the normal effects of natural processes through unsustainable use or through natural disasters such as storms, fire, landslides and floods (ITTO 2002)'. In tropical areas, secondary forests are estimated to account for 60% of the total tropical forest area (ITTO 2002). As they provide a large variety of forest products, with woodfuel as the most important, a sustainable **management of secondary forests** is crucial to maintain its viability.

Primary Forests have 'never been subject to human disturbance, or have been so little affected by hunting, gathering and tree-cutting that their natural structure, functions and dynamics have not undergone any changes that exceed the elastic capacity of the ecosystem (ITTO 2002)'. Primary forest can be degraded to secondary forest through unsustainable use of its resources or through natural desasters. **Primary forest management** aims to reduce the impacts of such exploitation in order to minimize the alteration from its original composition, and to maintain the ecosystem functions is as much as possible. Woodfuel from primary forest management usually represents a byproduct from logging activities, where only a small portion (approx. 30%, GTZ 2010) of the tree is transformed into timber products. Residues consist mainly of tree crowns and sawmill waste, of which 80-90% can be used for energy purposes (FAO 2008). The potential of wood energy from timber production still remains untapped; some companies are just beginning to integrate wood-residues into their forestry/energy planning.

2.2 Land-ownership

In many parts of the world unregulated land rights, land use conflicts and ineffective governance represent the main hurdles for significant expansion and long-term supply of sustainably-produced wood energy (FAO 2008).
Due to the long growing period for wood, investments in sustainable wood energy production are only worthwhile if the land ownership is clearly defined and political frameworks allow for longer-term, secured use of the land.
If, however, land-ownership is unregulated, woodfuel extraction can have devastating effects on natural forest resources. Without legal security there is no economic argument for farmers to maintain a forest. This is particularly true in cases of armed conflicts and land pressures. A study from Geist (2001) shows that property rights issues, including land-tenure insecurity and conditions of quasi open access lead to deforestation in tropical areas in 44% of all investigated cases. Land-ownership can ideally be classified into three systems: state ownership, private ownership and communal property (Figure 1).

If land becomes **State property**, it is usually to enforce the State's national policies (e.g. infrastructure, mining). When the government claims the ultimate authority for the assignment and use of the land, it can decide whether or not to take over the management and income from its use.

Communal property is the property of a well-defined and distinct group (e.g. a village), which uses their owned land jointly by generally known and mutually accepted rules. Non-members of the group are often excluded from the land use or have only minor rights (GTZ 1997).

Private property, with clearly defined disposal and land use rights, gives the owner the proceeds of their investments in the land, and assigns clear responsibilities (expense) and liability rules in case of disregard of those responsibilities (compensation, omissions).

Experiences from many countries show that particularly in countries with weak governmental structures, so called ‘open-access’ or ‘unregulated access’ scenarios develop, which are characterized by the lack of ownership. In these cases, where access is not limited, land and its natural resources are transformed into open access consumer resources. Since no one can be prevented from using the proceeds of the resource, there are hardly any incentives for individual investment in resource protection. These settings, also referred to as the problems of ‘common land’, can have devastating consequences for vegetation cover, soil or freshwater resources, and ultimately, on energy security.

2.3 Land use rights

If the land is not used/managed by the owner himself / herself, there are two main legal ways to give user rights to private individuals, communities or companies. Most common are **leasing contracts** or, for greater areas and foreign investors, **concessions** (e.g. forestry concessions, foreign direct investments (FDI)). In the case of lease, the lessee acquires easements on the land against regular bid, or payment in kind or labour. Especially in developing countries, the lease is often associated with great uncertainty and threat of withdrawal of land by the lessor at any time and without notice (GTZ 1997).
Leasing contracts and concessions are normally short-term agreements. If, however, the user rights are permanently transferred, we speak of the ‘**transfer of user rights**’ (s. figure 2) (Schlager et al. 1992).

3 Impacts of Sustainable Woodfuel Production

The sustainable production of woodfuel still has several challenges. Nevertheless, since wood energy provides a crucial part of energy consumption in developing countries, focus should be placed on its sustainable production. Many reports and recommendations suggest that the development of the wood energy sector can make a significant contribution to the attainment of broader political objectives of countries; energy planning, environmental protection or economical development (GTZ 2008; Jorez, et al. 2009; Mallet et al. 2009). This chapter provides an overview of impacts achieved in existing projects for sustainable woodfuel production in developing countries. The experiences described in these projects reveal the remarkable achievements in energy supply and sustainable development (Figure 2).

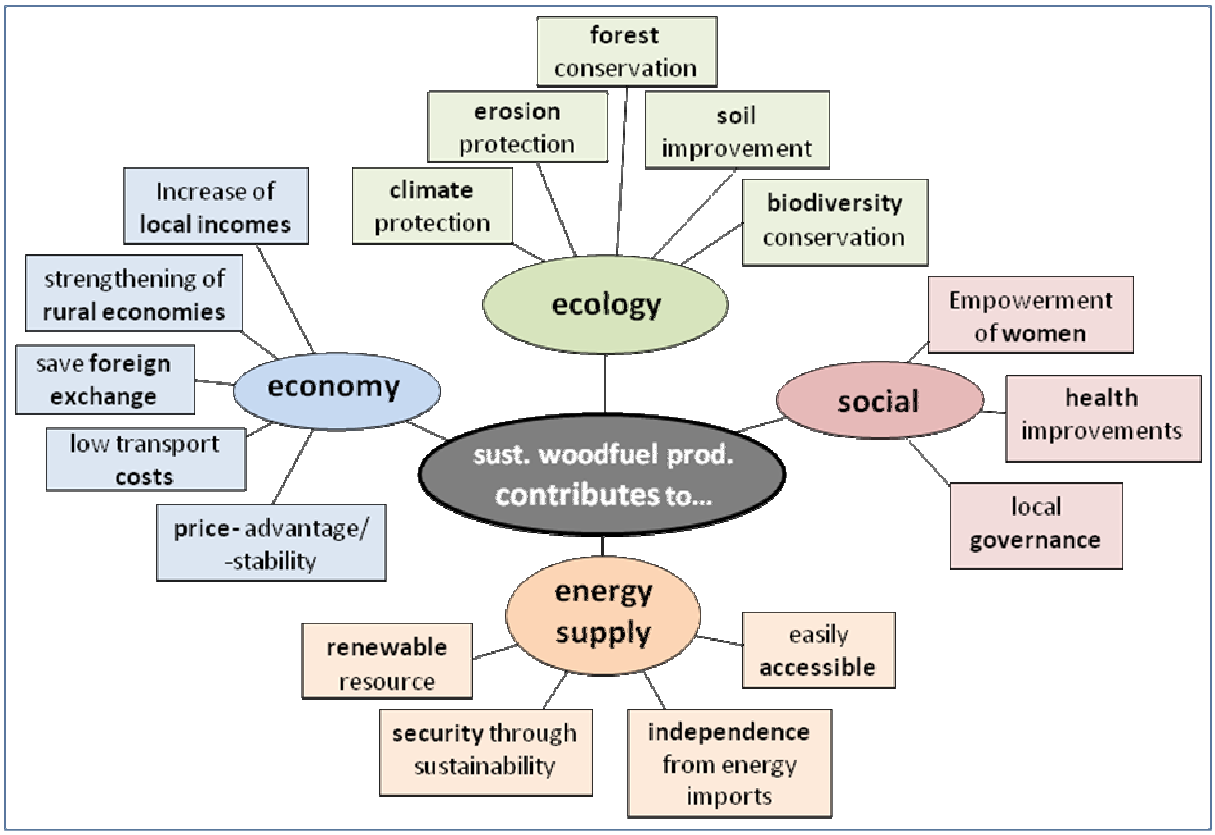

Figure 3: Impacts of sustainable wood energy production (source: S. Sylla, GTZ HERA)

3.1 Six exemplary projects

The projects (except *BEST*) have been allocated to illustrate the different land-use systems (Figure 4). A total of six projects from different countries in three continents are discussed in this paper.

1) **Biomass Energy Strategy** - BEST, Rwanda
2) **GREEN-Mad** - GTZ / Eco-Consult, Madagascar, tree plantations
3) **Mampu -** Hanns-Seidel Foundation, Democratic Republic of Congo, tree-plantations/agro-forestry
4) **PERACOD** - GTZ, Senegal, secondary forest management
5) **PMRN** - KfW/GTZ, Paraguay, agro-forestry/primary-/secondary forest management
6) **Joint Forest Management** - GTZ, Tajikistan, secondary forest management.

A short introduction to these projects is given here, a more detailed description is found in the Annex.

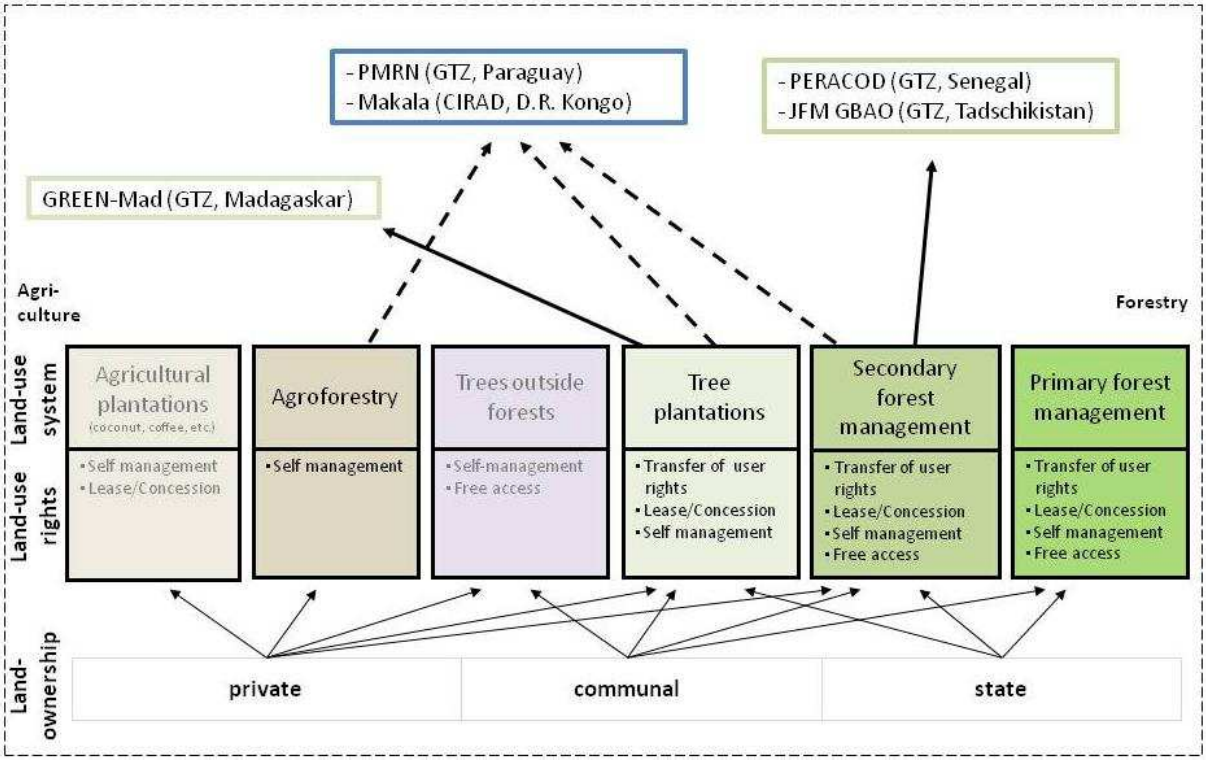

Figure 4: projects according to land-use systems

The ***BEST*** initiative in Rwanda was mainly to support the government of Rwanda to develop a Biomass Energy Strategy (BEST) for the improvement of the biomass energy sector. and in particular the charcoal value chain. The strategy provides recommendations for a more sustainable and efficient production and consumption of wood energy.

To curb deforestation in the north of Madagascar, the project ***GREEN-Mad*** (Gestion Rationelle de l'Energie et de l'Environnement à Madagascar) was established to supply the city of Antsiranana with sustainably produced charcoal. So far a total of 6500 hectares of eucalyptus trees are being planted on marginal land areas.

In a similar situation, the ***Mampu***-project in Democratic Republic of Congo was designed to improve local charcoal production and to supply the nearby capital Kinshasa with wood energy. The main basis for these activities are the acacia plantations which were planted during the 1980s and are today part of an agro-forestry system.

In Senegal, large-scale forest degradation due to overuse is a common problem. Within the ***PERACOD*** project (Programme pour la promotion of Renouvelables Énergies, de l'Electrification Rurale et de l'Approvisionnement en Combustibles Domestiques Durable) one intervention aims to implement forest management schemes to create more sustainable production and consumption of wood energy.
The *Proyecto Manejo Sostenible de los Recursos Naturales* ***(PMRN)*** in Paraguay works very closely together with local farmers who have fundamental problems with bad soil fertility and energy supply. With agro-forestry and forest management schemes, the project is consulting local stakeholders on ways to increase soil-productivity and to improve the management of agricultural land and forests.

Tajikistan has lost large parts of its forests due to a lack of fuel wood and virtually no land-use regulations. In order to strengthen the capacity of local authorities to implement forestry policies successfully, and to involve the population in these processes, a ***Joint Forest Management*** approach is being implemented.

3.2 Impacts on energy supply

Woodfuel is the most important source of energy in developing countries. This is mainly due to its large-scale availability and because it is simple to use. However, the situation changes as soon as woodfuel becomes scarce because of overuse or degradation of ecosystems. Such scenarios can have severe impacts on the regional energy supply, leading to rural poverty, particularly where there are no other affordable energy sources available. This highlights the importance of a sustainable management of forests or other wood-energy resources. Major advantages of sustainable woodfuel production for energy supply are:

1) the renewability of wood,
2) energy security through sustainable supply
3) independence from energy imports
4) the ease of access to wood energy (Figure 3).

In Madagascar it was shown that much of the urban charcoal demand in Antsiranana (107 000 inhabitants) can be sustainably supplied through rural small-holder tree plantations. Antsiranana has a yearly charcoal demand of 12 000 tonnes, of which 20% (2500 tonnes) are already supplied from tree plantations set up by the GTZ-*GREEN-Mad* project (GREEN-Mad, 2007). Local people involved in the project formulated their vision on how the whole region could be supplied with sustainable woodfuel by 2020, based on the experiences of the *GREEN-Mad* activities. They came to the conclusion that, by 2020, the production of sustainable wood energy could be increased to nearly 236 000 cubic metres, which is equivalent to 20 000 tonnes of charcoal, and is more than sufficient for the whole region (Jorez et al. 2009).

In some areas, woodfuel is scarce due to mismanagement of forest resources, or because of unfavourable environmental conditions. In eastern Paraguay, bad soil productivity is one of the reasons for persisting poverty and shortages of wood energy. The KfW/GTZ PMRN has been working on the improvement of productivity for small-holders' agricultural land and forest areas since 2000. Through better management in secondary and primary forests, a productivity increase of more than 30% was achieved, which undoubtedly led to a higher number of trees and thus to increasing amounts of available fuelwood (Grulke 2009).

3.3 Economical impacts

As a source of energy supply, woodfuel contributes directly to national and local economies. Moreover, wood energy has special economical advantages that distinguish it from other sources: price stability (compared to other energy sources and other consumer goods), saving of foreign exchange from avoided energy imports, the strengthening of rural economies and the increase of local incomes.
Wood energy is estimated to generate between USD 4 billion to USD 26 billion dollars per year worldwide (FAO 2005b). These figures do not include the informal woodfuel sector production in developing countries.

Saving foreign exchange

On a national scale, estimates in Rwanda have shown the replacement costs of current woodfuel consumption through fossil energy. If all households adopted kerosene as their replacement cooking fuel, as the next best and the least expensive alternative, kerosene imports in Rwanda would surge from an annual level of 20 000 tonnes (2007) to over

120 000 tonnes. This would increase kerosene import costs from USD 37 million to nearly USD 220 million per year (GTZ 2008).

Price stability /price advantage

Evaluation of the *GREEN-Mad* project in Madagascar showed wood energy prices to be comparatively stable and low. In Antsiranana, charcoal is by far the cheapest source of energy. Based on a survey of average prices for consumption in the year 2006, alternative sources of energy are less accessible to lower income segments of the population because the fuels cost more: kerosene and LPG range from USD 0,05-0,08/MJ, maximum price for charcoal is USD 0,02/MJ. Similar observations have been made in Rwanda, where LPG (bottled) gas prices reach USD 0.08/MJ, and charcoal costs can be less than USD 0,02/MJ (GTZ 2008b).
A comparison of the evolution of the price of charcoal compared to staple food in Antsiranana (Madagascar) shows that the rate of increase of the price for charcoal is less, between 1995 and 2006, than the rice price increase; charcoal prices rose from 0.06 to USD 0.1/kg (80%) whilst the price of rice rose from USD 0.16 to USD 0.41/kg (160%).

Strengthening rural economies

In the *Sambande* Forest (1045 hectares) in Senegal, the implementation of a forest management plan since 2004 has created additional incomes through sustainable charcoal production for about 70 households (PERACOD 2010a). These revenues were previously not available, since the forest was heavily degraded and could not adequately supply the surrounding villages with wood energy. Experiences from Madagascar (GREEN-Mad 2007) report that the charcoal value chain that has been established through reforested areas (6500 hectares to 2010) has generated a turnover of EUR 6.9 million from producer to consumer during the total production period of 27 years. Foresters and charcoal producers, carriers, wholesalers and retailers benefit from the economic advantages of the sustainable charcoal value chain in Madagascar.

Increase in local incomes

A common problem for the wood energy sector in developing countries is that most of the revenues that arise along the woodfuel value chain flow into the transport sector and the wholesale sector, while incomes for local producers will be small. This is especially true for the informal sector. The development of a sustainable wood energy value chain should therefore aim for a more equitable distribution of income relative to the investment risk, which is usually higher for producers (e.g. in case of leasing or wood energy plantations) than for transport-enterprises or wholesalers. The *increase of local incomes* discussed in this section refers to the increase in profit margin for local producers. This is not only a matter of higher sales, but may require political measures (e.g. taxation of non-sustainable products). Experiences from several countries indicate that economic/political support for producers can significantly increase incomes in rural areas. Its contribution to livelihoods varies according to the land-use system and the natural conditions that determine the productivity of the ecosystem.

Evaluation of the *GREEN-Mad* project showed that households which exploit their afforested land generated a mean income of EUR 487 per harvest (around EUR 100/year). This is equivalent to an increase of 20% of their yearly income (BIP Madagascar 2008 per capita: EUR 406). Based on the current area of plantations, and assuming a success rate of 80%, the 2500 households involved will generate cumulated revenues of approximately EUR 4 million during the next 27 years (GREEN-Mad 2007).

The *Mampu*-project of the Hanns-Seidel Foundation, situated in the western part of the Democratic Republic of Congo near the capital Kinshasa, is today part of an agro-forestry system, mainly for the production of charcoal, wood and vegetables. A successful farmer in Mampu currently generates, through the use of 1.5 hectares of forest, about EUR 7300/year,

which equals EUR 610/month. For comparison: a taxi-driver in Kinshasa earns about EUR 80-160/month (Hanns-Seidel-Stiftung 2009).

Revenues from natural/primary forest management seem to be less profitable than from other land-use systems like tree plantations or agro-forestry. In 2009, through charcoal production at the *Sambande* Forest in Senegal, farmers generated additional incomes of 2.393.625 FCFA (which makes about EUR 52 per farmer (PERACOD, 2010a) (BIP Senegal 2009 per capita: EUR 764). In the *PMRN*-project in Paraguay the estimated revenue per year per hectare from native forests management reach EUR 230; expectations for revenue from forest plantations are much higher: generation of up to EUR 1100 per year per hectare is anticipated (the usual income of rural people is EUR 1500/year; Grulke 2009).

The relatively low revenues from natural/secondary forest management obscure the fact that these activities protect the biodiversity of the forests, and thus the support they give to the ecosystem. Assessment of the economic value of these benefits is a difficult task; estimates suggest that cost savings through protection of ecosystem functions are many times higher than the costs of keeping the system in a functioning state (TEEB, 2009). Instruments to pay for these avoided costs, such as the *CDM* (Clean Development Mechanism*)* or *REDD* (Reducing Emissions from Deforestation and Degradation), are increasingly being developed and implemented.

3.4 Ecological impacts

Examples of ecological services, available through the protection and maintenance of ecosystems, include climate protection and regulation, erosion prevention, soil improvement, freshwater purification, provision of food, provision of pharmaceutical substances, timber, as well as sources of inspiration and recreation. As production of wood energy is directly linked to ecosystems, it can influence the provision of these ecosystem services. This can be positive or negative, depending on the sustainability of wood energy production.

Climate protection

Within the Mampu-project, 7500 hectares have been afforested so far for sustainable charcoal production and other uses. Based on yearly growing rates, Mampu currently captures 110 000 tonnes of carbon dioxide per annum. About thirty kilometres from Mampu is a sub-project for CDM. In the first phase of the project, an area of 4120 hectares is to be planted with eucalyptus, acacia varieties and native species. The volumes of carbon sequestration in total are estimated at 2.4 million tonnes of CO_2 over 30 years.

In Madagascar, the reforested areas in the Antsiranana-region will produce approximately 0.7 million cubic meters of wood during the total production period of 27 years. This corresponds to a potential of 1.48 million tonnes of CO_2 fixed.

Forest conservation and biodiversity

In eastern Paraguay, where farmers of the PMRN-project increasingly meet their fuelwood needs from their own (sustainably managed) forests, firewood removal from public forests is increasingly less common. This demonstrates the very important effect of woodfuel production on the protection of natural forests, through conservation of biodiversity. Moreover, the far more efficient land use within the PMRN-agro-forestry-system by a horizontal and vertical stratification of the agricultural and forestry production increases productivity of existing land (up to >30%) and thus significantly reduces the need for further expansion into natural forest areas. A similar effect is achieved by the regeneration/ improvement of soil fertility of already exploited, degraded agricultural land in eastern Paraguay, which reduces the ever-advancing clearing of forest areas for agriculture (Albrecht 2010). This is also shown in the Democratic Republic of Congo by the reforestation activities in Mampu, which avoid the destruction of 500 hectares of savannah and gallery forests each year.

The Gorno-Badakhshan Autonomous Oblast (GBAO) of Tajikistan suffers from a severe energy crisis, as the external fuel supply abruptly stopped after the breakdown of the Soviet Union, which was followed by a civil war. As a result, almost all forest areas belonging tot he state forestry agency (Leskhoz) have been degraded or destroyed. Under the Joint Forest Management scheme of the GTZ-project 'Sustainable Management of Natural Resources in Gorno-Badakhshan', the 'open access scenario' has been brought to a halt in areas of currently 1400 hectares. These areas, which have been given to 300 tenants so far for timber and non-timber production, already show the first signs of regeneration. Under proper management these former forests will rehabilitate again and serve as functioning ecosystems and a natural source for fuelwood (Hessen-Forst 2009).

In Senegal, presently 40 000 hectares of forests disappear annually (FAO 2010). The Sambande forest (1045 hectares) was previously fallow land and would now not exist if the management measures for woodfuel production had not been put into action. Today, Sambande is a species rich forest and provides important ecosystem services (PERACOD 2010a).

Erosion protection and soil improvement

Vegetation cover is the best protection for soils against erosion. Without vegetation, soils are vulnerable to the forces of water and wind, and the land is in danger of losing its fertility, leading to desertification. Many recent examples suggest that the use of wood energy threatens forest resources and thus exposes soils to erosion processes, especially where wood energy is scarce and where access to forests is not regulated due to lack of land-use arrangements and bad management. If the prerequisites for *sustainable* land-use management are known, the use of wood-energy creates an economical incentive to maintain the forest cover and thus protecting the soils against erosion. Moreover, trees can improve soil fertility, since over the years a humus layer evolves. Some trees will store nutrients within the soil.

The *PMRN*-Project in Paraguay revealed that in all the areas involved, farmers significantly improved the soil fertility of their lands through the implementation of agro-forestry and forest management for woodfuel/timber production. According to a survey, farmers see a connection between land-use management and the preservation of soils (Albrecht 2010).

The woodfuel-plantations at Mampu (Democratic Republic of Congo) are predominantly composed of acacia, which improves and maintains the soil fertility, mainly due to the abundant organic matter produced by the acacia, and the enrichment of soil nitrogen by bacteria present in the nodules that form on the roots of the acacia trees. Increase of soil-productivity in Mampu is up to 400% (Hanns-Seidel-Stiftung 2009).

In Tajikistan, the establishment of a Joint Forest Management scheme promotes the rehabilitation of degraded floodplain forests, and thus prevents further erosion of the riverbanks and by the wind.

3.5 Social impacts

The promotion and support of the wood-energy sector in rural areas has, in addition to economic and environmental effects, impacts on families, clans and whole communities. The most important impacts are empowerment of women and local governance. The woodfuel sector is particularly suitable for incorporating social improvements, as it includes many types of employment, including tree planting, forestry work, charcoal production, transport and sales, which can be done not only by both women and men, and by many different age groups. Since woodfuel use already represents a crucial part of everyday life in rural areas, such activities can be implemented within existing social structures.

Empowerment of women

The PERACOD-project (Senegal) seeks to enable women to run commercial activities, involving them in the supply chains around forest resources. Today (2010), women in the project area begin by selling firewood and charcoal, generating substantial incomes. These newly acquired funds give them a financial independence that improves their position in society (PERACOD 2010b).

In the Antsiranana-region (Madagascar), particularly single women are often engaged in reforestation activities. Through generating their own income, they may in the future improve their living conditions and strengthen their role in society and their households. The ownership of reforested areas is 61% men, 22% women and 17% of couples (GREEN-Mad 2007).

Women currently active in agro-forestry farming in Mampu (Democratic Republic of Congo) all recognize that their situation is far better than if they were involved in traditional agriculture, particularly since the production and sale of charcoal provides very significant additional revenue (Ducenne 2009).

Local governance

For several years, the local population at the Sambande forest stopped grazing and tree felling activities, so that now there is real potential for woodfuel production. Without the support both of PERACOD, and the long-standing commitment of the population, this would not have been possible. Today, people see the forest as their resource, which means that access is regulated by the community itself, with controlled woodfuel extraction regulations.

Reforestation measures in Antsiranana (Madagascar) allow individual grassroot groups to develop interest communities to obtain specific economic objectives. The potential for self-promotion and empowerment of village communities is strengthened, and this overcomes social differences. Some groups are engaged in collective investments, such as charcoal processing units, or activities that have social benefits, such as the fight against HIV/AIDS (GREEN-Mad, 2007). Such synergies have developed in the region around the Mampu-project, giving birth to a social dynamic that is the basis for a new form of solidarity where the origin of farmers does not influence the relations between them. The spatial distribution of the neighbourhoods, and inter-ethnic marriages clearly illustrates this change. The associates are not recruited according to their origins but because of their expertise and their capacity for work (Ducenne 2009).

Through Joint Forest Management in Tajikistan, the local population is integrated into management decisions about forest resources. Through their participation, they see the importance and output of their work (regeneration of forest areas and income from sustainable forest use) and are motivated to continue and extend their activities (Rosset 2010).

Health improvements

In Madagascar, monitoring results showed that the amount of additional revenues generated by afforestation is spent by households as follows: 20% for food and clothing, 15% for education, 14% for agricultural investments, 12% for health, 11% for housing, 4% for reinvestment in forest activities (GREEN-Mad 2007).

4 Conclusions

It has been demonstrated by these projects that wood energy represents a sector with a broad range of positive impacts. These impacts are diverse and affect many areas of political significance, such as the economy, energy, ecology and social issues (Figure 2). Some of them are noteworthy because they are of central importance to the other impacts, such as improvements in the economy, and resource protection.

Overall, it can be said that in almost all these projects, an increase in local income generation and improved energy supply was observed. This positively affects poverty reduction, education, health and gender issues.

The character of a sustainable energy production regime, described in the introduction, has been developed in most of the projects through business plans or forest management measures, where a more regulated and formalized setting with transparency, regulated land-use and land ownership could evolve.

Furthermore, every project shows clearly that the modernization of the wood energy value chain creates a positive impact on the environment, by mechanisms such as the rehabilitation of formerly degraded land, or by the protection of natural forests. This not only secures the continuous supply of fuelwood, but also creates a broader and more diverse range of ecosystem services. Finally, it should be stressed that the wood energy supply chain is an autonomous system that requires no physical inputs, such as imports, from outside the area. Therefore, wood energy is, due to its large-scale abundance, a way to generate independence and more economical mobility in many countries.

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6 Annex (Project outlines)

6.1 *GREEN-Mad* (GTZ, Madagascar)

Over 85% of Madagascar's population meets its daily household energy needs from firewood and charcoal. Mainly due to strong urban growth during the twentieth century, the pressure on the natural forests of Madagascar has risen sharply. Consequences, such as shortages in supply, deforestation and soil erosion, led first to afforestation projects within the reach of urban areas. However, large regions in Madagascar still exist where natural forests are exploited non-sustainably for wood energy and charcoal production. This includes the region of Antsiranana where, due to these developments in the 1990s, the project *GREEN-Mad* (Gestion Rationelle de l'Energie et de l'Environnement à Madagascar) was designed as an initiative of the Department of Energy Madagascar (MEM) collaborating with GTZ. *GREEN-Mad* a 16-year programme ending in 2010. Since 2005, *GREEN-Mad* has been integrated into the programme PGDRN (Le Programme de Protection et Gestion Durable des ressources Naturelles), which covers a period of nine years (until 2013). The budget for the project amounts to approximately EUR 8.75 million (according to final report 2005).
The overall aim of *GREEN-Mad* is the sustainable supply of the Antsiranana region with wood energy. The most important outcome of the activities is the afforestation with *Eucalyptus Camaldulensis*, the establishment of **plantation management** schemes and the overall **modernization of the charcoal value chain** (regulation of land-use and land ownership, transparency, more efficient conversion technologies). Antsiranana town (2007) has a population of 107 000 with an annual consumption of 12 000 tonnes of charcoal. At the beginning of the project, in 1992, there were 75 000 inhabitants whose energy consumption was 9000 tonnes of charcoal / year.

Further reading: (GREEN-Mad, 2007), (Jorez, et al., 2009)

6.2 Joint-Forest Management (JFM) (GTZ, Tajikistan)

After the collapse of the Soviet Union, a lack of heating material during the civil war in Tajikistan led to uncontrolled use of forest fuel, and thus to a sharp decline of the forests in the Gorno-Badakhshan Autonomous Oblast (GBAO), Tajikistan. Today, the weak and outdated structures of the State Forestry Agency (Leskhoz), prevent a natural regeneration of the highly degraded flood plain forests, and foster the persistence of open-access to forest resources.
In this context, the project 'Sustainable Management of Natural Resources in Gorno-Badakhshan' was created in order to rehabilitate the degraded flood plain forests in GBAO through ***Joint Forest Management*** (JFM) arrangements between *Leskhoz* and local forest users. To ensure a sustainable continuation of the project and to strengthen the capacities of *Leskhoz* to manage their forests, a business plan (Hessen-Forst, 2009) is being developed for the **support and promotion of rural value chains** including wood products for energy use (currently, about 45% of the required heating energy in GBAO is met by wood energy (Rosset, 2010)).

Further reading: (Hessen-Forst, 2009)

6.3 *Mampu* (Hanns-Seidel Foundation, Democratic Republic of Congo)

Since the 1980's, reforestation with acacia has been taking place on the Bateke plateau with the aim of supplying the Congolese capital Kinshasa with eco-charcoal, thus avoiding the deforestation of the rainforest and the destruction of vegetation in the river valleys. In 1986, the then *Ministry of Environment of Zaire,* with support from Belgium, started the planting of acacia. The initial budget amounted to EUR 8.5 million at that time. In 1994, the *Hanns-Seidel Foundation* independently took over the project 'Afforestation 8000 hectares' in Mampu. Due to a lack of exit strategy, the results that had been achieved since 1994 started, to fade. To prevent this, in 2004 an EU project for the 'revival of agro-forestry in Mampu' was launched, to develop the sustainable use of the acacia plantations (by 2007 this project was also supported by the *Hanns-Seidel Foundation*). This was mainly possible because acacia trees, by their nature, **improve the soil,** leading to **higher productivity and better revenue returns**. This intensified use of the existing acacia plantations is aiming to improve the living standards of the local population, and is helping to improve the food supply of Kinshasa.
At the beginning of the EU-project, 248 families were settled within the 6500 hectares of acacia forest in Mampu to manage the plantations. Since the project was proving to be successful overall, a further promotion was funded between 2007 and 2009 ('Promotion of agro-forestry and the surrounding communities'), in which the activities were extended to the surrounding villages and the town Mbankana.

Further reading: (Ducenne, 2009)

6.4 *PERACOD* (GTZ, Senegal)

The *Sambandé* forest, 35 kilometres south of Kaolack in the region Keur Baka, covers approximately 1045 hectares and is surrounded by a total of eight villages with a population of around 2615. Since 1995, the local population has tried to establish sustainable forest management, mainly to combat desertification. By 2004, the activities run by the original programme PAGERNA were taken over by PERACOD (Programme pour la promotion of Renouvelables énergies, de l'Electrification Rurale et de l'approvisionnement en combustibles domestiques durable), a Senegalese-German (GTZ) Cooperation. After the forest was protected for seven years and could be regenerated, a **forest management plan,** comprising regulation of land-use issues and greater transparency, was created in 2006. This plan is currently being implemented (2010).
The Sambandé forest is relatively rich in species; inventories identified up to seven species of trees that are suitable for wood energy use. The most common type is the *Acacia Seyal*.
A very important part of the PERACOD programme is the establishment **more efficient production and combustion technologies** for charcoal. These activities, together with a more diverse use of the forest resources, aim to improve local living standards and to protect the natural resources.

Further reading: (PERACOD, 2010a), (PERACOD, 2010b)

6.5 *PMRN* (GTZ, Paraguay)

Around 42% of the 5.8 million population of Paraguay live in rural areas, of whom 36% are classified as poor, and 20% extremely poor. In the project area in the eastern part of the country, 80% live below the poverty line. This poverty is mainly due to poor soil productivity, which cannot provide for subsistence needs, nor production of market goods. The overall objective of the project is therefore to improve the productivity of smallholder farmland and private forests and, at the same time, to implement sustainable resource use. Basically this is carried out with already-proven consulting methods of participatory rural development with skilled field workers.
The project is a collaboration project between *Kreditanstalt für Wiederaufbau (KfW)* and *GTZ*, where all conversion schemes of land management are financed by the *KfW*, and the operational implementation of **sustainable natural resource management** is supported by *GTZ*. The total project period is ten years and one month from October 2000 to October 2010. The total German contribution will amount to EUR 3.3million for technical cooperation (TZ) and EUR 16.9million for financial cooperation (FZ).

Further reading: (Grulke, 2009), (Albrecht, 2010)

6.6 *BEST* (GTZ, Rwanda)

Following a request from the Rwandan Ministry of Infrastructure, in 2008 the EUEI Partnership Dialogue Facility (PDF) supported the development of a national biomass energy strategy (BEST) with a focus on the **modernization of the charcoal value chain**. The strategy was aimed at supplying energy from biomass, to improve its sustainable use and to **promote better combustion technologies**. Following several studies and field surveys, a final strategy for the government was adopted and is being implemented.
An important finding of this programme is that farmers can operate tree plantations for the sale of firewood and charcoal profitably, mainly because of the shortage of naturally-growing woodfuel.

Further reading: (GTZ, 2008), (GTZ, 2008b)