Using forests to enhance resilience to climate change

The Case of the Wood-Energy Sector in Burkina Faso

Acknowledgements

This study on the role of forests in enhancing landscape resilience to climate change is part of a larger multi country project designed and led by Diji Chandrasekharan Behr (Sr. Natural Resources Specialist, World Bank) on the role of forests for enhancing resilience to climate change (www.profor.info/node/2032). The larger project aims to capture the role of forests in enhancing resilience to climate change of other sectors. It examines how sustainable management of forests can contribute to strengthen social and physical resilience of systems in other sectors. Using forest and tree management as part of a broader strategy to enhance resilience to climate change could provide a low-cost option for local landscapes while also contributing to balance production, livelihood, adaptation and mitigation goals.

The field data collection and preparation of the case study was done by two teams. The team working on the modelling of climate change scenarios was from the Center for International Forestry Research (CIFOR) and included Serge Rafanoharana, Bruno Locatelli and Aaron J.M. Russell. Initial data collection and analysis was done staff in CIFOR and CIRAD, specifically Denis Gautier (CIRAD-CIFOR), Maam Suwadu Sakho-Jimbira (CIFOR), Cathérine A. K. Coulibaly Péhou (CIFOR Consultant), and Jean-Paul Laude. A second and final round of data collection and analysis was done by staff in Eco-Consult, specifically Dr. Frank Richter, Marion Mundhenk, Martial Charpin, and Mamadou Lamine Bodin. A draft report was formally reviewed by Hocine Chalal (Lead Environmental Specialist, World Bank) and Loic Braune (Natural Resource Management Specialist, World Bank). This report, which draws on the various reports mentioned above and incorporates the comments provided by the reviewers, was finalized by Diji Chandrasekharan Behr.

The team is thankful for the financial support provided for this work by PROFOR and the Trust Fund for Environmentally and Socially Sustainable Development (TFESSD). TFESSD is a multi-donor trust fund with financing from Norway and Finland. The Trust Fund supports research on environmental, social and sustainable development topics. PROFOR is a multi-donor partnership housed at the World Bank, PROFOR finances forest-related analysis and processes that support the following goals: improving people's livelihoods through better management of forests and trees; enhancing forest law enforcement and governance; financing sustainable forest management; and coordinating forest policy across sectors. In 2012, PROFOR's donors included the European Union, Finland, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, and the World Bank. Learn more at www.profor.info

Executive Summary

It is common knowledge that the poor suffer disproportionately from climate change and climate variability than other socioeconomic strata in most countries. This is also the case is in Burkina Faso, a landlocked country in the middle of the West African Sahel region, and is one of the smallest economies in the world. Burkina Faso has limited natural resources and a highly variable climate. The country is dependent on agriculture with approximately 80% of employment related to subsistence farming. With depleted natural resources and poor soils with limited nutrients and low water-holding capacity, Burkina Faso struggles with food security and creation of economic opportunity.

Burkina Faso is prone to chronic drought, flash floods, wind storms, and disease outbreaks. Climate projections reveal a worrying increase in average temperatures of 0.8 °C by 2025 and 1.7 °C by 2050, and a high variability of rainfall (MECV, 2007). The country is extremely vulnerable to changes in rainfall, dust storms, and spikes in temperature as they directly affect food supplies and yields.

Climate change has a significant impact on food security and energy security. In Burkina Faso, wood covers 85% of household energy needs (MEDD, 2012a). The woodland areas (forests, plantations, parklands, hedgerows, fallow lands) are the main sources of supply to meet the demand of households and craft workers. Climate change is expected to decrease the biomass available in the woodlands (Burkina Faso NAPA, 2007[1]). Climate change is predicted to result in the disappearance of some flora and fauna species and the migration of other species in the Sahel to the Sudanese regions.

Government officials in Burkina Faso recognize the importance of forests for addressing climate change – whether mitigation or adaptation. Forests and trees are critical for the energy and food security of the Burkinabe people.

The current and projected importance of wood energy underscores the urgency of identifying how to ensure that the wood energy subsector is resilient to the project impacts of climate change; and how to ensure augmenting resilience does not result in other costs, such as those associated with increasing dependence on imported energy sources that are equally vulnerable to climate change – e.g., petroleum based products (because of water usage in their production, reliance on working infrastructure, and need for energy storage facilities.

Ecosystem-based adaptation.

Ecosystem-based adaptation (EBA) is the use of biodiversity and ecosystem services as part of a general adaptation strategy to help people adapt to the adverse effects of climate change." This concept is based on the idea that ecosystem services have the potential to reduce the vulnerability of society to climate change across sectors and sub-sectors.

Objectives of the study

This study, as part of a series of studies, explores how forests, through the provision of ecosystem services, contribute to adaptation of other sectors to climate change.[2] The purpose of this study is to examine the potential contribution of forests to the resilience of other sectors. The premise is that ecosystem-based adaptation (EBA) measures can complement other forms of adaptation, making them more cost-effective and increasing the potential co-benefits (whether livelihood related or mitigation benefits). For purposes of this case study, the focus is on the potential contribution of forests to increasing the resilience of the wood energy subsector in Burkina Faso given the reliance of a significant portion of the population on wood energy.

[1] http://unfccc.int/resource/docs/napa/bfa01f.pdf

[2] For more information on the set of case studies please visit www.profor.info/node/2032.

The objective of the study is to bring evidence to a discussion on the linkages between enegy and forests in the context of climate change (i.e., role of forests in enhancing the resilience of an wood energy subsector) to decision makers in government and development partner organizations, and inform engagements focusing on development and enhancing resilience to climate change in Burkina Faso; this is done by:

- Summarizing the vulnerability of the energy sector in Burkina Faso to climate change
- Examining how wood energy features in the current and future energy portfolio of Burkina Faso and assess the expected/potential role of wood energy in meeting future energy consumption;
- Reviewing current and projected impacts of climate change on the wood energy sector;
- Assessing the situation of the wood energy value chain: Supply and consumption of wood, actors and structure in the chain, the role of wood energy in the national energy mix;
- Identifying strategies to adapt to climate change by focusing on solutions oriented towards forest ecosystems;
- Evaluating the economic implications of the strategies identified by considering different climate change scenarios;
- Identifying political measures and the associated institutional changes that would facilitate the use of forests to reduce the vulnerability of the wood energy sub-sector and strengthen their resilience to climate change.

Below are some of the main findings of this case study.

Wood energy - now and for the future

Like the other Sahelian countries, Burkina Faso suffers from a paucity of energy and levels of energy consumption are low compared to neighboring countries. In 2007, the country's total energy consumption was estimated at 3.2 million tons of oil equivalent (TOE) that is an average consumption of 240 kg of oil equivalent per capita.

Improving energy systems is a huge development challenge especially if we consider that despite the importance given to poverty reduction in national development plans, poverty indicators are not showing positive developments. In Burkina Faso, rural populations constituted approximately 80 percent of the national population in 2010. Of the rural population, 52 percent are estimated to be poor (IFAD, ruralpovertyportal.org). In addition, there is a high population growth rate - generally reported above 3% and one of the highest in Africa - which will result in a doubling of the population within one generation. The urbanization rate is estimated to be twice as high as the rate of the population growth.

The primary form of renewable energy in Burkina Faso is wood. It meets 85% of household energy demand. The woodland areas are the main sources of supply to meet the demand of households and craft workers. According to the unanimous opinion of experts, wood energy will remain for decades the main source of domestic energy in Burkina Faso, especially for the disadvantaged sectors of the population. This energy situation combined with the potential impact of climate change requires the public authorities of Burkina Faso to consider the development guidelines to promote access to energy whilst also considering the viability and sustainability of the system.

Forests, which are often devalued sources of energy, provide a renewable energy source that can offer relative energy independence for the country. From an economic point of view, using forests for energy purposes represents more than 85% of the contribution of the forests activities contribution to

GDP (approximately 5.7%) that is 209 billion FCFA[3]. Sustainable production of wood energy also contributes directly to the creation of local employment and can help redirect public expenditure related to imported fossil fuels to investments in internal energy sources. The promotion of woody fuels can also help make a national transition to a strong greener economy.

The challenges that characterize the wood-based fuels sector cannot always be reduced to a simple relationship between supply and demand. The problems associated with woody fuels linked to fundamental shortcomings in the management and security of rural land, the development of a tax incentive policy, the existence of a structured and effective marketing network and the balanced management of communal areas to meet agro-forestry demands of local communities. Significant legislative progress has been made in Burkina Faso, mainly in the field of decentralized forest management. Consequently, several donor activities, in alignment with the National Programme for Rural Strategy, have as a target to increase the contribution of the forest sector to the national economy and the well-being of communities, especially through the promotion of wood and non-wood forest products.

Current situation in the wood energy subsector

A r**eview of the wood energy subsector in 2013** reported the following situation:

- The potential sustainable wood production under current practices is 9.2 million cubic meters. The major part of the production is in silvopastoral and forest areas of the country (60%), followed by production from trees outside forests (34%) and lastly forest plantations (6%).
- The national household wood based energy consumption is 7.945 million cubic meters of wood, which generates 5,045,093 tons of fuelwood and 226,518 tons of charcoal.
- The consumption of businesses amounts to 1,728,202 cubic meters of wood, including 1,350,261 tons of fuelwood and 11,326 tons of charcoal.
- Wood energy remains the main fuel used by households and demand keeps increasing with the combined effects of population growth and rural exodus. Charcoal consumption is concentrated in the major urban areas, especially Ouagadougou, Bobo Dioulasso and Banfora.
- Considering the domestic and business demands, as well as export, mainly to Niger, the local consumption amounts to 9.6 million cubic meters of wood per year of which about 1,921,967 m^3 are for the production of 236,284 tons of charcoal.
- The balance between potential supply and demand confirms a national deficit. The amount of wood sold on the basis of sustainable production helps to meet 95% of current domestic consumption. The gap between sustainable supply and demand totals 526,812 m^3 per year. A consequence of this deficit is over-exploitation of forest resources in Burkina Faso.

The **analysis of the value chain** conducted as part of this study reveals the following findings:

- Wood production and selling is an important source of seasonal employment and additional income in rural areas and has the advantage of being an activity carried out during the dry season.
- Although the majority of the potential biomass production is localized in silvopastoral and forest areas, the share of non-forest wood production is substantial (30%).

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[3] There are many shortcomings to the use of GDP to capture the value of substituting one fuel source with another. In the case of Burkina Faso, with their level of energy dependence on imported oil, substituting wood for oil where possible will have implications for their trade balance (given the country's large trade deficit). In addition, use of wood in place of oil will reduce the cost of price controls and subsidies used by government to global energy prices to pass through fully into domestic prices. (Economist Intelligence Unit, 2014. http://www.itfc-idb.org/sites/default/files/2-uv-007-eiu_report_on_burkina_faso.pdf)

- The cumulative area of managed forests officially reaches 880,000 hectares. However, most of the wood production comes from unmanaged forests and where communities are not organized. The administration partially allows the development of these supply chains fed from the exploitation of the unmanaged protected forests by issuing permits at the regional level.
- Charcoal production is controlled with the annual fixing of production sites by ministerial decree. Most charcoal producers are seasonal workers and use traditional carbonization techniques with low yields. Their profit margin is higher than the direct sale of wood.
- The transportation of the wood and charcoal is the most profitable segment in the wood energy value chain (28% of the consumer price). Despite the diversity of the means of transport used, the increasing distances from the production to consumption centers promotes motorized carriers.
- The network of traders-retailers is dense in urban districts and usually consists of women selling the wood in piles or bundles. The majority of retailers buy from carriers while some have their own means of transport.
- The consumer price of wood is relatively low (22 FCFA/kg) thus contributing to the attractiveness of this fuel.[4] The average price variability in charcoal is greater ranging between 80 and 170 FCFA per kilogram depending on the regions. Ouedrago (2014) found that In the case of urban households in Ouagadougou, woodfuel and charcoal demand are relatively inelastic and therefore are not very responsive to own prices.
- The cooking technologies used by households and professionals are generally energy intensive. But there are a range of improved cookstoves suitable for cooking and relatively affordable, developed as early as the 80s by specialized organizations. Production of cookstoves is primarily artisanal and workshops are under-equipped. The promotion of improved cookstoves is concentrated in urban areas with little consideration of rural areas which nevertheless represent 70% of the national domestic demand. The improved cookstoves have energy efficiencies that range from 30 to 45 percent.
- Political control of gas prices initiated by the State has made access to this source of energy easier for urban households but has failed to replace wood biomass. Recent fluctuation in the price of oil on the international market have led to an increase in the financial burden of this public policy leading to the revision of the ceiling price of gas refills in May 2013.[5]
- Initiatives for the development and distribution of alternative energy sources exist (biogas, biocarbon, solar cooker). However, the results achieved are mixed but give hope that distribution on a larger scale could significantly reduce wood consumption.

Vulnerability to climate change

The analysis of key climatic factors over a recent period reveals (1) a slight upward trend in annual average and maximum temperatures, (2) a high annual rainfall variability which is characterized by a sudden alternation between very dry and very wet years and (3) a reduction in the number of rainy days coupled with an increase in the median intensity of daily rainfall.

[4] The statement that the price is low is based on comparisons with price in similar countries and also estimations of management costs. Additional research would be needed to accurately estimate the cost of sustainable management of forests for wood energy production to gauge how much of a gap exists between the current price and the cost of sustainable management.

[5] In 2013, implicit and explicit transfers to the state-owned electricity company and state-owned fuel importing company totaled almost one-tenth of the central government budget (IMF, 2014)

Climate simulations predict an increase in temperature of about 0.8 °C by 2030, characterized by seasonal variation. Regarding the variability of rainfall, strong annual and seasonal variations are expected. July, August and September are likely to be affected by decreases in the order of 20-30% while rainfall in November will increase by 60 to 80%.

While it seems unquestionable that the country will face up to an increase in temperature and rainfall variability, quantitative projections are ambiguous. Consequently, conclusions about the impact on the productivity of forest resources as a factor limiting the supply of wood energy, also related to the concentration of CO_2 remain relatively uncertain. Furthermore, the analysis of various components of vulnerability shows that the impacts of climate change are not an isolated challenge for the sub-sector, including forest ecosystems.

Stress factors attributed to climate change exacerbate existing human pressures, such as the expansion of cropland and grazing lands, the over exploitation of wood, forest conversion into residential areas, causing both deforestation of forests and their degradation. Similarly, the impact of climate change is compounded by the existing anthropogenic factors. For example, the negative impacts of climate change on net primary productivity are not offset by anthropogenic factors in most optimistic scenarios, and the potential positive impacts of climate change on net primary production are almost lost because of land use change in the long term. Non-favorable framework conditions and institutional deficiencies often underpin these anthropic pressures.

Changes undergone by forest ecosystems and therefore ecosystem services due to environmental degradation and climate change could have an impact on the wood energy subsector in Burkina Faso.

Modeling of three scenarios for the wood energy value chain

To quantify the flow and framework scenarios of changes in supply and demand for wood energy by 2030, a model was developed as part of this study. Three scenarios were studied in order to provide projections of supply/demand balance for 2018, 2030 and 2050. The parameters considered are (1) the positive or negative impact of climate change on the productivity of forest resources, (2) population growth and (3) the rate of decline in forest area[6]. All scenarios lead to a more and more pronounced deficit over time if the selection of wood energy is made according to the rules of sustainable management. Given this situation, strategies need to be developed to meet the growing energy demand while taking into account the impact of climate change.

Two potential strategies

As part of this analysis, we identify two types of strategies that could be used to enhance the resilience of the sub-sector by 2030:

- A strategy for the modernization of the wood energy sub-sector, based mainly on the sustainable management of forest ecosystems and optimization procedures to the other links in the chain. This strategy, unlike previous efforts, adopts a holistic approach that addressing framework conditions and the entire value chain;
- A strategy that substitutes away from wood energy. For purpose of examination, in this study we use a primarily LPG strategy. The latter is chosen as an alternative approach because it is in line

[6] These scenarios are developed using available data on consumption and existing information on elasticities of demand. The scenarios are not built using growth and energy demand models. The use of a simpler approach is justified as the aim is not to reconcile supply and demand. Instead the study aims to explore whether, as climate change affects availability of wood energy there are ways, that still involve use of wood fuel to enhance the resilience of the subsector.

with the national vision 2020 (i.e., reducing the woodfuel demand by increasing the use of LPG and kerosene as well as improved cookstoves).[7]

The modernization strategy of the wood energy value chain is based on (1) the participatory and decentralized management of forest ecosystems, which is consistent with ongoing initiatives (2) increased energy diversification and (3) the optimization of firing technologies. The proposed strategy considers all the links following an optimization principle, in order to initiate a transition from the traditional sector to a formal and modern sector.

The five main intervention areas for modernizing the wood energy value chain are summarized in the table below:

Summary of intervention avenues for enhancing the resilience of the wood energy value chain

Sustainable wood energy production: The aim is to ensure that wood supply is from appointed or controlled areas while promoting sustainably managed and improved productivity of wood resources. Actions include:
• Promoting participatory management of natural forests • Increasing the area of forest plantations • Promotion and strengthening of agroforestry
Logging and processing of wood energy: The objective is to make the best natural wood including attempts to reduce losses related to exploitation and carbonization. Actions will include:
• Consolidating capacities of local actors in tools and techniques of forestry management • Increasing efficiency in logging • Increasing efficiency in carbonization • Testing and dissemination of innovative practices for the use of agricultural residues
Transportation and selling of wood energy: The aim is to promote access to consistent information and contribute to a fairer distribution of the economic capital gain generated by the sector. The main activities will consist of:
• Structuring of marketing channels • Implementation of an information system for the wood energy market
Use of wood energy: The aim of this step is to increase the efficiency of the firing equipment in order to achieve a reduction in the demand for woody fuels. Activities expected to deliver this result are:
• Optimization and testing models of improved domestic cookstoves • Distribution of improved cookstoves in urban and rural areas
Improve framework conditions. The main actions to achieve this improved framework conditions will include:

[7] It should be noted that there are several other alternative strategies (e.g., solar) that are not dependent on wood energy that could be considered as a means to enhance resilience of the energy subsector that caters to household energy needs that are met by woodfuel. A similar analysis to what is done in this study could be done using either one or a combination of these options. Due to data limitations and sophistication of analysis required, however, such an approach was not feasible for this study.

- Ensure the implementation of differential taxation
- Support the setting up of an effective monitoring system
- Support the setting up of a National Wood Energy Committee
- Development of regional strategies to modernize the wood energy value chain
- Development of guideline programs in wood energy supply
- Development of an information system on the wood energy value chain
- Facilitating the dissemination of best practices and lobbying

The measures listed in the table above can reduce the sensitivity and adaptive capacity of the subsector. In this report, the detailed description of the actions listed in the table specifies how to implement the activities in order to enhance resilience of the susbsector.

Financial viability of the two strategies

To be able to meet 90% of the energy needs of rural households from wood energy and 60% of urban households, the total costs associated with the modernization of the sector by 2030 vary between 232.2 billion FCFA (USD479.35 million) in the optimistic scenario and 306.3 billion FCFA (USD479.35 million) in the pessimistic scenario. Reported in average annual costs, investments range between 13.7 and 18 billion FCFA (between USD28.28 and USD37.16 million). If the investments for the improvement of framework conditions, the dissemination of improved cookstoves (about 1.7 million units) and the promotion of LPG (about 720,000 households) are assumed constant, the difference is allocated to the forest areas, other woodlands and plantations under management. In the optimistic scenario, the calculations are based on development planning of approximately 7.8 million hectares of forest and 185,000 ha of plantations, while the pessimistic scenario requires intervention on 11.3 million hectares of forests and 266,000 ha of plantations, net of existing quantities (e.g. area under management).

The total costs of the main LPG strategy are significantly lower than those of the modernization strategy and range from 170 billion FCFA to 220 billion FCFA (around USD350.94 to USD454.16 million). These LPG strategy costs, however, do not reflect the costs associated with enhancing the resilience of the hydrocarbon storage infrastructure, or risks associated with climate related risks of the transportation and port infrastructure in other countries.

While financially the main LPG strategy is more cost effective, a full economic analysis that also accounts for the ecosystem benefits of modernizing the wood energy value chain is likely to result in a different conclusion. Modernizing the wood energy value chain will result in positive climate change mitigation benefits and improve resilience. The use of wood energy can encourage land owners and farmers to better manage woodlands and invest in plantations. The sustainable production of wood energy contributes to the preservation of forests and woodlands while maintaining the associated functions such as soil conservation, protection of biodiversity and landscapes or carbon sequestration. Wood energy production is perfect for community management of forests and woodlands and is also in line with the current trend of deregulation and privatization of the energy and forestry sectors.

There are additional benefits to modernizing the wood energy value chain. For example, sustainable production of domestic fuels can lead to rural development consistent with coherent town and country planning. Forest resources are available locally and have a high potential for decentralized production and processing. The use of woody fuels promotes transport over relatively short distances with low environmental risks. Unlike other energy sources requiring more sophisticated technologies, woody fuels create jobs and income at the local level and especially for the poorest and most disadvantaged groups because of the low skill requirements.

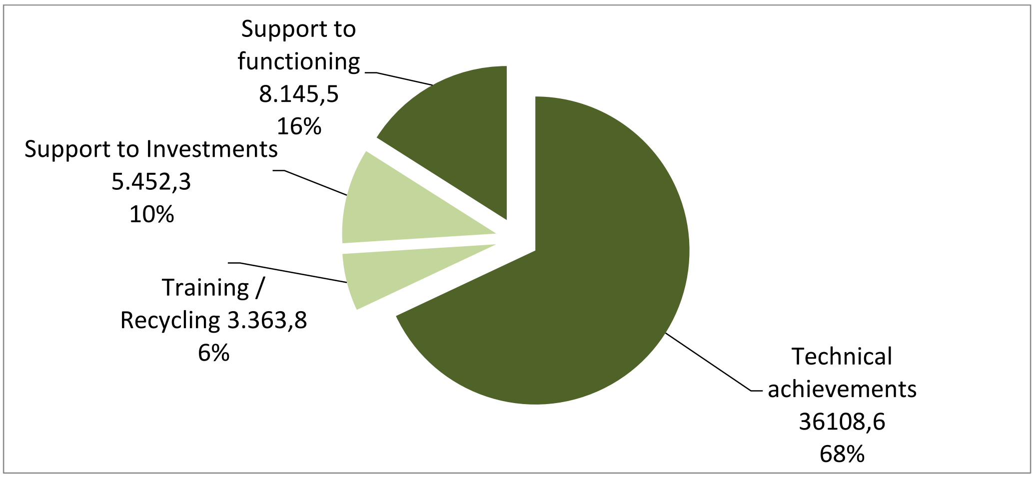
In addition, domestic woody fuels produced in a sustainable way, contribute to a carbon neutral energy supply and are therefore a key factor in the implementation of low carbon growth strategies.

Locally produced woody fuels also reduce dependence on finite fossil fuels. Therefore, in addition to the efficiencies through innovations, the promotion of wood fuels offer indirect benefits such as foreign currency savings and a reduction in the economic dependence of the country.

Action plan for implementing the modernization of wood energy value chain: 2014-2018

In order to make the strategy of modernization of the wood energy value chain operational, a detailed action plan for the period 2014-2018 is developed in this report. The action plan takes into account available human resources and the planning done by the major projects/programs that are in progress in Burkina Faso. The action plan which is for five years and the first phase in the modernization efforts includes: (1) the forest management of a total area of about 805,000 hectares, (2) the reforestation of 38,000 ha, (3) the protection of 260,000 ha, (4) large-scale distribution of improved cookstoves (390,000 cookstoves)8, (5) promotion of the use of LPG among 160,000 households and (6) support for people with alternative fuel projects. In parallel, training and investment plans will be implemented as well as efforts to improve framework conditions. The total costs related to the implementation of the action plan reach 53.07 billion FCFA, equivalent to USD 109.54 million.

Distribution of costs for the implementation of the action plan (in millions FCFA) by category; 2014-2018 period



In conclusion, Burkina Faso is heavily reliant on wood energy to meet household energy needs. Climate change projections till 2030 and 2080 indicate that the country will face up to an increase in temperature and rainfall variability, with a degree of uncertainty. Despite the ambiguity in the climate change models, the models indicate that the impact of climate change is compounded by the existing anthropogenic factors. Addressing these anthropogenic factors, therefore will be instrumental for enhancing the resilience of the wood energy subsector to climate change.

Wood energy, although often considered a 'dirty' form of energy is very important in the daily life of the Burkinabe people. Building the resilience of this energy subsector will be key to meet a significant part of the projected household energy needs. Modernization of the wood energy value chain is a key step to reduce the vulnerability of the wood energy subsector. Improving the resilience of the energy subsector will need to be augmented with the mainstreaming of other economically viable energy sources to meet anticipated national energy needs.

[8] There is evidence from work done by FAFASO on the feasibility of private dissemination models for cookstoves. This effort to promote cookstoves could potentially be linked with the biogas carbon finance initiative that is currently being prepared.

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Abbreviations and Acronyms

AAC	Artisans' Association from the Center
ADB	African Development Bank
ALR	Agrarian and Land Reform
ANR	Assisted Natural Regeneration
AOF	Afrique Occidentale Française (French West Africa)
C	Carbon
cum (m^3)	Cubic meter
CCD	Cellule des Combustibles Domestiques (Household Fuel Unit)
CEC	Clean Energy Center
CIFOR	Center for International Forestry Research
CILSS	Permanent Interstates Committee for Drought Control in the Sahel
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (International Cooperation Center in Agricultural Research for Development)
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
DDO	Distillate Diesel Oil
DEES	Direction de l'Economie de l'Environnement et des Statistiques (Directorate of Economics, Environment and Statistics)
DES	Domestic Energy Strategy
DGCN	Direction Générale de la Conservation de la Nature (General Directorate of the Nature Conservation)
DGFF	Direction Générale des Forêts et de la Faune (General Directorate of Forest and Wildlife)
DLA	Decentralized Local Authorities
DMP	Development and Management Plan
DTS	Decentralized Technical Service
EBA	Ecosystem-Based Adaptation
EDF	European Development Fund
FAO	Food and Agriculture Organization of the United Nations
FAFASO	Improved Cookstoves Programme in Burkina Faso
FCFA	West African currency
FDF	Forest Development Fund
FDP	Forest Development Plan
FIP	Forest Investment Programme
FMG	Forest Management Group
FMU	Forest Management Union

FSC	Forest Stewardship Council
FWL	Firewall
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GEF/LDCF	Least Developed Countries Fund (LDCF) of the Global Environment Facility
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Geo Positioning System
ha	Hectare
HIVOS	Humanist Institute for Cooperation with Developing Countries
IAP	Indoor Air Pollution
IC	Improved Cookstoves
ICPS	Improved Charcoal Production System
ICT	Information and communication technologies
IED	Innovation Energy Development
IGB	Institut Géographique du Burkina Faso (Geographic Institute of Burkina Faso)
INSD	Institut National des Statistiques et de la Démographie (Burkina Faso National Institute of Statistics and Demography)
IRSAT	Institute for Research in Applied Sciences and Technology
ISO	International Standardization Organization
ITC	Information and Communication Technologies
IVR	Individual Village Reforestation
km	Kilometer
LA	Local Authorities
LMP	Land Management Plans
LPG	Liquefied Petrolueum Gas
M&E	Monitoring and evaluation
MAHRH	Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques (Ministry of Agriculture, Water and Fisheries Resources)
MDG	Millennium Development Goals
MECV	Ministère de l'Environnement et du Cadre de Vie (Ministry of Environment and the Quality of Life)
MEDD	Ministère de l'Environnement et du Développement Durable (Ministry of Environment and Sustainable Development)
MEF	Ministère de l'Economie et des Finances (Ministry of Economy and Finance)
MIS	Market Information System
MMCE	Ministère des Mines, des Carrières et de l'Energie (Ministry for Mines, Quarries and Energy)
NFI	National Forest Inventory
NGO	Non-Governmental Organization

PAGT	Plan d'Aménagement et de Gestion de Terroirs (Plan for the Development and Management of Lands)
PANA	Plan d'Action National d'Adaptation à la variabilité et aux changements climatiques (National Action Plan for Adaptation to variability and climate change)
PASE	Programme d'Accès aux Services Energétiques (Energy Supply Programme)
PASF	Programme d'Appui au Secteur Forestier du Burkina Faso (Support Programme for the Forestry Sector in Burkina Faso)
PDC	Plan de Développement Communal (Municipal Development Plan)
PET	Potential Evapotranspiration
PGS	Plan de gestion simplifié (Simplified Management Plan)
PM	Particulate Matter
PNAF	Programme National d'Aménagement Forestier (National Forest Development Program)
PNB-BF	Programme National de Biodigesteurs (National Biodigester Program)
PNGT	Programme National de Gestion des Terroirs (National Land Management Program)
PPP	Public Private Partnership
PREDAS	Programme Régional de Promotion des Energies Domestiques et Alternatives au Sahel (Regional Programme for the Promotion of Household and Alternative Energies in the Sahel)
PROFOR	Program on Forests
REDD+	Reducing Emissions from Deforestation and Forest Degradation "plus" conservation, the sustainable management of forests and enhancement of forest carbon stocks
RPF	Réserve Partielle de Faune (Partial Wildlife Reserve)
RPTES	Regional Program on Traditional Energy Supply
RTF	Réserve Totale de Faune (Total Wildlife Reserve)
RWEM	Rural Wood-Energy Market
RUSPWE	Regional Urban Supply Programmes in wood energy
RWEU	Regional Wood Energy Unit
SCADD	Stratégie de Croissance Accélérée et de Développement Durable (Accelerated Growth and Sustainable Development Strategy)
SIDA	Swedish International Development Agency
SMEs	Small and medium enterprises
SMP	Simple management plan
SNV	Netherlands Development Organization
SONABHY	Société Nationale Burkinabés des Hydrocarbures (National Hydrocarbons Company of Burkina Faso)
SPI	Standardized Precipitation Index
SRAT	Schéma Régional d'Aménagement des Terroirs (Regional Land Management Programme)
SRT	Short Rotation Coppice
t	Ton
TFP	Technical and Financial Partners
TOE	Ton of oil equivalent

TOF	Trees Outside Forest
UFG	Union of Forestry Groups
UNDP	United Nations Development Programme
UWEM	Urban Wood Energy Market
VDP	Village Development Plan
WAEMU	West African Economic and Monetary Union
WC	Working Capital
WE	Wood energy
WEVC	Wood energy Value Chain

Conversion Factors and Exchange Rates

1 EUR	656 FCFA
1 USD	0.73843 EUR (Exchange rate of November 27, 2013)
1 m^3	0.83 t
1 stere	0.41 m^3

1. Introduction

It is common knowledge that the poor suffer disproportionately from climate change and climate variability than other socioeconomic strata in most countries. This is also the case is in Burkina Faso, a landlocked country in the middle of the West African Sahel region, and is one of the smallest economies in the world. Burkina Faso has limited natural resources and a highly variable climate. The country is dependent on agriculture with approximately 80% of employment related to subsistence farming. With depleted natural resources and poor soils with limited nutrients and low water-holding capacity, Burkina Faso struggles with food security and creation of economic opportunity.

Burkina Faso is ranked 162 out of 169 countries in the UN's Human Development Index, with 46% of its population below the poverty line (World Bank Climate Change portal[9], 2014). Rural areas continue to experience higher rates of poverty with 51% of the rural population living below the poverty line against 24% in urban areas (INSD, 2003). In addition, there is a high population growth rate - generally reported above 3% and one of the highest in Africa - which will result in a doubling of the population within one generation.

Burkina Faso is prone to chronic drought, flash floods, wind storms, and disease outbreaks. Climate projections reveal a worrying increase in average temperatures of 0.8 °C by 2025 and 1.7 °C by 2050, and a high variability of rainfall (MECV, 2007). The country is extremely vulnerable to changes in rainfall, dust storms, and spikes in temperature as they directly affect food supplies and yields. In addition, national weather early warning systems are lacking, and technical capacity, water storage, financial capacity and efforts in crop diversification and soil restoration are limited and require significant assistance.

Climate change has a significant impact on achieving food security in Burkina. It also can reduce opportunities for energy security. In Burkina Faso, wood covers 85% of household energy needs (MEDD, 2012a). The woodland areas (forests, plantations, parklands, hedgerows, fallow lands) are the main sources of supply to meet the demand of households and craft workers. Climate change is expected to decrease the biomass available in the woodlands (Burkina Faso NAPA, 2007[10]). Climate change also is predicted to cause the disappearance of some flora and fauna and the migration of other species in the Sahel to the Sudanese regions.

Government officials in Burkina Faso recognize the importance of forests for addressing climate change – whether mitigation or adaptation. Burkina Faso has submitted a proposal to the Forest Carbon Partnership Facility for support to develop a readiness strategy for reducing emissions from deforestation and degradation of forests (REDD+). The support is largely focused on reforestation as forests provide vital ecosystem services for local populations, such as the regulation of the water cycle, additional biomass and reduction in wind and water erosion. Trees, as a major element of the Burkina Faso landscape, are considered to be both protector and food provider. They help to meet the subsistence needs while helping maintain the production systems, particularly during dire times.

Forests and trees are critical for the energy and food security of the Burkinabe people. The linkage became quite evident in the last few years, especially at the time of the latest increases in oil prices which consequently led to the rapid increase in food prices. The Food and Agriculture Organization

[9] http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile&CCode=BFA (viewed, August 2014)

[10] http://unfccc.int/resource/docs/napa/bfa01f.pdf

(FAO) has emphasized that sustainable energy and food supply requires a "Nexus" approach -- an approach which involves the management and governance through sectors and depending on levels. Such an approach can facilitate the transition to a green economy, which aims, amongst other things, at the efficient use of resources and greater consistency in policies (Hoff, 2011).

While silvopastoral and agroforestry areas are often multi-purpose areas providing people with many goods and services, wood resources are threatened by various anthropic pressures, including changes in land use (agriculture), overexploitation, bushfires and animals (grazing land). All these pressures have lead to a reduction of plant resources of about 110,500 ha per year (MECV, 2007). Compounding the situation is the impact of climate change mentioned above.

The National Action Plan for Adaptation (NAPA) includes the concern for and use of forest resources because of its importance for socio-professional groups, gender issues, local implementation capacities, poverty reduction and the synergy with other multilateral environmental agreements. The NAPA proposes the use of forests in the framework of adaptation measures related to the sectors of water management, livestock/fodder plants, the fauna and the adaptive capacity of rural populations. In the NAPA the areas of intervention for the domestic energy sector, in view of the prospect of a significant increase in the demand for wood energy, are limited to improving the energy efficiency of cooking equipment (improved cookstoves) and to replacing wood by other renewable sources of energy (pressure cookers, water-heaters and solar dryers in particular) (MEDD, 2012a).

The current and projected importance of wood energy and the predicted impacts of climate change, however, underscore the need to ensure a sustainable supply of wood to build the resilience of the subsector and the wood energy supply chain. Doing so will reduce the likelihood that the energy portfolio does not rely too heavily on energy sources that are equally vulnerable to climate change – e.g., petroleum based products. The latter are vulnerable because of the reliance on water for their production, working infrastructure for their transportation, and the need to adequate climate-resilient energy storage facilities.

1.1. Objectives of the study

This study, as part of a series of studies, explores how forests, through the provision of ecosystem services, contribute to adaptation of other sectors to climate change. [11] The premise is that ecosystem-based adaptation measures can complement other forms of adaptation, making them more cost-effective and increasing the potential co-benefits (whether livelihood related or mitigation benefits). The objective of this case study is twofold. The first is to bring evidence to a discussion on the linkages between enegy and forests in the context of climate change (i.e., role of forests in enhancing the resilience of an wood energy subsector) to decision makers in government and development partner organizations, and inform engagements focusing on development and enhancing resilience to climate change in Burkina Faso; this is done by:

- Summarizing the vulnerability of the energy sector in Burkina Faso to climate change
- Examining how wood energy features in the current and future energy portfolio of Burkina Faso and assess the expected/potential role of wood energy in meeting future energy needs;
- Reviewing current and projected impacts of climate change on the wood energy sector;
- Assessing the situation of the wood energy value chain: Supply and consumption of wood, actors and structure in the chain, the role of wood energy in the national energy mix;

[11] For more information on the set of case studies please visit www.profor.info/node/2032.

- Identifying strategies to adapt to climate change by focusing on solutions oriented towards forest ecosystems;
- Evaluating the economic implications of the strategies identified by considering different climate change scenarios;
- Identifying political measures and the associated institutional changes that would facilitate the use of forests to reduce the vulnerability of the wood energy sub-sector and strengthen their resilience to climate change.

The second objective, which is tied to the broader set of studies, is to explore an approach of generating the needed evidence given the challenges of accessing data that would facilitate optimal decision-making.

There is limited analytical work linking climate change and resilience in the energy sector in the context of ecosystem-based adaptation to climate change. Most studies on energy and climate change have focused on the potential contribution of different energy portfolios on mitigation of climate change. Where ecosystem-adaptation has been taken into account, it often focuses on the potential contribution of watershed management on reservoirs and dams associated with hydropower (e.g., work in Kenya). Increased recognition of the role of biomass based energy in energy portfolios into the future is resulting in the examination of the impact of climate change on forests and the consequence for energy use and access.

This paper first provides a detailed description of the current situation in the woody fuels sub-sector (fuelwood and charcoal) based on a value chain approach. In the second part, a prospective analysis was conducted considering the vulnerability of eco geographical zones to climate and anthropic factors. A model helps to review the current and projected impacts on the wood energy value chain in order to identify adaptation strategies to climate change by focusing on solutions oriented to forest ecosystems.

The findings of this study are targeted at decision makers among development partners and in national government, and also for interested civil society.

2. Burkina Faso – Demographic and climatic profile

The population of Burkina Faso was 10 million in 1996 and 14 million in 2006 according to the results of the latest general population and settlement census (INSD, 2006). Current official forecasts stated a population of 17,322,796 inhabitants in 2013. At national level, there is a low population density (51.8 inhabitants per km^2) with significant regional variations. The urbanization rate is estimated to be twice as high as the rate of the population growth (CIA, 2013). The distribution by place of residence shows that 77.3% of the country's population lives in rural areas, i.e. an urbanization rate of 23% (INSD, 2006). 46.4% of the urban population is concentrated in the city of Ouagadougou only. Table 1 summarizes key demographics of Burkina Faso.

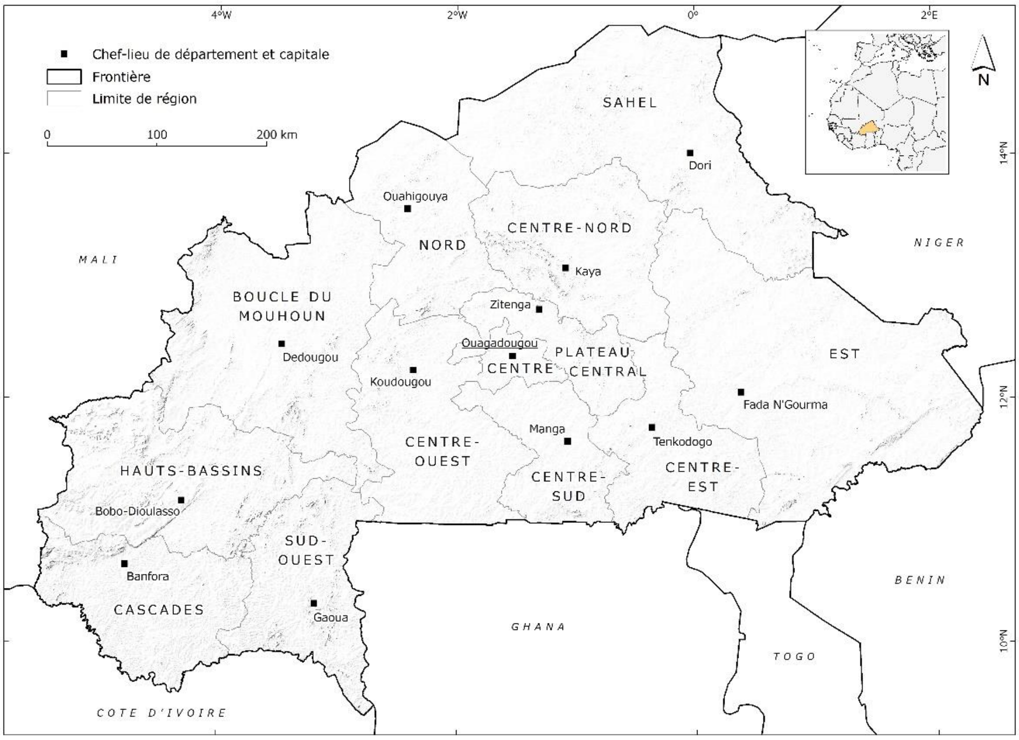
Table 1 Burkina Faso demographics

Description	Unit	Absolute value	Relative value
Total population	n	17,322,796	100
Urban population	n	3,932,335	23
Rural population	n	13,390,461	77

Female population	n	8,834,626	51
Male population	n	8,488,170	49
No. of people/household	n	7	
Growth rate			
Urban population	%/year	2.4	
Rural population	%/year	3.1	

Source *INSD, 2006*

On the administrative level, Burkina Faso has thirteen (13) regions (see Figure 1), forty-five (45) provinces, and since 2004, forty-nine (49) urban communes and three hundred and two (302) rural communes.



Source *IGN France International, 2005; ECO Consulting Group, 2013c*

Figure 1 The administrative map of Burkina Faso

The geographical distribution of the population is uneven in relation to the administrative regions. Indeed, the central region which houses the country's administrative capital (Ouagadougou) contains 12.3% of the entire population. It is followed by the Hauts-basins (10.5%) and la Boucle du Mouhoun (10.3%). The RGPH, (the population census) in 2006 showed that internal migration flows are mainly directed towards these three regions.

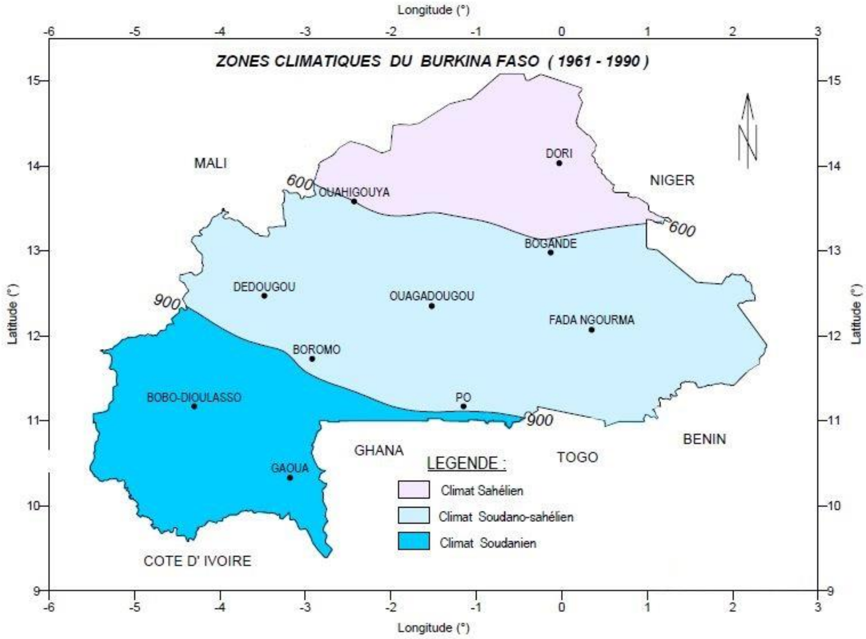
However, the Cascades region is the least populated (3.8%), followed in ascending order by the Southwest and South Central regions respectively with 4.4% and 4.6% of Burkina Faso's population (INSD, 2006).

Annex compiles these regional data by place of residence.

2.1. Climatic profile of Burkina Faso

In Burkina Faso, three climatic zones are discernible (see Figure 2): the Sahelian zone in the north, the northern Sudanian zone in the center and the south Sudanian zone in the south. The characteristics of each zone are shown in Table 2. The country's continental position and its location at the edge of the Sahara predispose climate elements to high spatial and temporal variability (diurnal, annual and inter-annual). This relates to the quantity, location and frequency of rainfall (MECV 2007; Simonsson, 2005).

The climate is characterized by the alternation of two contrasting seasons, a wet season from June to September and a dry season extending from November to April. The rainy season is characterized by humid winds from the south-west sector (monsoon) and the dry season is dominated by winds heavy with dust from the north-east sector (harmattan) (SP/CONAGESE, 2001; MECV, 2007).



Source *DM 1998, cited in MECV 2007*

Figure 2 **Burkina Faso's climatic zones**

Table 2 **Characteristics of Burkina Faso's climatic zones**

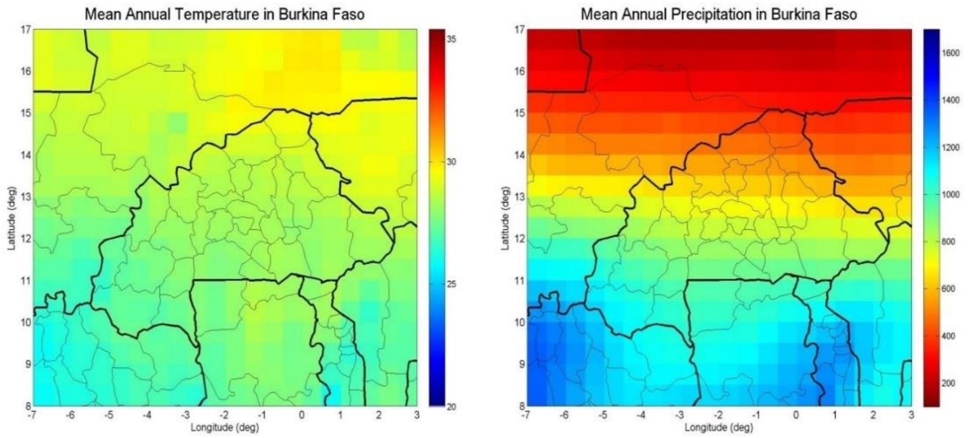
Climatic characteristics	Climatic zones		
	South Sudanian	North Sudanian	Sahelian
Annual pluviometry	900 – 1,200 mm	600 – 900 mm	300 – 600 mm
Rainy season period (days)	180 – 200	150	110
Number of rainy days	85 – 100	50 – 70	< 45

Annual average temperature	27 °C	28 °C	29 °C
Seasonal range of temperature	5 °C	8 °C	11 °C

Source *SP/CONAGESE 2001, data adapted from the Direction de la Météorologie from 1961 to 1990*

The values of potential evapotranspiration (PET) are very high throughout the year, over 100 mm per month, with maxima (up to 200 mm) observed between February and March. Minima are recorded in July, August and September, when the PET is compensated by pluviometry. PET is characterized by an irregular spatial distribution. It decreases by more than 2,260 mm/year in the Sahelian area and by less than 1,800 mms in the Sudanian zone).

The active growing season of annual plants varies between 160 days in the south and 60 days in the north with a strong inter-annual variation (MECV 2007).



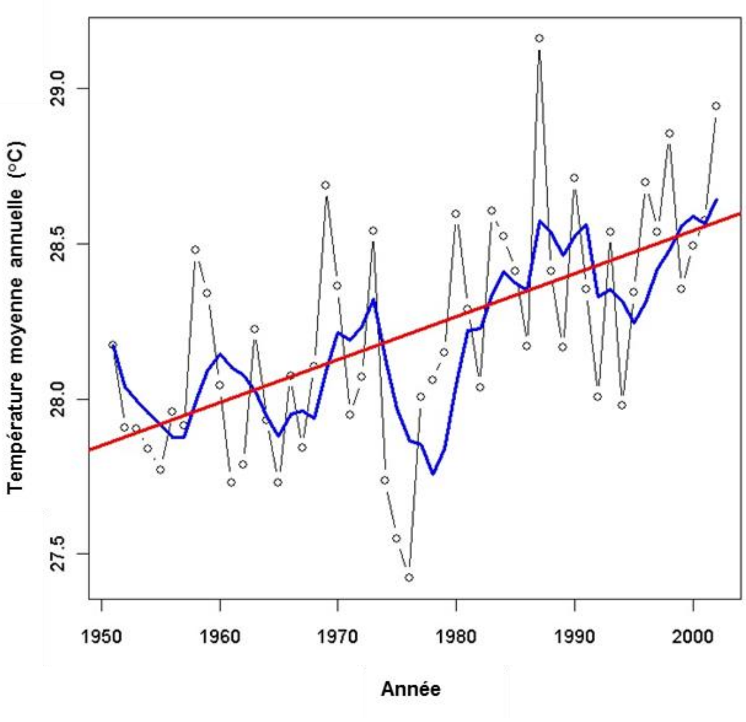
Source *Rafanoharana et al., 2012*

Figure 3 Temperature and current annual average rainfall in Burkina Faso

Regarding the current climate variability in Burkina Faso, there is a slight upward trend in average annual temperature (TAED, 2007) as shown in Figure 4. Maximum temperatures have experienced an annual change similar to the average temperatures and remain between 28 °C and 42 °C (SP, 2001).

The analysis of the Sahelian standardized precipitation index (SPI) highlights two distinct periods: the first (1950-1969) is characterized by persistent wet years and the second (1970-1993) results in a shift of isohyets to the South causing drought for over twenty years. Dry years are characterized by a decrease in average daily rainfall at the beginning and end of the monsoon.

After 1993, a change occurred. Three particularly wet years were recorded in the Sahel in 1994, 1999, 2003 and marked the emergence of a new inter-annual mode of variability in rainfall. This mode is characterized by a strong inter-annual variability manifested in an abrupt alternation between very dry and very wet years, rather than referring to dry or wet periods.



Source *Climate Wizard, 2009*

Figure 4 Evolution of the average annual temperature in Burkina Faso from 1951 to 2001

In general, the eastern part of the Sahel is experiencing a return of wetter conditions. There is a rise of isohyets to the north for the period 1994 - 2006 compared to the period 1970 - 1993 (Ali, 2010). Compared to the wet period around the mid-twentieth century, recorded rainfall shows fewer rainy days and an increase in the median intensity of daily rainfall (Giannini, 2013, East et al, 2008). Furthermore, the average seasonal cycles of wet years and dry years only differ late in the season. Dry years of the current period are characterized by a rather premature loss at the end of the monsoon (Ali, 2010).

As regards climate projections, simulations performed by MECV (2007) for the whole country, predict an increase in average temperatures of 0.8 °C by 2025 and 1.7 °C by 2050. This increase in temperature is accompanied by a seasonal variation. If in December, January, August and September it is noticeably warmer, the months of November and March have low increases. Simulations by CIFOR for the region of Ziro-Sissili (Rafanoharana et al., 2012) with four global climate models based on sixteen emission scenarios give a more pessimistic picture. The increase in average annual temperature by 2030 compared to the reference period from 1961 to 1990 is in the range of 0.73 °C to 1.58 °C by 2080, models reveal an increase between 1.37 °C and 5.33 °C. Monthly temperature projections for Ziro-Sissili show a consistent upward trend for the sixteen scenarios. The months most affected by the potential increase in temperature (> 25%) are between February and May.

Climate projections on rainfall for West Africa and the Sahel are characterized by a high degree of uncertainty (IPCC, 2001: OECD/SWAC, 2009), mainly because of the complexity of the climate system in the region and the respective limits of current climate models. This is evident in the CIFOR simulations of rainfall for the region of Ziro-Sissili, in which annual average rainfall projections for 2030 vary between -58.20 mms/year and +60.78 mms/year, and the projections for 2080 between -146.58 mms and +121.84 mms/year (reference period: 1961-1990) (Rafanoharana et al., 2012).

As regards the variability of rainfall, a strong inter-annual and seasonal variability is expected. In some models, July, August and September are likely to be affected by decreases of approximately 20-30% while the rainfall in November will increase by 60-80% (low absolute value). In contrast, results from the CIFOR model show a decrease and increase respectively, with a particularly wide range for the months of July and September (Rafanoharana et al., 2012).

2.2. Combining climate change and land use change

The Integrated Model to Assess the Global Environment (IMAGE) version 2.2 data was used by Rafanoharana et al., (2012) to develop scenarios from the combination of the impacts of climate change and land use change for short term (2030) and long term (2080) projections. The IMAGE 2.2 model is a "multi-disciplinary, integrated model designated to simulate the dynamics of the global society- biosphere- climate system" (Van Vuuren and Bouwman 2005 as cited by Rafanoharana et al., 2012). This data was combined with global maps of land use, the GLC 2000 database at a resolution of 1km. The scenarios were subdivided into previously observed categories A1 (market forces), A2 (security first), B1 (sustainable development), and B2 (dynamics as usual).

Using the Holdridge life zones, data on historical land cover change (2005-2009) and current and future projections of land use change, Rafanoharana et al., (2012) combined the climate change models with the land use change models. Combining the climate change and land use change in 2030 shows that negative impacts of climate change on net primary productivity (-11.3%) are not offset by the most optimistic scenarios (-24.5%) for the set of land use scenarios used. Positive impacts of climate change (+21.3%[12]) are almost lost because of land use change (-4.3%). In 2080, negative impacts of climate change (-23.8%) are not offset by the most optimistic scenarios (-23.6%) in the set of land use scenarios and positive impacts of climate change (+60.7%) can be almost lost because of land use change (+9.9%).

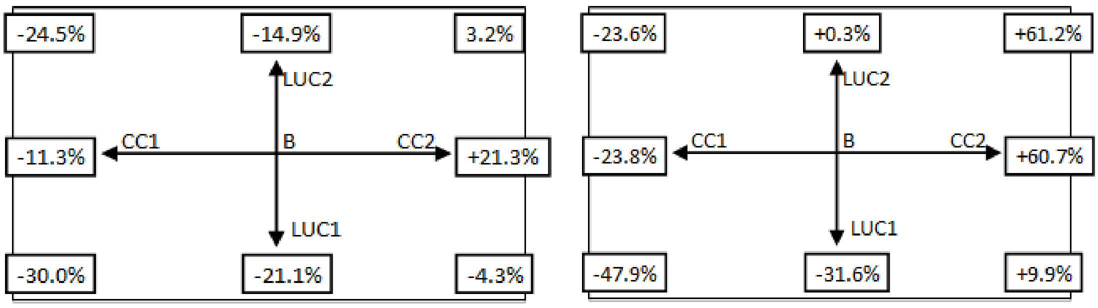


Figure 5. Change in Net Primary Productivity compared to the baseline (B) for two contrasting climate scenarios and two contrasting land-use change scenarios (CC1 - CSIRO2.B2A and CC2 - HAD3.B2M; LUC1 - IMAGE.B2 and LUC2 - IMAGE.B1) in 2030 (left) and (CC1 - CSIRO2.B2A and CC2 - CGCM2.A1FI; LUC1 - IMAGE.B2 and LUC2 - IMAGE.B1) in 2080 (right)

Land use change (LUC2) represents the minimum known parameters for net primary productivity change. Climate change (CC) parameters are uncertain. Given these data conditions, at minimum all planning has to account for the land use change (LUC2) between -24.50% and +3.2% in 2030 and -

[12] It should be noted that the benefits of CO2 decline with higher levels of warming. However, due to limited information on the rate of decline, this was not accounted for in the analysis. Accordingly the gains mentioned in terms of NPP may only partly materialize.

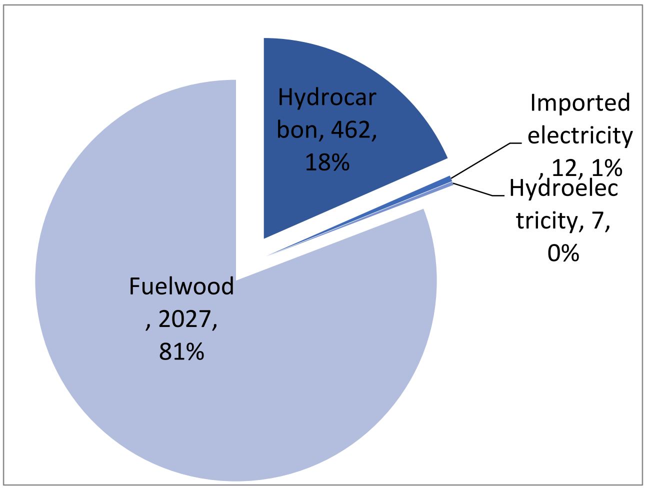
23.6% and +61.20% in 2080. In addition, however, if drivers of land use change are not addressed, the planner needs to expect large decrease of net primary productivity between -30% and -4.3% in 2030 and between -47.9% and +9.9% in 2080.[13]

3. The energy sector in Burkina Faso

Energy consumption is necessary for human life and human social and economic development. However, in Burkina Faso energy is relatively low (similar to other Sahelian countries). According to Minvielle (1999), the energy consumption of all the eight continental Sahelian countries, members of the Permanent Inter-State Committee for the Fight against Drought in the Sahel (CILSS), represents only 1% of the consumption of the New York urban area. In 2007, the country's total energy consumption was estimated at 3.2 million tons of oil equivalent (TOE), which is an average consumption of 240 kg of oil equivalent per capita while the world average was 1 TOE.

3.1. The energy balance in 2006

According to Laude (International conference on biofuel organized in Ouagadougou, Burkina Faso), the Primary Energy balance of Burkina Faso in 2006 is shown in figure X (in TOE, tons of oil equivalent, and for a total amount of 2.507 kTOE). In terms of distribution between the different sources of energy, wood plays a predominant role in the balance of energy with 2.02 million TOE, i.e. 81% of all primary energy. The second main source of energy consists of hydrocarbons which represent 462,000 TOE or 18% of all primary energy (this increased to 522,000 TOE, i.e. 17% of the balance according to MMCE, 2008).

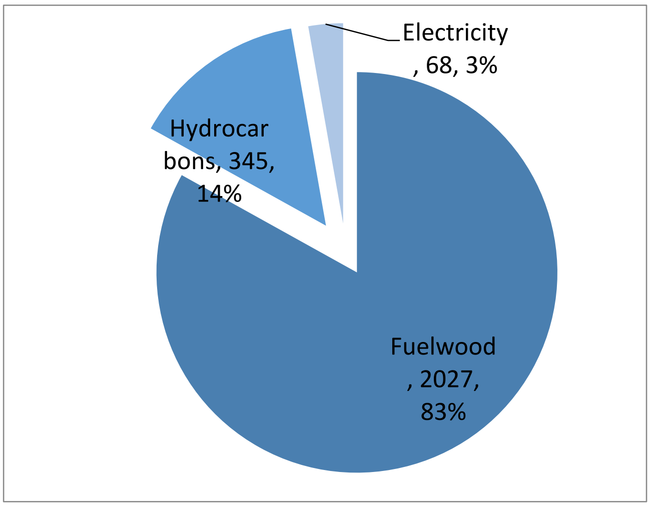


Since the country does not have any reserves, all petroleum products are imported via the ports of Côte d'Ivoire, Ghana and Benin.

The secondary energy balance for 2006, still in TOE and for a total amount of 2.439 TOE (see Figure X). Given the low rate of urbanization in the country (23%) (INSD, 2006), 72% of the energy produced from biomass is used in rural areas. Apart from the gas used for cooking and paraffin for lighting in the countryside, petroleum products are mainly used for transport and electricity generation. In 2007, transportation (light and heavy vehicles) running on diesel accounted for 33% of imports, gasoline engines 33% and electricity generation 23% (Dabat et al., 2009).

[13] It should be noted that forests as ecosystems are subject to both spatial and temporal shifts with climate. Net primary productivity is a useful proxy in this regard. It, however, does not capture sufficiently the spatial shifts - where entire vegetation zones could shift latitudinally or with respect to elevation. This becomes especially relevant as we are considering changes with respect to land use cover because this has both an anthropogenic dimension as well as climate induced - especially in the 2080s context. The anthropogenic factors that affect dispersal (including level of managmenet, species composition, deforestation) influence the extent of spatial shift. The climate factors that influence growth (temperature and precipitation and level of CO2). This could have implications for the proposed forest management strategies.

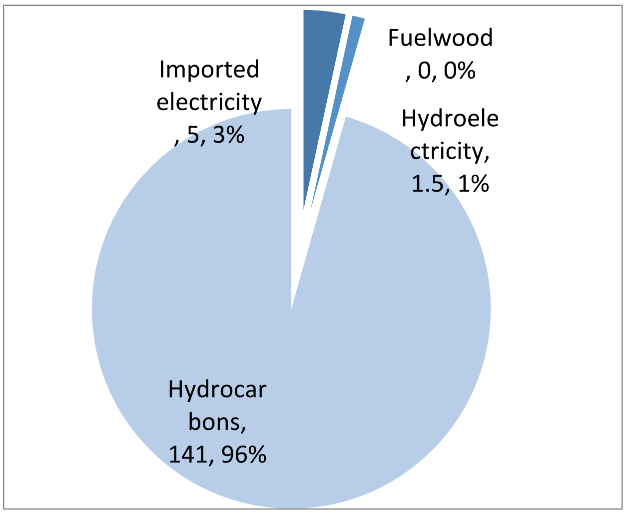
As regards access to electric power, Burkina Faso is characterized by a national access rate of up to merely 14% with only 1.2% in rural areas (ADB, 2012). For lighting, the majority of the population uses dry batteries, paraffin and wood. A recent IMF staff report (2014) noted concerns that plans to expand domestic capacity may still fall short of meeting energy needs. Accordingly, government is accessing a combination of sources: expanding imported energy (less expensive, but limited supply)[14]; expanding domestic thermal capacity (more expensive but more reliable); and developing alternative sources as much as possible (e.g. solar energy). In order to meet the needs of the population and contribute to the improvement of their standard of living, several interconnection projects with neighboring countries (Mali and Ghana) are in development with the aim of improving the condition in the medium term. In addition to these efforts, numerous projects are in the pipeline to meet demand that is estimated to be growing at more than 10 percent per year, while at the same time broadening access to energy for the rural population (IMF, 2014).



From 1993 to 2007, total oil consumption almost tripled (from 190,834 to 522,364 TOE). As regards gas, although its use remains marginal, quantities consumed increased fivefold over the period of 14 years. The paraffin quantities more than doubled up to 2005 but have experienced a sharp decline in the last two years due to the breakthrough of the diodes with dry batteries. With the development of electricity demand and the increasing number of vehicles, the national diesel consumption, DDO and four-star petrol were respectively multiplied by 4, 3 and 2. Thus, not only is the use of oil for transportation and electricity generation dominant, but in addition, its use is sharply increasing.

As Burkina Faso is a landlocked country, the increase in the price of a barrel of oil is reflected twice: (1) in the purchase price of raw materials and (2) in the cost of transportation. Therefore, petroleum products entering Burkina Faso have an additional cost of approximately 45% (transport and storage). Between 1995 and 2007, prices of four-star petrol, diesel and mixed fuels increased by over 60%. For an average price per barrel at 72 USD in 2007, the economic value of the national oil bill stood at more than 218 billion FCFA. Imports of petroleum products accounted for 44% of exports and nearly 67% of cotton exports alone in 2007.

[14] The country already imports part of its needs from Côte d'Ivoire but the supply was severely disrupted during the Ivorian crisis (ADB, 2012).



In terms of finance, the weight of hydrocarbons importations is very high for the Burkinabé State. For a total amount of 148 billion CFA Francs, the balance between the different sources of primary energy is the following in 2006 (see Figure Y)

Looking ahead, Burkina Faso is interested in biofuels as a renewable source of energy that can replace petroleum by-products (Tangerman, 2007). They could help to limit its dependence on imports and to diversify its energy sources, and possibly at a lower cost. They represent an opportunity to reduce its energy poverty, understood by UNDP as "the lack of choice that gives the country access to adequate affordable, efficient and sustainable energy, to support economic and human development". The government has already developed a policy framework document for the development of biofuels in the country (MMCE, 2009).

Thus, the energy sector in Burkina Faso is characterized by (Dabat et al., 2009):

- Low usage of "modern" energy (electricity, gas);
- The importance of the use of wood resources (mainly for cooking) which represents the majority of domestic consumption and almost all rural energy;
- An electricity supply of 68% provided by thermal power stations running on heavy fuels (diesel and DDO), 15% by the Bagré and Kompienga hydroelectric dams and 17% by importing electricity from Cote d'Ivoire;
- High dependence on imports of petroleum products, which, because of fluctuations in oil prices, create negative pressure on the country's economy;
- An inability to use the considerable solar resources, the operating cost of which is prohibitive on a large scale compared to traditional resources.

3.2. Wood energy - now and for the future

The main renewable energy in Burkina Faso is wood, which covers 85% of household energy needs (MEDD, 2012a). The woodland areas are the main sources of supply to meet the households and small-scale commercial demand. According to the unanimous opinion of experts, wood energy will remain for decades the main source of domestic energy in Burkina Faso, especially for the disadvantaged sectors of the population. Given the poverty level in the country and projected level of urbanization, predictions point to a sharp increase in demand for wood energy. The consumption of charcoal in particular, will continue to increase in the four major cities of Burkina Faso (Ouagadougou, Bobo Dioulasso, Ouahigouya and Koudougou).

Despite the positive characteristics of a wood based energy portfolio, its potential contribution to energy security is often underestimated. This may be partly due to the challenges that characterize the woody fuels' sector. These challenges cannot be reduced to a simple relationship between supply and demand. Instead, they are linked to systemic issues related to management and security of ownership of rural land, policy incentives, market access and networks, and management of municipal lands to meet agro-silvopastoral demands of local communities. Significant legislative progress has been made in Burkina Faso, mainly in the field of decentralized forest management (Kaboré, 2005), creating the basis for addressing several of these challenges. The overall challenges are discussed in greater detail in sub-section 3.5.

3.3. Other sources of energy

Liquified Petroleum Gas (LPG, also referred to as butane gas)

The most used alternative energy for household cooking is butane gas (or LPG). Shifting towards consumption of LPG is seen as upward progress on the energy ladder (which is based on the assumption that shifts towards more sophisticated systems is positive). Data availability on LPG consumption is limited. Surveys done in 1996 revealed that 13 percent of houesholds in Ouagadougou relied on LPG for daily use. Analysis of data from the National survey of household conditions, estimated that LPG made up approximately 30 percent of cooking energy use in Ouagadougou (Ouedrago, 2013). The success in the subregion of Senegal substituting fuelwood with LPG has motivate many countries in the subregion to explore similar approaches. Burkina Faso has

The importation of butane gas is organized and centralized by the Société Nationale des Hydrocarbures (National Hydrocarbons Company) (SONABHY) from the seaports of neighboring countries: Togo, Ghana and Côte d'Ivoire. This public company is in charge of the regular supply of hydrocarbons throughout the country by controlling stocks and prices. The transportation to the filling centers in Ouagadougou and Bobo-Dioulasso is made by road using tankers. SONABHY ensures the gas bottling for the following containers: 3 kg, 6 kg, 12.5 kg and 35 kg. Distribution and retailing is provided by companies with their storage/sale network in local areas (SODYGAZ) or service stations (TOTAL). Four companies share the gas market, they are: (1) SODYGAZ, (2) TOTAL (3) ORYX and (4) Pétrofa Gaz. Each company has its own stock of returnable bottles.

According to retail-traders consulted at the Ouagadougou market, an informal parallel circuit provides nonreturnable bottles from Mali and Senegal. The size of these imports could not be assessed. Two distributors only refill their own bottles; these are TOTAL and SODYGAZ, which is more recent. The other two distributors refill all types of bottles, including foreign ones.

The State has limited the maximum selling price of gas since the 1990s in order to promote its penetration among households and businesses. This public policy is bearing fruit as the gas market is in constant progression and has increased fivefold between 1997 (9,634 tons) and 2010 (51,545 tons) (Gautier et al., 2009). Until April 2013, the selling price of the bottles of 6 kg and 12.5 kg were respectively 1,560 and 4,000 FCFA (Zouré, 2013).

The main factors limiting the expansion of LPG (Liquefied Petroleum Gas) in Burkina are:

- The initial equipment (deposit, regulator, pipe or gas cooker) being relatively expensive;
- The problem of interchangeability between different distributors;
- Mobilization of financial resources to pay for the gas refill service, not affordable for poor households;
- The preparation of some local dishes which is difficult to make on a gas cooker.

Between 2010 and 2012, many supply disruptions were observed causing shortages of gas in the market and price volatility due to the opportunism of some traders. The main reasons put forward were the significant increase in global gas prices and the rising cost of the dollar which consequently has an impact on the public expenditure related to the subsidy for this fuel. To reduce the burden of this subsidy on the national budget, the government of Burkina Faso decided on 3 May, 2013, to increase the prices of the bottles of 6 kg and 12.5 kg respectively to 2,000 and to 5,000 FCFA (Zouré, 2013).[15]

Public subsidy has shown its effectiveness in promoting gas in urban households, especially in Ouagadougou. However, sustainability is questioned by its weight on the national budget and also by the WAEMU agreements signed for the removal of subsidies on petroleum products. Data from IMF staff report on Burkina Faso[16], indicates that government had written into the 2014 draft supplementary budget additional expenditure that included CFAF 3.7 billion tot SONABY. This is in addition to transfers to publicly-owned enterprises which was revised to CFAF 48 billion.

In the sub-region, Senegal has already applied this provision even if there are risks that poorer households may resort to woody fuels. The price of the refill of 12.5 kg is currently 7,800 FCFA.

The evaluation of the impact of the subsidy lifting on households in Dakar highlighted the following (ENDA ENERGY, 2013):

- The return to using charcoal which seems cheaper because it is bought in small quantities: the rate of charcoal use increased from 77.8% to 90.2%;
- Changing priorities of energy for cooking: gas has fallen from its position of primary energy source and charcoal has acquired a higher position. The percentage of households using LPG as the main cooking energy fell from 97.2% to 70%;
- The low-income households have seen their energy costs increase by 4.2% against 3.3% for households with higher income, which affects their socio-economic condition.

For small production units and commercial services, the following impacts have been identified:

- An increase of over 75% of operating costs;
- A doubling of monthly charges related to the purchase of the LPG;
- An increase in the monthly consumption of charcoal, that is nearly 50 kg per unit;
- Lower profits: 85% of business units surveyed found the profits from their activities lower.

Learning from this experience, it is noted that the Senegalese public authorities took some precautions to mitigate these effects on the population. A phased approach was adopted and the removal of the subsidy was accompanied by a deliberate tax exemption policy on LPG (abolition of VAT and Customs Duties). Regulatory provisions had also been taken to liberalize imports and for the approval of prices.

Paraffin

Paraffin is used for various purposes by households. It is mainly used for home lighting (65% of the population (Department of Energy, 2007)). It can also be used by households to make the combustion of fuelwood or charcoal quicker. However, the use of paraffin as a domestic source of energy by households is low.

An identification of target groups to promote the use of paraffin for cooking meals was conducted in January 2000 by the RPTES in two cities (Ouagadougou and Ouahigouya). It highlighted the possibility of nearly 12% of households to use paraffin for domestic cooking, if prototypes adapted to local foods were found (Department of Energy, 2007).

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[15] During the negotiations, SONABHY had given price suggestions for at least 2,400 FCFA for a refill of 6 kg and 6,000 FCFA for the 12.5 kg

[16] https://www.imf.org/external/pubs/ft/scr/2014/cr14215.pdf

Biogas

The formation of biogas is a natural biological phenomenon resulting from the anaerobic bacteria fermentation (bio methanization) of organic products. In the case of domestic biogas, it is produced in a bio digester usually fed from cow and pig dung. The biogas produced is a methane compound (representing 55 to 85% of the biogas), carbon dioxide (25 to 45% of the biogas) and varying amounts of water, nitrogen, oxygen and hydrogen sulphide. (Institut de l'Energie et de l'Environnement de la Francophonie, 2012).

In Burkina Faso, the technology of the bio-digester diversifies the energy supply by making available to rural and peri-urban populations biogas for cooking and lighting on the one hand, and compost to improve agricultural productivity and livestock (animal) production, on the other. Biogas facilities for experimental purposes were introduced in Burkina Faso in 1976 thanks to the Inter State Committee of Water - CIEH - with FAC funding. The International Association of Rural Development and IRSAT on EDF and GTZ funding, installed from 1978 to 1985 more than twenty facilities. The majority of these digesters are of a discontinued type. All the installed digesters were supposed to be for collective use.

Since 2009, the Ministry of Animal Resources runs the important National Bio-Digester Program (PNB-BF) with the support of two Dutch organizations experienced in this field: SNV provides technical assistance and HIVOS supports the financial management. Initially, the project foresaw, during its first phase, to install 10,000 bio-digesters. However, this target was lowered to 6,000 functional bio-digesters in 2014 (SNV, 2010).

Biogas can contribute to diversifying the sources of energy and reducing the pressure on wood resources. The range of proposed systems helps to equip private households, small businesses and also for community facilities (schools for example) and industrial (slaughterhouses).

However, the appropriation of the technology by rural populations is still difficult. For example, for a rural household, the minimum requirements to be eligible to get a bio-digester are: (1) have a fixed and permanent house, (2) have at least three oxen in an enclosure or six pigs in pen, (3) have a water point nearby and (4) have minimum financial means to participate in the installation of the bio-digester.

Beyond these access conditions, constraints remain. These are in particular:

- The low involvement of private companies in projects including biogas especially for the promotion of household waste;
- The high cost of installing a personal bio-digester (about 300,000 FCFA)
- The mobilization of raw material including adapting pastoral practices to the development of partial cattle enclosing.

Alternative charcoals

Commonly known as "biochar", charcoal substitutes are obtained from carbonization of:

- Agricultural residues: stalks of millet, cotton, or rice husks;
- agro-industrial residues: shells of peanut, cotton, and cashew, sugar cane bagasse;
- Aquatic invasive plants such as reed mace and duckweed.

Several technologies for the development of agricultural and agro-industrial biomasses have been developed and tested on the African continent. In the late nineties, the Government of Burkina Faso initiated a pilot project with the support of UNDP and the Kingdom of Denmark entitled "Development of agricultural residues and dried straw at Boromo" The main objective of the project was to reduce human pressure on the plant canopy through the production of reconstituted pressurized logs from agricultural residues such as cotton stalks (web capture, 2013).

The first stage of the project was completed with the opening of a production plant, May 21, 1999 at Boromo. Output objectives were around 3,000 tons per year and were intended to implement a strategy for the production and marketing of briquettes "*raadpaalga"* on a large scale and oriented towards the private sector. From the second stage of the project, difficulties were encountered (web capture, 2013):

- Lack of resources/poor infrastructure for regular transportation of agricultural residues from fields to the storage site of the plant;
- Lack of equipment owned by farmers (carts and cutting machinery);
- Late starting of field work which prevented the formation of a substantial stock of raw material at the beginning of the rainy season;
- Unavailability on the local market and/or high costs of spare parts for machines used.

In 2004, at the end of the second stage of the project, the plant management was passed on to the administration which unfortunately was unable to ensure the functioning and maintenance of this equipment.

Apart from these industrial attempts, some private entrepreneurs have engaged in the production of biochar. We can find small production units particularly in Ouagadougou. They use mainly plant residues and charcoal dust collected from storage places or from trucks used for the transportation of charcoal from forest to urban centers. The binder used is clay in varying proportions from 20 to 35% (Sawadogo, 2013). The craft biochar is packaged in bags of 1 kg and 20 kg respectively and sold at 100 FCFA and 2,000 FCFA (Sawadogo, 2013).

3.4. Consumption of energy (mostly wood energy)

Burkina Faso is ranked among the world's least developed countries.

Household consumption of wood energy

Wood energy remains the main fuel used by the Burkinabe households, both in rural areas (100% of households) and in urban areas (82% of households). A survey carried out in 2005 (Yaméogo, 2005) points out that neither electricity nor oil or agricultural residues are used as main energy sources (see Table 3).

Table 3 Relative importance of the different household fuels in urban and rural areas

Fuel	Urban area			Rural area
	Banfora	Bobo Dioulasso	Ouagadougou	
	(%)			
Fuelwood	94.0	88.0	71.0	99.1
Charcoal	69.0	60.0	69.0	11.9
Gas	21.0	34.0	56.0	0.7
Paraffin	18.3	0.0	0.7	0.0
Sawdust	3.6	0.0	0.9	0.0
Electricity	1.3	0.0	0.5	0.0

Source *Yameogo, 2005; Richter, 2013a*

The average consumption per year of fuelwood and charcoal is approximately 281 kg and 106 kg per person in urban areas (Energy Development Initiative, 2012; Energy Department, 2007). Rural populations use annually 343 kg of fuelwood and 15 kg of charcoal per person (Energy Department, 2007) (see Table 4). With an average household size estimated at six individuals (INSD, 2006), the consumption of an urban household is around 1,686 kg of fuelwood per year and 635 kg of charcoal.

Table 4 Annual domestic fuel consumption by urban and rural households

Fuel	Unit	Area	
		urban	rural
Fuelwood	(kg/person/year)	281.05	343.10
Charcoal	(kg/person/year)	105.85	14.60

Source *IED, 2012; Direction of Energy, 2007*

The increasing urbanization of the country is causing changes in the energy choices of households moving towards the use of cleaner energy sources such as charcoal or gas. In 2007, charcoal was growing rapidly in urban markets where it accounted for 15% of the market size and 21% in energy value (IED, 2012). This is partly explained by the cost of transportation of the different fuel sources.

Cooking technologies used by households

For woody fuels

The spreading use of improved cookstoves began in the 1970s and continued through the 1990s, and then became a priority again during the early 2000s (IED, 2012). In 2005, political commitment to meeting demand for woody fuels resulted in a Domestic Energy Strategy (MMCE, 2005) aimed at addressing environmental and economic issues related to sustainable access to woody fuels.

Research centers such as the Institute for Research in Applied Sciences and Technologies (IRSAT) were given a mandate to develop and improve household and community cookstoves.by developing technological innovations that made cookstoves energy efficient, affordable, and adapted to local culinary habits. Several types of stoves were tested, both fixed or portable, and ceramic or metal or a combination of both materials,[17] and a couple have emerged the frontrunners in terms of sales - *multi pot* model and Ouaga Metallic cookstove option for business purposes (restaurants, agricultural product processors).

[17] In the range of portable metal stoves, there are several types of improved stoves “Roumdé”:

- The cookstove Ouaga Metallic only works with wood and is a single pot model, that is to say, it can only take one size of pot. Its energy efficiency is 40% and its price varies between 2,000 to 3,000 FCFA;
- The cookstove Burkina Dual-system is also a single pot model but it offers the possibility of using two fuels: charcoal and wood. Its energy efficiency is of the order of 35-45% and its price varies between 2,500 and 4,000 FCFA depending on the size of the desired pot;
- The stove Multi pot can accommodate three sizes of pots at a time and allows the use of wood and charcoal. Its energy efficiency is a bit more modest with 30% to 35% but it remains affordable: 3,000 FCFA.

In 2005, an appraisal of the household consumption and equipment was carried out by the project for Improved Cookstoves in Burkina Faso (GIZ - FAFASO) in collaboration with the PREDAS-CILSS. The results of the surveys conducted in major cities such as Ouagadougou, Bobo-Dioulasso and Banfora, reveal a predominance of cookstoves called "traditional" such as the Trois Pierres (three stones) and Malagasy models in wood or charcoal. The purchase of improved stoves by households was noted and the choice of the user was primarily the dual-system models with the use of several fuels in a household.

According to a survey conducted by the FAFASO project with 900 households in Ouagadougou and Bobo-Dioulasso, a large majority of households are aware of the existence of improved cookstoves and the benefit they provide. At the country level, it is estimated that approximately 26% and 3% of the urban population use respectively improved wood cookstoves and charcoal cookstoves. The utilization rate of improved cookstoves in rural areas is about 7.4% for wood cookstoves and less than 1% for the charcoal cookstoves (Richter, 2013a, 2013b). On average, improved cookstoves save about 30% of wood and 25% of charcoal.

Gas

Urban households have a wide range of equipment to achieve an energy transition from wood to gas. Four major types of equipment can be differentiated:

- The camping stove (camping);
- The burner screwed directly on the bottle of 6 kg;
- The gas plate with one, two or three burners;
- The trivet with or without a framework.

In 2005, the number of households equipped for the use of gas was significant, particularly in the capital city, where it reached 11.34%. The most commonly used devices are the burner and the gas plate followed by the stove. Purchase prices on the Ouagadougou market are presented in the Table 5**Error! Reference source not found.**.

Table 5 Average purchase prices for Gas equipment; year 2013

Type of equipment	Selling price (FCFA)
Camping stove	3,000 to 17,500
Burner and device (6 kg)	3,000 to 6,500
Plate	12,500 to 45,000
Trivet only	6,800

Source Richter, 2013c

In Ouagadougou, dozens of retailers make readily available a wide range of products mainly from China, Turkey and Singapore that can be used to for substitution to gas.

National wood energy consumption by households

Based on the consumption figures above, the current national wood energy consumption of households in Burkina Faso amounts to 5,045,093 tons of wood energy (6,078,426 m³) and 226,518 tons of charcoal, which corresponds to a total annual consumption of 7.945 million cubic meters of wood (see Table 6).

Table 6 **Annual consumption of wood energy for urban and rural households; Total for Burkina Faso; year 2013**

Fuel	Area		
	Urban	**Rural**	**Total**
		(t/year)	
Fuelwood	593,249	4,451,844	5,045,093
Charcoal	203,253	23,265	226,518
Equivalent in m^3/year of wood [1)]	2,361,539	5,584,171	7, 945,710

Explanations:

1 = calculated from the carbonization weight yield equal to 15% and a density of 0.83 wood t/m^3

Business consumption

Apart from domestic cooking, wood energy is the fuel of choice in the craft industry. People who use fuelwood for productive purposes (professional consumers) are in particular:

- The local breweries called *dolo*;
- Traditional bakeries;
- People grilling meat and oven roasting pork;
- Large and small street restaurants;
- Police stations;
- The MACO (the prison of Ouagadougou).

In addition, there are some professional consumers and users of charcoal such as:

- Blacksmiths;
- People grilling fish and kebabs;
- Laundries;
- The street restaurants;
- People preparing seasonal food;
- Tea sellers.

These actors, though important in number, have not been subject to a detailed study to know their exact numbers, and their average annual consumption, or also the type of cooking equipment they use. If we consider several studies and surveys conducted mainly in urban areas but also in rural areas, the business consumption of fuelwood is estimated at 40% and 5% for charcoal of the national consumption of urban households. In rural areas, the business consumption of fuelwood is estimated at 25% of household consumption and 5% for charcoal.

Consequently, the total consumption of business consumers amounts to 1,350,261 tons of wood (1,626,820 m^3) and 11,326 tons of charcoal per year, which corresponds to a total consumption of 1,728,202 cubic meters of wood per year (2,082,171 tons) and about 22% of household consumption. Table 7**Error! Reference source not found.** shows the total business consumption in Burkina Faso.

Table 7 **Annual consumption of wood energy for urban and rural business consumers; year 2013**

Fuel	Area		
	Urban	**Rural**	**Total**
		(t/year)	
Fuelwood	237,300	1,112,961	1,350,261
Charcoal	10,163	1,163	11,326
Equivalent in m^3/year of wood 1)	369,758	1,358,443	1,728,202

Explanations:

1 = calculated from the carbonization weight yield equal to 15% and a density of 0.83 wood t/m³

Regional and cross-border flows of wood energy (export of wood energy)

The vast majority of fuelwood is entirely consumed by the population of Burkina Faso throughout the territory. However, according to the officials of the Forests Directorate, cross-border flows of charcoal from Burkina Faso to Niger, in particular Niamey, are identified. However, these flows are difficult to quantify because of their informal and clandestine nature. In this study these charcoal exports are estimated at approximately 1% of household consumption, which corresponds to 2,378 tons per year, equivalent to 19,220 cubic meters of wood.

Total consumption of wood energy

Based on figures of demand as mentioned above, the total consumption of wood energy and timber in Burkina Faso amounts to 8.3 million cubic meters of wood per year (see Table 8), with approximately 815,329 m^3 for the production of 85,610 tons of charcoal. Figure 6 shows the total consumption of wood energy per region.

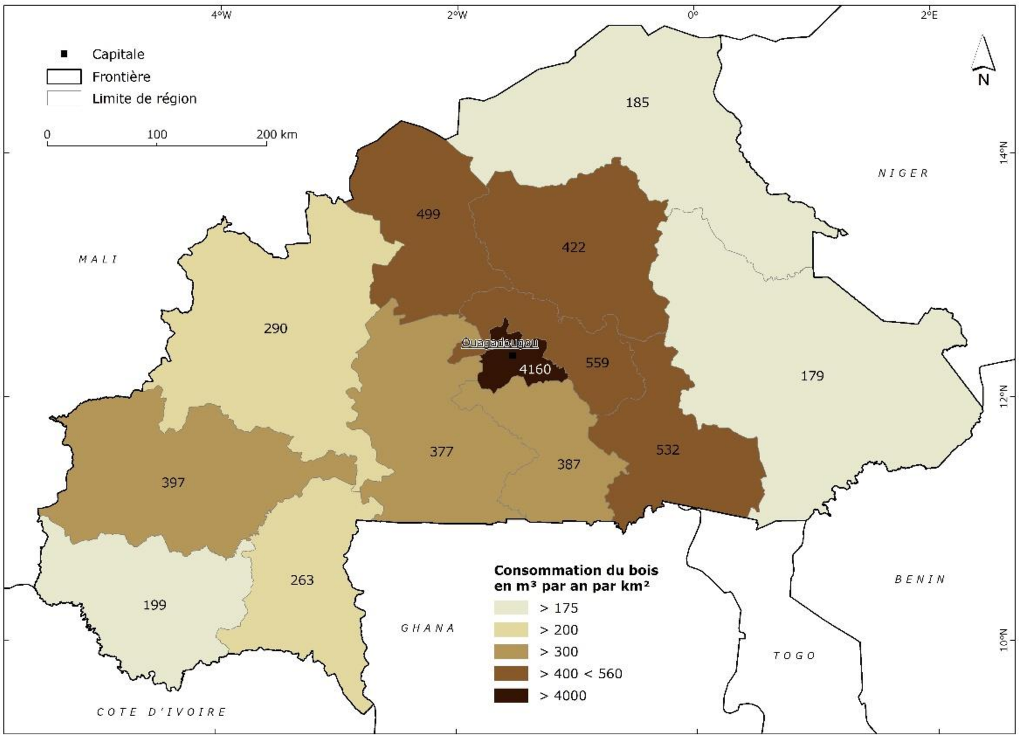
Table 8 **Total consumption of wood energy in Burkina Faso; year 2013**

Description	Demand		
	(m^3/year)	**(t/year)**	**(%)**
Urban and rural households			
Fuelwood	6,115,265	5,045,093	63.1
Charcoal 1)	1,830,445	1,519,270	18.9
Sub-total consumption of households	7,945,710	6,564,363	82.0
Business consumers			
Firewood	1,636,680	1,350,261	16.9
Charcoal 1)	91,522	64,066	0.9
Sub-total consumption of businesses	1,728,202	1,414,326	17.8
Sub-total regional consumption of wood energy	9,673,912	7,978,689	99.8

Regional flux/ wood energy exports	19,220	15,952	0.2
Total	9,693,131	7,994,641	100.0

Explanations:

1 = calculated from the carbonization weight yield equal to 15% and a density of 0.83 wood t/m³



Source *IGN France International, 2005; ECO Consulting Group, 2013f*

Figure 6 Wood energy consumption per region; year 2013

3.5. The wood energy value chain

The wood energy sector has a complex structure with many actors having different interests and different issues, often times at odds with each other. This section presents a brief summary of the wood energy value chain which includes details on the wood energy production chain, logging and processing chain, transportation and selling chain and consumption chain. Understanding the value chain is important to enhance the resilience of the system. A more details discussion of the value chain is presented in Annex 1.

Supply - Wood energy production

The sources of supply of wood energy include natural forests, plantations and trees outside of farms (on agricultural lands and parklands).

Natural forest

Natural forests provide the bulk of timber and non-timber forest products including wood for energy (MECV, 2009). Forest land is predominantly shrubby savannah (estimated at 20.1% in 2013), followed by wooded savannah and shrubby steppe (both estimated at 7.7 % in 2013) (IGN France international, 2005 and Mahrh 2006 (updated)). The State has control over forest resources with commercial value. The State along with local authorities delegate the management of forest resources based on management plans and a contract of concessions with terms of reference (National Assembly, 2011). Approximately 890,000ha of forests are managed or under management process. The total volume of timber was estimated at 176.5 million cum in 2013 (Richter 2013c). The volume that could be exploited in a sustainable manner (15 year rotation and a reduction rate of 50% of the standing capital) is approximately 5.8 million cum per year (see Table 2 in Annex 1). This corresponds to 4.8 million tons of wood.

Forest plantation

Plantations contain mainly species producing timber, fuelwood and fruit trees. There are plantations under state control, communal plantations and private and community micro-plantations (village wood). The area under plantations is estimated at 260,980ha with a standing volume of approximately 5,823,410 cum. The total potential production amount is approximately 582,340 cum/year (equivalent to 483,340 tons of wood), assuming a 10 year rotation (see Table 3 in Annex 1).

Trees outside of forests

Trees outside of areas defined as forest are important for the self-sufficiency of rural households in terms of biomass. Surveys in other African countries found that 'trees outside farms' (TOF) contribute between 20-35% of the energy supply of rural populations (Fall, 2011; Jorez, 2013; Jorez et al., 2009). TOF in Burkina Faso are found in cultivation areas located in the village lands where the administration has ensured the conservation of at least 35 plants per hectare; agroforestry areas where selected trees are planted, and areas consisting of cultivation fields, natural areas and short fallow periods (less than 5 years). It is estimated that there is approximately 99,233,230 cum of standing volume in TOF. Using a reduction rate comparable to that proposed for natural forests (50% of the standing volume) and a 15-year rotation, the potential volume of wood energy is approximately 3,207,770cum (see Table 4 in Annex 1)

Import of wood energy

According to the forest administration, Burkina Faso imports a very marginal amount of wood for energy purposes. The imports including charcoal were estimated at approximately 1.89 tons per year, equivalent to 9,610cum of wood[18]

Total supply of wood energy

Working with the potential standing supply of wood energy in Burkina Faso and considering operating losses, the total available volume would be about 9.15 million cum (7.55 million tons) per year (see table 5 and Figure 5 in Annex 1).

<u>Exploitation and processing of wood energy</u>

Wood harvesting is carried out between January and April (Apex, 2007) and mostly by local loggers and farmers either as a seasonal activity or an activity to supplement income. Logging is done as part of (i) an organized and authorized system in the Forest Development Plan (FDP), (ii) non-organized but authorized system in protected forests; and (iii) the unorganized and unauthorized system (illegal system).

[18] Calculated using denseness of wood at 0.83t/m3 and cabonization weight yield at 15%.

The organized and authorized system

In managed forests (specifically in FDPs) the local actors are organized in Forest Management Groups (FMG), including both men and women. The FMGs have in turn organized into unions - Forest Management Unions (FMUs). All the FMUs in Burkina Faso have formed a Federation which is a member of Faso Farmers' Confederation.

In this system, the government sets prices[19] and the selling price of a stere (unit by which bundle of wood is sold) includes (Richter, 2013a): the payment for loggers, contribution to the Forest Development Fund (FDF), the working capital (WC, often called the village investment fund), forest tax, and the communal tax (in some districts). The loggers and operators are paid enough to cover their costs and maintain their equipment. The FDF reinvests a portion of the profits from forestry in the protection and development of managed forests. The village investment fund is used for financing projects that deliver social benefits - schools, health centers, drilling wells and so on. The payment to the logger/operator, when considering the whole value chain, represents 11% of the retail selling price (making the loggers/operators the third beneficiary). The FDPs meets approximately 15% of the supply to Ouagadougou city which is supplied mainly from the Central West region. The rest of the needs are met from unmanaged forest areas and unorganized supply systems

The unorganized but authorized system

The operators/loggers conduct the harvesting outside of FPDs in protected forests with a permit from the forestry administration. While the pricing of the stere at the logging area should be relatively the same as for the organized system, the selling price is actually lower than in the organized system.

The unorganized and unauthorized system

The loggers in the unorganized and unauthorized system cut down valuable forest species and often work in close collaboration with wholesalers-transporters and do take into account sustainable resource management. There also are unorganized and unauthorized loggers who are women and children and live in villages that are in close proximity to the forest. They collect deadwood and branches abandoned by the loggers.

<u>Charcoal production</u>

Every year, the MEDD define the charcoal production sites either in the FDP or in protected areas. Apart from the selected sites, carbonization is not permitted. Charcoal is produced by occasional charcoal producers (usually local farmers who produce small quantities of charcoal) or professional charcoal producers who have extensive experience and are often foreign migrants.

Carbonization is important between December and April, but is practically permanent in some parts of the country. Carbonization is often done with traditional kilns and pits. The tree species that are most prized by households and artisans are: *detarium microcarpum* and *burkea africana* (Akossongo, 2013). Charcoal is packaged and sold by charcoal producers in big bags of 50kg. The price covers the payment for the charcoal producer, the forest tax, contribution to the forest development fund and contribution to the working capital.

In terms of income for farmers/charcoal producers, estimates from two FDPs revealed that approximately 70% of the income from logging and charcoal production comes from logging, while the remaining 30% comes from charcoal production. The exception is for the producers of traditional beer,

[19] The prices are set to guarantee the sustainability of the wood resource on one hand and to improve the living conditions of the people affected by the management of these zones on the other. This structure of wood pricing varies according to the region and falls within the framework of current efforts to liberalize commerce in Burkina Faso. (ILCF background paper, 2011)

who use large quantities of wood and have secondary charcoal production that is used for grilling or sold.

Transport and marketing of wood energy

There are several groups of persons involved in the wood transport chain. In Burkina Faso, the transporter plays the role of a wholesale trader, thus, the word transporter indicates both roles. There are several actors (Richter, 2013a):

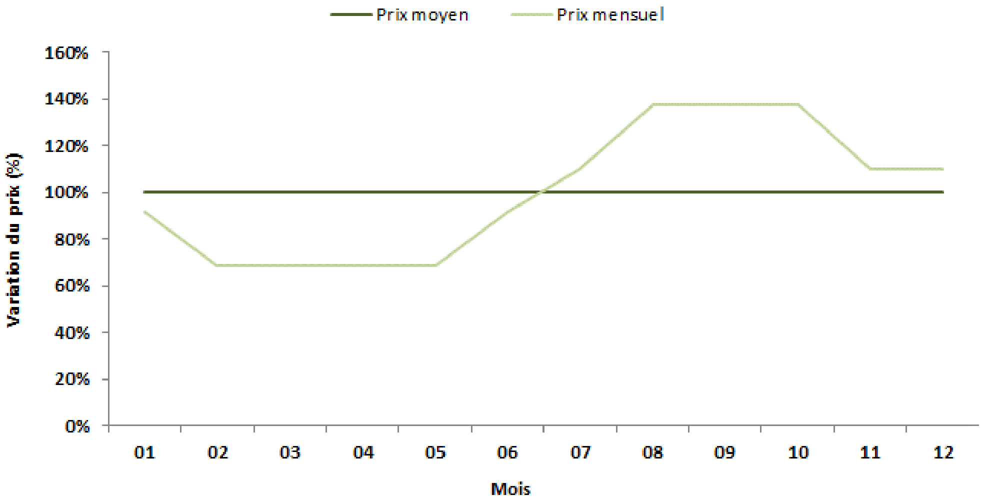
- wood energy transporters who own the means of transportation and load the wood in the production areas to deliver in wholesale quantities to retailers
- wood energy retail transporters: they carry out transport activities for wholesale and retail purposes. They get the purchased wood either from production areas or from wholesale traders
- Wood energy loggers/transporters: they are present at two levels in the value chain – the exploitation and the transportation (Forest Department, 2012a)
- Wood energy loggers/transporters, retailers: They own the means of transportation and hire the services of individuals who are responsible for logging and transporting, they then retail the wood themselves.

The modes of transportation that are used include (Forest Department, 2012a): pedestrians carrying wood on their heads, cyclists, carts, covered vans and pickup trucks, four-wheeled and six-wheeled trucks, and semi-trailers or trailers.

The actors using the more basic forms of transport usually combine transport, logging, and whole-sale trading and retailing. They are found in small towns. The actors using motorized vehicles generally live in urban centers and are considered wholesale-traders supplying primary and secondary urban centers. There are checkpoints along the supply routes to control the movement of wood. These fixed and mobile checkpoints are administered by the Forest Department and are found on the way out of managed forests or near centers of wood consumption.

The majority of trips are made by transporters during the dry season, with the aim of building up their stocks. The wholesale traders have their own storerooms for wood, with the intention of selling when prices are high (see Table 8 in Annex 1).

Surveys in some marketplaces (Richter, 2013c), have shown that the average price of fuelwood is currently around 22 FCFA per kg with a minimum of 15 FCFA/kg and a maximum of 30 FCFA/kg. Figure 247 provides an illustration of the relative fluctuation in the price of wood energy in Kaya.



Source *Richter, 2013a*

Figure 7 **Relative fluctuations in the price of wood energy in Kaya compared to the average price of 22 FCFA/kg**

The price of charcoal varies between the different regions: in Kaya the average price of charcoal is between 135 FCFA/kg (wholesale) and 170 FCFA/kg (retail). In Koudougou, the selling price ranges from 90 FCFA/kg to 130 FCFA/kg and in Bobo-Dioulasso the price of charcoal varies from 80 FCFA/kg to 120 FCFA/kg.[20] Seasonal variability in the selling price of charcoal corresponds more or less with the change in the price of fuelwood (Richter, 2013c).

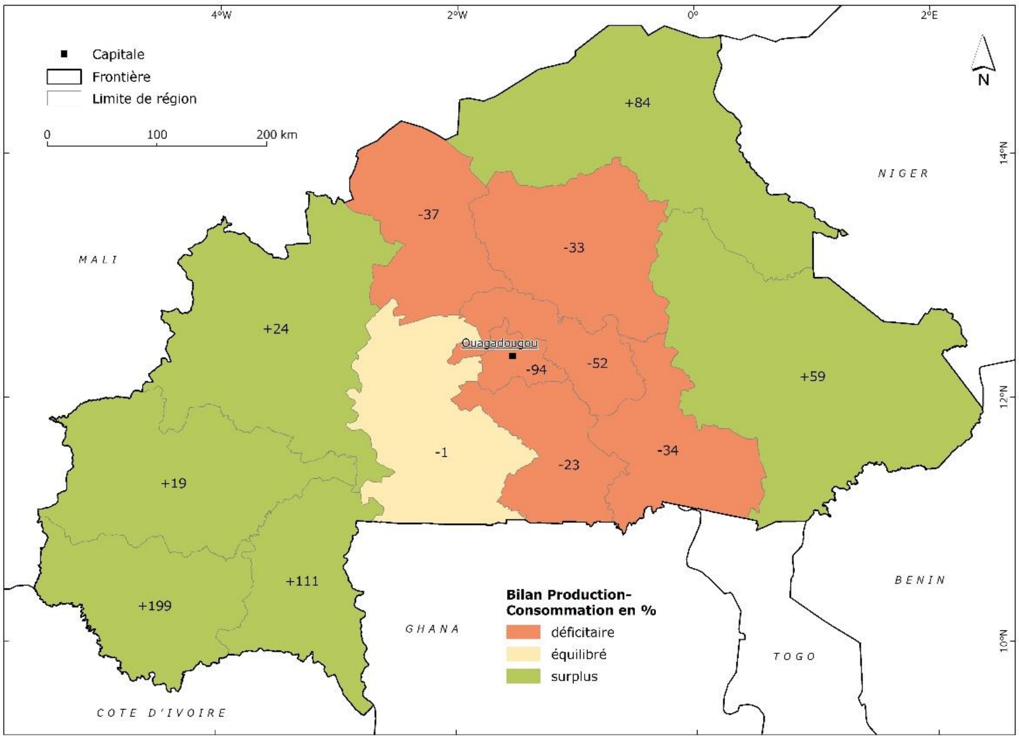
3.6. Balance supply/demand

Current balance

On the basis of information relating to the supply in Burkina Faso, the amount of wood energy consumed by households and businesses as well as the amount of WE (wood energy) exported is estimated at 9,693,131 m³/year (see section 0). For the supply, the sustainable production of natural forests, reforestation and forest mosaic (trees out of forests) and WE imports were estimated at 9,156,709 m³/year (see section 0).

Currently, the potential production of wood energy meets 95% of current domestic consumption and the gap between supply and current consumption needs amounts to 526,812 m³/year (see Table 9). To view the deficient regions, balanced regions and those with a surplus, Figure 8 shows the balance between supply and demand by region for the year 2013.

[20] Ouedrago (2014) examined both own price and cross price demand elasticity for wood fuel and charcoal. Ouedrago found that In the case of urban households in Ouagadougou (using data from 1996), fuel demand was relatively inelastic and therefore are not very responsive to own prices.



Source *IGN France International, 2005; ECO Consulting Group, 2013d*

Figure 8 Balance between supply and demand per region; year 2013

Table 9 Balance between supply and demand for wood energy (WE) in Burkina Faso; year 2013

Demand			Supply		
Category	**(m^3/year)**	**(%)**	Category	**(m^3/year)**	**(%)**
Urban and rural households in WE 1)	7,945,710	82	Production of natural forests 2)	5,295,711	58
Businesses in WE 1)	1,728,202	18	Production of forest plantations 3)	553,224	6
Exports in WE 1)	19,220	0	Trees out of Forests	3,307,774	36
		0	WE imports	9,610	0
Total	9,693,131	100	Total	9,166,319	100
Balance		-5		- 526,812	

Explanations:

1 = 1 the charcoal share was converted into wood equivalent, calculated with a weight of the carbonization yield of 15% and a density of 0.83 wood t/m³

2 = based on operating losses of 10.0% of the exploitable standing volume

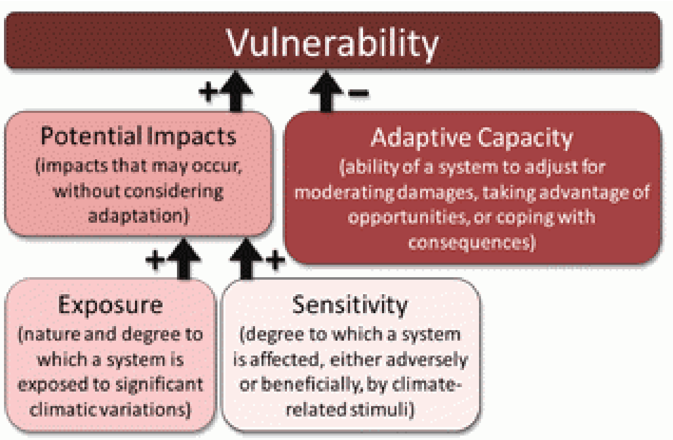
3 = based on operating losses of 5.0% of the exploitable standing volume

4. Vulnerability of the energy sources to climate change

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. Vulnerability is a function of exposure to climate stresses, sensitivity and adaptive capacity (see Figure 10). Vulnerability increases as the magnitude of climate change (exposure) or sensitivity increases, and decreases as adaptive capacity increases (IPCC 2007).

Conceptual aspects

The framework adopted in the series of studies for examining the vulnerability of a sector to climate change views the elements of vulnerability as illustrated in Figure X



Sensitivity

Sensitivity is the degree to which a system can be affected, negatively or positively, by changes (in climate). Changes may have direct or indirect effects (IPCC 2007). In ecological systems, sensitivity is described in terms of physiological tolerances to changing conditions.

4.1. Vulnerability of the energy sub-sectors other than wood based energy[21]

Wood and non-wood energy sources are vulnerable to climate change. There, however, is limited analysis in developing countries on the vulnerability of non-wood energy subsectors to climate change. Work done by the United States Environmental Protection Agency[22] has shown that warmer climate may reduce the efficiency of power production for many existing fossil fuel power plans because these plants require significant amounts of water for their cooling function. The colder the water, the more efficient the generator conversion of fuel to electricity and the need for fuel to convert to electricity decreases.

[21] The analysis in much of this subsection is based on CIFOR and CIRAD's modelling of climate change scenarios and their impacts on ecosystem services in Ziro-Sissili (Rafanoharana et al., 2012) and other published research.

[22] www.epa.gov/climatechange/impacts_adaptation.energy.html

Production of feedstock for biofuel as a source of energy can also stress water resources. The demand for water when temperatures are increasing can involve sourcing water from underground aquifers. The latter requires energy for pumping, further reducing the efficiency at which energy is produced. It is known that non-renewable energy sources often require significant use of water in their production. In the case of Burkina Faso, there is also reliance on ensuring there is climate-resilient infrastructure both nationally and in the source country and that there is adequate hydrocarbon storage capacity.

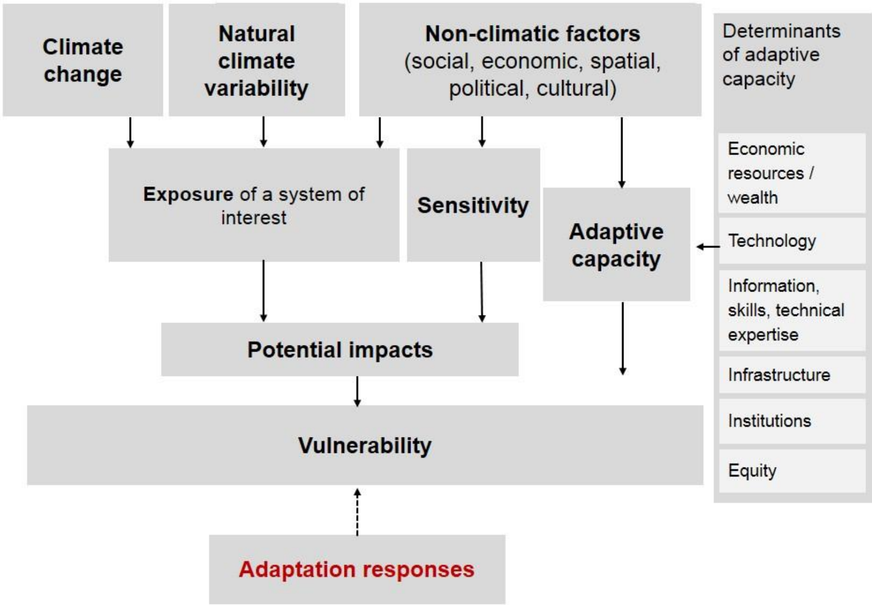
The other area of vulnerability is of the energy infrastructure. When a country is heavily dependent on oil three are several infrastructure related considerations. The first is ensuring that there are adequate hydrocarbon storage facilities to receive and store LPG because supply change is sensitive to price change. For countries, like Burkina Faso, that are fully dependent on imported oil, resilient infrastructure that will not be affected by changes in climate (e.g., increased flooding or extreme high temperatures) will be important. Burkina would also be sensitive to the level of exposure of the other links in the energy supply chain – e.g., the ports, the storage, and the transportation infrastructure in other countries.

The energy situation combined with the climatic changes Burkina Faso is facing, makes it necessary for the public authorities to consider, as a whole, the energy trajectory they should be considering based on its viability and resilience, including the social, economic and environmental sustainability**.**

4.2. Vulnerability of the wood energy sub-sector[23]

We have to consider that the impacts of climate change are often cannot be dealt with in isolation in socio-ecological system such as wood energy. Several stress factors attributed to climate change exacerbate existing anthropic pressures on the system. For example, the wood energy value chain depends on forest ecosystem services that are often threatened by a change in land use or fragmentation or degradation caused by unsustainable exploitation practices. The latter, in turn, causes deforestation as well as forest degradation. Often the underlying cause of the anthropic pressures is an inadequate legal framework which results in problems in terms of participation, access and management of natural resources or land (Geist & Lambin, 2001). Reflecting the anthropogenic pressures in the framework extends it as shown in Figure 9.

[23] The analysis in much of this subsection is based on CIFOR and CIRAD's modelling of climate change scenarios and their impacts on ecosystem services in Ziro-Sissili (Rafanoharana et al., 2012) and other published research.



Source *IPCC, 2001; Füssel & Klein, 2004; Smit & Pufosova, 2001*

Figure 9 Vulnerability functions

The sensitivity of social systems depends on economic, political, cultural and institutional factors. These factors can confound or ameliorate climate exposure (Marshall et al. 2010). The table below represents those factors that reduce and increase the sensitivity of the wood energy system.

Factors	Positive	Negative
Environmental factors		
Locating protected forests along main rivers and in the wettest parts of the country reducing their sensitivity to water stress.	x	
Distribution of vegetation types strongly related to temperature and rainfall regimes.		X
Relatively low biomass productivity, related to temperature and rainfall, (-> evapotranspiration) and concentration of CO_2 (Larwanou, 2011).		X
Predominance of soils which are essentially poor in nutrients and having a low water reserve (MECV, 2007).		X
Socioeconomic factors		
Existence of wood energy resources other than natural forests: • Forest plantations: total potential production reaches 164,342 m^3/year , equivalent to 115,039 tons of wood; • Existence of multifunctional parklands: source of wood energy and non-wood products, soil protection, etc. with high added value for farmers (Larwanou, 2011); • Trees outside forests.	x	

Significant forest area under planning and management or being managed (888,327 ha in 2013) (MECV, 2009).	x	
Taking into account enhancing aspects of the forest resources development (production of goods and services) and adaptation to climate change, in forest legislation (Forest Code).	x	
Taking into account precautionary measures in the forest management plans: reduction rate of 50% of the standing capital.	x	
High pressure on forest massifs causing their degradation. The main causes are (MECV 2007; MECV, 2012): • The expansion of agricultural and pastoral lands, promoted by the agriculture policy promoting agribusiness; • Forest fires; • The extraction of wood energy often exceeding by far the natural productivity (Larwanou 2011); • Forest clearing caused by urbanization and densification of facilities; • Mining.		X
High population growth and rapid urbanization (Larwanou, 2011) leading to an increase in demand for wood energy, especially for charcoal.		X
Strong dependence of households on woody fuels with a consumption exceeding the sustainable potential production of wood energy, especially in the northern part of the country.		X
Low penetration of efficient cooking equipment (improved cookstoves).		X
Predominance of inefficient carbonization techniques (traditional millstones, pits), resulting in production losses.		X
Cross-border flows of wood energy to Niger.		X
Low commercial value of natural forests making investment unattractive (FAO, 2003).		X
"Decentralized" production of wood energy: long-distance supply to cities.		X
Inadequate control of wood circulation by the forestry department at the exit of managed forests or at the entry of consumption centers.		X

4.3. Observed and potential impacts

The character and magnitude of climate change impacts are determined by (a) the exposure and (b) the sensitivity of the system. Biophysical impacts refer to the biophysical parts of a system and often directly result from climate change factors, e.g. damaged infrastructure due to flooding or erosion of shorelines due to storm surge. Socio-economic impacts (for the bigger part) follow biophysical impacts and affect socio-economic development, e.g. reduced access to services due to damaged infrastructure or losses in tourism revenues due to shoreline erosion.

Table Y provides an overview of observed and potential impacts on the wood energy value chain.

Impact	Positive	Negative
Biophysical impacts		
Increase in the intensity, frequency and seasonality of bushfires (Kalame et al., 2009; MECV 2007; GWP/WA, 2010). Case of Ziro-Sissili: slight change in areas affected (from 5% now to <9% in 2030 and 3% in 2080), except for the highest emissions scenario (17%) (Rafanoharana et al., 2012).		X
Changes in the formation and distribution of forest massifs, e.g.: • A movement of Sudanese/Guinean species to the south and an expansion of Sahelian species to the south (Gonzalez, 2001; MECV, 2007) ; • Loss of some tree species (Lindqvist & Tengberg 1994; MECV, 2007 Kleine et al., 2010. MECV, 2012), particularly in the North-West and South of the country (Heubes et al., 2013); • Case of Ziro-Sissili: changing ecosystems into drier systems (Rafanoharana et al., 2012).		X
Changing the water regime with the following phenomena: flood, water erosion, lowering of ground water (TAED, 2007 Hien, 2010) influencing soil quality and water availability.		X
Uncertain effects on forest productivity related to changes in temperature, rainfall and the CO_2 fertilization effect: • Reduction due to higher evapotranspiration caused by the increase in temperatures (Delire et al., 2008) • Reduction due to a decrease in rainfall (MECV, 2012); • Ziro-Sissili case: probability of increasing the net primary productivity by 2030 and 2080 (except for the worst emissions scenario) (Rafanoharana et al., 2012).	x	X
Decrease in production areas of some crops, reduced agricultural productivity and poor harvests due to extreme events (periods of drought, floods) (MECV, 2007 Lona & Sarr, 2009; Hien, 2010).		X
Social impacts		
Change of the wood energy supply probably spatially heterogeneous (depending on the region).	X	x
Migration of a part of the population from the Plateau Central to the west and east of the country contributing to degradation of the reception areas (MECV, 2007).		X
Widespread practice of transhumance as an alternative livelihood (MECV, 2007) leading to increased pressure on forests.		X
Increased pressure on forest resources due to the negative impacts on agriculture.		X

4.4. Adaptive capacity

Adaptive capacity is the ability by a human or natural system to adjust to climate change and variability, to moderate potential damage, to take advantage of opportunities or to cope with impacts from climate change.

Adaptive capacity is a function of the relative level of a society's economic resources, access to technology, access to climate information, skills to make use of the information, and institutions and equitable distribution of resources. It tends to be correlated with the level of development: more developed countries and communities tend to have more adaptive capacity (IPCC 2001, OECD 2009).

In ecosystems, adaptive capacity is influenced by biodiversity (genetic, species and their inherent variability). In social systems adaptive capacity is determined by the individual and/or common ability to cope with change (the ability to learn, manage risks and impacts, develop new knowledge, and devise effective approaches) and the institutional setting (Marshall et al. 2010). Table Z lists the how different aspects influence adaptive capacity.

Aspect	Positive	Negative
Political/institutional aspects		
Political will to secure sustainable access to woodfuels which was materialized in 2004 with the definition of a Domestic Energy Strategy.	X	
Existence of a National Strategy for Fire in Rural Areas with the objective of minimizing the damage caused by bushfires. A program on the control of forest fires, which began in 1998, has strengthened the institutional management capacity of organizations fighting against forest fires (Kalame et al., 2008).	X	
A certain level of organization for actors managing forests: • Existence of about 400 Forest Management Groups (FMG) consisting of nearly 12,000 members (FD, 2012); • Bringing together FMGs in a Union at the provincial or regional level and in national federation.	X	
Good organization of the "transport" chain: the existence of associations of transporters in most regions.	X	
Low level of involvement of regional communities in forest management: lack of motivation (nonexistence of revenue sharing) and lack of human and financial resources (FAO, 2003).		X
Lack of organization and training for charcoal operators.		X
Poorly defined skills for organizations specialized in forestry.		X
Low level of organization of retailers, with the exception of a few associations.		X

Technological aspects		
Existence of research centers, such as the Research Institute of Applied Sciences and Technologies (IRSAT), which are specialized in the development and improvement of improved, affordable cookstoves, which are adapted to the culinary habits of households.	X	
Emergence of new technologies: bio-digester for biogas combustion.	X	
Availability of equipment needed for a substitution to gas, in the urban market and gradually in the peri-urban market.	X	
Mastery of management and assisted natural regeneration techniques for dominant species in parklands (Lewardou, 2011).	X	
Limited opportunities for households to resort to alternative fuels, e.g. gas, despite public subsidy policy, because of : • High costs of equipment and gas refills; • Disadvantages in the use: interchangeability between distributors, not suitable for local dishes.		X

4.5. Overall assessment of vulnerability

While it seems indisputable that the country will face an increase in temperature and rainfall variability, quantitative projections are ambiguous. Consequently, conclusions about the impacts on the productivity of forest resources as a factor limiting the supply of wood energy, also related to the concentration of CO_2 remain relatively uncertain.

Figure 10 (adapted from CIFOR, World Agroforestry Centre & USAID, 2009) gives a schematic overview of the potential impacts of climate change on wood energy supply.

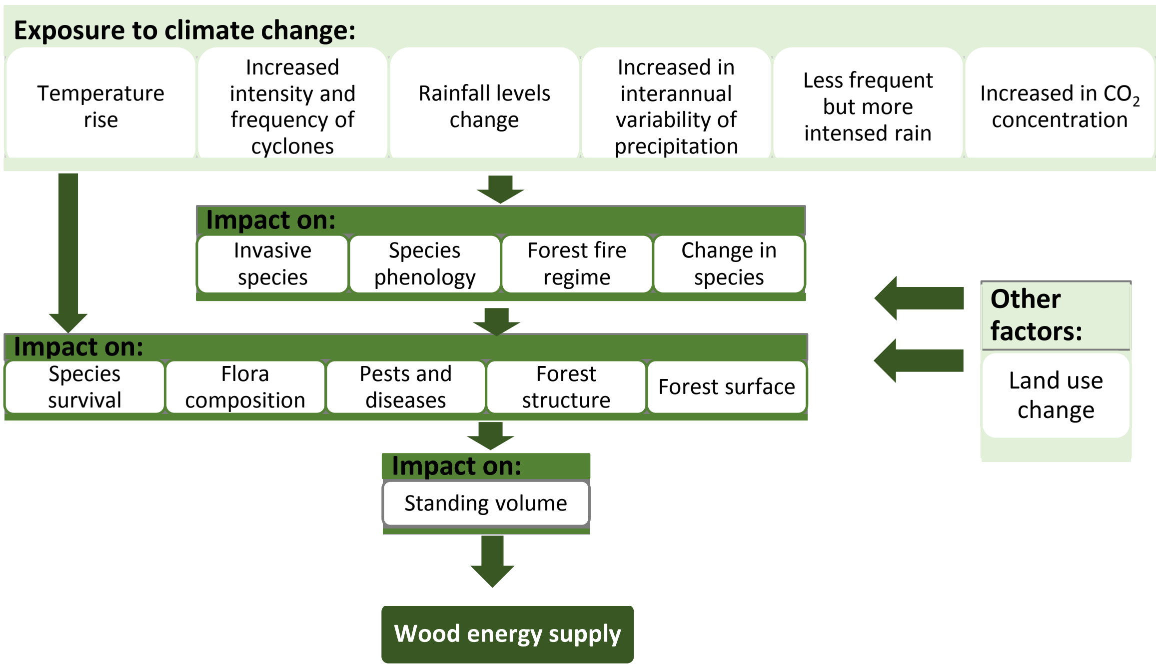


Figure 10 Potential Impacts on wood energy supply in Burkina Faso

However, the analysis of various components of vulnerability shows that the impacts of climate change are not an isolated challenge to the sub-sector, and especially forest ecosystems. On the contrary, stress factors attributed to climate change exacerbate existing anthropic pressures, such as the expansion of cultivated land and grazing land, the overexploitation of timber, forest conversion into residential areas, causing both a deforestation and degradation of forests. This is also confirmed by the CIFOR analysis (Rafanoharana & al., 2012). Unfavorable framework conditions and institutional boundaries are often the basis of these human-induced pressures.

5. Modeling the future of the wood energy sub-sector

5.1. Description of scenarios

The following modeling of the sub-sector by 2018, 2030 and 2050 is based on three change scenarios[24], including climate variables and assumptions about the development of the population and the deforestation rate:

Base scenario

- No impact of climate change on forest productivity;
- Population growth: 3.4% per year in urban areas, 3.1% per year in rural areas;
- Regression of forest land area: 0.54% per year.

Optimistic scenario

- Positive impact of climate change on forest productivity due to increased rainfall and a fertilizer effect of CO2: improvement of the 15% increase by 2050 compared to 2013;
- Population growth: 3.4% per year in urban areas, 3.1% per year in rural areas;
- Regression of forest land area: 0.54% per annum.

Pessimistic scenario

- Negative impact of climate change on forest productivity due to high temperatures and high rainfall variability: decrease of the 25% increase by 2050 compared to 2013;
- Population growth: 3.4% per year in urban areas, 3.1% per year in rural areas;
- Increased regression of forest land area, partly due to the negative impacts on agriculture: 1.08% per year (doubling compared to the year 2013).

5.2. Results of modeling

Figure 11 shows the evolution of wood energy consumption and production in the three scenarios by 2018, 2030 and 2050. Production figures refer to the total potential for sustainable wood energy production in the country's forest ecosystems.

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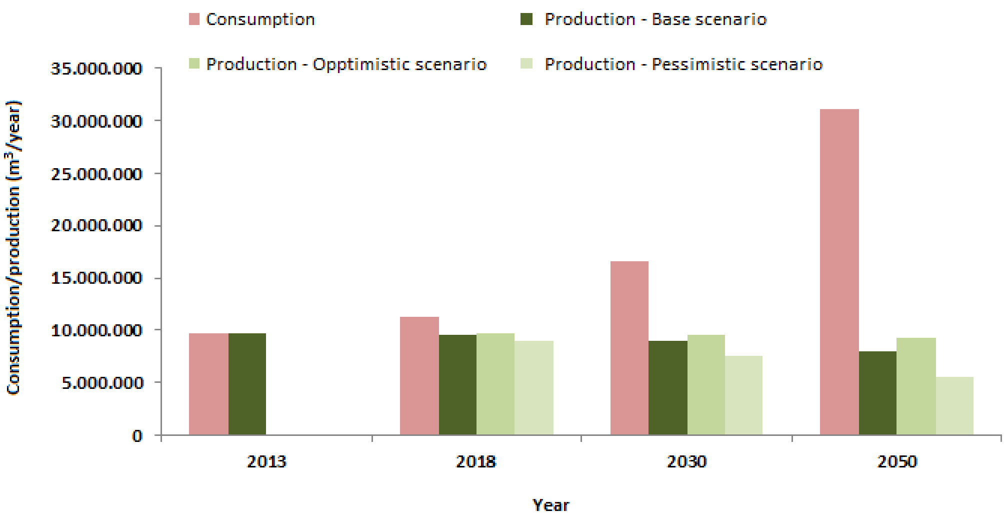
[24] The wood energy consumption element of the scenarios are developed using available data on consumption and taking into account existing information on elasticities of demand. The scenarios are not built using growth and energy demand models. The use of a simpler approach is justified as the aim is to explore whether, as climate change affects availability of wood energy it is justified to use approaches that involve wood fuel to enhance the resilience of the subsector, and not to reconcile supply and demand in the energy subsector that caters to household energy needs met using wood energy.

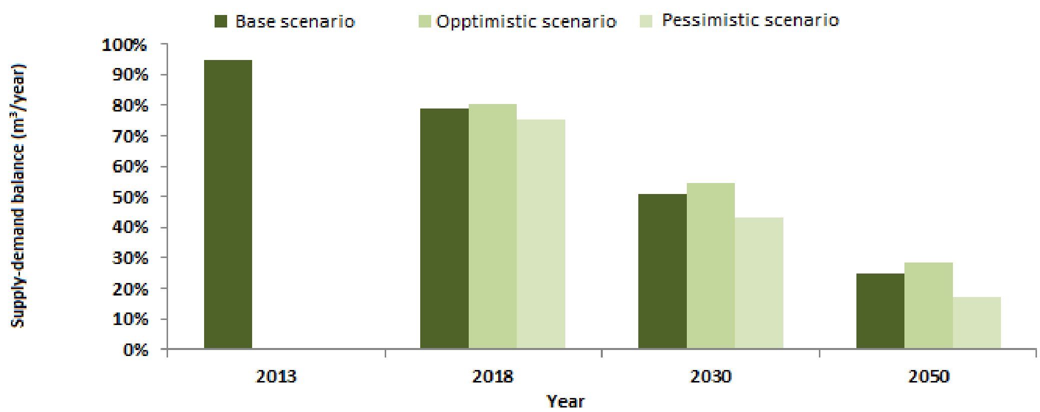


Source *Richter et al., 2013b*

Figure 11 Evolution of wood energy consumption and production in the three scenarios

The proportion of consumption that can be met by a sustainable management of forests and trees outside forests (see Figure 12) currently stands at approximately 95%. In other words, if all the forests in the country were managed, we could almost reach a balance between consumption and production. However, the situation is less favorable for the future. Even the optimistic scenario, showing increased forest productivity cannot overcome the rapid growth in demand for wood energy and compensate for losses in forest land and accelerated degradation. In 2018, potential sustainable production will only cover between 75% and 81% of demand, in 2030 between 43% and 55% and in 2050, the production does not reach 30% of consumption.

It should be noted that the current under managed forest land area stands at around 800,000 ha.



Source *Richter, 2013b*

Figure 12 Evolution of the wood energy supply-demand balance in the three scenarios

6. Adaptation strategies in the sub-sector

As illustrated by the analysis of vulnerability, the changes experienced in forest ecosystems and therefore ecosystem services due to environmental degradation and climate change could have an impact on the energy security in Burkina Faso (see also IUCN 2013). It is therefore important to develop adaptation options for energy sector, with a special emphasis on wood energy given the demand and level of reliance on wood energy. This would ensure domestic energy supply in the long term.

Among the possible approaches to reduce vulnerability (Adger et al., 2005):

- Reducing exposure to climate change and immediate effects (e.g. the installation of warning systems);
- Reducing sensitivity to climate change (e.g. using drought-resistant species);
- Maintaining or increasing their adaptive capacity (e.g. improving the well-being of the population).

Efforts to build resilience in the energy system are distinguished by different energy sources. According to our preliminary analysis it was found that a strategy focusing purely on wood energy is not feasible and that interventions on the supply side should be accompanied at least by measures to reduce demand. As part of our analysis, we therefore distinguish two types of development strategies for the sub-sector by 2030:

> Ecosystem-based adaptation
>
> We can define EBA as "the use of biodiversity and ecosystem services as part of a general adaptation strategy to help people adapt to the adverse effects of climate change." (CBD, 2009). This concept is based on the idea that ecosystem services have the potential to reduce the vulnerability of society to climate change across sectors and sub-sectors (Vignola et al., 2009).

<u>Strategy to modernize the wood energy value chain</u>

- Based primarily on the sustainable management of forest ecosystems and optimization of the other links in the value chain;
- Increased energy diversification with the promotion of butane gas as a supplementary measure;
- Achieving coverage for 90% of the energy needs of rural households from wood energy, and 60% of urban households' needs.

<u>Strategy focusing on LPG</u>

- Based largely on the supply of LPG;
- Targeting the coverage of 60% of the energy needs of rural households from wood energy and 30% of urban households' needs.

The first strategy is part of the ecosystem-based adaptation. It uses the forest ecosystem services in an overall adaptation strategy which can generates social, economic and environmental benefits (SIB 2012). It is also an approach that is based on the recognition that the anthropogenic factors often compound the negative impacts of climate change. Furthermore, as noted in the model by Rafanoharana et al. (2012), anthropogenic factors (approximated by land use change) can result in the loss of potential positive impact of climate change projections on net primary productivity. The strategy to modernize the wood energy value chain, unlike previous efforts, adopts a holistic approach that addressing framework conditions and the entire value chain. The second strategy is chosen as an alternative approach because it is in line with the national vision 2020 (i.e., reducing the woodfuel demand by increasing the use of LPG and kerosene as well as improved cookstoves).[25]

6.1. Strategy to modernize the wood energy value chain

Overview of areas of intervention

As specified in the previous chapters, wood energy plays a very important role at the economic and environmental levels in Burkina Faso. Unfortunately, wood energy - particularly charcoal - has a bad reputation because it is considered an outmoded, dirty and inefficient energy source. This is in contradiction with local reality not only because of the current importance of wood for the Burkina Faso population, but also due to the enormous potential the improvement of the wood subsector has in sustainable development of the energy sector and other economic and environmental benefits. It also could enhance the resilience of the heavily wood dependent energy sector of Burkina Faso.

Traditionally, energy strategies based on biomass address the issue around two components: supply and consumption. Instead, we propose a modernization strategy based on a holistic intervention approach along the value chain by optimizing its entire links (Figure 13).

	Sustainable production of wood energy	
	• Promoting participatory management of natural forests	(S, A)
	• Extension of forest plantations	(S, A)
	• Promotion and strengthening of agroforestry	(S, A)
	Exploitation and processing of wood energy	
	• Strengthen the capacities of local actors in tools and techniques for managing forest resources	(CA)
	• Increased efficiency in the field of exploitation	(CA, A)
	• Increasing the efficiency of the carbonization	(CA, A)
	• Test and dissemination of innovative methods to use agricultural residues	(S)
	Transportation and marketing of wood energy	
	• Structuring of marketing channels	

[25] It should be noted that there are several other alternative strategies (e.g., solar) that are not dependent on wood energy that could be considered as a means to enhance resilience of the energy subsector that caters to household energy needs that are met by woodfuel. A similar analysis to what is done in this study could be done using either one or a combination of these options. Due to data limitations and sophistication of analysis required, however, such an approach was not feasible for this study.

	• Setting up of an market information system for wood energy	(CA)
	Use of wood energy	
	• Optimization and testing of models of household improved cookstoves	
	• Dissemination of improved cookstoves in urban and rural areas	(S, A)
	Framework conditions	
	• Ensure the implementation of differential taxation	(S)
	• Support the establishment of a system of effective control	(S)
	• Support the establishment of a National wood energy committee	(CA)
	• Development of regional strategies to modernize the wood energy value chain	(CA)
	• Development of regional wood energy supply programs	(CA)
	• Development of an information system for the wood energy value chain	(CA)
	• Facilitating the dissemination of best practices and lobbying	(CA)

S = reduces sensitivity, CA = increase adaptive capacity A = contribute to mitigation

Figure 13 Overview of areas of intervention along the wood energy value chain

The proposed actions are evaluated according to their relevance to adaptation to climate change and their potential role in mitigation (adaptive capacity, reducing sensitivity and contribution to mitigation). Annex 2 presents more detailed description and relevant data and schematic of the strategy and the assessment of its relevance to adaptation.

In the context of sustainable domestic energy supply, strengthening the role of forests in adaptation has a double mission: firstly, it is to allow forests to withstand climate change constrains and anthropogenic pressure. On the other hand, it is about exploiting the potential of forests for the adaptation of the wood energy value chain to future changes. It is important to note that many management measures, taken in the context of ecosystem-based adaptation, also play an important role in mitigating climate change; such as the prevention of large scale bushfires through the implementation of management plans for forest fires (Ravindranath, 2007). In addition, most interventions are justified independently of climate change, i.e. these are “no regrets” measures.

Sustainable production of wood energy

Production of wood energy needs to give priority to the protection and management of forestry and forest areas of the country. Priority actions to be carried out will be related to the demarcation of forests, the definition of access and management regulations in a concerted manner and the organization of village structures to enforce these rules based on consensus (see Table 10).

Table 10 Priority actions on the introduction participatory management of natural forests

Priority actions
• Supporting sustainable management of natural forests; • Identifying priority natural forests for participatory management and the production of wood energy; • Facilitating the development of simple management tools; • Supporting the management of bushfires; • Assisting the setting up of organizations and facilitating the transfer of skills in managing forest resources to local authorities and management structures (FMG); • Assisting the management and securing of reforestation plots; • Extending the forest plantation area for energy purposes; • Testing alternative methods of wood energy production; • Promoting and strengthening agroforestry.

Support sustainable management of natural forests

The development planning of forests targets their sustainable management and can significantly reduce anthropic pressure on resources. This reduces the sensitivity of forests and reduces CO_2 emissions related to deforestation and degradation.

From the perspective of improving national energy planning, it is necessary to identify the main forest and forestry areas already contributing, or likely to contribute in the future, to the population's needs for wood energy. Although some regions are more affluent in terms of wood resources (Southwest, Midwest and East regions) and offer significant comparative advantages from a financial point of view (for example cost and profitability of forest planning), development initiatives need to be supported throughout the country, including the North given the demand for wood energy extends throughout the country and this would reduce risks and costs associated with transportation.

Achieving production of wood for energy will require decentralized and participatory management of all selected priority sites, planning and the development of management plans. Given the recent regulatory changes (Governor AOF, 1935; National Assembly, 2012), management actions in the future should be part of the technical assistance that the Forest Department must provide to local authorities. There also will be new needs for mobilization of human and financial resources including allowing rural communities to become involved in forestry with the resources they can expect from national and international sources.

The involvement of local people in the management of forest resources added to the technical, organizational and financial capacity building of supporting organizations and villagers increase **adaptive capacity** in the sub-sector. Access to information plays a key role in this context.

The other option is to protect and rehabilitate reserve forests. Many reserve sites have high rates of degradation. Substantial efforts must be made for the clearance and rehabilitation of these forests. Consequently, development and management plans should consider regeneration and enrichment actions (including approaches such as farmer managed natural regeneration – see Figure 18 in Annex 2 for favorable conditions for rehabilitation of woodlands). The forest administration and its technical partners will support these communities and local management structures in the acquisition of technical and organizational skills necessary for the development and implementation of management and development planning actions.

Facilitate the development of simple management tools

In 2013, more than 35 forests were affected by management activities. Yet only two development and management plans have been approved by the forest department. This issue poses the problem of development and validation procedures for management documents.

In the context of a large scale decentralized management of forestry resources, it is highly recommended to accelerate the development of simple management tools to reduce the time and costs required for forests management. This will require development of simplified inventory standards for each eco-geographical region to serve as a standard for forest managers; "software" that standardizes the input and automates the data analysis; a simplified management plan (SMP) and a simplified management plan framework. The SMP framework must also include adaptation measures.

The existence of a network of partners in the sub-sector and the availability of financial resources is a major advantage and **strengthens adaptive capacity**.

Support the management of bushfires

At the local level, in order to protect forests against fires, it is strongly recommended to set up an effective firewall system (FWL). The objective is to set up Firewalls in a strategic manner to strengthen the firewall network while maximizing protection of the established "resource".

An effective strategy for the management and the fight against bush fires may reduce the **sensitivity of forests to** climate change impacts in a context of more intense forest fires.

Assist the setting up of organizations and facilitating the transfer of management skills

The number of stakeholders involved in the management of forest resources significantly increased (MEDD 2012) with the full municipalization that occurred in Burkina Faso in 2006 and the transfer of a part of the forests to local communities. The decentralized management of natural resources is recent. While the administrative bills seem clear, their communication and application to users in the wood energy sector are, currently, fairly limited. It is therefore necessary to take action on two levels:

- Technical, organizational and financial capacity building for supporting organizations (NGOs, government, private, etc.), which in turn will support communities and villagers; and

An appropriate institutional set-up promotes responsible and sustainable exploitation of forest resources and thus **reduces the sensitivity of forests**. A clear distribution of skills by local stakeholders promotes adaptive capacity in the sub-sector.

- Reduction of anthropogenic pressures such as transhumance, livestock breeding and agriculture on forest resources needed for wood energy.

Reduction of the anthropic pressure (transhumance, breeding, agriculture) on forest resources makes the wood energy resources **less sensitive.**

Increase forest plantations

It is necessary to develop existing plantations and create new plantations for energy purposes. With this perspective, first it is necessary to develop, in a concerted manner, simple management plans that can specify the forestry works to be carried out with quantified and localized sampling. In addition, it is recommended to promote (1) regulated reforestations carried out by the forest department or local authorities, (2) community forest plantations and (3) individual/private village forest plantations in the coming years.

The management of existing forest plantations and the creation of new plantations for energy purposes reduces the anthropic pressure on forest resources and makes them **less sensitive.**

The recommendation is to identify and map existing plantations to facilitate their planning and also map potential land for reforestation for the inclusion into spatial planning (SRAT, PDC, etc.). Looking at different uses in a harmonized manner will reduce negative impacts of human conflicts. Some additional enabling conditions will include security of land using existing systems and in a manner that is consistent with the laws governing decentralization (National Assembly, 2004c) and rural development (National Assembly, 2012a).

Extend the reforestation area for energy purposes

In recent decades, mainly because of the progressive decentralization, the participation of political, traditional and religious authorities as well as different socio-professional groups in reforestation activity has increased. This strong mobilization resulted mainly from the State commitment to make the preservation of the environment a national priority (MEDD, 2012b).

The choice of species plays on the **sensitivity** of plantations with harmful impacts of climate change.

To avoid failures when creating large scale plantations and to achieve significant impacts in areas like energy supply, the fight against poverty and the conservation of natural forests, it appears necessary to meet some standards to ensure the quality of reforestation (see Annex). In view of the climate change dynamics, climate projections are a fundamental criterion to take into account for a wiser selection of species for reforestation. In this respect, the determining factor is the ability to adapt to climate variability of selected tree species while considering their acceptance by the village communities. This applies especially to sites showing rainfall less than 800 mm where the choice of species must be carried in a well-targeted manner.

The installation of new plantations aims – in addition to the production of wood energy - to maintain the forest ecosystems and their biodiversity by reducing pressure on natural vegetation. Therefore, afforestation or reforestation of bare land near national parks and massifs of degraded natural forests will be a priority for the implementation of reforestations. The plan should also be to increase the density of the forest cover located near streams and watercourses in order to reduce erosion caused by heavy rains.

The development of private plantations and in particular the coordination of activities on production and planting of seedlings, will require organization of interested foresters in associations in each village or local community. Particular attention will need to be paid to the integration of women in associations of foresters. Once organized their capacity building will be fundamental to facilitate the implementation of the technical and socio-organizational stages of a reforestation campaign. Activities of these associations are not limited to reforestation but extend to the sharing of acquired knowledge in the field.

Test alternative production methods of wood energy

Drawing on successful efforts in other regions, crops with short rotation will also be an option to increase the supply of wood energy in Burkina Faso. The short rotation coppice (SRC) is a variant of the forestry processing system "simple coppice". The distinguishing feature of the SRC is the rotation; the frequency of coppice cutting is significantly shortened to 1 or 2 years. Based on previous experiences, the annual production of woody species is around 20 to 30 m^3/ha (Schenkel & Benabdallah, 2005).

However, these SRC require special processes and handling conditions. To be successful, this operation must fulfill a certain number of conditions (Schenkel & Benabdallah, 2005). Indeed one must create from nothing a value chain including:

- The selection of species;
- The choice of crop system;
- The setting up of harvesting techniques;
- The transport and handling of the product;
- Energy use.

The development of short rotation coppice contributes to the diversification of sources of wood energy and **therefore reduces the sensitivity of the sub-sector**.

This value chain must be analyzed and optimized at all stages to be competitive with other forms of energy. Generally, wood produced by SRC is fully chopped up and sold as "wood chips" for energy purposes. Hence the importance of checking before that openings exist or could exist, or to have a supply contract. Channels should be shorter than those of charcoal.

For Burkina Faso where the wood is largely for house consumption, SRC eucalyptus may be a promising energy crop, with a very favorable energy assessment and the wood produced can be promoted as "wood stick" (forest residues) for specific improved cookstoves or in the long term, for electricity production units. Pilots, however, will need to design an optimal system.

Promote and strengthening the culture of trees outside forests

Following significant land clearances observed in recent years, farmers are encouraged to reintroduce the tree in the agricultural area or build agroforestry systems. Three actions can play an important role in the production of wood energy and grazing in farming techniques:

- The promotion of tree set-asides (fallow periods);
- Enrichment/densification of parklands;
- Installation of hedges or windbreaks.

The promotion of growing and conservation of trees outside forests contributes to the diversification of sources of wood energy and **therefore reduces the sensitivity of the sub-sector**.

The practice with tree set asides in the appropriate regions should be to create parklands. Intensification on parklands would also help meet agronomic, economic and environmental needs. Intensification should blend increasing trees while maintaining diversity. Approaches that work include: assisted natural regeneration, coppicing, fight against mistletoe, pruning, etc. (MEDD, 2012b).

Linear plantations of the hedge or windbreak type are also to be promoted following a traditional farming approach. Tree planting should be done on lands where this use is traditionally recognized by farmers-planters. In order to guarantee the coming exploitation of wood energy, the owners of these woods should have a forester's booklet detailing the geolocation of the woodlands and forestry works to provide.

Exploitation and processing of wood energy

Overview of intervention avenues

The main actions proposed for the chain "exploitation and processing" are presented in table 11.

Table 11 Overview of priority actions relating to the exploitation and processing of wood energy

Priority interventions
• Strengthen the skills of local actors in tools and management techniques for forest resources and in exploitation techniques; • Support the organization of loggers and strengthen their management skills; • Organize charcoal producers and introduce the use of the improved kiln; • Test and disseminate biochar production methods.

Strengthen the skills of local actors in tools and management techniques for forests

For a better production of wood (standing), forestry techniques must be understood and assimilated by managers of natural forests and tree planters to help them to get motivating and optimized results. For this, it is advisable to give them various restoration and regeneration techniques for wooded areas while focusing on compliance with the technical requirements contained in the management documents (for example rotation length).

Forestry research should lead to an accurate determination of cutting heights for each of the main forest species rejecting stumps and that are used for energy purposes. Because of the lack of rules to control exploitation, management structures should define simple exploitation rules in a concerted manner, with woodcutters-loggers.

The capitalization of good practices and the capacity building of local actors in management and logging also **increases their resilience**.

At the same time, the pressure on forest resources, caused by bad practices (e.g. overharvesting) increases consequently the **sensitivity**.

Regulatory mechanisms and forest control measures used to reduce the pressure on forests and to **reduce sensitivity**. This is facilitated by helping management/operational actors to get organized.

To facilitate their supervision and training, it is advisable to promote the formalization of wood energy loggers within groups or associations.

Support the organization of woodcutters and strengthen their management skills

In parallel with the introduction of new technologies and methods as well as training for their use, it is important to provide a framework in terms of organizational development. Organization support will require establishing groups of woodcutters into associations or cooperatives with their own governance structure. The group should also include a unit for monitoring and controlling the quality of the charcoal, compliance with logging and management rules, and use of improved carbonization technology

The organizational development of local stakeholders and their financial technical and management capacity building **increases adaptive capacity**

Increase the efficiency of carbonization

Increasing the efficiency of carbonization will also require the organization of charcoal producers to facilitate the introduction of the use of the improved kiln. Actions to be taken in the field of carbonization must be in line with the implementation of new guidelines set for the production and marketing of charcoal in Burkina Faso and the action plan adopted for this in December 2005.

The introduction of more efficient processing techniques allows reducing the pressure on wood resources and therefore the **sensitivity.**

At the same time, carbonization technologies with high yield also contribute to the **reduction of CO_2 emissions**.

Due to the nonlinear relationship between improved technology and carbonization, the introduction of more efficient processing techniques can reduce the production area by a far greater percentage than the increase in efficiency to get the same amount of charcoal. The efficiency of carbonization in turn influences the profitability of natural forest management (Richter, 2008).

Given the potential GHG emissions associated with carbonization technology, improved kilns often need to be tested for suitability and workers need training.

This campaign for developing an optimized kiln in Burkina Faso should only concern organized charcoal producers (see below) in managed forests.

Test and disseminate innovative carbonization techniques

In the medium term, to achieve modernization of the subsector it is necessary to increase the quantity and quality of charcoal production, to test the construction and use of a kiln of semi-industrial category. Systems like the “ICPS” (Improved Charcoal Production System) or "Adam-retort” kiln will need to be tested and scale out as has happened in other countries (Adam, 2005). The semi-industrial kiln can carbonize wood volumes (on average 3 m³) with a shorter carbonization phase and with less supervision, compared to other types of improved kilns. The effectiveness of the Adam-retort kiln is very high; and makes the carbonization of biomass from agricultural residues possible. It also provides burnt wood and “wood vinegar” and other products that may contribute to the significant increase in charcoal workers’ revenues.

Adam-retort-kiln type also enables carbonization of the biomass from agricultural residues and allows by-products to be obtained. This diversifies the potential energy and revenue generation sources and **makes the sub-sector less sensitive**.

Test and disseminate methods for producing biochar

Diversification of energy sources contributes to reducing the anthropogenic pressure on natural resources. As part of this diversification, biochar could prove to be an alternative to charcoal. Its promotion should be part of protection strategies for the environment and it could help provide a diverse range of fuels to households at a socially acceptable price for users and an economically attractive price to businesses. Several forms of biomass other than wood are also useable for biochar. The latter implies that surpluses of agricultural biomass which with proper management would provide an alternative to oil.

The diversification of sources of energy helps to reduce pressure on natural resources and therefore reduces **sensitivity**.

Locally adapted technological processes and studies on social, biophysical and economic feasibility, and technical capacity building would be needed to implement this measure. In Burkina Faso, however, as there are no specific rules regarding the production and marketing of charcoal made from agricultural or agro-industrial residues, coal dust or biomass. A regulatory framework helps the development of an organized value chain.

Transportation and marketing of wood energy

Overview of intervention avenues

Together, the proposed interventions on the target N° 3 will aim to help reduce transportation costs, improve the flow of forest products and the fight against illicit products. Particular attention will be paid to the localization and development of storage and supply sites. Table 12 summarizes the spheres of activity relating to the marketing and transport of wood energy.

Table 12 Overview of priority interventions on the transportation and marketing of wood energy

Priority interventions
• Organize the marketing of wood energy by the setting up of Rural and Urban Wood Energy Markets; • Develop an information system for the wood energy market; • Facilitate access to microcredit for transporters and traders; • Support the marketing of green space wood energy products.

Structure the marketing channels

Organize the marketing of wood energy by the setting up of Rural and Urban Wood Energy Markets

The restructuring of marketing channels would firstly help to increase the profits accruing to wood energy producers and to reduce the flow of illegal products, reducing the anthropogenic pressures on the natural systems. At the same time, it will standardize supply points to facilitate the distribution and sale of products. The structuring and formalization of marketing channels will be based on the establishment of a network of wood energy rural markets associated with one or more urban markets (see Figure 19 in Annex 2).

Restructuring marketing channels in favour of wood energy producers therefore reduces their **sensitivity**.

With such an arrangement, eventually, markets will be supplied both with wood coming from forests and savannas under participatory management and with the products of future plantations. Such a structure would also bring together logger/charcoal producer associations for better trade negotiations with buyers and transporters, and help facilitate the production and marketing of charcoal and implement tax-based incentives.

The setting-up of RWEMs facilitates the supply planning of urban centres in wood energy thus influencing adaptive capacity in the sub-sector.

Having a similar arrangement for urban wood energy markets (UWEM) would further increase the profit for the actors through the elimination of intermediaries, and help improve consumer access to better charcoal quality, help buffer shocks from fuel price changes and facilitate a stable supply.

New sites for storage and sale of wood energy could be developed at the points of sale of improved cookstoves or Energy shops to be set up by the PASF program. Such a "Clean Energy Center" (CEC) would combine the sale of "green charcoal" with the modern cooking technologies.

The setting-up of UWEM ensures a stable supply of domestic fuels in case of shortage and controls the socioeconomic impacts if price increases, which contributes to **strengthening adaptive capacity.**
tween actors of the sector is **synonymous with high adaptive capacity**.

Setting up and developing rural markets is in three stages (described in Annex 2), and requires close collaboration between foresters, administrators of natural forests, loggers, transporters and relevant public authorities (forest administration and local authorities).

Support the marketing of green field wood energy products

This would require setting up a specific label referring to the quality and legality of products sold by RWEMs.

<u>Develop an information system for the wood energy market</u>

TO ensure the modernized wood energy value chain does further marginalize the small producers/loggers or traders of wood energy who are not organized, it will be important to ensure all actors have access to needed information about the value chain. An information and communication system in the value chain between stakeholders can facilitate this. This market transparency should contribute to a reorganization promoting complementarity between the different economic stakeholders involved in the value chain.

An information system will enable to improve market transparency for the benefit of stakeholders in the value chain and to monitor the markets and provide insights for public policy makers, which makes the stakeholders of the value chain better **equipped for adaptation.**

Timely diffusion of information adapted to the needs of private actors (David -Benz et al., 2012):

- Improved market efficiency through the intensification of arbitration and competition, reduction of transaction costs and a better allocation of resources, should result in a reduction of the price differences between the producer and consumers and in a better integration of markets;
- Improved equity by reducing information asymmetries, especially between traders and producers, which would result in a better return for producers;
- Stimulation of rural development through better functioning of the market.

Drawing on experiences from other parts of Africa, like Rwanda, a market information system (MIS) for the wood energy value chain in Burkina Faso would focus primarily on flows, quantities and prices of wood energy. This would allow a more effective management of the value chain connecting the various links of the value chain from production to consumption including transportation and marketing. The future WE-MIS could, for example, collect updated information on rural and urban markets. Occasional investigators or RWEM/ UWEM managers would collect information on prices and quantities of stored wood energy and would send this information via SMS to a server. The latter would then be accessible to customers or to those who request the information via text messaging.

<u>Facilitate access to micro-credit for transporters and traders</u>

To purchase equipment and materials for the working capital of RWEM s and UWEM s, and for the renewal of transporters' fleet, it would be necessary to facilitate the relationship of future producer groups and RWEM/ UWEM managers with micro-credit institutions. This connection must be preceded by training sessions in simplified accounting.

Access to funding is a key factor for the adaptive capacity of stakeholders.

<u>Improve use of wood energy</u>

Overview of avenues of intervention related to the operation chain

The medium-term impact of actions in saving wood energy can be ensured with improved cookstoves and effective ways to distribute them in rural and urban areas. This will also have significant health benefits. Priority interventions related to improving efficiency in the use of wood energy will be as follows (see Table 13).

Table 13 Overview of priority actions related to the use of wood energy

Priority interventions
• Optimize models of improved household cookstoves and test innovative combustion techniques; • Train or retrain producers and professionalize the marketing of cookstoves; • Distribute improved cookstoves in urban and rural areas; • Facilitate the use of alternative energies.

Optimize types of improved household cookstoves and test innovative combustion techniques

It is proposed to support the optimization of improved cookstoves at three-levels:

- Improved charcoal cookstoves: It is proposed to develop a type of improved charcoal cookstove. In this context it is highly desirable not to reinvent the wheel, but to rely on existing experiences (see Annex 2 for more details).
- Improved wood cookstoves: Here it is not about developing new types of improved cookstoves, but rather about improving the existing models in Burkina Faso.
- Improved wood oven/cookstoves specifically adapted to the needs of large consumers: The development of types of improved cookstoves large capacity wood ovens/stoves for professional consumers should be revived.

In addition, it would be worthwhile to test innovative combustion techniques and the feasibility of using wood "chips" (pieces of shredded wood) in this type of cookstove.

> The introduction of more efficient combustion techniques helps to reduce demand and therefore the pressure on wood resources (**sensitivity)**
>
> At the same time, these technologies with high yield also contribute to the **reduction of CO_2 emissions**.

Train and retrain producers and professionalize the marketing of cookstoves

In order to achieve a maximum usage rate of improved cookstoves, it would be necessary to provide extensive training to improved cookstove producers. This includes training farmers to produce quality products and sell them at prices which are affordable for customers, while leaving a profit margin for the producer. All stakeholders need to benefit from the value chain for its permanence.

The failure of previous improved cookstove initiatives underscores the importance of maintaining the quality of the improved cookstoves to foster their use.

In this context it is also advisable to define quality standards for existing IC and the setting up of a system for monitoring compliance with these standards. The decision on standards should involve both the research community (e.g., through national research institutes such as the Institute for Research in Applied Sciences and Technologies (IRSAT)) and involve the producer groups.

> The organizational development of producers and traders of improved cookstoves and their technical, financial and management capacity building, **increases their adaptive capacity.**

Support/advice for the organizational development of these groups or producer associations will in particular be related to capacity building in negotiation and protection of their interests. Such an association could act as interlocutor with government authorities or research institutes, and in the ideal case, organize its own implementation of systematic quality control of improved cookstoves amongst its members.

Spread improved cookstoves in urban and rural areas

A mass distribution strategy of improved cookstoves in urban areas should include the implementation and securing of the cookstove production system depending on the model selected. Based on the observation that 77% of the population live in rural areas and consume about 4,000,000 m^3 of wood annually, it is a reasonable proposition to reduce consumption in rural areas through the distribution of improved cookstoves. This distribution can begin in peri-urban and rural areas where households already buy their fuel, i.e. areas showing a shortfall in wood energy. A second priority area will involve the neighboring villages on managed forest areas where logging and production of charcoal are carried out. Public awareness about the issue of fuel economy could be carried out in parallel, or at village activities on participatory management of forest resources.

Spreading use of improved cookstoves can reduce demand and therefore the pressure on wood resources **(sensitivity).** At the same time, these technologies with high yield also contribute to the **reduction of CO_2 emissions**.

The implementation of a commercial strategy and the mass distribution of improved cookstoves will be based on an awareness campaign that captures the benefits and modern nature of the stoves. There would also be campaigns would also build understanding regarding proper use; the objective being to accelerate adoption.

Facilitate the use of alternative energy

Awareness campaigns contribute to give fuelwood consumers access to information and thus their **adaptive capacity**.

In the immediate to medium term, enhancing the resilience of the energy sector requires solutions that reduce the vulnerability of the wood energy value chain. A resilient energy sector of the future, however, will need to be based on a mixture of several types of energy. It, however, is currently unlikely that these alternative fuels can play a major role in a medium term substitution strategy due to uncertainties about the results of actions to be undertaken.

Regardless, pilots should be undertaken to assess the feasibility, social acceptability and economic viability of alternatives for a diversification of household fuels.

The use of substitute energy works with a diversification of fuel sources, which makes the sub sector **less sensitive**.

Diversification of supply in alternative fuels faces several obstacles. These constraints to the penetration of a new fuel in the practices of households can be technical, socio-cultural, about tariffs (pricing), informational, and so on.

To increase the weight of LPG in the future energy mix, it would be desirable to establish an offensive strategy based on the following elements:

- Provide a positive information campaign on LPG and its use;
- Communicate and promote possible LPG savings when using this fuel;
- Ensure necessary climate resilient storage is in place;
- Improve supply conditions of the current market and develop conditions for greater penetration of the gas in areas where it is currently used in a minority way (multiplication of points of sales particularly in peri-urban areas);

Improve framework conditions

Overview of avenues of intervention related to framework conditions

Formalizing the wood energy value chain must be part of a comprehensive approach which intervenes and optimizes the entire value chain. Indeed, this includes some development in framework conditions. Table 14 summarizes the priority interventions to achieve this result.

Table 14 Overview of avenues of intervention related to framework conditions

Priority interventions
• Support the forest administration in the implementation of differential taxation of wood; • Contribute to the adaptation of the regulatory and fiscal framework for the emergence of RWEM and UWEM by the implementation of tax incentives; • Support the setting up of an effective monitoring system in the region; • Set up a tracking system; • Facilitate the decentralization of the control system through the integration of local authorities and local stakeholders of the value chain; • Include the modernization of the wood energy value chain in regional planning; • Promote the creation of a wood energy Unit; • Develop regional wood energy supply directives; • Set up an information system on the wood energy value chain; • Regularly disseminate up to date information on the value chain.

Set up a differential taxation system

One of the preconditions to reach the target of formalization and modernization of the wood energy value chain is about developing legal, fiscal, and administrative mechanisms which incentivize, strengthen and support the sustainable and efficient management of resources, reforestation for economic purposes and any legal activity.

Incentives make implementation of regulations (at national, regional and local level) easier, and together with recognition of achievements, and assistance to manage plantations and natural forests in a sustainable manner, will discouraging illegal logging. Incentives need to be reinforced with control and repression mechanisms focused on illegal logging.

Favorable framework conditions (regulations, institutions etc.) are a key factor for the sustainable management of forest ecosystems and, therefore, **sensitivity**.

Wood is an undervalued good. At current logging costs, prices do not provide the incentive for sustainable forest management. The gradual degradation of forest resources leads to a liquidation of “natural resource” capital. This process is not desirable from both an economic point of view and from the development policy angle. The rural population is thus robbed of their ability to be self-sufficient in forest products and to make some income. The communities suffer from the ecological consequences of forest destruction (erosion, loss of soil fertility, degradation of water resources, and loss of biodiversity).

The introduction of differential taxation system penalizes and discourages anarchic and uncontrolled logging and therefore **decreases sensitivity**.

The lack of a legal framework for regulatory policy in the market enables such a situation to arise. A corrective measure would be to consider policies that are based on the 'polluter pays' principle. In the context of formalizing the wood energy value chain, it appears essential to introduce such a system of differential taxation that penalizes and discourages uncontrolled exploitation.

From the point of view of ecology and forest policy, the objective should be the establishment of a market price for wood energy that would cover all expenses for an efficient and sustainable forestry economy. Obviously, this objective can only be achieved if the State defines a proper framework for action suitable for economic actors, by implementing regulatory instruments. Annex 9 explains the principle of differential taxation based on an example.

If sustainable production systems become profitable, people are encouraged to invest in forest management. These economic incentives and the availability of financial resources represent a kind of **adaptive capacity**.

Differential taxation causes wood energy price increases. A risk is that the poor and vulnerable are negatively affected. Complementing the tax system should be the introduction of regulatory or compensatory measures such as the use of improved cookstoves.

The differential taxation causes price increases of wood energy accentuating the **sensitivity of consumers**, especially the poorest. The introduction of regulatory or compensatory measures, such as the distribution of improved cookstoves, serves to **reduce the difficulty**.

The addition revenues generated from the tax should finance the control system and needed technical assistance of sustainable forest production systems and effective processing techniques, strengthening decentralized forest control.

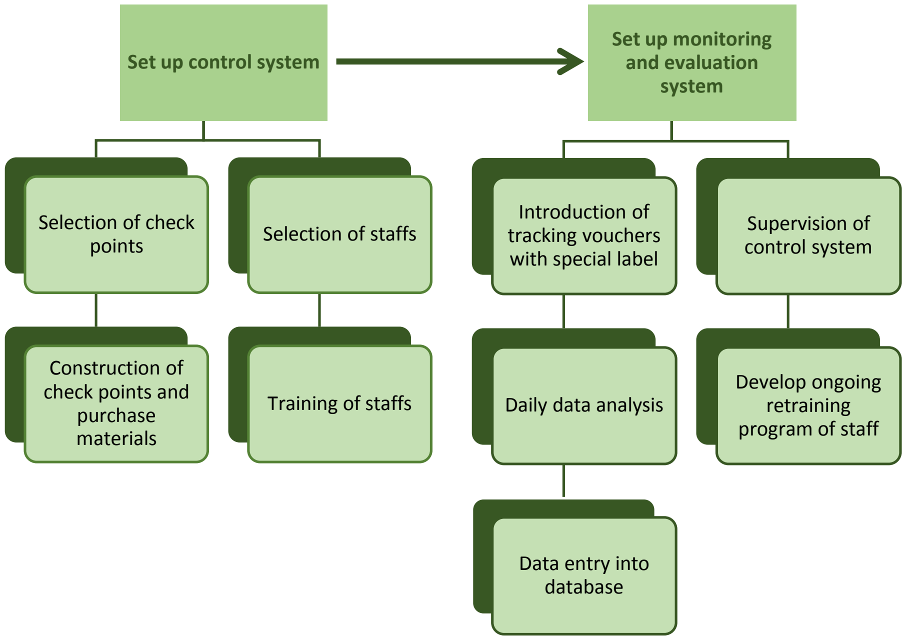
The availability of additional revenues from the differential taxation makes the sub-sector **more able to adapt to change** (climate).

Strengthen the effectiveness of the forest control system

The setting up of a control system must be considered an integral part of the general concept of the value chain approach. The control system would allow for the collection of taxes on wood energy, measurement of the flow of wood and charcoal into urban centers, providing statistical information on the geographical origin of the goods (see section 0 in Annex 2 (look at numbering). The system strictly speaking requires in particular (1) the selection and management of check points, (2) the setting up of mobile control units for spot checking in remote areas (3) the selection and purchase of the necessary equipment (e.g. means of transport and communication), (4) compulsory and transparent agreement between the authorities on spatial and physical assets, accountability in the implementation and the power of intervention, setting up formal regulations upon this basis, and finally (5) the selection of staff and training.

The creation of a control system, supported by the setting up of a monitoring and evaluation system, reduces pressure on forest ecosystems (**reduced sensitivity**).

This control system should be supported by the implementation of a monitoring and evaluation system to ensure the effectiveness of the forest control (see Figure 14). A tracking system, using vouchers with preprinted values, would be important a reducing fraud and corruption in the system. There are opportunities to follow models that have worked in other parts of Africa. In parallel with the implementation of the forest control system itself, it is advisable to develop a monitoring system on the activities of control agents which would allow regular use of the data collected.



Source *Ibrahim, 2001*

Figure 14 Diagram for the implementation of a forest control system at national level

Many of the international certification and chain of custody tracking systems are likely to be difficult to apply in Burkina Faso, considering the number of small actors in the wood energy value chain. For the context in Burkina Faso, the tracking system would emphasize monitoring and follow-up over compliance with environmental and social standards. (Annex 2 contains additional details on how this could be done)

Empowerment of local communities for forest control and respective strengthening of their technical, organizational and financial skills **increases adaptive capacity** in the sub-sector.

To ensure the setting up of an effective control system, it is important to involve the participation and accountability of management bodies within the overall control concept. This would include engagement in the upstream control carried out at the local level, control during transportation, and control of wood energy at points of sale, especially around RWEMs/UWEMs and around major roads of wood energy traffic.

Capacity development of local planning in general, and the integration of energy issues and climate change adaptation into development planning in particular, adds to the stakeholders' **adaptive capacity**.

Facilitate planning, monitoring and dissemination of best practices

As part of the new socio-political approach marked by the decentralization process and sustainable development, Law No. 055-2004/AN December 21 and Law No. 065-2009/AN of 21 December on the general code, the authorities in Burkina Faso are to provide to urban areas, to rural districts, as well as to regions, the power to develop and implement policies and development plans in accordance with broad guidelines of the State. To fulfill accelerate the transfer of power and capacity, the MEDD, interdepartmental operational and extension committee for the transfer of skills and local authorities, must prepare the needed text to facilitate the transfer.

Setting up of national and regional coordination committees' strengthens collaboration between stakeholders of the sector in line with **strong adaptive capacity**.

Promote the creation of a national wood energy unit

To overcome the constraints resulting from the lack of synergy between actors of the sector and within the administration (in particular MEDD, MMCE) a coordinating committee is needed to better direct, validate and coordinate development actions planned for the wood energy value chain. The committee should operate at two levels: (i) national and (ii) regional.

Develop regional supply programs in wood energy

All scheduled activities around different stages of the value chain should gradually contribute to a rebalancing of the national balance supply/demand in wood energy. Given the concentrated demand in urban areas, the Regional Urban Supply Programmes in wood energy (RUSPWE) developed over the 1990s should be updated to prioritize areas to develop and more precisely target local and economic actors involved in the supply chains of the cities. The new national forest inventory data will be important and the priority should be on the urban areas with high demand

Regional wood energy supply programmes enable coherent planning in wood energy supply, a key factor influencing **adaptive capacity** in the sub-sector.

Monitor the wood energy value chain

Spatial and non-spatial Information on the wood energy value chain (WEVC) is available in a fragmented manner. Modernization of the wood energy sector requires information for each link in the value chain. In this context, the setting up of a single information system should be considered. The system would service the following objectives:

- The structuring, organization and concentration of quantitative and qualitative information on the WEVC available at the country level;
- Standardized and automated analysis of data relating to the WEVC;
- Information on stakeholders involved in the implementing a modern wood energy sector

An information system will enable proper management and capitalization of data and information, basic conditions for planning, monitoring and evaluation. Access to information is a key element of **actors' adaptive capacity.**

The design of the structure of the database for the capture and analysis of data on the wood energy chain value, this information must be integrated into the system of other actors. Accordingly, the Forest Department and the Economy, Environment and Statistics Directorate will all need to be engaged. The database modules will be designed for application throughout the Burkinabe territory. And a standard methodology for collecting relevant data for each ecogeographic region will need to be operationalized.

An ecological monitoring system will provide relevant data and information on the environmental and socioeconomic impacts of sustainable management of forest resources. Access to information is a key element of the **adaptive capacity of stakeholders**.

Ecological monitoring should be part of the monitoring system as it provides information on the evolution of forest formations in the country in time and space, both in terms of global vegetation physiognomy and the potential in forest products and natural regeneration capacity of the species. Building on past efforts that were unsuccessful, a simple and standardized ecological monitoring system with a political dimension (showing investment opportunities) may be able to generate results. There are existing ecological monitoring systems that should be reviewed and ideally brought together or adapted to meet the purpose of the wood energy subsector.

Analysis or periodic measurement and systematic indicators will provide the basis for monitoring changes and trends of these indicators, and finally for the progress developed in the sustainability of various functions provided by forests.

Regularly disseminate information on the value chain

A well-functioning monitoring system of the value chain will provide a significant boost to efforts to disseminate information to stakeholders. Good examples of wood energy management, their economic impacts and environmental benefits could be widely disseminated and promoted through the monitoring system. The information collected by the monitoring system could help to guide efforts to support industry actors with the latest technical information. The system should have the data to help generate maps, visual aids, interactive “atlas summarizing available information on the wood energy value chain, and more. Analysis of the data and experiences can also help generate a portfolio of “best practices” on the formalization of wood energy value chains. The latter in turn would support for the dissemination and development of the “national wood energy model strategy”.

Dissemination of information, best practices and lessons learnt will help to strengthen the **adaptive capacity** of stakeholders in

6.2. A strategy focusing on butane gas

This strategic alternative option of the sub-sector plans to expand LPG supply, with the aim to cover 40% of the rural households energy needs from wood energy and 70% of the urban households needs.

The price of gas for sale will be subsidized in order to encourage increasing penetration among households and professionals.

It is a question of maintaining the progress of gas fuel in cooking practices as the main domestic fuel in all areas already conquered and facilitating the transition to butane gas in other cities and in rural areas. In this context, it is appropriate to maintain an attractive selling price of gas compared to other domestic fuels.

To maintain achievements in gas penetration in the energy practices of households, attendant measures to consumers are necessary (PREDAS, 2008).

In this perspective, the strategy includes the following intervention avenues:

- Implementation of technical studies to develop a labeling system of combustion equipment;
- Implementation of market research: development potential, volumes of corresponding storage capacities, storage and bottling facilities, packaging, extension or reinforcement of distribution networks;
- Design and implementation of communication and awareness campaigns on the use of the product and its positive impacts (environment, health) and best practices (energy savings, safety), especially in rural and peri-urban areas;
- Support for private operators to promote investment in storage, packaging and distribution: incentives (tax systems and prices) for the development of new storage and filling facilities with improvement of distribution networks.

7. Assessment of adaptation strategies

7.1. Action Plan for the period 2014-2018 for the modernization of the wood energy value chain

The action plan proposed for the period 2014 - 2018 aims enhancing resilience of the wood energy value chain to climate change. Details of the steps to doing this through the modernization of the wood energy value chain are tabulated in Annex 6.

The action plan takes into account the available human resources and the planning carried out by ongoing projects/programs. The action plan for the modernization of the wood energy value chain is aiming for the period 2014-2018, to put under management a total area of approximately 805,000 hectares of forest. In addition, it is planned to create 38,000 ha of plantations, as well as the protection of 260,000 ha. The program includes the beginning of the distribution of improved cookstoves on a large-scale (390,000 cookstoves) and promotion of the use of butane gas to 160,000 households. As an additional measure, it is scheduled to enhance the installation of biogas units. At the same time, the modernization of the wood energy sub-sector expects the setting up of an effective control system coupled with a tracking system and a system of monitoring and evaluation. These technological developments will be supported by training and retraining programs, as well as investments particularly in infrastructure and equipment.

Table 15 summarizes the costs of the different intervention measures for modernizing the wood-energy sub-sector in Burkina Faso for the period 2014-2018. Figure 24 shows the distribution of costs per category.

The total cost of the implementation of the action plan reaches 53.07 billion FCFA, equivalent to USD 109.54 million.

Table 15 Implementation costs of the action plan by intervention measure; period 2014 – 2018

Activity	Annual Costs (million FCFA)					
	2014	2015	2016	2017	2018	Total
Line 1: Production of wood energy						
Technical operations	2,309.23	3,777.77	5,390.43	6,397.87	8,179.09	26,054.38
Training/Recycling	139.11	284.50	423.95	420.35	382.35	1,650.26
Support for investments	18.50	59.50	59.50	59.50	59.50	256.50
Support for functioning	165.34	290.09	377.69	427.89	515.05	1,776.06
Sub-total	2,632.18	4,411.86	6,251.57	7,305.60	9,135.99	29,737.20
Line 2: Logging and processing of wood energy						
Technical operations	0.00	40.74	38.64	51.89	4.00	135.26
Training/retraining	37.87	108.44	193.46	218.80	220.82	779.39
Support for investments	25.33	69.88	137.28	144.07	143.22	519.78
Support for functioning	12.35	29.33	36.84	39.11	36.78	154.41

Activity	Annual Costs (million FCFA)					
	2014	2015	2016	2017	2018	Total
Sub-total	75.54	248.39	406.22	453.87	404.82	1,588.84
Line 3: Transport and marketing of wood energy						
Technical operations	2.00	233.32	375.21	589.77	587.94	1,788.24
Training/retraining	0.00	16.75	28.75	41.25	37.25	124.00
Support for investments	0.00	91.84	188.60	277.98	275.52	833.94
Support to functioning	7.98	65.82	98.19	127.30	120.32	419.60
Sub-total	9.98	407.73	690.76	1,036.30	1,021.03	3.165.79
Line 4: Use of wood energy						
Technical achievements	514,75	1.023,98	1.564,77	1.905,20	1.882,25	6.890,96
Training/retraining	38,88	52,64	60,23	78,17	77,42	307,32
Support for investments	330,88	435,44	502,81	662,06	658,94	2.590,13
Support for functioning	53,41	111,20	133,38	154,09	149,31	601,38
Sub-total	937,93	1.623,25	2.261,18	2.799,52	2.767,91	10.389,79
Line 5: Specific Conditions						
Technical operations	22,17	265,31	284,78	301,77	365,68	1.239,72
Training/retraining	7,71	87,53	175,30	148,28	84,00	502,82
Support for investments	6,20	433,62	406,06	406,06	0,00	1.251,94
Support for functioning	392,90	827,94	1.146,74	1.353,67	1.472,79	5.194,04
Sub-total	428.99	1,614.40	2,012.89	2,209.78	1,922.47	8,188.53
Total	4,084.61	8,305.62	11,622.62	13,805.08	15,252.21	53,070.15

The costs of technical operations amount to 36.11 billion FCFA (68%, USD74.54 million) and training costs to 3.36 billion FCFA (6%, USD 6.95 million). For the funding of facilities and small equipment, the action plan provides for investments in the order of 5.45 billion FCFA (10%, USD8.31 million). Operating costs, including monitoring and evaluation for the implementation of the action plan, amounts to 8.15 billion FCFA (16%, USD16.81 million).

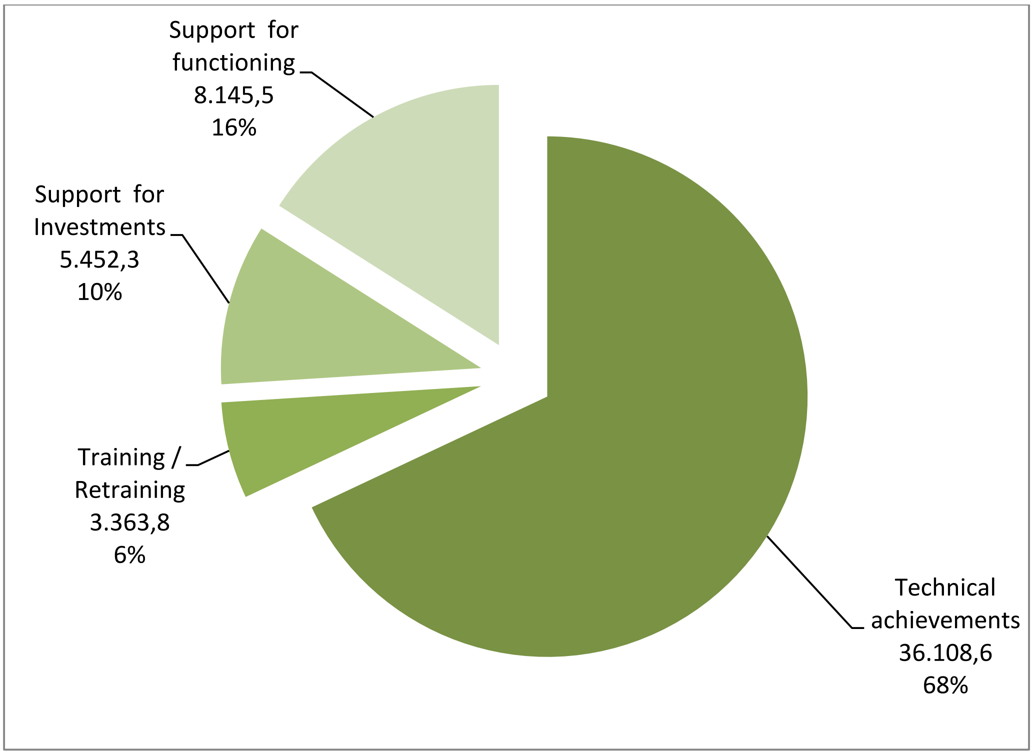


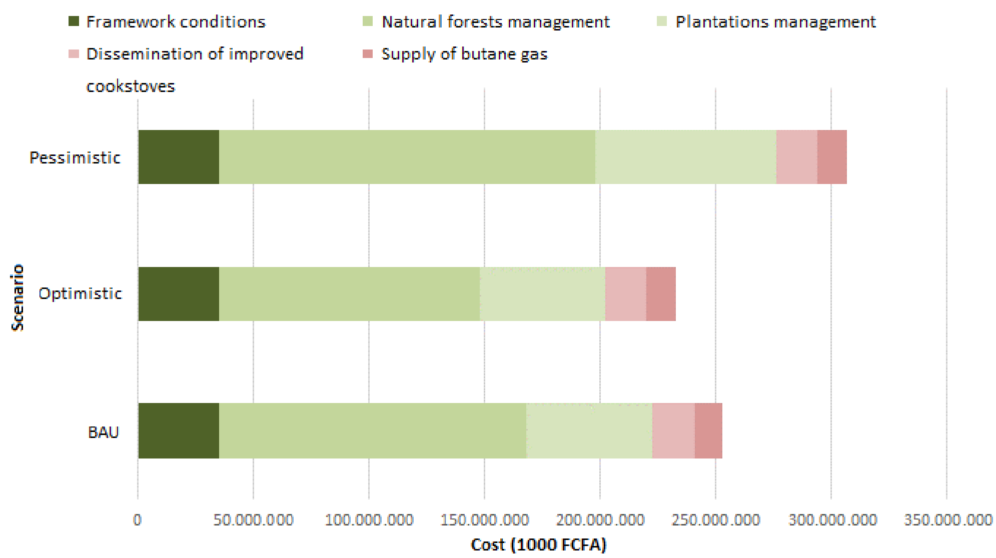
Figure 15 Distribution of costs (million FCFA) for the implementation of the action plan per category; period 2014-2018

7.2. Cost of adaptation strategies

The cost analysis of the implementation of the two strategies under the three scenarios (business as usual, optimistic, pessimistic) is based on a simulation model using MS Excel and refers to the period 2013-2030. This period covers the initial stage from 2014 to 2018 and a consecutive stage 2019-2030. Forest area put under management varies between 2.1 and 4.2 million hectares, approximately one third of the wood energy strategy and that of plantations established between 185,000 ha and 270,000 ha depending on the scenario.

Regarding the modernization strategy of the wood energy value chain, total costs in 2030 for its implementation vary between 232.2 billion FCFA in the optimistic scenario and 306.3 billion FCFA for the pessimistic scenario (see Figure 16). Added to average annual costs, investments range between 13.7 and 18 billion FCFA.

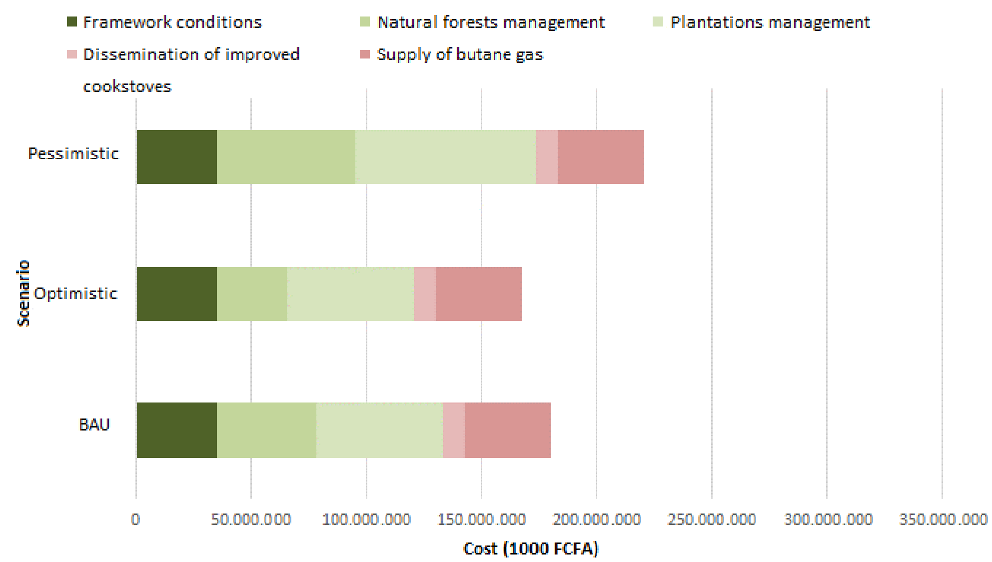
If the investments for the improvement of framework conditions, the dissemination of improved cookstoves (about 1.7 million units) and the promotion of butane gas (about 720,000 households) are assumed constant, the difference is allocated to the forest areas, other woodlands and plantations under management. In the optimistic scenario, the calculations are based on development planning of approximately 7.8 million hectares of forest and 185,000 ha of plantations, while the pessimistic scenario requires intervention on 11.3 million hectares of forests and 266,000 ha of plantations, net of existing quantities (e.g. area under management).



Source *Richter, 2013b*

Figure 16 **Total costs for the implementation of the modernization strategy to the wood energy value chain for three scenarios; period 2013 - 2030**

Regarding the focus on LPG strategy, the simulation is based on the supply of approximately 2.2 million households in butane gas and the distribution of 950,000 improved cookstoves. The total costs are significantly lower than those of the modernization strategy and range from around 170 billion FCFA to 220 billion FCFA (see Figure 23). The total annual costs of the pessimistic scenario are lower than the optimistic scenario for the wood energy dominant strategy. These costs, however, do not reflect the costs associated with enhancing the resilience of the hydrocarbon storage infrastructure, or risks associated with climate related risks of the transportation and port infrastructure in other countries.



Source *Richter, 2013b*

Figure 17 **Total costs for the implementation of the butane gas strategy for three scenarios; period 2013 – 2030**

It should be noted that the financial analysis presented above looks at a particular scale at which modernization of wood energy would occur. Due to data limitations, it was difficult to identify the optimal blend of the EBA strategy (involving modernizing the wood energy value chain) and the use of an alternative adaptation strategy. The latter would be a useful follow-up analysis because EBAs are often more effective when combined with infrastructure based measures to enhance resilience.

7.3. Rationale for the modernization of the wood energy value chain

Among the main arguments for the ecosystem-based adaptation strategies (EBA) the idea that ecosystems can provide inexpensive protection against some threats from climate change is often mentioned. Approaches based on ecosystems (forest) can complete or replace the most expensive investments on facilities, they are perceived as comparatively profitable and accessible to poor communities (World Bank, 2010; TEEB 2009).

With the available data, the financial analysis presented above does not support the aforementioned premise that EBAs can be beneficial. The financial analysis, however, does not account for the economic benefits that an EBA generates. Using an EBA can provide additional co-benefits through the provision significant mutual economic, social, environmental and cultural benefits (UNFCCC SBSTA - 2011). The production of wood energy can encourage land owners and farmers to better manage woodlands and invest in plantations. The sustainable production of wood energy thus contributes to the preservation of forests and woodlands while maintaining the associated functions such as conservation of soil, protection of biodiversity and landscape, or sequestration of carbon. The production of wood energy is perfect for community management of forests and woodlands and is also part of the current trend of deregulation and privatization of the energy and forestry sectors.

A sustainable production of household fuels can play a dynamic role in rural development and in coherent country planning. Forest resources are available locally and have a high potential for production and decentralized processing. The use of woody fuels encourages transportation over relatively short distances with low environmental risks. Unlike other energy sources requiring more sophisticated technologies, woody fuels generate employment and revenue at the local level, especially for the poorest and most disadvantaged groups and generally these employment opportunities have low barriers of entry.

Woody fuels, and especially charcoal, are multipurpose and represent a high potential for technical innovations in terms of conversion and improved combustion. Most of these technologies are available in the market, while others are still in a development and demonstration stage. They have a potential for major technical innovation (e.g. wood chips, pellets, gasification and liquefaction) depending on the availability of investment capital. Thus strategic interventions, which strive for the promotion of specific conditions, create business opportunities for a wide range of contractors and service providers promoting development and the creation of local revenues.

In addition, domestic woody fuel products contribute sustainably to neutral energy supply in carbon and therefore are a key factor in the implementation of growth strategies with low carbon footprint. Woody fuels produced locally also reduce dependence on limited fossil fuels. Therefore, in addition to gains in efficiency through innovations, promotion of woody fuel offers indirect benefits such as currency savings and reducing the economic dependence of the country. The modernization of the woody fuels sector, and in particular, the introduction of more efficient combustion technologies significantly contribute to a reduction in respiratory problems and even deaths due to internal domestic long-term pollution.

If these non-monetary benefits of the the modernization of the wood energy value chain could be quantified and the risks associated with an LPG strategy accounted for, an economic analysis would likely conclude that the modernization strategy would be well positioned to augment resilience of the sub-sector.

8. Conclusion and Recommendations

Climate change projections till 2030 and 2080 indicate that Burkina Faso will face up to an increase in temperature and rainfall variability, with a degree of uncertainty. Despite the ambiguity in the climate change models, the models indicate that the impact of climate change is compounded by the existing anthropogenic factors that drive land use change. For Burkina Faso, these climate change projections have significant implications for its energy sector because of the heavy reliance on wood energy to meet household energy needs. Addressing these anthropogenic factors in a manner that takes into account potential impacts of climate change, therefore, will be instrumental for enhancing the resilience of the wood energy subsector to climate change.

There are multiple ways for enhancing the resilience of the energy sub-sector that caters to the household energy needs that are met by wood energy. Several approaches could involve the use of alternative or non-wood based energy sources (e.g., solar, butane gas, and so on). Another approach is one that would employ a more EBA approach. EBA uses the ecosystem services of natural systems to reduce the vulnerability of society to climate change across sectors and sub-sectors. The advantage of using the latter is that EBA generates co-benefits both in terms of mitigation and development.

The adoption of an EBA approach would involve working to modernize the wood energy subsector. This is not often perceived as a progressive approach, because wood energy is considered a 'dirty' form of energy. However, given its importance in the daily life of the Burkinabe people, modernization of the wood energy value chain is a key way to reduce the vulnerability of the wood energy subsector.

Building the resilience of the wood energy subsector using an EBA approach is one step towards addressing some of the energy shortfalls faced by Burkina Faso because the approach improves supply and also identifies ways to reduce demand for some household needs. There, however, will be the need to also invest in mainstreamining other alternative energy sources to meet the growing household demand for energy that wood energy aims to cater to. Fully balancing supply and demand for energy will require a more comprehensive analysis of the sector and alternatives than presented in this report. Such efforts must also consider climate change parameters as these will influence the feasibility of adopting alternative energy sources. Additional work in this area examining options would be important for Burkina Faso.

Assuming the Government of Burkina Faso agrees with the analysis presented in this report regarding the medium- and long-term values of adopting an EBA approach for enhancing the resilience to climate change of the wood energy subsector, this final section provides some guidance on how to implement the strategy and how development partners could work with the Government to achieve modernization of the wood energy subsector.

8.1. Recommendations for implementation of the modernization strategy

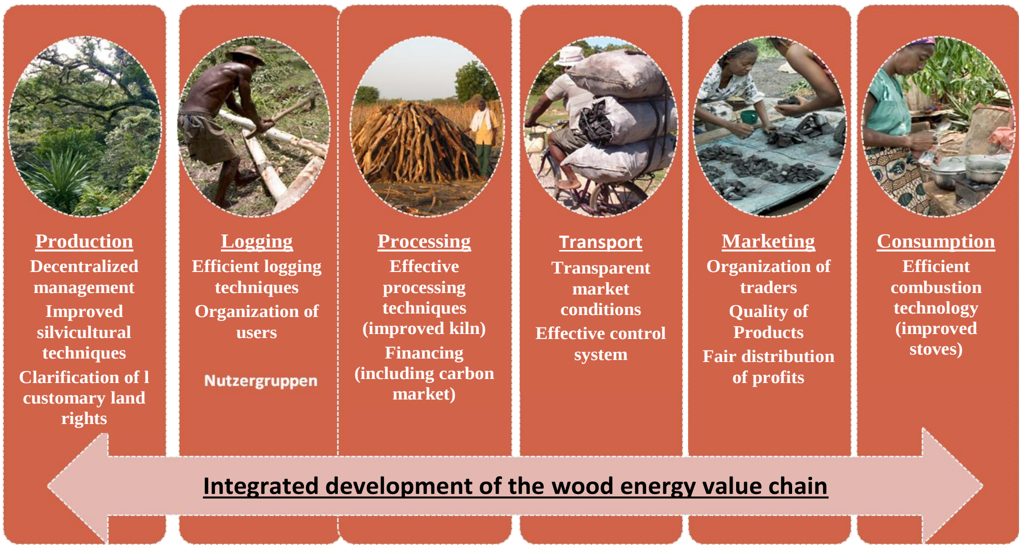
Modernization of the wood energy value chain implies preconditions including the revision of targets in household energy. Indeed, until now, all policies and strategies rather referred to progressive substitution of woody fuels by other sources, primarily butane gas.

Additional information is needed to illustrate to all relevant stakeholders in government about the benefits of the wood energy value chain in terms of efficiency, employment and country planning for increased resilience in the wood energy sector, especially when levels of dependence on wood energy are high. It will also be important to encourage them to review their policies and strategies in the direction of promoting a combination of different energies. Therefore, it would be desirable to develop a political dialogue with key representatives at national and regional level on the potential benefits of modernization of the wood energy value chain. Some of the issues to consider in discussions are as follows:

- Strengthening advice and support;
- Creating incentives;
- Improving the efficiency of the implementation of the modernization of the wood energy sub-sector through coordination with other initiatives and networks related to energy;
- Increased information exchange between actors;
- The incentive to react in time faced with new knowledge and developments.

Value chain approach

The “value chain” approach is proposed as the approach for operationalizing the modernization of the wood energy subsector and improving resilience of the energy sector to climate change. The value chain approach (see Figure 18) is about considering all links of the wood energy value chain, from production through processing, marketing to the use and the improvement of relevant framework conditions. Consideration and support for all links of the wood energy value chain are basic conditions for the informal sector (traditional) to go through a transition stage to a modern formal sector and thus becomes a driving force behind rural economic development at national and regional level.



Source *Sepp & Sepp, 2008*

Figure 18 Diagram of the approach wood energy value chain

Test of innovative technologies

Significant technical support will be absolutely necessary to disseminate technologies that are more efficient and cleaner for the environment. The chosen methodological approach provides testing technologies or more effective tools in one stage, to learn from the implementation of these tests and disseminate more widely in the next stage, and so on, in a permanent process.

Through support to research, development, production and use of new innovative sustainable energy technologies, this approach gives the country the opportunity to provide, as a place of innovation, a decisive contribution to environmental protection.

Simplification

In terms of techniques and proposed measures as part of the action plan, the approach must be characterized by simplicity and focus on helping local actors master the techniques to ensure continuity in the monitoring of forestry and the wood energy value chain in general.

Subsidiarity

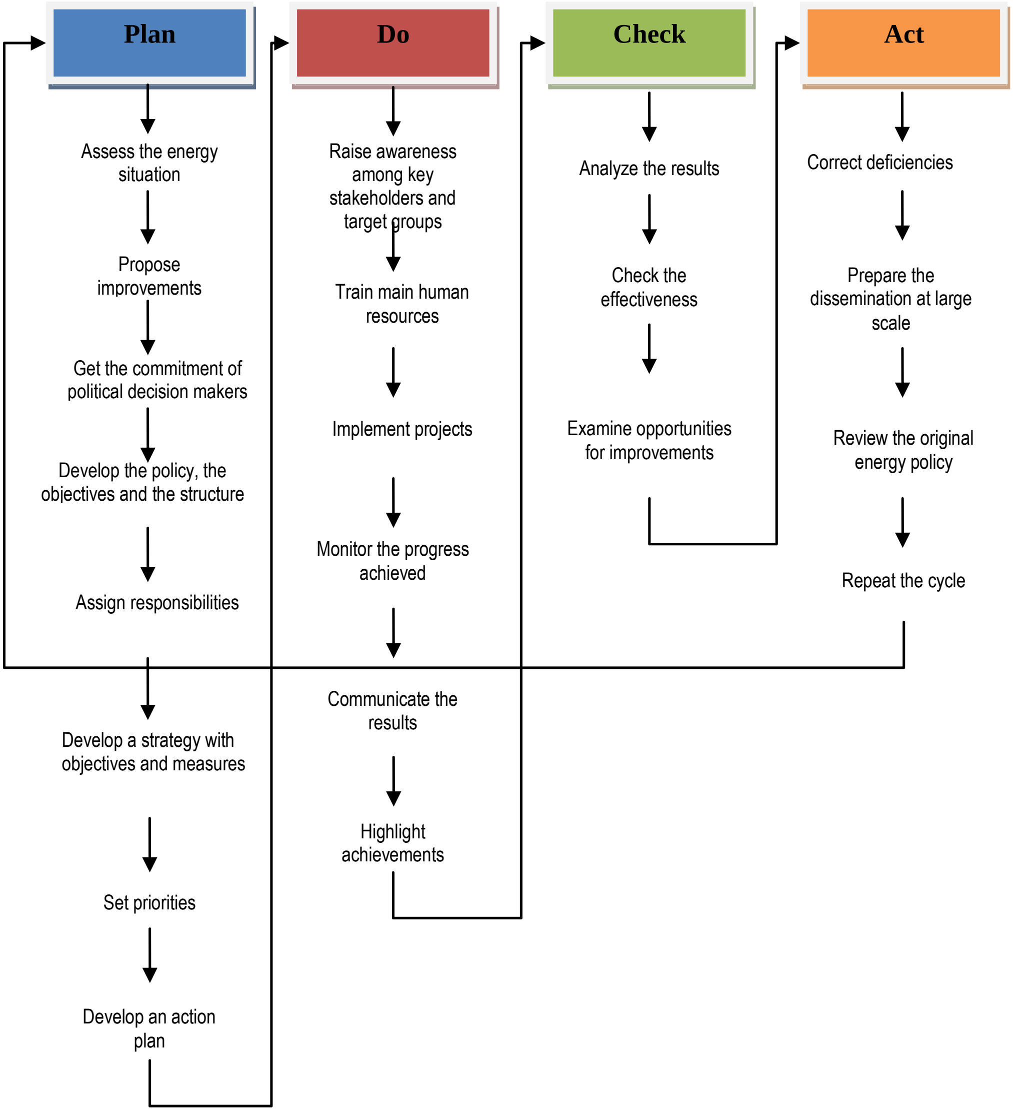
The principle of subsidiarity is a maxim for modernizing the wood energy value chain. It provides that the responsibility of an action (public) is allocated to the smallest entity able to solve the problem independently. This principle ensures the transfer of appropriate decision-making and responsibility powers (administrative, legal, technical and fiscal) and skills of local actors to ensure effective sustainable management of natural resources and support to development.

In this context, one of the concerns of the program will be to focus on the conditions needed to promote, monitor, control and empower actors, rather than forbidding actions. This means reconsidering the role and areas of responsibility of the different actors involved in forest areas and the wood energy value chain.

Continuous monitoring and evaluation of the implementation of the strategy

The implementation of the strategy to facilitate the transition to a modern wood energy value chain is a continuous process with four steps (see Figure 19).

These steps are part of the methodological approach for the implementation of the Strategy. Figure 19 summarizes the activities behind the various stages of the feedback scope.



Source *Richter & Sepp, 2009, as amended*

Figure 19 Continuous monitoring of the action program

Given the evolution of forest policy, energy and climate change and multiple interactions with other policy areas, as well as developments in technology and the market, the implementation of planned activities in this document cannot claim to provide a definitive response to the development of an energy policy in the medium term.

This is the reason why a review at regular intervals - the first could take place in 2017 – must be carried out to decide if an evaluation and adjustment of energy strategy is necessary. External experts as well as national and institution networks will be involved in carrying out the work. The results will be made public.

Organization

The implementation of planned activities involves several actors:

- State: Forest Department, technical services, partners and the General Administration;
- Local authorities;
- Private sector and NGOs;
- Civil society in which lies the population, socio-professionals groups, etc.;
- Agencies/cooperation institutions.

Table 16 specifies the respective roles of actors in the context of the implementation modernization strategy.

Table 16 Roles of actors in the implementation of the modernization of the wood energy sub-sector

<table>
<tr><th colspan="3">Category of actors</th><th>Roles</th></tr>
<tr><td rowspan="3">State and departments in the same category</td><td colspan="2">Forest department</td><td>• Policy and technical direction
• Development of legal and institutional provisions
• Support - advice to actors
• Monitoring - control of interventions
• Arbitration of possible conflicts
• Developing dialogue
• Support to actors’ capacity building
• Capitalization of the results</td></tr>
<tr><td colspan="2">Ministry of Energy</td><td>• Policy and technical direction
• Support - advice to actors
• Developing dialogue
• Support to actors’ capacity building
• Capitalization of the results
• Implementation of the monitoring system for the wood energy value chain</td></tr>
<tr><td>Technical partners departments</td><td>Research structures</td><td>• Improved knowledge of forest resources through research
• Testing of new technologies (cooking, carbonization etc.)
• Dissemination of research outcomes</td></tr>
</table>

Category of actors			Roles
		Other technical partners	• Technical support to actors in their respective areas of expertise • Participation in discussions
	General Administration Departments (Governorates High Commissions, Prefectures)		• Recognition of socio-professional organizations • Settlement of disputes related to the use of forest resources
	Organization in charge of finances and budget administration		• Mobilization of external funding for the implementation of projects • Monitoring - control of the use of allocated funds
	Decentralized local authorities		• Implementation of actions to manage forest resources • Concession of forest management for individual managers or organized communities • Development of partnerships • Taking additional regulatory acts in the management of the forest estate under its supervision • Approval of development and management plans of the protected forest area
Private sector/NGO			• Technical, financial and material support to local communities • Distribution and promotion of forest products • Distribution and promotion of improved cookstoves • Participation in discussions • Capacity building of actors
Civil society (non-political and non-profit organizations)			• Advocacy with the State on issues related to sustainable management of the country's forest resources
Grassroots communities (including social - professionals groups)			• Participation in the design, implementation, monitoring • Voluntary Financial Contribution • Participation in discussions • Creation of Rural and Urban wood energy Markets
Cooperation partners			• Technical and financial support • Capacity building for actors

Source MECV, 2007, amended

It is necessary to coordinate the activities of the different actors. To facilitate dialogue at the national level, the setting up of a Unit of Household Fuels (CCD) is suggested. It could be placed under the supervision of the Ministry in charge of Energy and the Ministry in charge of forest resources. Its role would mainly be consultative and advisory.

For the implementation and monitoring of the modernization of the wood energy sub-sector, it is proposed to set up technical committees in regional planning commissions to ensure coordination and monitoring of different activities.

Private actors and civil society of the value chain should be represented as well. This includes particularly umbrella organizations of producers, transporters and distributors of wood energy. At the same time, partners to multilateral and bilateral cooperation and international NGOs should be observer members of this commission.

8.2 Recommendation regarding potential financing

As it is specified in the Regional Management of Forest Resources Programme 2006 - 2015 MECV (2007), potential financing sources for the implementation of the modernization strategy are:

- The State budget: undertaking salaries of forest agents and functioning of Forest Departments, exemptions from various taxes on acquisitions and national counterpart projects and national programs with forest constituents;
- The budget of the Local Authorities: Local Authorities' own funds devoted to actions related to forest management;
- The Forestry Development Fund (FDF): formed from a levy on the sale of forest products managed by UFG (managed forests) or the Local Authorities (non-managed forests);
- Contributions from grassroots communities: funding negotiated with development partners on the basis of Land Management Plans (PGT), Land Management and Development Plans (PAGT) or Village Development Plans (VDP);
- The private sector and NGOs: compensation for the destruction caused to forest resources during the implementation of some infrastructure projects or exploitation of mineral resources (mining and quarrying, large farms) according to the principle "destroyer – payer", funding the development and management of private forests, supporting the promotion of forest products;
- The Agencies/Cooperation institutions: implementation of actions to support the implementation of the Strategy.

On the side of investment from donors, the Forest Investment Program (FIP) will be an important possibility. As part of the implementation of the FIP, the country has received a grant of USD 30 million from the Strategic Climate Fund: the African Development Bank (ADB) is funding the participatory management project of protected forests (PGFC) for the Reduction of Emissions from Deforestation and Degradation (REDD+) amounting to USD 12 million. The Decentralized Project Management of Forests and Woodlands received financial support of USD 18 million from the World Bank (MEDD, 2012c).

To that may be added USD 4.5 million under support to NGOs and associations for protection of the environment and USD 10.8 million from the European Union (which is channeled through a trust fund that is attached to the World Bank FIP project) for a project to improve climate governance in the forest sector. There also is the Forestry Sector Assistance project funded by Luxembourg and Sweden.

Regarding the funds made available in the resilience to climate change strengthening plan, many organizations are involved in supporting the National Action Programme for Adaptation to Variability and to Climate Change (NAPA):

- GEF/LDCF: project implemented by UNDP on the implementation of silvopastoral best adaptation practices (USD 2.9 million);
- Danish Cooperation: project implemented by WWF focused on capacity building for the civil society in the field of climate change and variability;
- A Japanese cooperation aims to support the integration of climate aspects in regional and local planning (World Bank, 2011a).

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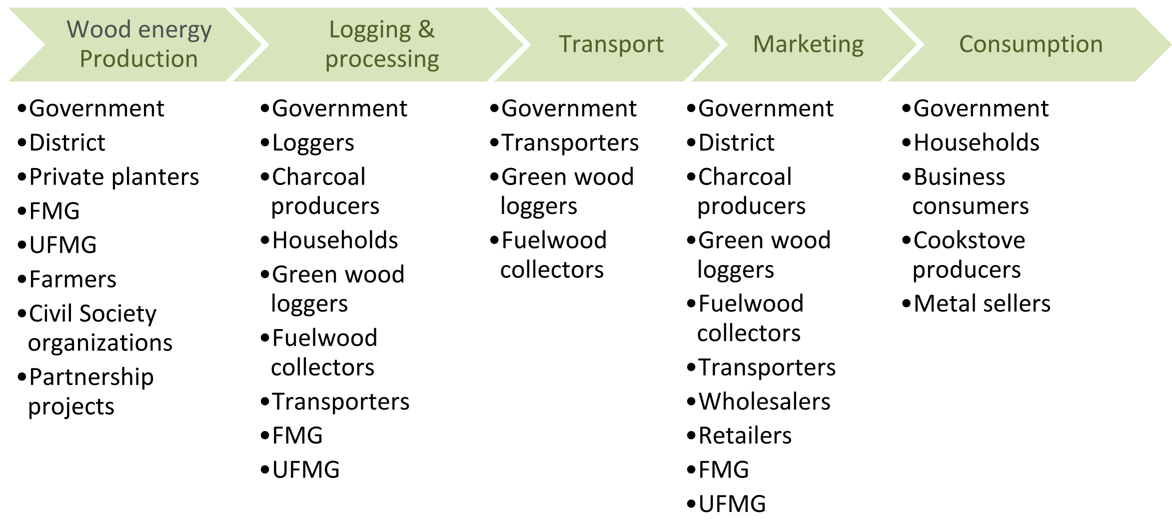
Annex 1: Situation Analysis of the Wood Energy Sub-Sector

A1.1 Overview of the wood energy value chain

As shown in Figure 20, the wood energy sector has a complex structure, with many actors having different interests and different issues which are sometimes, divergent.



Source *IED, 2012; Yameogo, 2005; Energy Department, 2007; APEX 2007; Richter, 2013c*

Figure 20 The base structure of the wood energy value chain in Burkina Faso

The analysis of the wood energy sub-sector in Burkina Faso is based on the value chain approach. Consequently, the presentation of the current situation in the wood energy sector is structured as follows:

- The wood energy production chain;
- The logging and processing chain;
- The transportation and selling chain;
- The consumption chain.

A1.2 Supply – wood energy production

The assessment of wood energy supply is based on the following elements: natural forests; plantations; and trees outside forests (i.e., trees on farms and parklands). These sources of wood are described briefly below including the legal status, available volume of wood, and potential to sequester carbon.

Natural forests

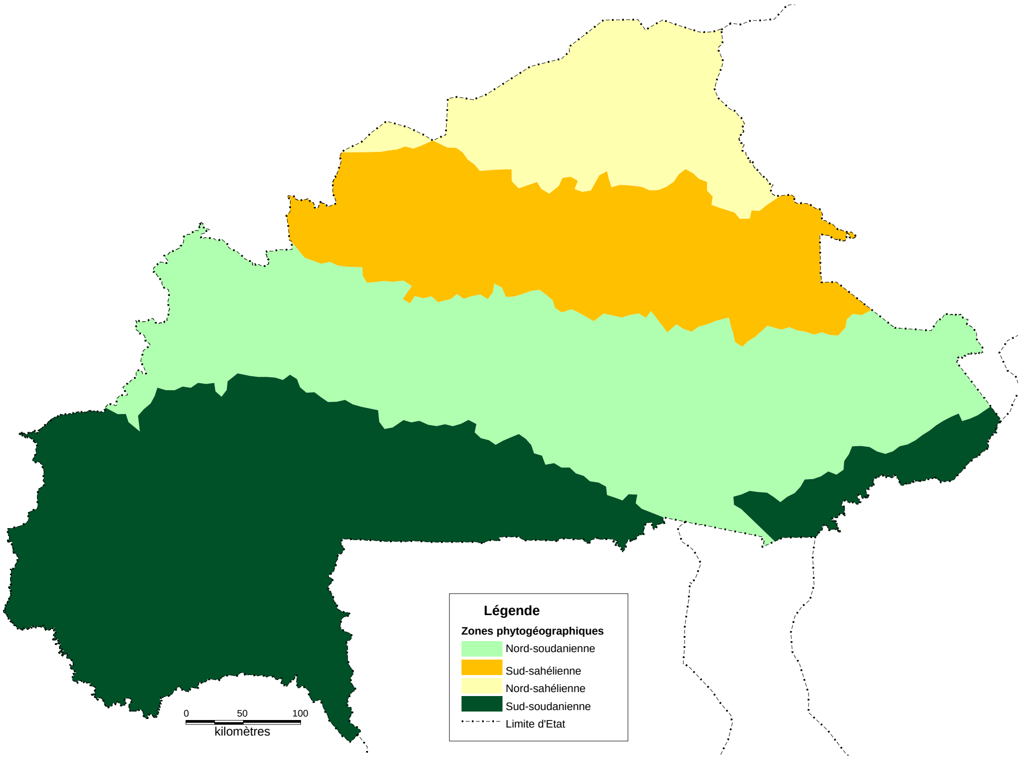
Forest stratification

Burkina Faso consists of two phytogeographic areas: (1) the Sahelian area and (2) the Sudanese area, separated near the 13th parallel north (see Figure 21). A subdivision into sectors and zones is made based on the combination of (1) the weather, (2) the flora and (3) the vegetation (MECV 2009).

Three major types of vegetation are identified (IGN France International, 2005):

- The steppes which are the dominant vegetation in the Sahelian area;
- The savannahs found in the northern Sudanese sector;

- The wooded savannahs and woodlands interspersed with forest galleries located in the southern Sudanese sector.

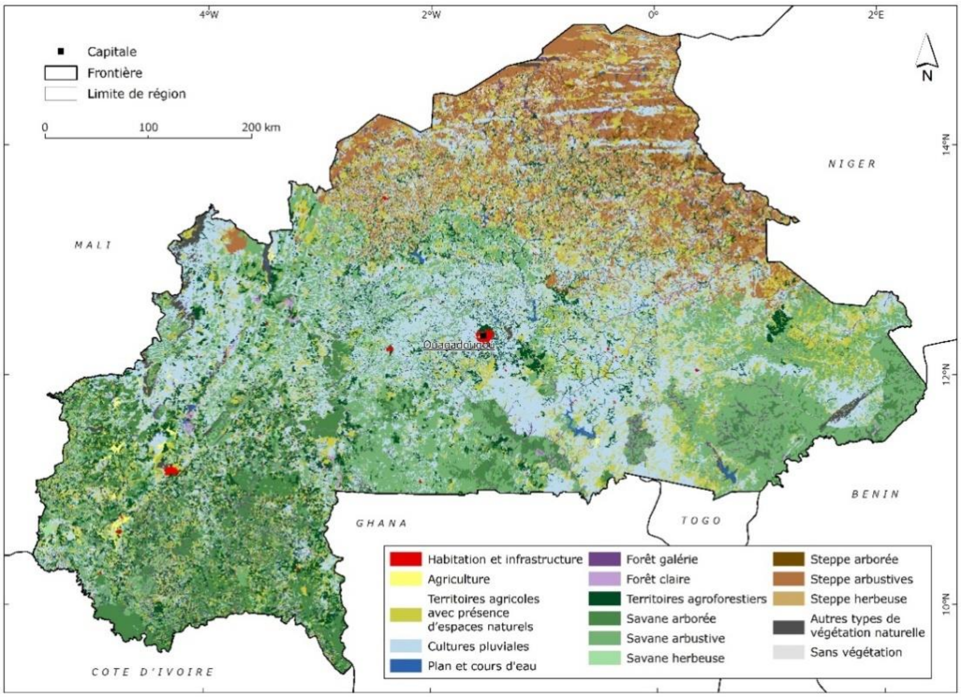


Source *MMCE, 2005*

Figure 21 Burkina Faso's phytogeographic sectors

The southern Sudanese sector is the preferred immigration area for livestock breeders and farmers. The demand for agricultural and pastoral lands leads to uncontrolled forest clearing and contributes to the reduction of forest areas. It is the natural forests, however, that provide the bulk of the production of the various timber and non-timber forest products including wood energy (MECV, 2009).

Under the National Programme for Land Management (PNGT), a diachronic analysis was carried out in 2005 on the basis of satellite images from 1992 and 2002. Figure 22 shows the spatial distribution of forest strata in 2002. In 2002 the total area of forest land was estimated at 13,305,238 hectares (IGN France International, 2005). Based on the regression rate observed between 1992 and 2002, the forest area in 2012 was estimated at 12,200,188 hectares. This was a 8.3% decrease in forest land. At the same time some of this land was converted for agricultural purposes - pluvial crops, agroforestry land and agricultural land with the presence of natural areas.(IGN France International, 2005; Mahrh, 2006 (updated)).



Source *IGN France International, 2005; MAHRH, 2006; ECO Consulting Group, 2013a*

Figure 22 Land Use in Burkina Faso; year 2002

To contribute to a better understanding of the potential of the natural forests, the Ministry in charge of Forests initiated in 2012 a second national forest inventory, but the data are not yet available.

<u>Forest History</u>

The forest area in Burkina Faso was formed from the Decree of 4 July 1935 on the Forest Plan in French West Africa (AOF Governor, 1935). That first forest legislation gave the State the power to control forest resources with commercial value, while products without market value were passed on to indigenous populations (Ribot, 2006).

The application of that decree was extended to the whole of AOF. The decree reaffirms the state ownership of forests and all the forest products that are sold commercially. The decree required the acquisition of felling permits for any business concern and listed a number of protected tree species (Ribot, 2006). The decree of 1935 still remains in force.

Burkina Faso developed and adopted its first forest code in 1997. It is the founding law on forest, wildlife and halieutic resources. The code emphasizes the need to ensure a harmonious relationship between the protection of resources and the satisfaction of the population's socioeconomic and cultural needs. It also defines favorable conditions for the development of forest, wildlife and fisheries sub-sectors, while ensuring the promotion of participatory and sustainable management principles for the resources involved (MEDD, 2012a).

The Forest Code of 1997 was reviewed and replaced by the one of 2011 (The National Assembly, 2011). The priorities are:

- The protection and promotion of forest resources as well as the contribution to production of forest goods and services;
- The preservation of the natural environment, the conservation of biodiversity;
- Mitigation of greenhouse gas emissions;
- Adaptation to climate change, the fight against desertification.

The legal status of forests

With reference to the 2011 Forest Code (The National Assembly, 2011), the administration distinguished public forests and private forests (art. 9 of the Forest Code). Public forests are divided between State ownership (reserved forests, national parks and wildlife reserves) and the heritage of Local Authorities (LA) (art. 15 of the Forest Code). The State guarantees the preservation of forest resources. It carries out this responsibility through the forest technical services, in consultation with all stakeholders involved in the use, exploitation and management of natural resources (art. 5 of the Forest Code). The State, along with local authorities, can delegate the management of forest resources, based on a management plan and a contract of concession with terms of references (National Assembly, 2011).

Law No. 034-2012/AN on the Agrarian and Land Reorganization (ALR) in Burkina Faso is a legislative and regulatory reference covering all permanent natural resources such as soil, or any renewable resources such as forest, water and wildlife (National Assembly, 2012).

State protected areas

Most State forests were protected before the country's independence by the French colonial administration. This State protected forest area occupies 14% of the total land area that is 3,815,000 hectares[26] (Forestry Department, 2007). These areas are mainly located along the major rivers and in the wettest regions[27] of the country. The Central and northern part of the country have few protected areas except the creation of the Sahel silvopastoral and part wildlife reserve that stretches over 1,600,000 hectares.

Particular attention is paid to the protection of wildlife. All wildlife protected areas are listed in **Error! Reference source not found.** (General Directorate for Nature Conservation, 2010). As part of the assessment of wood energy supply, these forest areas (Sahel RPF excluded) will be deducted from the calculation because of the strongly controlled or prohibited forest exploitation in those areas.

Nine out of the thirteen regions in the country contain all the wildlife areas. The Eastern and Sahelian regions have more than 76% of the wildlife reserves in terms of land area. Regions with almost no wildlife areas are Central, Central East, North and Central North (Forestry Department, 2007).

Locally controlled forests

Burkina Faso has experienced a relatively late decentralization process compared to other countries in the sub region. According to Law No. 055-2004/AN of 21 December 2004 on the local authorities general code (National Assembly, 2004a), Burkina Faso has three types of local authorities: the region, the urban commune and the rural commune.

All the forests in the country are owned by local authorities, except those owned by people in the private sector and those which are classified in the name of the State (art. 22 of the Forest Code), i.e. the current reserved forests are protected areas subject to a special restrictive regime affecting the exercise of usage rights and exploitation plans (art. 26 of the Forest Code, National Assembly, 2011).

These local authorities now have the ownership of natural forests located outside the State protected area. These natural forests cover an area of approximately 9,490,238 ha[28] that is about 86% of the

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[26] National Parks 390,000 ha, wildlife reserves 245,000 ha and reserved forests 880,000 ha (Forestry Department, 2007)

[27] The wettest regions are: Hauts – Bassins (15 reserved forests), Cascades (13 reserved forests) and la Boucle du Mouhoun (12 reserved forests).

[28] Area taken from National Forest Areas (13,305,238 ha) from which the State Protected areas (3,815,000 ha) are deducted.

total area. Among the wildlife areas which cover 3,548,371 hectares at national level (MECV 2009), 199,246 ha do not have the status of State protected areas and are being regularized in order to have a clear legal status which could be that of protected forest on behalf of one or several local authorities.

Finally, as provided by the Forest Code (National Assembly, 2011), the State may transfer to a local authority part of its classified area; either as a title deed or as a management arrangement. Thus in 2001, the State granted the management of the Barrage reserved forest (approximately 260 ha) to the Municipality of Ouagadougou. Part of that forest (240 ha) has been built and established as an urban recreation park. The forest now plays an important role in terms of environmental education.

Other management experiments of reserved forests are in progress. This is the case for the Kou reserved forests (117 ha) in the Rural commune of Karangasso-Sambla as well as Dindéresso (8,500 ha), Poa (350 ha) and Koulina (2,150 ha) located in the commune of Bobo-Dioulasso. Forests in Dindéresso and Kou are the only forests in Burkina Faso which have an approved management plan.

Private forests

Owners of private forests may be people or legal entities who have legally acquired or planted them and hold regular title deeds on the land (art. 33 of the Forest Code). To date, there are no natural private forests in Burkina Faso.

Managed forests or forests under management process

Today, the total forest area which is managed or under the management process has reached 888,327 ha (MECV, 2009). Annex shows a list of managed forest areas or those under the management process.

The wood energy potential of natural forests

Based on the model used for this study (Richter, 2013c), the total volume of timber was estimated at 176.5 million cubic meters in 2013.

To calculate the volume that could be exploited in a sustainable way, a rotation of 15 years was applied to natural forests. After taking into consideration a reduction rate of 50% of the standing capital, which includes the protected species, the non-exploitable trees, the accuracy of the sampling, and non-accessible areas and areas to be protected; the potential exploitable volume in Burkina Faso is approximately 5.8 million cubic meters per year (see Table 2). By using a conversion factor of “0.83”, this corresponds to 4.8 million tons of wood.

Table 17 The standing average volume by forest stratum and the exploitable volume in Burkina Faso; year 2013

Stratum	Exploitable area 1) (ha)	Standing volume per ha (m^3/ha)	Standing volume Total (m^3)	Annual exploitable volume 2) (m^3/year)
Gallery forest	741,594	71.12	52,742,178	1,758,073
Sparse forest	24,974	42.25	1,055,134	35,171
Wooded savannah	1,760,563	19.60	34,507,032	1,150,234
Shrubby savannah	4,457,444	14.60	65,078,679	2,169,289
Grassy savannah	199,802	10.30	2,058,402	68,613

Wooded steppe	186,462	8.14	1,517,604	50,587
Shrubby steppe	2,096,405	8.75	18,343,486	611,450
Grassy steppe	1,240,168	0.98	1,221,187	40,706
Total	**10,707,411**	**10.03**	**176,523,702**	**5,884,123**

Source *Forestry Department, 2007; IGN France International, 2005; Charpin & Richter 2013; Mahrh, 2006*

Explications:

1 = area of forest strata minus the area of national parks and wildlife reserves
2 = potentially exploitable volume calculated with: standing volume (m³/ha) * logging rate (50%) / rotation (15 years)

Carbon sequestration in natural forests

In the context of the adaptation of forest ecosystems to climate change and in the context of carbon financing, the FAO methodology (Brown, 1997) was used to calculate the biomass of forest resources in Burkina Faso and the carbon sequestration potential. It is estimated that aerial forest resources make on average 184 tons of CO2 per hectare in biomass. In total, these resources have sequestration potential of 2,043,000 tons of CO2, or about 557 million tons of carbon (Richter, 2013c) (see Annex).

Forest plantations

Status and potential of wood energy plantations

To this estimate of the wood production from natural forests we can add production from the country's forest plantations. The plantations contain mainly species producing timber, fuelwood and fruit trees. Woody plantations are of three types: (1) plantations under state control, (2) communal plantations and (3) private and community micro-plantations (village wood).

The total area of these plantations is estimated at 260,984 ha and the total standing volume at 5,823,410 m³. Considering an average ten-year rotation, the total potential production amounts to 582,341 m³/per year, equivalent to 483,343 tons of wood (see Table 3).

Table 18 Area, standing volume and volume of exploitable plantations in Burkina Faso; year 2013

Stratum	**Area**	**Standing volume**		Annual exploitable volume [1)]
		per ha	**total**	
	(ha)	**(m³/ha)**	**(m³)**	**(m³/an)**
Plantations under state control	151,423	25.0	3,785,575	378,558
Communal plantations	n.d.	7.0	0	0
Private plantations	109,561	18.6	2,037,835	203,783
Total/Average	260,984	16.9	5,823,410	582,341

Source *DirFOR, 2013*

Explanations:

1 = potentially exploitable volume is calculated with: standing volume (m³/ha) / rotation (10 years)

Carbon sequestration from reforestation

In terms of carbon sequestration, reforestation in Burkina Faso would make an average 177.6 tons of CO_2 per hectare in the aerial biomass. In total, these resources have a sequestration potential of 54.6 million tons of CO_2, or about 14.9 million tons of carbon (Richter, 2013c) (see Annex).

Trees outside forests

Typology and potential of trees outside forests for wood energy

The biomass accumulation outside the areas defined as forests play a particular role, especially in the context of rural households' self-sufficiency. Surveys conducted in other African countries have shown that these "trees outside forests" (TOF) can contribute to the energy supply of the rural population by 20% and 35% (Fall, 2011; Jorez, 2013; Jorez et al., 2009).

In the case of Burkina Faso, three features are considered. These are:

- Cultivation areas located in the village lands where the administration has ensured the conservation of at least 35 plants per hectare;
- Agroforestry areas where the tree has been set a yield target. These areas consist mainly of parklands at Karité, Parkia (Néré) or Faidherbia and the combination of pluvial (rainfed) crops and fruit trees (mango trees, citrus fruits, etc.);
- Areas consisting of cultivation fields, natural areas and short fallow periods (<5 years).

Referring to data on land use at the national level, and by specifying an average standing volume for each feature, the total standing volume of trees outside forests is estimated at 99,233,232 m³. By holding a tax rate comparable to that proposed for the natural forests (reduction rate of 50% of the standing resources) and a fifteen-year rotation, the potential volume of wood energy is approximately 3,307,774 cubic meters per year (see Table 4).

Table 19 Assessment of the standing volume and the exploitable volume of trees outside forests; year 2013

Stratum	Area [1)]	**Standing volume**		Annual exploitable volume [2)]
		Per ha	**Total**	
(name)	**(ha)**	**(m³/ha)**	**(m³)**	**(m³/year)**
Pluvial crops	8,682,864	3.5	30,390,025	1,013,001
Agroforestry areas	2,598,310	7.5	19,487,321	649,577
Fields with natural areas	3,602,619	13.7	49,355,885	1,645,196
Total/Average	**14,883,793**	**8.2**	**99,233,232**	**3,307,774**

Source *Kabore, 2005; IGN France International, 2005; Akossongo, 2013*

Explanations:

1 = area of forest stratum minus the area of national parks and wildlife reserves

2 = potentially exploitable volume calculated with: standing volume (m³/ha) * exploitation rate (50%) / rotation (15 years)

Carbon sequestration from trees outside forests

In terms of carbon sequestration, biomass outside areas defined as forests would make an average 123.9 tons of CO_2 per hectare in the aerial biomass. In total, these resources have a potential to sequester 1.6 billion tons of CO_2, or about 450 million tons of carbon (Richter, 2013c) (see Annex).

Regional and cross-border flows of wood energy (import of wood energy)

According to the forestry administration, the importance of wood imports for energy purposes from Burkina Faso's neighboring countries is very marginal. These imports, including charcoal, are estimated at approximately 1,189 tons per year, equivalent to 9,610 m³ of wood[29].

Total supply of wood energy

In total, the potential standing supply of wood energy in Burkina Faso is estimated in our study, at 9.7 million cubic meters per year, equivalent to 8.1 million tons of wood (see Table 5). Considering operating losses of 6.3% on average, the total available volume would be about 9.15 million cubic meters (7.55 million tons). Figure 23 shows the potential of sustainable production by region.

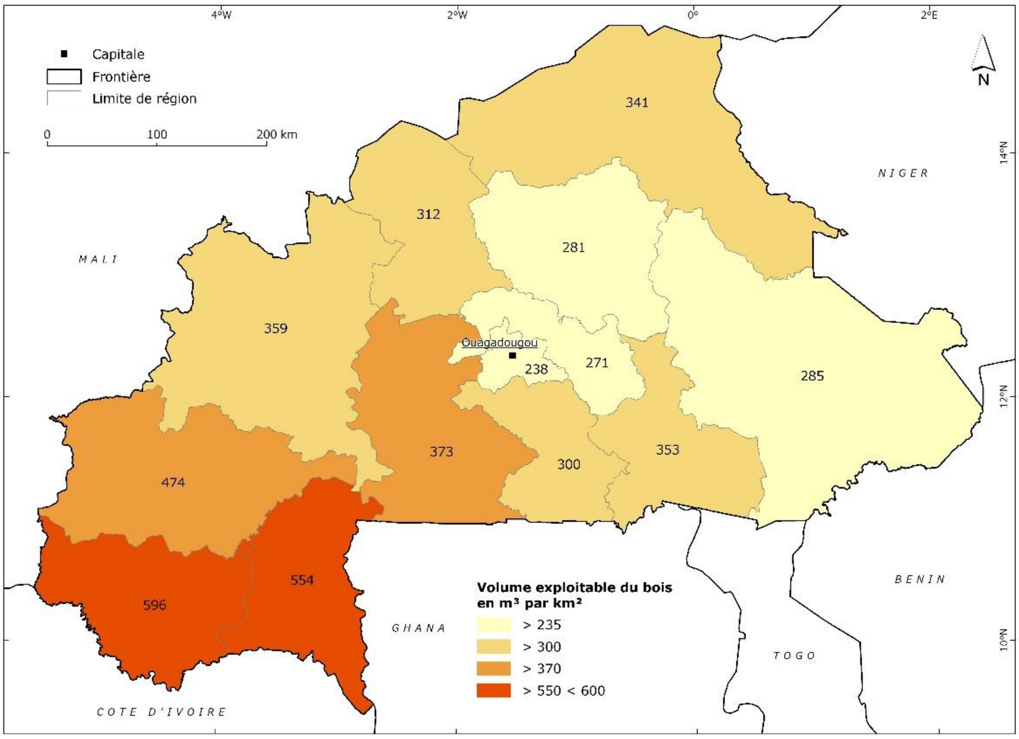
Table 20 Distribution of total supply in wood energy in Burkina Faso; year 2013

Wood energy source	Supply (m³/year)	(t/year)	(%)
Production from natural forests	5,884,123	4,883,822	60
Production from forest plantations	582,341	483,343	6
Trees outside forests	3,307,774	2,745,453	34
Regional flows/imports of wood energy	9,610	7,976	0
Total standing	**9,783,849**	**8,120,594**	**100.0**
Total exploited [1)]	**9,156,709**	**7,554,285**	**93.7**

[29] Calculated: denseness of wood: 0.83 t/m³; Carbonization weight yield: 15%

Explanations:

1 = based on average operating losses of 6.3% of the standing exploitable volume



Source *IGN France International, 2005, updated; ECO Consulting Group, 2013e; Richter, 2013b*

Figure 23 Average exploitable volume by region; year 2013

A1.3 Exploitation and processing of wood energy

Fuelwood production

Based on the decree No. 98 306/PRES/PM/MEF/MCIA, a logger is any person or legal entity who fells, or collects wood and sells it in its natural state or as charcoal. This category of actors consists mainly of local loggers and farmers who make wood exploitation either a seasonal activity or an extra activity to earn additional income. They are sedentary or migrant.

They present the wood in single or double steres in order to make the control and taxation work carried out by Forest agents easier. Usually wood exploitation is carried out between January and April (Apex, 2007).

There are three systems/types of logging:

- The organized and authorized system in the Forest Development Plan (FDP);
- The non-organized but authorized system in protected forests;
- The unorganized and unauthorized system (illegal system).

<u>The organized and authorized system</u>

In managed forests, specifically in Forest Development Plans (FDP) forest actors are organized in Forest Management Groups (FMG), including men and women. The FMG is a voluntary economic and social organization which has legal status and in which members have equal interests. The FMG are regulated by Law No. 014/99/AN of April 1999 on the regulation of cooperative bodies and groups in Burkina Faso (National Assembly, 2004b).

In 2013, the administration listed 400 FMGs which have nearly 12,000 members (Forestry Department, 2012). At the FDP level, FMGs have formed the Forest Management Union (FMU). In 2013, the administration listed nineteen FMUs in Burkina Faso. In 2006, all the country's FMUs formed a federation in Koudougou. Since December 2006, it has been a member of the Faso farmers' confederation.

Within these regular production channels, the selling-pricing scheme of a stere - which varies between 1,700 and 2,500 FCFA - on the logging site includes (Richter, 2013a):

- The remuneration of loggers;
- The Forest Development Fund (FDF);
- The working capital (the WC, often called village investment fund);
- The forest tax;
- The communal tax (this is only in some districts).

The remuneration of forestry operators/loggers covers their work and the expenses they have to bear to maintain or renew their equipment (Obou, 2013). The remuneration varies between 900 and 1,400 FCFA/stere (Richter, 2013a).

The Forestry Development Fund (FDF) was set up by joint Decree No. 01-048/MEF/MATD/MEE of November 8, 2001. Its role is to allow the gradual financial self-sufficiency of development plans through the self-financing of activities related to forest management. As a local funding mechanism, the FDF helps to reinvest a portion of the profits from forestry in the protection and development of managed forests. The contribution to the fund is determined on the basis of a reference unit, the stere of fuelwood (Working Group on Wood energy, 2007). The amount of the contribution is 600 FCFA/stere for local species (Obou, 2013). However, for some species, like *gmelina* the amount is set at 300 FCFA/stere (Richter, 2013a).

The working capital (or village investment funds) is used for the co-financing of socio-economic projects of collective interest for villages managing forests under management. As such, this fund is used for building schools, health centers, drilling, etc... The FMGs are responsible for its management. Depending on the species, the amount varies between 100 and 300 FCFA/stere (Richter, 2013a).

Forest tax is set by ministerial decree. It is the same across the country and is 300 FCFA per stere of wood. This fee is fully transferred to the Public Revenue Department (Kaboré, 2005).

Table 21 Distribution key for the selling price of a stere of fuelwood at the logging site; year 2013

Beneficiaries	Amount of the contribution	
	FCFA	%
Logger	900 - 1,400	53 - 56
Forest development fund	300 - 600	18 - 24
Working capital	100 - 300	6 - 12
Forest tax	300	12 - 18
Total	1,700 - 2,200	100

Source Richter, 2013a

Although the remuneration of forestry operators reaches half the selling price of the stere in the forest, these actors are however prejudiced. A further analysis across the value chain as a whole (Ouedraogo, 2007) confirms that the first beneficiaries are the wholesalers-transporters with a revenue representing 28% of the selling price of one stere to the consumer. Retailers are the second beneficiaries and they receive 12% of the selling price of a stere to the consumer. Loggers only occupy the third place with 11% of the selling price.

It is estimated that FDPs cover only 15% of the supply of Ouagadougou city and that the city is mainly supplied by the Central West region. In other words, 85% of the city's needs for fuelwood and charcoal are satisfied by unorganized forestry, hence in unmanaged forest areas.

<u>The unorganized but authorized system</u>

In the unorganized system, forestry operators carry out their activity outside FDPs in protected forests with a permit from the forestry administration. For those wood energy exploitation areas, there is no annual levy rate. Generally, the wholesaler-transporters apply for a logging license at the Environment Regional Directorate where they pay the forest tax and the contribution required for the Management Fund and the Working Capital directly. In principle, the distribution key for the selling price of a stere of fuelwood at the logging area in this system should be the same as in the organized system (see Table 6). However, the selling price on site is usually lower than the price of the organized system and varies between 500 and 1,000 FCFA/stere (Richter, 2013a).

<u>The unorganized and unauthorized system</u>

Unorganized loggers who cut down the valuable forest species and use it as fuel without permission are usually working in close collaboration with wholesalers-transporters, and care little about the sustainability of the resource.

In this category a second group of loggers consists of women and children who live in the villages surrounding forests; they are active in the collection of deadwood and branches abandoned by loggers. They also recover wood from clearings following the extension of fields. Selling is done along the roads by bundle or in bulk to the transporters.

Charcoal production

Every year, the MEDD define the charcoal production sites either in the FDP or in protected areas. Apart from those sites, carbonization is not permitted.

Charcoal production is first and foremost, a secondary activity for most charcoal producers. The number of people involved in processing varies from one region to another. It is possible to distinguish two types of charcoal producers (Forests Department, 2012a):

- Occasional charcoal producers: they are usually local farmers, who produce small quantities of charcoal;
- The professional charcoal producers: these are exclusively men and often foreign migrants (Sudanese or Nigerians) who have extensive experience in the field.

Following the results of the study RPTES/APEX, 5 to 10% of charcoal producers carry out the activity mainly in Bobo and Satiri while in Niangoloko, Banfora and Sidéradougou, the rate is respectively 14%, 27.8% and 14.3% (Forests Department, 2012a).

Carbonization becomes important between December and April. However, it is practically permanent in Soubaka and in Sidéradougou. The most often-used carbonization techniques are traditional kilns or pits. Some FMGs located in the Central West region have been trained in the improved technique of the Casamance kiln. The carbonization gross weight yield ranged from 13.6% with the traditional kiln to 21.1% with the pit and 26.6% for the Casamance kiln (Forests Department, 2012).

Tree species that are most prized by households and artisans are: *detarium microcarpum* and *burkea africana* (kondré) (Akossongo, 2013).

Charcoal is packaged and sold by charcoal producers in big bags of 50 kg (this is a bag called "bag of 100 kg" which weighs between 45 and 55 kg). The price scheme of charcoal consists of (Akossongo, 2013):

- The remuneration of charcoal producers;
- The forest tax;
- Contribution to the Forest Development Fund;
- The contribution to the working capital.

The following table summarizes the elements setting the price of a quintal of charcoal on the production site.

Table 22 Distribution key for the selling price of a 50 kg bag of charcoal; year 2013

Beneficiaries	Amount of the contribution	
	FCFA	%
Charcoal producers	1,200 - 1,450	66 - 72
Forest Development Fund	300 - 500	18 - 23
Working capital	50 - 125	3 - 6
Forest tax	125	6 - 7
Total	1,700 - 2,200	100

Source Richter, 2013a

The analysis of the structure of income of farmers/charcoal producers active in Silly-Pouni-Zawara and Sissili FDPs helps to form an estimate of the average annual income as 129,399 FCFA of which 89,176 FCFA come from logging and 40,223 FCFA from charcoal production (Ouedraogo, 2007).

With the production of charcoal, there is one special case, the dolotières. Producers of traditional beer made of millet or maize use large quantities of wood to heat up pots. Consequently, they have a secondary charcoal production. This is used in the tavern for grilling or is retailed.

A1.4 Transport and marketing of wood energy

According to the MEM (2005), the intrinsic value of wood energy could be in the order of 5 to 6 billion FCFA. With sustainable management at the national level, this local value could be trebled in 2015 to reach nearly 29 billion FCFA (SP/CONECV, 2004).

In 2007, a study commissioned by the Ministry of Environment and the Quality of Life on the financial and economic impacts of the organized wood energy value chain supplying the city of Ouagadougou, reveals a distribution of income as follows (IED, 2012):

- Producers: 16%;
- Transporters-wholesalers: 45%;
- Retailers: 20%;

- The public revenue department: 9%.

Based on Article 20 of decree No. 98-306/PRES/PM/MEE/MEF/MCIA the wood transporter, is any trader who buys wood, be it processed or not, in order to send it to a place of consumption (National Assembly, 2011). In the context of Burkina Faso, most transporters play the role of a wholesale trader; thus, the word transporter indicates both roles. The transport chain is probably the most structured one. Wood transporter associations exist in most regions. These include the association Tiis la Vim based in Ouagadougou which has 1,060 members; the Kaya association of cart transporters or the Provincial Union of Wood and Charcoal Operators of Boulkiemdé.

There are several profiles of actors (Richter, 2013a):

- Wood energy transporters: They own the means of transportation and load the wood in the production areas to deliver in wholesale quantities to retailers;
- Wood energy retail transporters: They carry out transport activities for wholesale and retail purposes. They get the purchased wood either from production areas or from wholesale traders;
- Wood energy loggers/transporters: They are present at two levels in the value chain, namely at the exploitation and the transportation of wood (carts drawn by mules, cyclists and pedestrians) (Forest Department, 2012a);
- Wood energy loggers/transporters, retailers: They own the means of transportation and hire the services of individuals who are responsible for logging and transporting, they then retail the wood themselves.

Depending on the means of transport used, transporters can be grouped into several categories (Forest Department, 2012a):

- Pedestrians carrying wood on their head;
- Cyclists;
- Carts;
- Covered vans and pickup trucks;
- Four-wheeled (4) and six-wheeled (6) trucks;
- Semi-trailers or trailer

In the unorganized systems, owners of carts drawn by mules, cyclists and pedestrians combine the roles of wood producers or loggers, transporters, wholesale-traders and/or retailers (Forests Department, 2012a). These actors are generally found in small towns.

Fuelwood transporters using a truck, a van or a pickup, generally live in urban centers. They are considered to be wholesale-traders mainly supplying primary and secondary urban centers. The analysis of Ouagadougou supply channels confirms the influence of wholesale-traders with regard to the amount of money used in their activities. This type of transporter buys the wood from different production sites at their own expense and transports directly to business consumers, or he goes around neighborhoods of urban centers to sell the wood to retailers or households (Richter, 2013a).

Supply distances for Ouagadougou city have increased from 100 km in the seventies to an average of 250 km in 2013 (Akossongo, 2013). For the city of Bobo Dioulasso, supply distances increased from 50 to 70 km in the nineties (Forests Department, 2012a), and have reached 120 km today.

A control of the movement of wood is provided by the Forest Department through fixed and mobile checkpoints located on the routes of transporters and especially on the way out of managed forests or at the entry to wood consumption centers. However, the checkpoints on the outskirts of Ouagadougou and Bobo Dioulasso have been abolished (Akossongo, 2013).

In the dry season, when access to the areas is easier, these transporters do the maximum possible number of trips to build up large stocks. During this period, they make an average of three trips per week. In a year, this type of carrier does an average of 80 trips (Akossongo, 2013; Obou, 2013).

These wholesale-traders have their own storerooms for wood, often at their home premises. The stock is usually sold at the market at a good price during the rainy season when access to production areas is difficult and thus, when selling prices are higher (Akossongo, 2013; Obou, 2013).

Despite the overheads they carry, wholesale-traders, manage to get a comfortable net income of about 3,487 FCFA per stere or more than 25% of the consumer price. **Error! Reference source not found.Error! Reference source not found.** summarizes the revenues and expenses of a wholesale-trader.

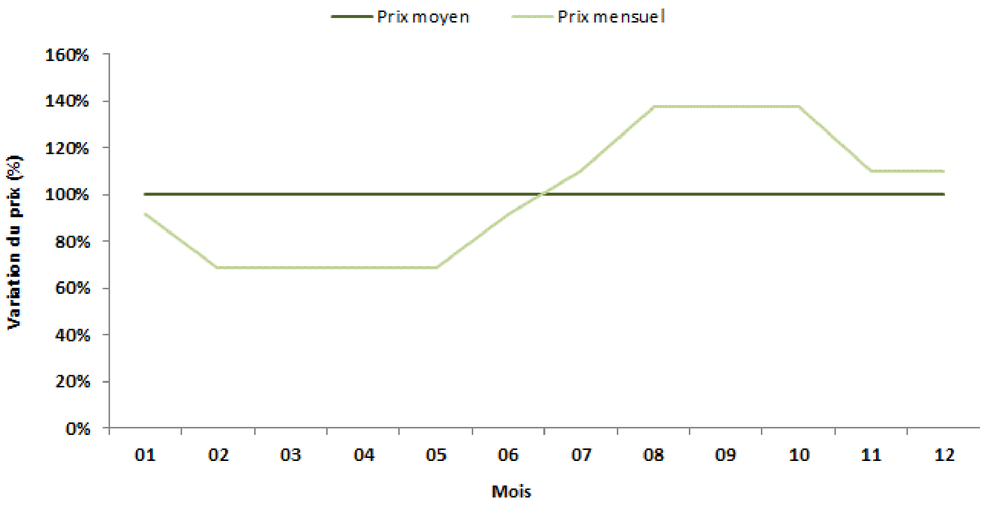
Article 22 of the Decree n° 98-306/PRE/PM/MEE/MEF/MCIA stipulates that a wood energy retail-trader is any trader who sells processed or unprocessed wood to consumers. They buy wood in large quantities and sell it to the consumer in small quantities after chopping it.

Retail-traders are usually women selling wood in piles or bundles. Given the daily fuel demand, the selling network is dense and covers all areas of urban municipalities. Retail-traders usually work independently and buy their goods from wholesale-traders. However, it is possible to meet forestry operators that are wood energy transporters. They own their means of transportation, subcontract logging to individuals and take care of the retail selling in urban markets.

Although retail-traders must pay for a selling permit from the forestry department, it has not been possible to get accurate data on the number of retailers from the forestry administration. These actors fully benefit from wood energy sale as they get a net profit of about 1,519 FCFA per stere (Ouedraogo, 2007). This profit margin gives retailers the second place behind the transporter-wholesalers.

Organizational initiatives exist particularly in Ouagadougou, where more than 700 retailers and 150 wholesalers, mostly women, have formed an association called "Koglwéogo".

Surveys in some marketplaces (Richter, 2013c), have shown that the average price of fuelwood is currently around 22 FCFA per kg with a minimum of 15 FCFA/kg and a maximum of 30 FCFA/kg. Figure 24 provides an illustration of the relative fluctuation in the price of wood energy in Kaya.



Source *Richter, 2013a*

Figure 24 Relative fluctuations in the price of wood energy in Kaya compared to the average price of 22 FCFA/kg

The price of charcoal varies between the different regions: in Kaya the average price of charcoal is between 135 FCFA/kg (wholesale) and 170 FCFA/kg (retail). In Koudougou, the selling price ranges from 90 FCFA/kg to 130 FCFA/kg and in Bobo-Dioulasso the price of charcoal varies from 80 FCFA/kg to 120 FCFA/kg. Seasonal variability in the selling price of charcoal corresponds more or less with the change in the price of fuelwood (Richter, 2013c).

Annex 2: Modernizing the wood energy value chain.

Traditionally, energy strategies based on biomass address the issue around two components: supply and consumption. Instead, we propose a modernization strategy based on a holistic intervention approach along the value chain by optimizing its entire links, as shown in Figure 1325. The proposed actions are evaluated according to their relevance to adaptation to climate change and their potential role in mitigation.

In the context of sustainable domestic energy supply, strengthening the role of forests in adaptation has a double mission: firstly, it is to allow forests to withstand climate change constrains and anthropic pressure. On the other hand, it is about exploiting the potential of forests for the adaptation of the wood energy value chain to future changes. It is important to note that many management measures, taken in the context of ecosystem-based adaptation, also play an important role in mitigating climate change; such as the prevention of large scale bushfires through the implementation of management plans for forest fires (Ravindranath, 2007). In addition, most interventions are justified independently of climate change, i.e. these are “no regrets” measures.

Sustainable production of wood energy	
• Promoting participatory management of natural forests	(S, A)
• Extension of forest plantations	(S, A)
• Promotion and strengthening of agroforestry	(S, A)
Exploitation and processing of wood energy	
• Strengthen the capacities of local actors in tools and techniques for managing forest resources	(CA)
• Increased efficiency in the field of exploitation	(CA, A)
• Increasing the efficiency of the carbonization	(CA, A)
• Test and dissemination of innovative methods to use agricultural residues	(S)
Transportation and marketing of wood energy	
• Structuring of marketing channels	
• Setting up of an market information system for wood energy	(CA)
Use of wood energy	
• Optimization and testing of models of household improved cookstoves	
• Dissemination of improved cookstoves in urban and rural areas	(S, A)
Framework conditions	
• Ensure the implementation of differential taxation	(S)
• Support the establishment of a system of effective control	(S)
• Support the establishment of a National wood energy committee	(CA)
• Development of regional strategies to modernize the wood energy value chain	(CA)

	• Development of regional wood energy supply programmes	(CA)
	• Development of an information system for the wood energy value chain	(CA)
	• Facilitating the dissemination of best practices and lobbying	(CA)

S = reduces sensitivity, CA = increase adaptive capacity A = contribute to mitigation

Figure 25 Overview of areas of intervention along the wood energy value chainSustainable production of wood energy

As a first step, priority must be given to the protection and management of forestry and forest areas of the country. Priority actions to be carried out will be related to the demarcation of forests, the definition of access and management regulations in a concerted manner and the organization of village structures to enforce these rules based on consensus (see Table 20).

Table 23 Priority actions on the introduction participatory management of natural forests

Priority actions
• Supporting sustainable management of natural forests; • Identifying priority natural forests for participatory management and the production of wood energy; • Facilitating the development of simple management tools; • Supporting the management of bushfires; • Assisting the setting up of organizations and facilitating the transfer of skills in managing forest resources to local authorities and management structures (FMG); • Assisting the management and securing of reforestation plots; • Extending the forest plantation area for energy purposes; • Testing alternative methods of wood energy production; • Promoting and strengthening agroforestry.

Supporting sustainable management of natural forests

Identifying priority natural forests for the production of wood energy

The term “sustainable management of forests” is understood as the management of forests and other woodlands ensuring the preservation and improvement of their productivity, their health and vitality, their biological diversity, in order to meet the present and future needs of communities at economic, social, environmental and cultural levels.

From the perspective of improving national energy planning, it is necessary to identify the main forest and

The development planning of forests targets their sustainable management and can significantly reduce anthropic pressure on resources. This reduces the sensitivity of forests and reduces CO_2 emissions related to deforestation and degradation.

forestry areas already contributing, or likely to contribute in the future, to the population's needs for wood energy. Although some regions are more affluent in terms of wood resources (Southwest, Midwest and East regions) and offer significant comparative advantages from a financial point of view (for example cost and profitability of forest planning), development initiatives need to be supported throughout the country, including the North. Consistent with the policy directions of Burkina Faso, priority will be given to decentralized and participatory management of these areas. For all selected priority sites, planning and management plans should be progressively developed.

In 2013, the combined managed forest area reached just over 888,000 ha, and were mostly found in the Southwest, the Midwest and East. Most of these forests were managed under forest programs implemented by the Forestry Department with variable involvement of local authorities. Given the recent regulatory changes (Governor AOF, 1935; National Assembly, 2012), management actions in the future should be part of the technical assistance that the Forest Department must provide to local authorities. This development suggests new perspectives in terms of mobilization of human and financial resources including allowing rural communities to become involved in forestry with the resources they can expect at the national and international level. For instance, in Senegal, local authorities succeeded in developing co-operative relationships with European local authorities (France, Italy, Spain, etc.) and they obtained co-financing for a regional forest management strategy led by the Regional Council (Conseil régional de Fatick, 2011). The results demonstrate decentralized cooperation as a promising tool for local authorities since it fits in the long term and may lead to the mobilization of additional co-financing (MAE - DAECT, Social Development Fund, etc.) (Charpin et al., 2013).

The Forest policy of Burkina Faso aims to develop 50,000 ha of forest each year (National Assembly, 2012b). The Ministry of Environment and Sustainable Development is currently receiving technical and financial support from several cooperative bodies and international donors in order to contribute to the implementation of this policy and the achievement of its objectives. The FDF programme aims in particular to support state institutions (Forest Department and local authorities) as well as local communities to achieve the planning and management of 20,000 ha per year (MEDD, 2012a).

Regarding the case of reserved forests, an inventory was conducted in 2007 to develop an action plan for their protection and rehabilitation (Forest Department, 2007). The report specifies that the previous management initiatives were concentrated in the regions of the West and Midwest where reserved forests had an existing resource likely to generate short-term income and achieve financial independence. Many other sites in the regions of the Boucle du Mouhoun, the Plateau Central and Hauts-Bassins have worrying rates of degradation. From an operational point of view, it therefore appears urgent to reconsider the perimeters of these forests whilst taking into account recent human settlements and the agricultural encroachment observed. Substantial efforts must be made for the clearance and rehabilitation of these forests. Consequently, development and management plans should

The existence of a network of partners in the sub-sector and the availability of financial resources is a major advantage and **strengthens adaptive capacity**.

consider regeneration and enrichment actions. Raising awareness and informing local communities must be done in collaboration with the local authorities to assert new management powers of the local authority including the co-management of reserved forests.

There are promising examples in the region where institutional developments managed to initiate the natural regeneration of forests: in Niger in particular, the Assisted Natural Regeneration (ANR) of woody species by producers in their crop fields is an encouraging example (Reij et al., 2009).

In response to the ecological and economic crisis of the 1970s and 1980s, characterized by severe drought, local farmers in some areas (Maradi, Zinder) systematically invested in the protection and management of trees and thus they established parklands. These parklands predominantly consisting of F. albida, A. digitata, P. africana and P. reticulatum, led to agricultural intensification and recapitalization of farms because they contribute to maintaining and improving soil fertility and livestock (fodder).

In addition, wooded areas reduce the vulnerability of the population to drought periods because they allow the gathering of leaves and fruits, the selling of wood and fodder for livestock which constitute a safety net. In terms of energy, the local population notices a reduction in the use of cow dung as cooking fuel and a substantial decrease in the time women and girls spend collecting fuelwood (Larwanou et al., 2006). Despite unfavorable macro-economic and macro-political conditions in Niger between 1985 and 2000, farmers continued to build and manage parklands that are beneficial for them ecologically and socio-economically (Larwanou et al., 2006).

Changes in national policies have encouraged in great measure these achievements of the population. Inspired by the Commitment of Maradi to the fight against desertification, national policies have subsequently promoted the diffusion of assisted natural regeneration, particularly in terms of the involvement of local people, their awareness and technical capacity building.

Local farmers manage the trees within their fields believing that they have an exclusive right over these trees (individual appropriation). In this context, Baggnian et al. (2013) state that the existence of these ANR surveillance committees and the village chief's leadership contribute enormously to maintaining and promoting assisted natural regeneration.

Among the factors that motivated farmers to invest in the development and management of woodlands, Larvanou et al. (2006) also point out the demographic factor. It seems likely that, even if at the beginning of the 20th century the expansion of cultivation has resulted in the gradual disappearance of grazing land and large forest areas, the combined effects of the ecological crisis, demographic pressure and depletion of soils compelled farmers to agricultural intensification. Therefore farmers were obliged to increase yields per unit area by developing new integrated production systems (plants - wood - animals).

Efforts of several development projects in the region have also played a role in the awareness of the population about the protection and management of the ANR in this part of Niger.

From the perspective of creating favorable conditions for the restoration and the sustainable management of forest lands, it rests with the governments to ensure harmony between the forest policy and the policies of other sectors, particularly the agricultural sector (FAO, 2001). Creating a favorable environment for sustainable agriculture, for example, will have positive effects on forest resources, as illustrated by the example of Niger.

This is particularly the case in the context of adaptation to climate change.

Figure 26 Favorable framework conditions - influencing factor on the rehabilitation of woodlands

In the short term, it would be desirable to identify the most motivated local authorities to take on these new responsibilities inherent in management transfer. The forest administration and its technical partners will support these communities and local management structures in the acquisition of technical and organizational skills necessary for the development and implementation of management and development planning actions.

<u>Facilitating the development of simple management tools</u>

In 2013, more than 35 forests were affected by management activities. Yet only two development and management plans have been approved by the forest department. This issue poses the problem of development and validation procedures for management documents.

In the context of a large scale decentralized management of forestry resources, it is highly recommended to accelerate the development of simple management tools to reduce the time required for the management of forests but also the related costs. First it would be desirable to develop simplified inventory standards for each eco-geographical region, validated by the national administration to serve as a standard for forest managers. Moreover, to facilitate the processing of inventory data, it seems appropriate to develop “software" that standardizes the input and automates the data analysis.

Likewise, it seems urgent to conceptualize a simplified management plan (SMP). The “Methodological forest management manual in Burkina Faso” is a recognized reference document but which raises the problem of development costs in the case of forestry degraded areas. A simplified management plan framework will help to standardize the format and content of documents about forest management complying with the technical requirements while also considering the social and environmental realities of the related areas.

In response to international concerns and the need for action at the local level on issues related to climate change, it seems necessary to include specific adaptation measures in the framework of the SMP.

Supporting the management of bushfires

The management of bushfires can be summarized as a set of techniques, activities and planned arrangements implemented in a participatory and coordinated manner by communities on their land in order to use fire as a working tool in the sustainable management of their natural resources (Forest Department, 2006).

At the national level, in 2006 Burkina Faso adopted a management strategy for fires in rural areas (Forest Department, 2006). A project co-financed by the Finnish cooperation entitled "Management of fires in Rural Areas" was implemented from 1998 to 2006. Achievements and lessons learned should be extracted (Makela & Hermunen, 2007) particularly in the context of the revision of the national strategy.

An effective strategy for the management and the fight against bush fires may reduce the **sensitivity of forests to** climate change impacts in a context of more intense forest fires.

At the local level, in order to protect forests against fires, it is strongly recommended to set up an effective firewall system (FWL). The objective is to set up Firewalls in a strategic manner to strengthen the firewall network while maximizing protection of the established "resource".

Techniques to be used in the context of fire management are described in various handbooks and manuals. The "Methodological forest management manual in Burkina Faso" could serve as a reference since it has the special feature of being based on other handbooks and research in Burkina Faso, and also on experience, research and development conducted by the staff of the finnish-burkinian project mentioned above (Makela & Hermunen, 2007).

Stages for the development of FWLs are:

- Consultation with local communities and the forestry department on the importance of Firewalls;
- Identification of natural FWLs, anthropic and mechanical existing networks based on satellite pictures and in close collaboration with users;
- Development of the FWL card (computer or manual);
- Validation of firewall patterns with communities and the forestry department.

Assisting the setting up of organizations and facilitating the transfer of management skills

An appropriate institutional set-up promotes responsible and sustainable exploitation of forest resources and thus **reduces the sensitivity of forests**. A clear distribution of skills

Participatory management could be defined as a process through which stakeholders' influence and share control over the development of initiatives, decisions and resources that affect them. Thus "stakeholders" are a group of organized or unorganized people who share a common or particular interest on issues (UNDP, 2012).

In Burkina Faso, previous actions carried out in the field of forest management were initiated within a legal framework laying the foundations of decentralization but not fully integrating the local authority in the organizational and financial operations. Only FMG/ UFMG and technical departments were involved in the contractual relationship and financial necessities (taxes, business rates). The number of stakeholders involved in the management of forest resources significantly increased (MEDD 2012) with the full municipalization that occurred in Burkina Faso in 2006 and the transfer of a part of the forests to local communities.

Recent developments regarding decentralization, land reform and the forest code form a new framework to enable such redefinition of organizational decision-making, and management of litigation including areas where FMU already exist. MEDD created a working group by decree in 2011 (MEDD, 2011) to reflect on an institutional mechanism in order to promote responsible and sustainable exploitation of forest resources by local stakeholders (managers, operators, local communities, etc.) with the support of NGOs and TFP (Ouoba, 2011). Administrative bills seem clear, but their communication and application to users in the wood energy sector are, currently, fairly limited. In addition, the new allocation of powers also requires a change of attitude, role, and functioning from the state administration. It must evolve from the culture of concentrating skills in State departments to another culture concerned with designing technical and administrative support for communities and their services to help them to assume their new powers (Ouoba, 2011).

The decentralized management of natural resources is recent and is characterized by some caution from the State which only transferred the social departments to LAs (health, education). According to Ouoba (2011), shortcomings related to the decentralization process are:

- Communication difficulties, in particular, in understanding the role of protection and control that the forestry worker should play in his workplace;
- The low technical capacity of local organizations and communities;
- Shortcomings in the participatory approach (low involvement of people and the administration in management activities);
- The lack of a comprehensive inventory of all the forests in order to know the potential that can motivate the transfer;
- The lack of a legal status for all the current forest management projects;
- The complexity of administrative and technical procedures.

It is therefore necessary to take action on two levels:

- Technical, organizational and financial capacity building for supporting organizations (NGOs, government, private, etc.), which in turn will support communities and villagers.
- In this context, a "public private partnership" PPP approach would involve small and medium enterprises (SMEs) mastering the techniques and the market.
- More specifically supportive measures of the SMP implementation process require among other things capacity building of local actors in the following areas:
- Socio-organizational training;
- Training in basic administrative and accounting management;
- Training on the bills and laws about decentralization and forest regulation;
- Training on facilitation techniques, the use of GPS, inventory techniques, development of local agreements;

The involvement of local people in the management of forest resources added to the technical, organizational and financial capacity building of supporting organizations and villagers increase **adaptive capacity** in the sub-sector. Access to information plays a key role in this context.

- Training on local management rules;
- Technical training (production of plants, fighting bush fires);
- Training and support in monitoring and evaluation;
- Reducing perversion of the process by certain stakeholders: limiting corruption, developing commitment to the process, the empowerment of communities, improving the transparency of the process, developing equitable access to information and resources;
- A well-developed communication strategy deserves special attention to ensure that the contents of SMP are understood, accepted and properly implemented by all concerned.

More specifically, the practice of transhumance is ancient in the North of the country and is part of sub-regional migration between Mali and Niger. Under the combined effects of human and animal demographic growth and the expansion of cultivated areas (cotton, sorghum), risks of conflict between farmers and herders increase on transhumance routes. In this context, initiatives should be taken to ease tensions between users of natural resources. Actions could be:

- The geo-referencing and physical marking of transhumance corridors;
- The creation and securing of pastoral planning (water taps, drilling, marking grazing areas, etc.) and a pastoral water network;
- The setting up of planning management committees and joint local committees to prevent conflicts involving local authorities, farmers, local breeders and herders.

Reduction of the anthropic pressure (transhumance, breeding, agriculture) on forest resources makes the wood energy resources **less sensitive.**

Increase forest plantations

Assist in the management and securing of forest plantations

The recommendation is to identify and map existing plantations to facilitate their planning. Thus, potential land for reforestation should be mapped and included in the spatial planning (SRAT, PDC, etc.). This will provide an overview of different uses of the communal areas and even the regional ones in a harmonized way. This helps to prevent or manage competing uses of the same space, and in the same way, reduces potential conflicts.

Given a massive increase in forested or reforested areas for energy purposes, security of land is a key success factor. What is needed here is the creation of a favorable environment for wood energy reforestation, and for this, facilitating access to land in various domains (certificate of land ownership, title deed, concession, etc.).

Management of forest plantations helps to reduce potential threats in these areas and means **reducing their sensitivity**.

In Burkina Faso, three types of experiments are discernible and guide the national security policy of rural land (Mahrh, 2007):

- The implementation of land management institutions at the base (CVGTs);
- Securing individual rights;
- Securing collective title deeds on shared resources.

Regarding the different areas considered for the production of wood energy, these three systems can contribute to securing the land. Specifically in the case of forest plantations, the recognition of collective deeds (village woods) or private (individual reforestation) should be achieved consistent with the laws governing decentralization (National Assembly, 2004c) and rural development (National Assembly, 2012a).

Extend the reforestation area for energy purposes

For decades, reforestation operations have been conducted in Burkina Faso. In recent decades, mainly because of the progressive decentralization, the participation of political, traditional and religious authorities as well as different socio-professional groups in reforestation activity has increased. This strong mobilization resulted mainly from the State commitment to make the preservation of the environment a national priority (MEDD, 2012b). However, this positive mobilization remains only partially quantifiable since monitoring and information systems within the decentralized technical departments have not changed accordingly.

In the beginning, restoration was the main objective of reforestation efforts carried out in Burkina Faso, following the droughts of the 1970s. Unfortunately, the approaches applied were often varied in terms of governance, participation and individuals involved, and did not always produce the desired results. The case studies conducted in Burkina Faso have confirmed the good results achieved through community and individual approaches despite the legal and socio-economic difficulties (MEDD, 2012b).

The available forest data are generally mainly related to yearly plant production and an estimate of planted areas. Unfortunately, for the moment, there is no inventory or description of populations to allow a specification of the overall condition and the real resources for reforestations carried out in the country. However, to ensure the supply of wood energy in the country in a sustainable manner while protecting the environment, it is necessary to develop existing plantations and create new plantations for energy purposes. With this perspective, first it is necessary to develop, in a concerted manner, simple management plans that can specify the forestry works to be carried out with quantified and localized sampling. In addition, it is recommended to promote (1) regulated reforestations carried out by the forest department or local authorities, (2) community forest plantations and (3) individual/private village forest plantations in the coming years.

The choice of species plays on the **sensitivity** of plantations with harmful impacts of climate change.

To avoid failures when creating large scale plantations and to achieve significant impacts in areas like energy supply, the fight against poverty and the conservation of natural forests, it appears necessary to meet some standards to ensure the quality of reforestation (see Annex).

In view of the climate change dynamics, climate projections are a fundamental criterion to take into account for a wiser selection of species for reforestation. In this respect, the determining factor is the ability to adapt to climate variability of selected tree species while considering their acceptance by the village communities. This applies especially to sites showing rainfall less than 800 mm where the choice of species must be carried in a well-targeted manner.

The management of existing forest plantations and the creation of new plantations for energy purposes reduces the anthropic pressure on forest resources and makes them **less sensitive.**

The installation of new plantations aims - except the production of WE - to maintain the forest ecosystems and their biodiversity by reducing pressure on natural vegetation. Therefore, afforestation or reforestation of bare land near national parks and massifs of degraded natural forests will be a priority for the implementation of reforestations. The plan should also be to increase the density of the forest cover located near streams and watercourses in order to reduce erosion caused by heavy rains. These riparian forests are important traffic corridors for structuring a network for the migration of species between different wooded ecosystems. In the case of conflicting interests, socio-economic objectives (especially poverty reduction) should prevail (see Principle 11) and aims related to biodiversity of forests thus will be pushed into second place.

To facilitate the development of private plantations and in particular the coordination of activities on production and planting of seedlings, it is recommended to encourage the organization of interested foresters in associations in each village or local community. Particular attention will be paid to the integration of women in associations of foresters. These associations should enjoy an official status of association or cooperative conforming to a structure with an executive office.

Their capacity building is also essential. It covers modules in organization, planning, negotiating skills and financial management. The aim of the planters' association is to facilitate the implementation of the technical and socio-organizational stages of a reforestation campaign. Activities of these associations are not limited to reforestation but extend to the sharing of acquired knowledge in the field.

Testing alternative production methods of wood energy

Since the oil crisis, many European and North American experts have been concerned with selecting fast growing species, likely to produce, in a short-term, a significant amount of biomass. One of the options is to partially switch farmers into biomass producers for energy purposes. In Europe, Sweden, Denmark, Great Britain and Italy are the most advanced countries in this field. In these areas, it is estimated in the short term that the redevelopment of agriculture will release several million hectares of land.

In this context, crops with short rotation will also be an option to increase the supply of wood energy in Burkina Faso. The short rotation coppice (SRC) is a variant of the forestry processing system "simple coppice". The distinguishing feature of the SRC is the rotation; the frequency of coppice cutting is significantly shortened to 1 or 2 years. The goal is to produce the maximum biomass in as short a time as possible. Based on previous experiences, the annual production of woody species is around 20 to 30 m^3/ha (Schenkel & Benabdallah, 2005).

However, these SRC require special processes and handling conditions. To be successful, this operation must fulfill a certain number of conditions (Schenkel & Benabdallah, 2005). Indeed one must create from nothing a value chain including:

- The selection of species;

- The choice of crop system;
- The setting up of harvesting techniques;
- The transport and handling of the product;
- Energy use.

The development of short rotation coppice contributes to the diversification of sources of wood energy and **therefore reduces the sensitivity of the sub-sector**.

This value chain must be analyzed and optimized at all stages to be competitive with other forms of energy. Generally, wood produced by SRC is fully chopped up and sold as "wood chips" for energy purposes. Hence the importance of checking before that openings exist or could exist, or to have a supply contract. Channels should be shorter than those of charcoal.

In this study, SRC products may be intended for the home consumption of producers. SRC eucalyptus may be a promising energy crop, with a very favorable energy assessment and the wood produced can be promoted as "wood stick" (forest residues) for specific improved cookstoves or in the long term, for electricity production units. To achieve this, it is necessary to launch a series of eucalyptus SRC tests in peri-urban areas. Each producer would grow about 0.2 ha of eucalyptus at the rate of 15,000 plants per hectare. The area can produce between 2000 kg and 4000 kg of wood energy yearly that can be used directly. It should be noted that it is not about large scale diffusion. For this reason, during the test stage, a total area of about 8 hectares, spread over 35 producers would be realistic.

Promote and strengthen the culture of trees outside forest

Following significant land clearances observed in recent years, farmers are encouraged to reintroduce the tree in the agricultural area or build agroforestry systems. Three actions can play an important role in the production of WE and grazing in farming techniques:

- The promotion of tree set-asides (fallow periods);
- Enrichment/densification of parklands;
- Installation of hedges or windbreaks.

The promotion of growing and conservation of trees outside forests contributes to the diversification of sources of wood energy and **therefore reduces the sensitivity of the sub-sec-**

In regions characterized by the rapid expansion of agricultural areas (West, South West), controlled clearances leaving a certain number of trees in agricultural areas during clearing works should be favored to create parkland (MEDD, 2012b).

The setting up of the tree fallows can be done in combination with subsistence crops for two years for the wood species to benefit from soil preparation (Tandja method). Subsequently, a combination with a fodder crop is possible while maintaining a moderate animal usage (Peltier).

Intensification on parklands would simultaneously meet agronomic, economic and environmental needs. It should be about increasing the number of trees, while maintaining diveristy, and not promoting one tree species above others at the risk of provoking their decline and disappearance from the market. Intensification of an area planted with trees should be considered along with farming practices in order to optimize the effectiveness of agricultural activities and uses of the tree-resource.

Different management techniques also allow rejuvenation of parklands and the protection of the resource: assisted natural regeneration, coppicing, fight against mistletoe, pruning, etc. (MEDD, 2012b). Achievements regarding tree productivity show that pruning techniques based upon a ten-year rotation is a good compromise to allow different users to take products necessary for their activities in a sustainable ways. For this production to extend into the future, it is necessary to consider the regeneration of tree resources (Peltier et al., 2007).

Linear plantations of the hedge or windbreak type are also to be promoted following a traditional farming approach. Tree planting should be done on lands where this use is traditionally recognized by farmers-planters. In order to guarantee the coming exploitation of WE, the owners of these woods should have a forester's booklet detailing the geolocation of the woodlands and forestry works to provide.

Public afforestation programs along major roads have been implemented from the seventies. Sanitary conditions of some of these forest trails and the volume of some of the trees' crowns now raise security problems. Lopping of trees, and if needed renewals, should be organized by local authorities. Technical teams of public sector and seasonal employees must be trained and equipped by the local authorities to carry out the work safely and in compliance with technical standards. Gradually, and in a controlled manner, it would be possible to set lopping objectives to contribute to a supply of WE for consumers.

A2.1 Exploitation and processing of wood energy

Overview of intervention avenues

The main actions proposed for the chain "exploitation and processing" are presented in the following table.

Table 24 Overview of priority actions relating to the exploitation and processing of wood energy

Priority interventions
• Strengthen the skills of local actors in tools and management techniques for forest resources and in exploitation techniques; • Support the organization of loggers and strengthen their management skills; • Organize charcoal producers and introduce the use of the improved kiln; • Test and disseminate biochar production methods.

Strengthen the skills of local actors in tools and management techniques for forest resources and in logging techniques

For a better production of wood (standing), forestry techniques must be understood and assimilated by managers of natural forests and tree planters to help them to get motivating and optimized results. For this, it is advisable to give them various restoration and regeneration techniques for wooded areas while focusing on compliance with the technical requirements contained in the management documents (for example rotation length).

Forestry research should lead to an accurate determination of cutting heights for each of the main forest species rejecting stumps and that are used for energy purposes. Knowing that coppiced trees tend to weaken because of the successive cutting, it would seem wise to sow forest tree species collected in the region directly on the cutting beds.

The capitalization of good practices and the capacity building of local actors in management and logging also **increases their resilience**.

At the same time, the pressure on forest resources, caused by bad practices (e.g. overfishing) decreases consequently the **sensitivity**.

Given the omnipresence of livestock in the region, it is advisable to keep the cultivated plots away from domestic animals to allow proper development of stumps. Breeders and shepherds will be informed and made aware of the need to avoid grazing herds in recently exploited areas for wood harvesting.

Finally, based upon the finding of the lack of rules to control exploitation, it is important for management structures to define simple exploitation rules in a concerted manner, with woodcutters-loggers.

To facilitate their supervision and training, it is advisable to promote the formalization of WE loggers within groups or associations. These organized loggers will benefit from practical training provided by the Forest Department and/or partners (NGOs, projects). These training sessions will take place in the field and will deal with the selection of trees, logging techniques and organization of exploitation sites.

Regulatory mechanisms and forest control measures used to reduce the pressure on forests and to **reduce sensitivity**. This is facilitated by helping management/operational actors to get organized.

Support the organization of woodcutters and strengthen their management skills

In parallel with the introduction of new technologies and methods as well as training for their use, it is important to provide a framework in terms of organizational development. This organizational support will be achieved through the grouping of woodcutters in associations or cooperatives with their own operational and decision making autonomy. After the setting up and the legal recognition of these groups, it would be necessary to organize basic training sessions in accounting and basic administrative management, to facilitate the economic development of their business.

From the perspective a better promotion of charcoal, it is useful to develop within the group a unit that will monitor and control the quality of the product. This unit will verify the effective application of logging rules (choice of tree species to be exploited, height of the tree to be cut) as well as the use of improved kiln by loggers. It will also be responsible for ensuring the management structures that all loggers are complying with the legal procedures.

> The organizational development of local stakeholders and their financial technical and management capacity building **increases adaptive capacity**
>
> At the same time, the pressure on forest resources, caused by bad practices (e.g. overexploitation) decreases consequently **sensitivity**.

Increase the efficiency of carbonization

<u>Organize charcoal producers and introduce the use of the improved kiln</u>

Formerly used as a backup fuel for craftsmen and households from the coast, charcoal has become a major fuel in urban centers such as Ouagadougou and Bobo-Dioulasso. Different reasons explain such an increase; changing cooking/eating habits, and conveniences offered to the household by the use of charcoal (no smoke, ability to move the stove, easy storage of the product) (IED, 2012).

In recent years, there has been an anarchic approach to the production of charcoal in several regions of the country (Forest Department, 2006). Besides the fact that this activity is one of the causes of overexploitation of forest resources, more often it is practiced in ways which are disrespectful to environmental protection, with low economic benefits for local people and the State. Actions to be taken in the field of carbonization must be in line with the implementation of new guidelines set for the production and marketing of charcoal in Burkina Faso and the action plan adopted for this in December 2005. Eventually, it will not be possible to produce charcoal in a non-managed forest or located in an area declared deficient in wood products (IED, 2012).

> The introduction of more efficient processing techniques allows reducing the pressure on wood resources and therefore the **sensitivity.**
>
> At the same time, carbonization technologies with high yield also contribute to the **reduction of CO_2 emissions**.

From a technical viewpoint, note that the impact of an increase in the performance of the kiln on productivity is nonlinear. For example, an increase in the yield from 15 to 28% corresponds to an increase in the productivity of carbonization of 86%. In other words, the introduction of more efficient processing techniques can reduce the production area by 86% to get the same amount of charcoal. In addition, case studies in Senegal (Richter, 2008), have shown that the profitability of natural forest management strongly depends on carbonization techniques. Simulations carried out show that the implementation of techniques with less than 20% yield cannot generate substantial profits.

In addition, optimization of carbonization technology ensures greater fuel quality but also reduces the working time of charcoal producers, the hardness of their work and can finally contribute to increasing their income.

Carbonization technologies with high efficiency also contribute to the reduction of carbon dioxide (CO_2) and other greenhouse effect emissions, including methane, which is twenty times more polluting than CO_2.

In this context, it is necessary to develop and test an improved type of kiln adapted to production conditions for each eco geographical region and to train charcoal workers in the use of the kiln at the pilot sites. Development tasks and tests to improve the weight yield of the carbonization process should include:

- The moisture management of wood: we recommend the use of well-seasoned wood, at least one week between the date of logging (green wood) and the beginning of the stacking up of wood for the assembling of the kiln;
- Management of the chimney: it is advisable to use a chimney to regulate the air flux during the process of dehydration and pyrolysis in the kiln;
- The shape of the kiln: we recommend to test the impact of the shape (rectangular or semi truncated-cone type Casamance kiln) and then propose a standard shape for the kiln;
- The covering of the kiln: it is proposed to test the impact of the type of kiln covering, either by a better soil or sand, or by means of a metal wall;
- The construction of the wood stack: it is recommended to test the classification system of logs according to diameter and to obtain a high stacking coefficient;
- The size of the kiln: the construction of large kilns can also contribute to increase the yield;
- The management of the kiln: in order to reduce the risk of fire spreading accidentally, it is advisable to clear a space of at least 5 m wide around the kiln.

This campaign for developing an optimized kiln in Burkina Faso should only concern organized charcoal producers (see below) in managed forests.

Test and disseminate innovative carbonization techniques

In the medium term, it is also proposed, with a view to increasing the quantity and quality of charcoal production, to test the construction and use of a kiln of semi-industrial category. In this context, it is advisable to test, the “ICPS” (Improved Charcoal Production System) or "Adam-retort” kiln type on two selected pilot sites. The kiln has already been tested and popularized in Kenya, Burundi, Senegal, Madagascar and India (Adam, 2005). The Adam-retort is a fixed kiln type. It has a rectangular shape and is built with traditional bricks and covered with metal sheeting. The system operates on the basis of two chimneys. The time required for the construction of the kiln is about two weeks. Simplification and reduction of the working time for charcoal producers could be considered during the test phase.

Adam-retort-kiln type also enables carbonization of the biomass from agricultural residues and allows by-products to be obtained. This diversifies the potential energy and revenue generation sources and **makes the sub-sector less sensitive**.

The semi-industrial kiln can carbonize wood volumes (on average 3 m³) with a shorter carbonization phase and with less supervision, compared to other types of improved kilns. The effectiveness of the Adam-retort kiln is very high; tests in Kenya showed a weight yield of around 30%.

The Adam-retort kiln also makes the carbonization of biomass from agricultural residues possible. It also provides burnt wood and "wood vinegar" and other products that may contribute to the significant increase in charcoal workers' revenues. In this domain, it is proposed to study the market for these by-products.

Managed forests or future reforestation plots are an ideal field for the implementation and extension of the semi-industrial process, which however represents a relatively high investment cost of about 677 to 1,354 USD.

Another great advantage of the introduction of this type of kiln is the reduction of greenhouse effect emissions, and especially those from methane. The reduction potential is estimated at about 75% (Adam, 2005). In this context, it would also be interesting to find external funding under the Clean Development Mechanism of the Kyoto Protocol (CDM) to cover the additional costs for charcoal producers associated with the introduction of this innovative technology.

Test and disseminate methods for producing biochar

Diversification of energy sources contributes to reducing the pressure on natural resources. As part of this diversification, biochar plays a predominant role and could prove to be an alternative to charcoal. Its promotion should be part of protection strategies for the environment and it could help provide a diverse range of fuels to households at a socially acceptable price for users and an economically attractive price to businesses. Biochar production is in line with the goal of reducing CO_2 emissions, resulting from the Kyoto Protocol and has great potential for projects eligible for the CDM. Forms of biomass, other than wood, convertible into biochar are:

> The diversification of sources of energy helps to reduce pressure on natural resources and therefore reduces **sensitivity**.

- Agricultural residues: shea shells, millet and cotton stalks, rice husks;
- The agro-industrial residues: shells from groundnuts, cotton and cashew nuts, sugarcane bagasse;
- Harmful aquatic plants with high proliferation as the cattail.

Several technologies for the promotion of agricultural and agro-industrial residues for energy purposes have been tried in African countries. For example, in Senegal, subject to satisfactory conclusions of technical and social acceptability tests, the biochar value chain appears as a major asset of the energy diversification and job creation policy in rural areas in the current context where the return to agriculture is advocated by the government. This implies significant surpluses of biomass which with proper management would provide an alternative to oil.

To improve the quality of these alternative fuels, it is necessary to develop technological processes adapted to the context and the availability of local biomass. This could be done with the involvement of craftsmen already embarked on this sector, as well as SMEs present in Burkina Faso. These private businesses will be interested in testing and implementation of effective systems suitable for the production and marketing of biochar.

In Senegal, the Programme for Rural Electrification and Sustainable Supply of Household Fuel (PERACOD) supported the introduction of different technologies based on biochar production channels (Ehemba, 2009):

- The artisanal value chain with "3 shafts" carbonization technologies and agglomeration with the manual rotor press of which the production capacity is, 60 kg per hour; for example, for biochar made from cattails or from coal dust,
- The semi-industrial value chain using a motorized agglomeration technology (rotor press) with a production capacity of around 140 kg per hour for biochar made from coal dust;
- The industrial value chain production of biochar made from groundnut shells which has a production capacity of approximately 1,800 tons per year.

These different levels could also be study fields in order to explore and improve the production of biochar in Burkina Faso. More specifically:

- Conduct technical and economic feasibility studies for the value chain:
- Market Research;
- Study on the potential and the type of biomass (annual cycle of the biomass potential);
- Identification of technologies appropriate to the current potential;
- Conduct technical studies on the acceptability of the product;
- Laboratory tests (water boiling test, controlled cooking test);
- Tests of acceptability at the household level;
- Encourage the setting up of a distribution network;
- Identify interested businesses for the implementation of the value chain;
- Implement Public-Private Partnership contracts (PPP);
- Conduct the transfer of skills for the use of different technologies.

However, in Burkina Faso, unlike biofuel (MMCE, 2009), no specific rules have been put in place for the production and marketing of charcoal made from agricultural or agro-industrial residues, coal dust or biomass. The existing regulation only applies to charcoal made from woody biomass. Thus, to ensure the organized development of the value chain, it is desirable for the concerned departments to set up a specific regulatory framework for the production and marketing of biochar. Under this condition, biochar sector could be structured and become a real economic development lever.

A2.2 Transportation and marketing of wood energy

Overview of intervention avenues

Together, the proposed interventions on the target N° 3 will aim to help reduce transportation costs, improve the flow of forest products and the fight against illicit products. Particular attention will be paid to the localization and development of storage and supply sites. Table 22 summarizes the spheres of activity relating to the marketing and transport of wood energy.

Table 25 Overview of priority interventions on the transportation and marketing of wood energy

Priority interventions
• Organize the marketing of wood energy by the setting up of Rural and Urban Wood Energy Markets; • Develop an information system for the wood energy market; • Facilitate access to microcredit for transporters and traders; • Support the marketing of green space wood energy products.

Structuring the marketing channels

Organize the marketing of wood energy by the setting up of Rural and Urban Wood Energy Markets

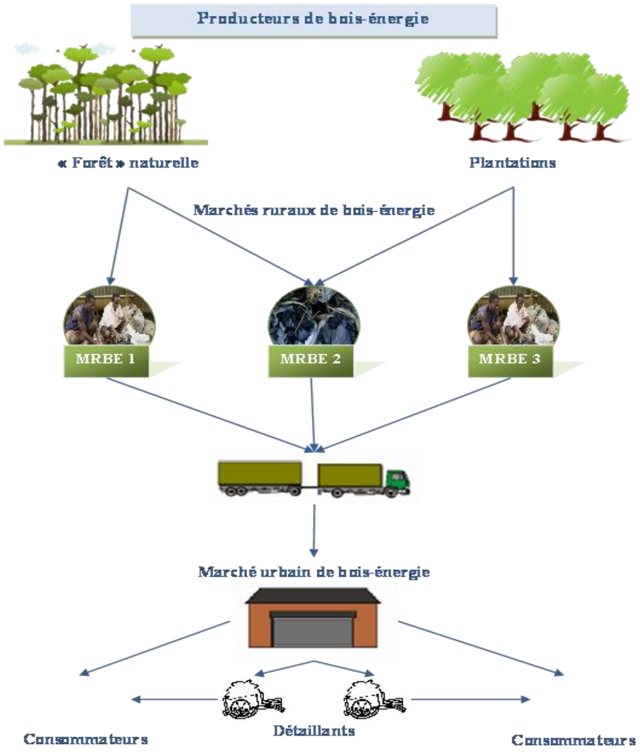
The restructuring of marketing channels aims firstly to increase the profits accruing to wood energy producers and to reduce the flow of illegal products. At the same time, it will standardize supply points to facilitate the distribution and sale of products. This structuring and formalization of marketing channels will be based on the establishment of a network of wood energy rural markets associated with one or more urban markets (see Figure 27).

> Restructuring marketing channels in favour of wood energy producers therefore reduces their **sensitivity**.

A wood energy rural market can be defined as a point of sale for fuelwood and charcoal located in rural areas and managed by a local management structure. It is supplied from one or more specific exploitation area(s) by mutual agreement between the local population and the local authority with the technical support of the Forest Department. Eventually, markets will be supplied both with wood coming from forests and savannas under participatory management and with the products of future plantations.

> The setting-up of RWEMs facilitates the supply planning of urban centres in wood energy thus influencing adaptive capacity in the sub-sector.

RWEMs help in making the "modern" nature of the value chain more visible thanks to a better accessibility of products. This structure also contributes to bringing together logger/charcoal producer associations for better trade negotiations with buyers and transporters. The concentration of forest products, in rural and urban areas (see below), will also facilitate the future implementation of tax incentives, and at the same time control of the production and marketing of charcoal. Finally, the setting up of RWEMs facilitates the wood energy supply planning for urban centers.



Source *Richter & Sepp, 2009*

Figure 27 Modern supply through a network of rural and urban wood energy markets

Like the RWEMs, upstream of the value chain, it is advisable to set up one or more wood energy point of sales in the main consumption centers especially in Ouagadougou and Bobo-Dioulasso. These "Urban Wood Energy Markets" (UWEM) have many advantages:

- Reduction of intermediaries in the value chain and a profit increase for each actor;
- Ensuring stability of the household supply in household fuels such as buffer stocks in case of shortage;
- Ease of control of socio-economic impacts in case of increase in fuel prices;
- The guarantee of a better charcoal quality;
- The accessibility of the fuel "Green zone charcoal" to the housewife;
- The possibility of collaborative marketing for formal wood energy producers;
- The possibility to disseminate new types of packaging for the charcoal.

The setting-up of UWEM ensures a stable supply of domestic fuels in case of shortage and controls the socioeconomic impacts if price increases, which contributes to **strengthening adaptive capacity.**

New sites for storage and sale of wood energy could be developed at the points of sale of improved cookstoves or Energy shops to be set up by the PASF programme. Such a "Clean Energy Center" (CEC) would combine the sale of "green charcoal" with the modern cooking technologies.

The process of setting up and developing rural markets is in three stages (see below).

Achieving the following three stages requires close collaboration between foresters, administrators of natural forests, loggers, transporters and relevant public authorities (Forest Administration, Local Authorities).

Good collaboration between actors of the sector is **synonymous with high adaptive capacity**.

Preparatory stage, identification of potential RWEM sites: It consists of choosing the locations of RWEMs, including villages next to “forests” under simplified management plans or major traffic routes. Considering the experience of other countries, particularly Madagascar, the maximum distance between the resource and RWEMs must not exceed 15 km to make the transport between the production site and the market easier.

During the first stage, it will also be obligatory to make contact with the related local authorities and put together the authorization application to set up the market. This will be supported by the organizational and institutional selection of the management structure and the training of local actors.

The formalizing stage for the setting up of the rural market: This stage in particular deals with the promulgation by the competent authority of an official text establishing the formal creation of the market and the award of an administrative act of land tenure.

Stage for supporting rural market - Support the functioning of markets: After the formal creation of rural RWEM markets, support measures are necessary:

- Support to start the RWEM in order to undertake capacity building of producers in negotiating with transporters and collectors;
- Management capacity building of RWEM members, including in accounting and simplified management. It is recommended to support this training block with a functional module in literacy;
- Supporting the setting up of a specific label for the RWEM referring to the quality and legality of products (issuing log books/permits);
- Support for the setting up of a control system for the flows of wood energy.

A control device will be used to reduce the pressure on **forests and reduce sensitivity.**

Support the marketing of green field wood energy products

Stage 3 “Support the functioning of markets” (see above) also includes the setting up of a specific label referring to the quality and legality of products sold by RWEMs. In this context, it would be justified to develop a concept for the marketing of wood energy from sustainably managed forest resources and market around RWEM s and UWEMs.

Develop an information system for the wood energy market

The modernization of the wood energy value chain involves significant changes which could affect the current organization. In this context, it is possible that some “small” producers/loggers or traders of WE will be in an unfavorable situation given the new market conditions. Currently, loggers (woodcutters, charcoal producers) are the least well organized group in the value chain. Most of them are operating on a small scale, using traditional techniques, depending on family labor and having little capital to make investments.

In contrast, the best structured group within the value chain is the one of transporters/collectors. They have logistical and human resources, they have an association recognized by the administration and an investment capacity or, at least, they have access to bank credit. Due to the remoteness and the increased competition around the resource, "small" producers and WE traders may lose in the modernization process. With a view to equity and sustainability, it appears necessary to promote the emergence of new WE production or marketing opportunities which ensure revenues and jobs. One of the tools to achieve this goal in a proactive approach is to develop an information and communication system in the value chain between stakeholders. This market transparency should contribute to a reorganization promoting complementarity between the different economic stakeholders involved in the value chain.

An information system will enable to improve market transparency for the benefit of stakeholders in the value chain and to monitor the markets and provide insights for public policy makers, which makes the stakeholders of the value chain better **equipped for adaptation.**

Information is a vital resource in the operation and management of the value chain. It must be a bond between all the different links in the value chain to ensure optimum functioning. The reliability of information and its timely availability are essential, for example, to implement a support strategy. The current value chain is mainly composed of "small" actors who only have partial and sometimes incorrect information on the WE market. One consequence of this situation is the development of a speculative strategy, often coordinated by the most influential stakeholders, leading to heightened volatility in market prices.

In developing countries, the market information systems (MIS) were introduced as part of the liberalization policies of the 1980s. Presented as public support systems, their primary function was to collect and disseminate information on trade in agricultural products. The purpose of these systems was to make the market more transparent, improve stakeholders' decision making for an optimal allocation of human and financial resources. Although primarily targeting private operators in the market (producers, traders and consumers), the MIS first and foremost provided information to the Government on the market situation which aimed to support decision making for agricultural policies and food security (David-Benz et al., 2012).

The MIS are information systems aiming on the one hand, to streamline the marketing of agricultural products and, on the other hand, to enhance the relevance of food and agricultural trade policies, through a better consideration of the situation and market dynamics. Their objective is twofold and targets two main categories of stakeholders (David-Benz et al., 2012):

Improving market transparency and reducing information asymmetries in order to facilitate spatial and temporal arbitration and promote equitable redistribution of the capital gain between the different actors from production to consumption. In this sense, MIS are primarily accorded to the following stakeholders:

- Producers: whose production or investment choices are facilitated and arbitration and trade negotiation skills are improved;

- Traders and main stakeholders in the value chain whose expectations are reinforced by the flow of trade between surplus areas and consumption centers.

Monitor markets and provide analysis for public decision makers:

- Align agricultural food and trade policies;
- Assess the impact of implemented measures;
- In this respect, the MIS particularly benefit national and local decision makers, donors, and more broadly, institutions involved in development.

The key deliverables of the timely diffusion of information adapted to the needs of private actors (David -Benz et al., 2012):

- Improved market efficiency through the intensification of arbitration and competition, reduction of transaction costs and a better allocation of resources, should result in a reduction of the price differences between the producer and consumers and in a better integration of markets;
- Improved equity by reducing information asymmetries, especially between traders and producers, which would result in a better return for producers;
- Stimulation of rural development through better functioning of the market.

In Rwanda, the State launched a computerized platform that aims to provide information on the market for agricultural products. The project aims to collect and provide updated information on prices used by the different stakeholders in the agricultural sectors. The system is a database that covers more than 60 agricultural products in 41 markets across the country. To provide information to the greatest number and to bypass problems associated with managing a computer network, the MIS, called "e-SOKO", communicates the updated elements to farmers and cooperatives via mobile phones. The MIS subscribers enter a code with the name of the goods and the relevant market and then receive a text message with the current price of the product.

Based on this experience, it would be possible to support the development of a MIS for the wood energy value chain in Burkina Faso structured to focus primarily on flows, quantities and prices of WE. This would allow a more effective management of the value chain connecting the various links of the value chain from production to consumption including transportation and marketing.

National context must be considered objectively, with its strengths and weaknesses, to promote a viable and effective MIS. The first constraints identified are the low educational level of economic operators, the limited access to new information and communication technologies (ICT) not to mention the problems related to maintenance and supply of computer networks and especially the fact that the number of computers accessible to stakeholders is limited. As an alternative, mobile telephony offers new perspectives. The coverage provided by the phone companies across the country, makes using a phone equally possible in urban areas and rural villages. Inspired by the Rwandan experience, it is possible to opt for a system involving the collection and dissemination of information via mobile phones. To address the limitations related to screen size and the number of possible characters, a simplified codification would be preferable as it has been developed and tested in Bangladesh (Roekel et al., 2002).

The future WE-MIS could, for example, collect updated information on rural and urban markets. Occasional investigators or RWEM/ UWEM managers would collect information on prices and quantities of stored WE and would send this information via SMS to a server. The latter would then be accessible to customers or to those who request the information via text messaging.

Access to funding is a key factor for the adaptive capacity of stakeholders.

<u>Facilitate access to micro-credit for transporters and traders</u>

To purchase equipment and materials for the working capital of RWEM s and UWEM s, and for the renewal of transporters' fleet, it would be necessary to facilitate the relationship of future producer groups and RWEM/ UWEM managers with micro-credit institutions. This connection must be preceded by training sessions in simplified accounting.

A2.3 Use of wood energy

Overview of avenues of intervention related to the operation chain

To ensure the medium-term impact of actions in saving wood energy, we can draw up, on the one hand, specific technical proposals with respect to the optimization of improved cookstoves and, on the other hand, proposals related to the professionalization of the production and the marketing. Added to this, proposals related to the distribution strategy of improved cookstoves both in urban and rural areas.

In the context of health, optimization and distribution of improved cookstoves require special attention. Cooking with fuelwood or charcoal generates greater air pollution inside the dwelling compared to the use of kerosene or LPG. It is estimated that exposure to smoke from biomass combustion is the largest source of pollution to humans as suspended breathable particles (Particulate Matter - PM). Particles have a diameter of less than 10 micrometers (PM10). Because of their microscopic size, they can easily penetrate into the lungs and are therefore considered to be particularly harmful for human health.

The concentration of the harmful substances is changed inside the dwelling, by the type of fuel, by the combustion technology used, as well as the characteristics of the premises. It is expressed in micrograms per cubic meter of air (mg/m³). Households using charcoal for cooking, experience PM10 concentrations in the order of 500 mg/m³ in their dwellings while concentrations greater than 3,000 mg/m³ can be reached in the dwellings of households using wood in open fires (Bailis et al., 2002). However, according to the standard defined by the OECD, people should not be exposed to PM10 concentrations above 50 mg/m³ for health reasons.

The mortality rate due to the presence of smoke gas in sub-Saharan African homes, particularly affecting women, amounts to 4.3% and is thus, after the lack of hygiene (5.9%), the second most important health risk related to the environment (WHO).

Consequently, priority interventions related to improving efficiency in the use of wood energy will be as follows (see Table 23).

Table 26 Overview of priority actions related to the use of wood energy

Priority interventions
• Optimize models of improved household cookstoves and test innovative combustion techniques; • Train or retrain producers and professionalize the marketing of cookstoves; • Distribute improved cookstoves in urban and rural areas; • Facilitate the use of alternative energies.

Increase the energy efficiency of wood energy combustion

<u>Optimize types of improved household cookstoves and test innovative combustion techniques</u>

It is proposed to support the optimization of improved cookstoves at three-levels:

- Improved charcoal cookstoves: It is proposed to develop a type of improved charcoal cookstove. In this context it is highly desirable not to reinvent the wheel, but to rely on experience, for example from the supra-regional GIZ programme "Vital energy supply" (HERA) and the "Improved Cookstoves Project" in Burkina Faso"(FAFASO). Cookstoves of the Jambaar Multi marmite (Multi pot) type are recommended for testing the stage.
- Improved wood cookstoves: Here it is not about developing new types of improved cookstoves, but rather about improving the existing models in Burkina Faso including the Ouaga metal cookstove.
- Improved wood oven/cookstoves specifically adapted to the needs of large consumers: The development of types of improved cookstoves large capacity wood ovens/stoves for professional consumers should be revived.

The introduction of more efficient combustion techniques helps to reduce demand and therefore the pressure on wood resources (**sensitivity)**

At the same time, these technologies with high yield also contribute to the **reduction of CO_2 emissions**.

Indeed, the spread of this type of model can serve as a catalyst for increased demand at the household level. The places where large capacity cookstoves are used (restaurants, etc.) are busy places, big charcoal and fuelwood consumers, sensitive to fuel budget savings and their users are potential "facilitators" (Jorez, 1991).

The "controlled" distribution of improved optimized cookstoves to a small sample of households (100) where the real economic savings and acceptability of the cookstoves will be tested and verified would allow the optimization of the models and ensure the success of a mass distribution.

Beyond the optimization of improved cookstoves, it would be interesting to run a series of tests on innovative combustion techniques. In this context, the activities are as follows:

- Test the cookstove "Save 80": Given the current high price of about 65,000 FCFA, the "Save 80" is not the type of improved cookstove that can be distributed on a large scale. Linked to the testing of very short rotation coppices (SRC) of eucalyptus or neem (see section 0), it would be reasonable to test and distribute the "Save 80" since its small-sized door requires the use of wood with small diameter and length. Each cookstove user should grow about 0.2 ha of SRC at a rate of 15,000 plants per hectare. This area can produce annually between 2,000 kg and 4,000 kg of wood energy that can be used directly in “Save 80” cookstoves. It should be emphasized that it is not about large scale implementation, but first, on a total area of about 8 hectares divided among 35 producers.

In parallel, it would be desirable to test the possibility of using wood “chips” (pieces of shredded wood) in this type of cookstove.

- Test improved cookstoves of the “gasifier” type: A biomass gasifier is the general term for a system that converts solid biomass into gas. This gas can then be burned in a controlled manner. Unlike open fires, gas generation could be controlled in space and time. While open fires and most conventional cookstoves are regulated by adding wood energy, most types of gas generator cookstoves are controlled by the air supply. The gasifier therefore offers the possibility of optimizing the combustion of wood energy. While controlling heat and air intake, an exceptionally clean combustion of biomass can be achieved.

As part of the modernization of the wood energy sub-sector, it is necessary to test this type of cookstove on a small scale and especially in urban centers such as Ouagadougou and Bobo-Dioulasso.

- Test the use of wood “chips” in various types of improved cookstoves: The wood chips form a more homogeneous fuel than fuelwood. The cutting of products with various dimensions facilitates the storage, transport and drying of the fuel. To shred the wood, there are several types of shredders (disc, drum, etc.), automated or not. According to their characteristics, they can accept different types of wood and produce chips of defined dimensions (through the use of a sieve). Pieces of chipped wood have approximately the shape of a parallelepiped of which length is the only adjustable dimension. The width and thickness are subject to the vagaries of fragmentation. The length of the pieces of chipped wood range from 10 to 80 mm. For the tests, it would be possible to produce wood chips from a garden shredder which will cut branches and stems up to a diameter of 8 cm.

For these tests, it is necessary to experiment with this fuel using existing types of cookstoves as the Ouaga metal and also with the Save 80 and improved cookstoves of the gasifier type.

<u>Train and retrain producers and professionalize the marketing of cookstoves</u>

In order to achieve a maximum usage rate of improved cookstoves, it would be necessary to provide extensive training to IC producers. This is a set of activities aiming for the creation of production and independent marketing of economic and quality cookstoves by small entrepreneurs. The aim is to sustainably supply the relevant local markets. To achieve this, it is important to train farmers to produce quality products and sell them at prices which are affordable for customers, while leaving a profit margin for the producer. It is only if we succeed in this challenge that there will be a chance of sustainability, since each party should get something out of it.

The organizational development of producers and traders of improved cookstoves and their technical, financial and management capacity building, **increases their adaptive capacity.**

The quality of improved cookstoves is a key element for the sustainability of activities to promote IC. Many initiatives and IC expansion projects failed to result in the production of improved cookstoves which were compliant with initial quality standards.

Without external support, producers began to reduce the quality of their cookstoves for economic reasons or to gain time. Ignorant about the characteristics of a good cookstove, customers first continued to buy the lower quality IC. But later, they became aware of the poor performance or imperfections (smoke emission) of these cookstoves and therefore did not renew their purchase. Gradually, a decline in demand for IC was observed causing consequent disinterest amongst most craftsmen and producers of these cookstoves.

In this context, particular attention should be paid to the training and retraining of producers. The content and process of their technical training will be developed as specific manuals. The selection of future entrepreneurs should be given special attention in order to identify people expressing a real interest in launching a new business, demonstrating a sufficient spirit of openness to learn new production techniques and to try new marketing approaches.

For all types of IC, it would be necessary for the quality concept of the product to be at the heart of the training session. To ensure a better productivity and ensure the quality of IC, small adapted and modernized production tools, or production kits could be distributed to the trained people. While maintaining these targets, it would be necessary to support the mechanization of the production process or of certain stages. This development would also promote the reduction of IC production costs.

In this context, it seems appropriate to make working capital available to the producer groups to help them start their businesses. This working capital could be in the form of an initial donation of raw materials (mainly steel) or equipment.

In addition, it appears necessary to define quality standards for existing IC and the setting up of a system for monitoring compliance with these standards. This activity could be carried out by national research institutes such as the Institute for Research in Applied Sciences and Technologies (IRSAT). It will be essential to work closely with producer groups. Producers are indeed the primary guarantors in the field of sustained quality control of IC.

Support/advice for the organizational development of these groups or producer associations will in particular be related to capacity building in negotiation and protection of their interests. Such an association could act as interlocutor with government authorities or research institutes, and in the ideal case, organize its own implementation of systematic quality control of improved cookstoves amongst its members.

The professionalization of producers is not limited to the technical aspects of production. It is also important to produce as efficiently as possible and to launch the product on the market at prices which cover costs. Thus, it would be desirable for a part of the training session to focus on aspects of business management and marketing.

Spread improved cookstoves in urban and rural areas

A mass distribution strategy of improved cookstoves in urban areas should include the implementation and securing of the cookstove production system depending on the model selected. Based on the observation that 77% of the population live in rural areas and consume about 4,000,000 m^3 of wood annually, it is a reasonable proposition to reduce consumption in rural areas through the distribution of improved cookstoves. This distribution can begin in peri-urban and rural areas where households already buy their fuel, i.e. areas showing a shortfall in wood energy. A second priority area will involve the neighboring villages on managed forest areas where logging and production of charcoal are carried out. Public awareness about the issue of fuel economy could be carried out in parallel, or at village activities on participatory management of forest resources.

The implementation of a commercial strategy and the mass distribution of improved cookstoves will be based on a coordination and awareness campaign. This is about spreading the benefits of efficient cookstoves to the general public in terms of energy performance, speed of cooking and cleanliness in the kitchen. At the same time, it is necessary to convey a modern image to attract the interest of housewives and potential customers to purchase such a cookstove.

> Spreading use of improved cookstoves can reduce demand and therefore the pressure on wood resources **(sensitivity).**
>
> At the same time, these technologies with high yield also contribute to the **reduction of CO_2 emissions**.

These coordination and awareness campaigns would be conducted by radio, which is the most widespread means of communication in rural areas, and also by television channels and billboards in markets. Locally, this information campaign will be supported by local activities like cooking demonstrations and theatrical performances in public places or homesteads. Through these actions, information on the benefits of improved cookstoves would be spread and households would be able to compare models in order to decide on the purchase of the IC most suited to their family situation. These targeted campaigns will convince and increase the number of people in possession of an efficient cookstove for cooking of meals in rural areas.

In parallel, it would be desirable to launch awareness campaigns and training sessions on the proper use of improved cookstoves. This will allow new IC users to know and apply the “right actions” for optimal use and maintenance of the cookstoves. A training module on the positive effects of regular maintenance of new cookstoves and their future replacement is to be included in the training and monitoring schemes.

> Awareness campaigns contribute to give fuelwood consumers access to information and thus their **adaptive capacity**.

These actions could further increase the household demand in IC, instead of waiting for slower word of mouth marketing result. The subsidy for such advertising and marketing campaigns will also support the newly established IC producers so that they can specialize and gradually strengthen their positions in this market.

Facilitate the use of alternative energy

Whilst being very conscious that the future energy sector will be based on a mixture of several types of energy, it should be noted that modernization of the wood-energy sub-sector only targets solutions for the wood energy value chain and does not consider other types of energy. At the moment, the real challenge remains to manage the contribution of wood energy to national socio-economic development while preparing the transition to a gradually reducing share of wood energy in the overall energy balance, through the use of other energy sources. For the time being, it is unlikely that these alternative fuels can play a major role in a medium term substitution strategy due to uncertainties about the results of actions to be undertaken.

However, to prepare the energy transition from woody fuels to other energy sources, it is important to create new technology showcases or carry out pilot scale testing. These experimental models will demon-

> The use of substitute energy works with a diversification of fuel sources, which makes the sub sector **less sensitive**.

strate the technical feasibility, social acceptability and economic viability of alternatives for a diversification of household fuels. A first allocation will be granted in the first five years to develop a series of pilot projects for the installation of biogas plants and the production of biochar. An evaluation is planned for 2017 to estimate the possibilities of a wider diffusion of such equipment. The spreading of these applications, if they prove conclusive, will be scheduled during the second five years of the process for modernizing the wood energy sub-sector.

Diversification of supply in alternative fuels faces several obstacles. These constraints to the penetration of a new fuel in the practices of households can be technical, socio-cultural, about tariffs (pricing), informational, etc... The experience of butane gas is indicative and it can help us to visualize new scenarios. Diversification of supply in alternative fuels with butane gas especially collides with obstacles of an institutional and regulatory nature, and regarding attractive pricing structures for potential investors. Thus, the supply of butane gas is characterized by private investment focused on storage, bottling and distribution.

To increase the weight of LPG in the future energy mix, it would be desirable to establish an offensive strategy based on the following elements:

- Provide a positive information campaign on LPG and its use;
- Communicate and promote possible LPG savings when using this fuel;
- Improve supply conditions of the current market and develop conditions for greater penetration of the gas in areas where it is currently used in a minority way (multiplication of points of sales particularly in peri-urban areas).

A2.4 Improving framework conditions

Overview of avenues of intervention related to framework conditions

Formalizing the wood energy value chain must be part of a comprehensive approach which intervenes and optimizes the entire value chain. Indeed, this includes some development in framework conditions. Table 24 summarizes the priority interventions to achieve this result.

Table 27 Overview of avenues of intervention related to framework conditions

Priority interventions
• Support the forest administration in the implementation of differential taxation of wood; • Contribute to the adaptation of the regulatory and fiscal framework for the emergence of RWEM and UWEM by the implementation of tax incentives; • Support the setting up of an effective monitoring system in the region; • Set up a tracking system; • Facilitate the decentralization of the control system through the integration of local authorities and local stakeholders of the value chain; • Include the modernization of the wood energy value chain in regional planning; • Promote the creation of a wood energy Unit; • Develop regional wood energy supply directives; • Set up an information system on the wood energy value chain; • Regularly disseminate up to date information on the value chain.

Set up a differential taxation system

<u>The first step to a formalization of the wood energy value chain</u>

One of the preconditions to reach the target of formalization and modernization of the wood energy value chain is about developing legal, fiscal, parafiscal and administrative mechanisms which incentivize, strengthen and support the sustainable and efficient management of resources, reforestation for economic purposes and any legal activity.

The requirement of the "incentive" nature mentioned above fixes the implementing of regulations (at national, regional and local level) in the foreground, together with structures able to promote the achievements, and sustainable management of plantations and natural forests, while discouraging illegal logging. Obviously, this approach should be reinforced by control and repression mechanisms for illegal logging. It must be emphasized that the concentration of efforts in this field is a *sine qua non* condition to help increase the income of actors in the legal wood energy value chain.

> Favorable framework conditions (regulations, institutions etc.) are a key factor for the sustainable management of forest ecosystems and, therefore, **sensitivity**.

Currently, wood is an undervalued good. The important part of the logging price in the final price removes any possibility for the forest actor to implement sustainable forest systems. If to avoid wood consumption peaks, the means adopted are the reduction of the household level of wood consumption (for the distribution of improved stoves) or increasing the supply of wood energy (reforestation), the market value of wood energy decreases even more. This has the following consequences:

- Increased consumption:
- The less expensive a good is (compared to others); the less motivation there is to save it.
- Wastage during production:
  With free access to forest resources, as is currently the case in practice, inefficiency of the processing technology, exploitation losses during transport and so on, are not taken into consideration.
- Problem transfer:
  Urban traders and consumers benefit from the undervaluation of wood energy at the expense of the rural communities who are directly affected by deforestation.
- Lack of attractiveness in forestry investments:
  Maintaining the partial regulation of access to the forest with selling prices of wood energy in the forest, sustainable forest management is not profitable.
- Loss of public funds:
  Once investments are necessary to remedy environmental damage, they must be supported by public funds and not from market prices.

If we reconsider the problem from the perspective of poverty reduction, which is a priority development policy objective, the following findings can be drawn from this situation:

The gradual degradation of forest resources leads to a liquidation of "natural resource" capital. This process is not desirable from both an economic point of view and from the development policy angle. The rural population is thus robbed of their ability to be self-sufficient in forest products and to make some income. The communities suffer from the ecological consequences of forest destruction (erosion, loss of soil fertility, degradation of water resources and loss of biodiversity).

Urban consumers only benefit in the short and medium term from low wood prices. In the long term, they will also be affected by the consequences of the destruction of natural resources.

The only beneficiaries of abusive and unregulated exploitation are currently actors of the logging and selling/marketing links of the value chain.

FAO (2003) emphasizes that most of these revenue sharing systems have been introduced recently in the context of specific pilot projects that have been funded and administered by donors. Also the institutional capacities to maintain these systems in the long term are often lacking.

<u>Support the forest administration in the implementation of differential taxation</u>

The major problem that emerges from the previous analysis is the failure to set up a legal framework for regulatory policy in the market. In industrialized countries, making final consumers proportionally support additional costs generated by the consumption of unsustainable resources has become an integral part of environmental policy instruments. This is the principle of "polluter pays" where prices should reflect the economic reality of the pollution costs. As an alternative to State interventionism, which is based on guidelines and prohibitions, it is based on compensation under the market economy through corrective taxes paid by originators/beneficiaries for unsafe behavior for the environment and victims.

The introduction of differential taxation system penalizes and discourages anarchic and uncontrolled logging and therefore **decreases sensitivity**.

In the context of formalizing the wood energy value chain, it appears essential to introduce such a system of differential taxation that penalizes and discourages anarchic and uncontrolled exploitation; heavily taxed for the benefit of controlled exploitation, not or slightly-taxed.

The approach proposed here relies on economic incentives to guide the behavior of people towards energy saving. The price increase of wood energy on the market in this case plays a key role and provides - through the regulatory changes to the framework conditions - the transition to sustainable economic practice, which is socio-ecologically sustainable; both for the consumer and for the supplier.

From the point of view of ecology and forest policy, the objective should be the establishment of a market price for wood energy that would cover all expenses for an efficient and sustainable forestry economy. Obviously, this objective can only be achieved if the State defines a proper framework for action suitable for economic actors, by implementing regulatory instruments. Annex 7 explains the principle of differential taxation based on an example.

If sustainable production systems become profitable, people are encouraged to invest in forest management. These economic incentives and the availability of financial resources represent a kind of **adaptive capacity**.

The foundation stone of the proposed approach is regulatory intervention including effective control of transport flows of wood energy (for further details see Section 0). This would require a series of measures that are just as important as other interventions (reforestation, improved stoves, etc.) in terms of design and implementation cost:

- The creation of sufficient legal room of maneuver while avoiding legal changes. In practice, this means opening up a field of experimentation, administratively legal for a defined intervention avenue in accordance with policy makers and corresponding authorities, the experiences of which may be included at a later date, in the formulation of the current policy and the adaptation of the law;
- The systematic and objective determination of the amount and the assignment of corrective taxes on the use of unregulated wood, from economic analysis calculations, that takes into account the production costs of wood as a raw material;
- The introduction of a certificate of origin for sustainably produced wood energy;
- The creation of a control system in the strictest sense;
- For internal control and observation of impacts, the performance data must be entered and evaluated at the central level.

To make the implementation of differential taxation and tax incentives operational, it is desirable to launch a training programme for trainers to support the forestry administration.

Differential taxation causes wood energy price increases. This creates the risk of a deterioration of standards of living, especially for the poor and the potential risk of social unrest. This is why it is extremely important for the public to be informed through awareness-raising measures about the reasons for the price increase and simultaneously be prepared for the introduction of regulatory or compensatory measures such as the use of improved cookstoves. The supply of these should be sufficient to cover the demand of consumers. Therefore, it is compulsory to contribute to the organization of information sessions on the control system and validated tax system.

> The differential taxation causes price increases of wood energy accentuating the **sensitivity of consumers**, especially the poorest. The introduction of regulatory or compensatory measures, such as the distribution of improved cookstoves, serves to **reduce this difficultv**.

<u>Contribute to the adaptation of the regulatory and fiscal framework for the emergence of RWEMs and UWEMs through the implementation of tax incentives</u>

Additional revenues deriving from differential taxation must be redistributed to fund the control system and to disseminate sustainable forest production systems and effective processing techniques supporting the implemented tax incentives.

Tax incentives to implement in the price of wood energy upstream of the value chain are a means to realize and take into account the principles of decentralization within the value chain, it must go hand in hand with a strengthened decentralized forest control.

The principle of taxation is based on incentives and accountability of WE loggers to become professional in their business and also to encourage them to pay their taxes, so that the wood energy market becomes profitable at all levels in the hierarchy before reaching the consumer centers. In this context, it is important to support the relevant actors to facilitate the distribution of tax charges.

> The availability of additional revenues from the differential taxation makes the sub-sector **more able to adapt to change** (climate).

Strengthening the effectiveness of the forest control system

<u>Support the implementation of an effective control system at national level</u>

Any increase in taxes should also include appropriate measures for forest control to avoid problems such as corruption or unfair competition between unlawful products and those from developed areas. Strengthening forest control and administrative monitoring are the guarantors of the compliance with technical requirements mentioned in the management documents, to achieve a sustainable use of forest resources.

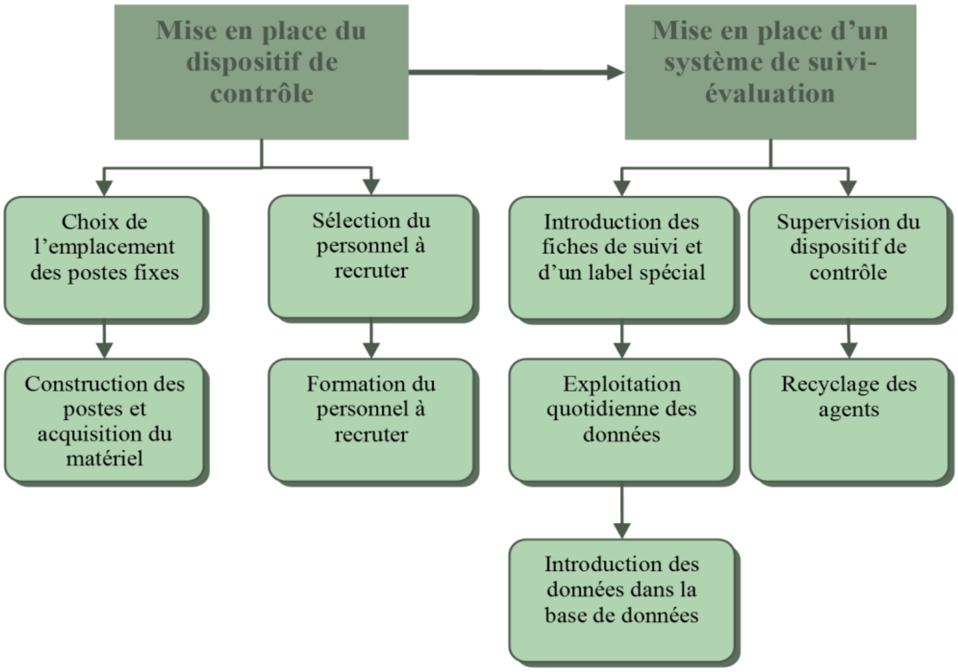
The setting up of a control system must be considered an integral part of the general concept of the value chain approach. The implementation of a control system for wood energy must meet several objectives.

Indeed, it is not only that the control system allows the collection of taxes on wood energy (see section 0), but it also allows the measurement of the flow of wood and charcoal into urban centers. In addition, monitoring this flow should provide statistical information on the geographical origin of the goods in order to know more about the local area. This is in the context of information necessary for the implementation of the Regional Urban Supply Programmes in Wood Energy (RUSPWE) (see section 0).

> The creation of a control system, supported by the setting up of a monitoring and evaluation system, reduces pressure on forest ecosystems (**reduced sensitivity**).

The creation of a control system strictly speaking requires in particular (1) the selection and management of check points, (2) the setting up of mobile control units for spot checking in remote areas (3) the selection and purchase of the necessary equipment (e.g. means of transport and communication), (4) compulsory and transparent agreement between the authorities on spatial and physical assets, accountability in the implementation and the power of intervention, setting up formal regulations upon this basis, and finally (5) the selection of staff and training.

This control system should be supported by the implementation of a monitoring and evaluation system to ensure the effectiveness of the forest control. The elements of the forest control monitoring system could be as follows: (1) entry sheets and a specific label for the tracking of wood energy, (2) daily data analysis and (3) their entry into a database. This enables (4) the supervision of the control system and the identification of weaknesses, (5) to develop an ongoing retraining program of the staff (see Figure 28).



Source *Ibrahim, 2001*

Figure 28 Diagram for the implementation of a forest control system at national level

Furthermore, to achieve better efficiency, it is essential to know how to train an efficient and motivated team with enough resources together with coaching which is also motivated and full of integrity.

The principle for the control system could be a combination of fixed checkpoints dispatched on the major roads of urban centers coupled with mobile teams.

It should be noted that these fixed checkpoints require high human resources for their functioning, 24 hours a day and 7 days a week. In addition, it would be useful to ensure a control around RWEMs and UWEMs. This could help to facilitate the monitoring and fining the products from illegal logging.

For the staff recruitment and training, we recommend the application of strict selection criteria for recruitment among the foresters. This recruitment may be performed in two steps. The first thing to do is a pre-recruitment, to select motivated and honest agents who will then be given recruitment tests.

At the same time, it would be obligatory to develop training programs; both theoretical in class and practical in the field. Training modules could then be delivered by service providers. Only after this training would the agents to serve in the control team be selected, and would then be organized in teams.

In order to minimize the temptations and opportunities for fraud, it is important to develop a tracking system, for example by using vouchers with preprinted values. This type of voucher has been successfully tested in Chad. It has the advantage of not being able to issue a voucher with a different amount on the sheet intended for the Treasury. In addition, this system would have the advantage of allowing easy tracking of quotas of forest resources submitted to management plans through limiting to quota the value of vouchers allocated to each forest.

In parallel with the implementation of the forest control system itself, it is advisable to develop a monitoring system on the activities of control agents which would allow regular use of the data collected.

This system could focus on activity monitoring cards by checkpoint or team. This will both help to monitor controls carried out and also the number of violations and the origins of the products. This is an important tool to control the work of agents in checkpoints or mobile teams.

Implementing a tracking system

In recent decades, various initiatives have emerged at world level, aiming at "normalization" of standards for forest management. The objectives of these initiatives include improving forest management and reducing deforestation. Some of these voluntary initiatives directly affect the forestry sector while others have been developed around various agricultural products (Hinrichs et al., 2011).

Forest certification aims to provide an independent audit of forest management systems by a third party, often called "environmental management system". The evaluation is carried out by private organizations such as the "American Forest and Paper Association" (AF & PA), ISO or FSC. Adherence to these regulations has been voluntary rather than imposed by the State. In addition, it is more and more seen as a marketing strategy and an eco-labeling process leading to a greater acceptance of "green" forest products by consumers (Hinrichs et al., 2011).

These international approaches however seem difficult to apply to the wood energy value chain in Burkina Faso. Neither the certification of forest management alone nor its combination with a "chain-of-custody (CoC) tracking" could be a realistic option.

The current structure of the value chain, characterized by a very high number of small-scale actors, does not allow the introduction of a certification system without avoiding exorbitant administrative costs. In addition, the increase related to management costs would be a negative incentive that can lead to a shift towards forest products from illegal logging. The profile of current users of woody biomass needs to opt for a cheap and easy solution to implement. Given this situation, we propose the development and implementation of a simple tracking system for the monitoring of wood energy from the forest to the final consumer. Emphasis should be placed on the monitoring and follow-up and not on the judgment of compliance with environmental and social standards.

The setting up of a tracking system enables the emergence and strengthening of a legal and controlled value chain, which reduces the pressure on forest ecosystems and therefore **sensitivity**).

The tracking of WE is then to be put in place through legal and regulatory means; a system for assessing and controlling the flow of material from the open spaces for exploitation in developed forests to the marketing to ensure its legality. One of the expected outcomes of the tracking is to enable the emergence and strengthening of a legal and controlled value chain while strengthening the repressive measures against operators working illegally. This direction implies a revision of the allocation and control system for logging. For instance, it would be appropriate to create two "tickets with stubs": (1) the production certificate and (2) the transportation permit precut including different elements that could be delivered to authorities during the transportation.

For the production certificate, three sheets should be provided:

- 1st sheet: kept by wood energy operators to prove the quantities actually produced;
- 2nd sheet: recorded by the management structure;
- 3rd sheet: recorded and archived by the Forest Service (Departmental Delegation).

As regards the transportation permit, it would be delivered by the manager of RWEM to transporters. The ticket will include:

- 1st sheet for the RWEM manager and team leader;
- 2nd sheet for transporters. This sheet could replace the current permit for wood transport;
- 3rd sheet for UWEM managers.

<u>Facilitate the decentralization of the control system through the involvement of local authorities and local stakeholders in the value chain</u>

To ensure the setting up of an effective control system, it is important to involve the participation and accountability of management bodies within the overall control concept. Forest monitoring can be divided into three types:

The upstream control carried out around forest resources or at local level: It is performed by the management bodies and local authorities with the support of agents from the forest department. The idea comes from the finding that it is mainly rural people who know best what is happening in their communities. When illegal logging has been identified, one of the roles of the management structure is to carry out monitoring and control around the legality of the logging.

Empowerment of local communities for forest control and respective strengthening of their technical, organizational and financial skills **increases adaptive capacity**

Control during transportation: This control will be done on major roads and at the entrance of the main cities under the responsibility of the region, by agents from the forest department and national security forces (see above).

Downstream control: This control will be primarily on WE points of sale especially around RWEMs/UWEMs and around major roads of WE traffic. The control involves checking authorizations and vouchers/tickets. It will be done under the responsibility of agents from the forest department and the public security forces.

The implementation of this system is based on the accountability of local actors. In this context it is necessary to support the development of local agreements in collaboration with the local authorities and the forestry administration. In addition, it will be compulsory to provide training to local authorities and inter-communal agents on the implementation of the control system.

The proposed action for the exploitation and processing link further provides major support for organizational development. This organizational support can be achieved through the facilitation of association groupings or cooperatives of local WE loggers and by creating a union of legal WE loggers. For all loggers and producers to know the laws governing forestry, the development of a dissemination strategy of the laws in force on the forest legislation is considered.

Facilitate planning, monitoring and dissemination of best practices

Involving modernization aspects of the wood energy value chain in the planning of local development

As part of the new socio-political approach marked by the decentralization process and sustainable development, Law No. 055-2004/AN December 21 and Law No. 065-2009/AN of 21 December on the general code, the authorities in Burkina Faso are to provide to urban areas, to rural districts, as well as to regions, the power to develop and implement policies and development plans in accordance with broad guidelines of the State.

In this way, regional and local planning is becoming more and more obvious as an effective method for decision makers, program managers and all development stakeholders in general. It aims to ensure, on the one hand, a greater consideration of potentialities and development constraints, and on the other hand, an effective involvement of communities in the process of identifying needs and decision making, as well their better ownership of investments.

Capacity development of local planning in general, and the integration of energy issues and climate change adaptation into development planning in particular, adds to the stakeholders' **adaptive capacity**.

Planning means the development of a shared vision of development and relevant actions, including identification of the material, financial and human resources necessary for its implementation in a geographic and temporal space. Local planning is a process which consists of boosting and organizing development at the community level. Within the responsibility of the town, it starts from the base and involves the ambitions of communities, neighborhoods, villages, towns and takes into account the great rational and sectoral guidelines.

The analysis of the current legislative and regulatory context of Burkina Faso reveals that the basic application texts (decree on the transfer of skills and resources, operational process, etc.) on the transfer of skills and resources in the environmental and decentralized management field of natural resources remain partial to date (Ouedraogo, 2011).

We note that many texts recognize the role and responsibility of local authorities in environmental management but do not have the methods to make it happen. To accelerate the transfer process, the MEDD joined members of the interdepartmental operational and extension committee for the transfer of skills with local authorities. Without being exhaustive, some important texts should be developed as soon as possible. These include (Ouedraogo, 2011):

- The order for the devolution of state property to local authorities and regions in the field of environment and management of natural resources;
- The process for skills and resources transfer of the state to the town/region in the field of environment and management of natural resources;
- The implementation law of the decree on detailed rules for the provision of public civil servants to local authorities;

- The joint decree involving the approach, content development and validation of local charters about forest management;
- The joint decree fixing fees and royalties of forest products from commercial and industrial logging for the State and local authorities.

Promote the creation of a national wood energy Unit

The lack of synergy between actors of the sector and within the administration (in particular MEDD, MMCE) is one of the main constraints identified in the structuring and development of the wood energy value chain. To overcome these constraints, it appears necessary to set up a coordinating committee to better direct, validate and coordinate development actions planned for the wood energy value chain. Two levels could be considered: 1 - National and 2 - Regional.

Setting up of national and regional coordination committees' strengthens collaboration between stakeholders of the sector in line with **strong adaptive capacity**.

Nationally, an interdepartmental committee should be created to bring together relevant institutions, MEDD and MMCE in particular, national associations of local representatives as well as federations or NGO platforms.

At the regional level, a light structure involving decentralized technical departments, local authorities and civil society could be considered within regional planning commissions of the country. This committee should be involved with the organizational arrangements of local authorities in order to support the definition and implementation of a concerted, consensual and comprehensive development strategy for the wood energy value chain. The actions identified will appear in the planning documents of the region in particular the regional programme of action for the environment.

Develop regional supply programmes in wood energy

All scheduled activities around different stages of the value chain should gradually contribute to a rebalancing of the national balance supply/demand in wood energy. However, given the concentration of the demand in major urban centers such as Ouagadougou and Bobo-Dioulasso, it would be desirable to update the Regional Urban Supply Programmes in wood energy (RUSPWE) developed over the 1990s in order to prioritize areas to develop and more precisely target local and economic actors involved in the supply chains of these cities.

Regional wood energy supply programmes enable coherent planning in wood energy supply, a key factor influencing **adaptive capacity** in the sub-sector.

This planning will be based in particular on the next updated forest data from the national forest inventory. The methodology of the Regional Urban Supply Programmes in wood energy (RUSPWE) will focus on the following areas (Charpin & Richter, 2013c):

- Location and characterization of supply areas/basins in wood energy;
- The quantified flow in the supply to urban centers, including flows of charcoal;
- The current situation and the development outlook for the household and artisanal demand;
- Identification of priority avenues of intervention;
- The determination of intervention types in each area compared with each link in the value chain;

- Prioritization for the implementation of action plans by area.

First, it is planned to develop a RUSPWE for the cities of Ouagadougou and Bobo- Dioulasso.

Monitor the wood energy value chain

<u>Develop an information system on the wood energy value chain</u>

At the moment spatial and non-spatial data on the wood energy value chain (WEVC) are broken up and it is difficult to have regular access to updated information. In addition, the monitoring of the implementation of the modernization of the wood-energy subsector requires information for each link in the value chain. In this context, the setting up of a single information system should be considered.

> An information system will enable proper management and capitalization of data and information, basic conditions for planning, monitoring and evaluation. Access to information is a key element of **actors' adaptability**

An information system is on the one hand a basic useful tool, to carry out properly all research, planning, with monitoring and evaluation of ongoing activities. On the other hand, it contributes to take enlightened decision-making based on reliable information. Such a system has, more particularly, the following objectives:

- The structuring, organization and concentration of quantitative and qualitative information on the WEVC available at the country level;
- Standardized and automated analysis of data relating to the WEVC;
- Information on stakeholders involved in the implementation of the modernization of the wood-energy subsector.

The monitoring system could be made of (see Figure 29) the networking of:

- MS Excel: calculation software;
- MS Access: database software;
- MapInfo/ArcGis: GIS software;
- GPS type Trimble GeoExplorer.

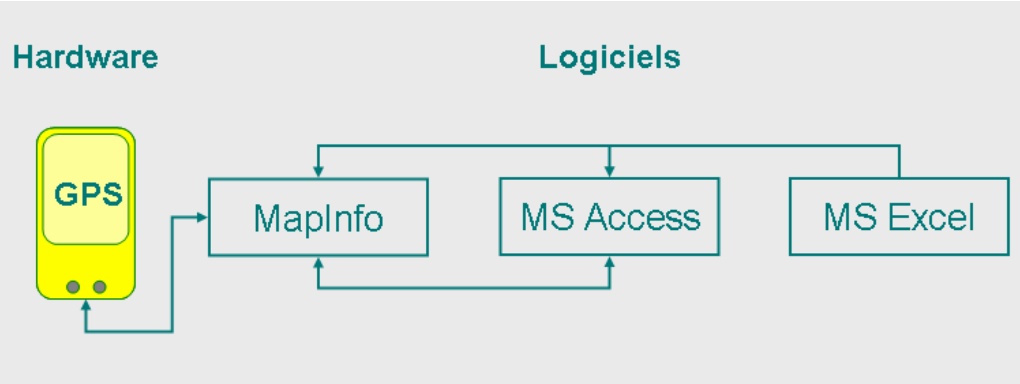


Figure 29 Overall Structure of the System

GPS is used to store the geographic coordinates and to create map objects (points, lines, polygons). Field data recorded in GPS are transmitted directly through an interface to GIS software.

With GIS software, field data are adjusted and combined with other existing sets of data. The information is then available for thematic analysis and mapping processing.

All data stored or updated in MapInfo/ArcGIS are automatically transmitted to the central database stored in MS Access:

- The structure and organization, as well as recording of all information takes place at this level;
- All non-spatial data are captured using forms (tables/forms);
- The predefined queries allow an automated analysis;
- The data prepared and summarized are submitted in reports (reports/statements).

Tables with spatial data in MS Access are linked to the corresponding tables in the GIS software. The homogeneity of the permanent structures of the tables and data integrity is thus assured. The programme of MS Excel calculation tables primarily serves the provisional data capture that is then transmitted to MS Access or the GIS software.

Yet in the design of the structure of the database for the capture and analysis of data on the wood energy chain value, this information must be integrated into the system of other actors. To this end, it is essential to work closely with those responsible for the implementation of the information system within the Forest Department and the Economy, Environment and Statistics Directorate. The type of database modules can then be designed so that it is applicable without problems throughout the Burkinabe territory.

To feed the database, it is first necessary to operationalize the methodology for collecting relevant data at each ecogeographical region. Here, it is about the definition of different information to be collected and the types of surveys to be conducted. Thus it would be possible to develop a type of "observatory" that would allow the monitoring of socio-economic impacts of the implementation of the modernization of the wood-energy subsector and the monitoring of regional wood energy balances where a RUS-PWE is set up. In this context it is essential to set up observation points at different stages of the of wood energy value chain:

- Production of wood energy: an inventory of different types of forest training sessions and different types of logging according to the main supply areas and the statement of logging plots;
- Transformation: estimation of the distribution of different types of kilns and their performance through surveys conducted in production plants;
- Transportation of goods: creation of observation positions for different categories of transport;
- Marketing of products: creation of observation positions in accordance with the traders representatives and storage and selling points of fuelwood (RWEM / UWEM, etc.);
- Consumption: Setting up a sampling system of targeted households in rural and urban areas.

For data collection, it is important to intensify collaboration with legal and organized actors in the wood energy value chain. This can be done by promoting partnership between major entities, supporting the delivery of a wide range of relevant information, combining the efforts of training and capacity building while using watchdogs to promote participation and accountability in decentralized authorities.

Ecological Monitoring

As an important component of the system to assess forest policies, ecological monitoring can help to assess the evolution of forest formations in the country in time and space, both in terms of global vegetation physiognomy and the potential in forest products and natural regeneration capacity of the species. This importance was identified during the development of the regional programme PREDAS and allowed the development of a specific component on the structuring of the national ecological monitoring activities of woody resources (Kerkhof & Laude, 2010). Although Burkina Faso was one of the two countries selected for this activity, the results were very limited given the choice of a research-oriented system.

An ecological monitoring system will provide relevant data and information on the environmental and socioeconomic impacts of sustainable management of forest resources. Access to information is a key element of the **adaptive capacity of stakeholders**.

On the basis of past experiences and in view of upcoming productions of data deriving from IFN-2, it seems appropriate to develop a simple and standardized ecological monitoring system having a political dimension to generate results. In other words, these productions should allow the demonstration of the investment interest in forestry management to decision makers in the light of the ecological and socioeconomic impacts they provide (Kerkhof & Laude, 2010).

The National Programme for Management of Forest Resources (MECV, 2009) identifies the following levels for the structuring of ecological monitoring:

- Monitoring at national level will deal with changes in forest areas, sown and burned areas;
- Monitoring at the local level (regions and communes) will measure the impact of actions taken by different Local Authorities on the development of forest resources within their territories.

A number of technical partners have an ecological monitoring system (PNGT, INERA, CIFOR, IRD, CILSS, etc.). It is necessary to carry out their inventory in order to achieve a better synergy of action between these systems and those to be implemented in the framework of rural and environmental development programmes.

Particular attention should be paid to the concerted and realistic definition of the monitoring criteria. First, it is necessary to define the elements or principles of participatory and decentralized forest management from which their sustainability can be assessed. Each criterion of sustainable forest management may be characterized by one or more associated indicators that can be quantitative, qualitative or descriptive. In general, these indicators should be comprehensible and accessible including for members of local management bodies.

Analysis or periodic measurement and systematic indicators will provide the basis for monitoring changes and trends of these indicators, and finally for the progress developed in the sustainability of various functions provided by forests.

Regularly disseminate information on the value chain

The process of setting up a monitoring system of the value chain should give a significant boost to the programmed actions, particularly in terms of information dissemination. For example, greater attention to the dissemination of information on the importance of the wood energy value chain, regulations, appropriate procedures and related training could help to educate many people involved, through dissemination of additional information, with a reduced additional cost.

Dissemination of information, best practices and lessons learnt will help to strengthen the **adaptive capacity** of stakeholders in the subsector.

Similarly, greater attention to good examples of wood energy management, their economic impacts and environmental benefits could be widely disseminated and promoted through the monitoring system. The information collected by the monitoring system could help to guide efforts to support industry actors with the latest technical information.

Collecting information at the research unit will monitor and disseminate not only non-spatial information but also spatial information. It would be profitable and desirable to take advantage of existing GIS and existing mapping capacities to follow, convey and disseminate such types of information. Maps generate much more interest and actions that the publication of a list of figures or tables. The research unit should take full advantage of opportunities to use maps and documentation of activities in the field with maps and photographs. These maps and files will be made available to the media, local authorities, etc...

In addition, it could be an option to develop a frame of reference of key figures of the wood energy value chain that makes the dissemination of information easy. Also it would be desirable to develop an interactive "atlas" summarizing the available information in the WE value chain, including mapping, key documents as well as different ongoing activities on a CD that could be regularly sent out.

The proposed action programme includes the handling of tests and pilot dissemination of best technologies and production methods, processing, marketing and use. These measures would enable a rational management and use of forest resources in wood energy. For this purpose, it is necessary to deal with a promotion and capitalization of technical and methodological achievements.

In this context, it is proposed to develop and disseminate a portfolio of "best practices" on the formalization of wood energy value chains. The brochure will present technical data sheets, methodological notes and training modules for stakeholders in the value chain as well as monitoring and evaluation tools focusing on results.

The brochure will also provide support for the dissemination and development of the "national wood energy model strategy".

Annex 3: Protected areas with wildlife focus in Burkina Faso: 2013

Region	Protected areas	Area (ha)	Protection decree
Boucle du Mouhoun	Deux Bâlés	115,000	1639/SE/EF June 19, 1937
	Pâ	15,625	1639/SE June 19, 1937
	Sâ	5,400	3320/SE October 13, 1938
	Sourou	14,000	1092/SE March 27, 1937
Cascades	Boulon	12,000	4087/SE/F May 31, 1955
	Comoé-Léraba	124,500	37/PRES/PM/MEE/MEF September 11, 2001
	Dida	75,000	688/FOR August 4, 1955
	Koflandé	30,000	8106/SE/F November 4, 1953
West-Center	Sissili	32,700	1093/FOR Dec 31, 1955
South-Center	Parc National Kabore Tambi	155,500	020/13/PRES/ET September 2, 1976
	Ranch de Nazinga	91,300	Decree n°2000-093/PRES/PM/ MEE March 17, 2000
Est	R.P.F. d'Arly	130,000	8885/SE/F December 12, 1954
	R.T.F. d'Arly	76,000	8885 December 23, 1954
	R.P.F. de la Kourtiagou	51,000	3146/SE/F March 29, 1957
	R.T.F. Madjoari	17,000	Decree 175 April 13, 1970
	R.P.F. de Pama	223,700	176/PRES August 13, 1970
	R.T.F du Singou	192,800	6098/SE/EF August 3, 1955
	Parc National du W	235,000	2606/SE April 14, 1953

Region	Protected areas	Area (ha)	Protection decree
High Basins	Dibon	24,000	4637/SEF/F June 24, 1954
	La Mou	34,000	3406/SE October 20, 1938
	Mare aux Hippo-potames	19,200	836/SE March 26, 1936
Central Plateau	Wayen	12,000	3009/SE August 26, 1941
Sahel	R.P.F du Sahel	1,645,000	N°70/302/PRES/AGRI-EL December 9, 1970
South-West	Koulbi	40,000	690/FOR August 4, 1955
	R.P.F. Nabéré	48,500	5768/SE/F August 3, 1953
	R.P.F. de Bontioli	29,500	3147/SE/F March 23, 1957
	R.T.F. de Bontioli	12,700	3417/SE/F March 29, 1957
Total area		3 461 425	

Source *General Directorate for Nature Conservation, 2010*

Annex 4: Forests under management or not managed in Burkina Faso: 2013

Region	Name of the forest	Developed area (ha)	Validity period of the PAG (year)	Management concession to UFG (year)
West-Center	Cassou	29,515	1993-207	2001
	Bougnounou-Nébielianayou	24,914	1993-2007	2002
	Nazinon	24,899	1988-2007	2002
	Sapouy-Bieha	21,000	2000-2014	2001
	Sud-Ouest Sissili	55,145	2000-2014	2001
	Silly-Zawara-Pouni	52,550	1999-2013	2001
	Tiogo	30,000	-	-
West-Center Sub-Total		238,023		
South-Center	Nazinon-Nord	21,424	1998-2017	2001
South-Center Sub-Total		21,424		
Hauts Bassins	Dindéresso	8,500	Development	-
	Kou	117	Development	-
	Koulima	2,150	Development	2008
	Poa (Koua)	350	Development	2008
	Maro	52,000	Before-PAG	-
High Basins Sub-Total		63,117		
South-West	Nabéré	36,500	-	-
	Djarkadougou	12,000	-	-

Region	Name of the forest	Developed area (ha)	Validity period of the PAG (year)	Management concession to UFG (year)
	Nabourgane			
	Gaoua-Nord	44,000	Validation	-
	Gaoua-Sud	50,000	Development	-
	Koulbi	42,000	Validation	-
South-West Sub-Total		184,500		
North-Center	Yabo	3,416	Development	-
	Korko-Barsalogho	24,763	Development	-
North-Center Sub-Total		28,179		
Est-Center	Moaga-Sablogo	17,000	-	-
North-Center Sub-Total		17,000		
Center	Gonsé	6,000	2004-2018	-
Center Sub-Total		6,000		
Boucle du Mouhoun	Nosébou	14,000	2005-2019	-
	Sorobouli	5,800	2005-2019	-
	Tissé	21,500	2005-2019	-
	Ouoro	14,000	2005-2019	-
	Toroba	2,700	2005-2019	-
	Kari	13,000	2005-2019	-
Center Sub-Total		71,000		
Cascades	Gouandougou	9,500	-	-
	Kongouko	27,000	-	-
	Bounouma	1,300	-	-

Region	Name of the forest	Developed area (ha)	Validity period of the PAG (year)	Management concession to UFG (year)
	Toumousséni	2,500	-	-
	Dida	75,000	-	-
Center Sub-Total		115,300		
Est	Matiacoali	92,000	Validation	
	Gayéri	51,784	Development	
Center Sub-Total		143,784		
Total		888,327		

Source *DirFOR, 2013*

Annex 5: Resident population by region and place of residence: 2013 estimates

Regions/Place of residence	Population (Number)	(%)	Density (inhab. /km²)
Boucle du Mouhoun region	**1,782,976**	**10.3**	**42.2**
Urban	150,675		
Rural	1,632,302		
Cascades region	**531,808**	**3.8**	**28.8**
Urban	126,563		
Rural	530,656		
Center region	**2,134,741**	**12.3**	**615.8**
Urban	1,823,870		
Rural	310,871		
Est - Center region	**1,398,967**	**8.1**	**77.2**
Urban	245,305		
Rural	1,153,662		
North – Center region	**1,485,485**	**8.6**	**60.6**
Urban	120,445		
Rural	1,365,040		
West- Center region	**1,466,381**	**8.5**	**54.6**
Urban	192,905		
Rural	1,273,475		
South-center region	**792,707**	**4.6**	**56.7**
Urban	83,591		
Rural	709,117		

Regions/Place of residence	Population (Number)	(%)	Density (inhab. /km²)
Est region	**1,498,163**	**8.6**	**26.2**
Urban	98,513		
Rural	1,399,650		
Hauts-Bassins region	**1,816,164**	**10.5**	**58**
Urban	638,137		
Rural	1,133,027		
North region	**1,465,429**	**8.5**	**73.2**
Urban	172,502		
Rural	1,292,927		
Sahel region	**1,196,819**	**6.9**	**27.4**
Urban			
Rural			
Plateau Central region	**860,590**	**5.0**	**73.2**
Urban	67,907		
Rural	792,683		
South-West region	**767,156**	**4.4**	**38.4**
Urban	86,772		
Rural	680,384		
TOTAL	**17,322,796**	**100**	**51.4**
Urban	3,932,335	23.0	
Rural	13,390,461	77.0	

Source *INSD, 2006, updated*

Annex 6: Action plans – planning of activities for the period 2014-2018

Activities	Unit	Quantity					
		2014	2015	2016	2017	2018	Total

Main line 1: wood energy production

Main line 1: A – Technical achievements

Support to the revitalization of existing FMGs and FMGUs	number	50	255	120	80	40	515
Finalization or updating of development and management plans	ha	120,000	180,000	250,000	150,000	120,000	820,000
Identification of priority natural forests for the production of WE	lump-sum	100,000	150,000	250,000	300,000	350,000	1,150,000
Development of an inventory model and an automated analysis model	lump-sum	0.00	0.30	0.70	0.00	0.00	1.00
Implement the development of new forests	ha	70,000	105,000	175,000	210,000	245,000	805,000
Facilitation of the negotiations between LA and UFMGs during the plan development and definition of management contracts	lump-sum	40	60	100	120	140	460
Diagnosis and mapping of forestry or conservation areas on the communal territory	number	10	50	100	100	100	360
Protection/restoration of degraded areas apart from managed forests	ha	20,000	45,000	65,000	55,000	75,000	260,000
Implementation of the reforestation under State control	ha	1,500	2,500	2,500	2,500	2,500	11,500
Implementation of the regional communal reforestation	ha	500	1,000	1,500	2,500	2,500	8,000

Implementation of individual/private village reforestation	ha	500	1,000	2,000	5,000	10,000	18,500
Development of a simplified framework management plan for reforestation	lump-sum	0.0	1.0	0.0	0.0	0.0	1.0
Test to implement short rotation reforestation	ha	0.0	2.5	2.5	3.0	0.0	1.0
Support for the creation of communal/village tree nurseries	number	50	80	110	110	110	460
Support for the reforestation planning	ha	2,500	4,500	6,000	10,000	15,000	38,000
Land security for wooded plots of land or reforested	ha	1,000	2,000	3,500	7,500	12,500	26,500
Installation, regeneration of linear plantations (windbreak, hedge)	km	35	55	75	95	95	355
Enrichment of parklands and cultivation areas	ha	12,500	15,000	17,500	17,500	20,000	82,500
Support for the management of tree fallows and agroforestry parklands	lump-sum	0	450	750	1,500	2,000	4,700
Research and development action on the management of trees outside forests	ha	0	10	15	0	0	25
Updating of the national strategy for fire management	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Implementation of the national strategy for fire management	km	0.0	1.0	0.0	0.0	0.0	1.0
Implementation of a strategy for climate change adaptation and integration of CC aspects in development plans	lump-sum	0.0	1.0	0.0	0.0	0.0	1.0

Line 1: B - Training/Retraining

Elected officials and local leaders on the texts and laws on decentralization and forest regulations	at-tendees	0	160	280	320	40	800
The MEDD technical and commune staff on facilitation techniques, using of GPS, and inventory techniques, development of local convention	at-tendees	0	120	220	200	120	660
Forester engineers or service providers on inventory techniques, mapping, use of GPS development and implementation of simple management plans	at-tendees	5	50	70	70	50	254
Support for the creation of FMGs	at-tendees	680	1,500	2,300	2,600	3,100	10,180
FMGs members on the local management rules	at-tendees	750	1,400	2,300	2,600	3,100	10,150
Members of the FMGs on simplified accounting management	at-tendees	80	220	300	310	280	1,190
Members of the FMGs on cooperative management and organizational dynamics	at-tendees	350	480	650	550	480	2,510
Members and communal officials on the plants production techniques	at-tendees	50	100	150	150	150	600
GGF members and communal staff on control techniques against fires	at-tendees	550	710	900	850	800	3,810
GGF members and communal staff on the development of micro-projects	at-tendees	80	220	300	310	280	1,190
Breeders on local rules and management of grazing	at-tendees	350	480	650	550	480	2,510
Awareness among FW value chain stakeholders on local management rules	lump-sum	0	50	100	150	200	500

Technical and organizational support to nurserymen	attendees	50	100	150	150	150	600
Private farmers in managing their plantations	attendees	50	100	150	200	150	650
Agriculture in the management of fallow trees outside forests for the production of WE	attendees	500	1,000	1,500	1,500	1,500	6,000
Technical staff of MEDD and Communes on the integration of adaptation issues to climate change in management plans	attendees	0	120	220	200	120	660

Line 1: C - Support to investments

Materials and equipment for the management of natural forests	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Materials and equipment for nurseries	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Materials and equipment for the implementation of Firewalls	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Equipment (GPS inventory equipment, software, computers) for the MEDD	lump-sum	0.0	1.0	1.0	1.0	1.0	4.5

Line 1: D - Support to functioning

Administrative costs	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Travel expenses	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5

Activities	Unit	Quantity					
		2014	2015	2016	2017	2018	Total
Line 2: Exploitation and processing of wood energy							
Line 2: A - Technical achievements							
Test improved kilns	lump-sum	0.0	0.5	0.5	0.0	0.0	1.0
Production test of biochar from agricultural residues	lump-sum	0.0	0.0	0.0	1.0	0.0	1.0
Feasibility study and techno-economic potential of the artisanal and industrial production of biochar from agricultural waste	lump-sum	0.0	1.0	0.0	0.0	0.0	1.0
Laying alignment plantations	lump-sum	0.0	1.0	1.0	1.0	0.0	3.0
Production test of woodchips	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Transformation and valorization PENL	lump-sum	0.0	1.0	1.0	1.0	0.0	3.0
Line 2: B – Training/Retraining							
WE exploitation organized in cutting techniques	attendees	250	550	1,250	1,250	1,250	4,550
Support the formalization of economic operators to the exploitation of the PFNL collection and processing	attendees	31	69	156	156	156	569
Organized groups on technical processing of PFNL	attendees	15	50	15	100	100	340
Charcoal burners on improved carbonization techniques	attendees	50	110	110	120	110	500
Economic operators on the administrative and financial management of their business and supply management	lump-sum	139	356	694	769	769	2,726

Economic operators access to micro-credits	at-tendees	12	30	58	64	64	227
Sedentary breeders on pruning techniques	at-tendees	88	120	163	138	120	628
Communal staff on lopping and pruning techniques	at-tendees	0	20	30	50	50	150
Economic operators on the briquetting of biochar	at-tendees	0	20	30	75	100	250
Strengthening actors for the implementation of the organizational scheme	at-tendees	0	150	150	150	150	600
Transformers on the production of woodchips	at-tendees	0	6	10	20	20	56
Managers and forest department staff on indicators of the environmental monitoring and collecting data capitalization	at-tendees	0	55	55	85	85	280

Line 2: C –Support to investments

Equipment for PFNL processing units	lump-sum	3.0	10.0	15.0	20.0	20.0	68.0
Equipment for the production biochar units	lump-sum	0.0	5.0	10.0	15.0	20.0	50.0
Equipment for the production of WE (axe, chainsaw, safety equipment	lump-sum	31	69	156	156	156	568.8
Equipment for the production of charcoal (fireplace)	lump-sum	10.0	22.0	22.0	24.0	22.0	100.0
Materials and equipment for the production of woodchips	lump-sum	0.0	2.0	2.0	1.0	0.0	5.0

Line 2: D – Support to functioning

Administrative costs	lump-sum	0.50	1.00	1.00	1.00	1.00	4.50
Travel expenses	lump-sum	0.50	1.00	1.00	1.00	1.00	4.50

Activities	Unit	Quantity					
		2014	2015	2016	2017	2018	Total
Line 3: Transportation and Marketing of wood energy							
Line 3: A – Technical achievements							
Support for the selection of sites and mapping in RWEM and UWEM for Ouagadougou and Bobo-Dioulasso	lump-sum	0.0	0.5	0.5	0	0	1.0
Setting up of MRBEs to supply Ouaga and Bobo-Dioulasso	number	0	15	30	45	45	135
Setting up of MUBEs in cities of Ouga and Bobo-Dioulasso	number	0	5	10	15	15	45
Identification and implementation of opening up measures	km	0.0	10.0	15.0	25.0	75.0	75.0
Setting up of a market information system of a WE	lump-sum	0.2	1.0	0.5	0.5	0.2	2.1
Organization of marketing campaigns for "green" wood energy products	lump-sum	0	2	6	11	11	30
Test for the implementation of a "chip" wood value chain	lump-sum	0.0	0.0	1.0	1.0	0.5	2.5
Line 3: B – Training/Retraining							
Supporting the formalization of economic operators involved in the transportation and marketing of WE	attendees	0	30	50	50	50	180
Administrators of RWEMs and UWEM on the management of markets	attendees	0	60	120	180	180	540

Transporters and traders on the administrative and financial management of their business and supply management	attendees	0	50	80	120	100	350
Economic operators on micro-credit	attendees	0	50	80	120	100	350
Supporting actors to facilitate the development of partners	attendees	0	50	80	120	100	350

Line 3: C – Support to investments

Management of RWEMs and construction of administrative buildings	number	0	15	30	45	45	135
Management of RWEMs and construction of administrative buildings	number	0	5	10	15	15	45
Computer Equipment for the WE Market Information System	lump-sum	0.0	0.0	1.0	0.5	0.0	1.5

Line 3: D – Support to functioning

Administrative costs	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Travel expenses	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Computer Equipment for the WE Market Information System	lump-sum	0.0	0.0	1.0	0.5	0.0	1.5

Activities	Unit	Quantity					
		2014	2015	2016	2017	2018	Total

Line 4: Use of wood energy

Line 4: A – Technical achievements

Optimization and test of improved cookstove samples (households)	lump-sum	0.0	1.0	0.5	0.0	0.0	1.5
Optimization and test of improved cookstove samples (Professional)	lump-sum	0.0	1.0	0.5	0.0	0.0	1.5
Test and development of improved cookstoves type "gasificateur"	lump-sum	0.0	1.0	0.0	0.0	0.0	1.0
WE test for the use of "chip" wood	lump-sum	0.0	0.0	0.0	1.0	0,0	1,0
Market analysis and development of a national programme	lump-sum	0	1	0	0	0	1
Distribution of improved cookstoves (households) according to market approach	number	50,000	65,0000	75,000	100,000	100,000	390,000
Distribution of improved cookstoves (professional)	number	450	1,500	2,500	3,500	3,500	11,450
Distribution of improved cookstoves type « gasificateur »	number	0	0	1,500	3,500	4,000	9,000
Distribution of butane gas	number	10,000	20,000	40,000	45,000	45,000	160,000
Development of biogas units	number	100	200	300	400	400	1,400
Setting up of a WE quality control system	lump-sum	0.0	1.0	0.5	0.5	1.0	3.0
Implementation of WE marketing campaigns	number	6	11	22	22	15	76
Developing a MDP project	lump-sum	0.0	1.0	0.2	0.0	0.0	1.2

Line 4: B – Training/Retraining

Support the formalization and grouping of artisans and potters engaged in the production of improved cookstoves	at-tendees	84	111	129	173	173	669
Artisans and potters on the production of improved cookstoves	at-tendees	118	155	181	242	242	937
Artisans and potters about marketing	at-tendees	118	155	181	242	242	937
Inspectors on the quality of the sold improved cookstoves	at-tendees	0	16	18	24	24	82
Support the formalization of sellers of improved cookstoves	at-tendees	39	52	60	81	81	312
Organized WE retailers on simplified accounting	at-tendees	78	103	121	161	161	624
Training of gas fitters for biogas	at-tendees	35	45	45	45	40	210

Line 4: C – Support to investments

Support for the setting up of point for sales for improved cookstoves	number	59	78	90	121	121	468
Support for the setting up of production workshops for improved cookstoves	number	118	155	181	242	242	937
Support the purchase of equipment for the construction of biodigesters	number	18	23	23	23	20	105

Line 4: D – Support to functioning

Administrative costs	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Travel expenses	lump-sum	0.5	1.0	1.0	1.0	1.0	4.5
Support the functioning of the WE control of quality system	lump-sum	0.5	1.0	0.5	0.2	0.0	1.7

Activities	Unit	Quantity					
		2014	2015	2016	2017	2018	Total

Line 5: Framework conditions

Line 5: A - Technical achievements

Setting up of an efficient control system	lump-sum	0.0	1.0	1.0	0.5	0.3	2.8
Setting up of a tracking system	lump-sum	0.0	1.0	0.5	0.3	0.0	1.8
Organisation of awareness campaigns regarding an institutional and legal reform (control, tracking, etc.)	number	0	22	11	11	11	55
Development of implementing regulations	lump-sum	0.2	1.0	0.8	0.5	0.0	2.5
Dissemination of adopted regulations	lump-sum	0.0	1.0	1.0	0.5	0.3	2.8
Setting up of a M&E system	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Installation of an environmental monitoring system for managed and unmanaged forest areas	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Setting up of a communication system	lump-sum	0.0	0.5	1.0	1.0	0.5	3.0
Development of regional wood energy supply plans for major cities	number	0.0	2.0	4.0	4.0	4.0	14
Integration of wood energy planning into local development plans	number	5	15	25	40	55	140
Support to the coordination, fundraising, assembly of records and communication	lump-sum	0.0	0.5	1.0	1.0	0.5	3.0

Dissemination of information on the wood energy value chain (brochures, etc.)	lump-sum	0.0	0.0	1.0	0.0	1.0	2.0
Participation in conferences/workshops on wood energy	lump-sum	0.0	1.0	1.0	1.0	1.0	4.0
Organisation of a national conference on wood energy	lump-sum	0.0	1.0	0.0	0.0	1.0	2.0
Evaluation of the implementation of the wood energy value chain action plan	lump-sum	0.0	0.0	0.5	0.0	1.0	1.5
Update of the wood energy value chain action plan	lump-sum	0.0	0.0	0.0	0.0	1.0	1.0

Line 5: B – Training/Retraining

Stakeholders of the FVC on traceability	attendees	0	550	1,200	1,200	800	3,750
Control agents on the regulatory framework	attendees	0	250	500	500	300	1,550
Agents on the control procedures	attendees	0	250	500	500	300	1,550
Agents on the methodology for M&E and environmental monitoring	attendees	0	150	300	300	180	930
Users of the monitoring system on data entry and analysis	attendees	5	10	20	10	0	45
Actors on data collection for M&E systems and environmental monitoring	attendees	0	250	500	300	180	1,230
Key actors of the wood energy value chain on the communication system	attendees	68	150	150	150	180	588
Agents on gender and development	attendees	0	150	300	300	180	930

Line 5: C – Support to investments

Logistics (cars, motor bikes, means of communication) to strengthen the control system	lump-sum	0.0	0.5	0.5	0.5	0.0	1.5
Equipment for the M&E system	lump-sum	0.0	1.0	0.0	0.0	0.0	1.0
Equipment for cartographic analysis and map production	lump-sum	1.0	0.0	0.0	0.0	0.0	1.0

Line 5: D – Support to functioning

Administrative costs	lump-sum	1	1	1	1	1	5
M&E activities	lump-sum	1	1	1	1	1	5
Travel expenses	lump-sum	2.0	2.0	2.0	2.0	2.0	10.0

Annex 7: Potential carbon sequestration of forest resources; 2013

Potential sequestration carbon of natural forests by stratum, 2013

Stratum	C	CO_2	Area	Total C	Total CO_2
(Name)	(t/ha)	(t/ha)	(ha)	(t)	(t)
Gallery forest	101.59	372.54	813,754	82,670,792	303,153,793
Sparse forest	78.55	288.03	46,852	3,680,101	13,494,930
Planted forest	53.75	197.09	2,087,813	112,212,427	411,482,968
Shrubby savannah	46.47	170.40	5,439,974	252,791,220	926,985,403
Grassy savannah	39.12	143.44	216,524	8,469,721	31,058,468
Planted steppe	34.82	127.68	186,462	6,492,109	23,806,565
Shrubby steppe	36.08	132.32	2,096,405	75,648,680	277,403,709
Grassy steppe	12.26	44.98	1,240,168	15,210,602	55,777,277
Average/total	50.33	184.56	12,127,952	557,175,651	2,043,163,114

Source *Brown, 1997; Richter, 2013c*

Potential carbon sequestration of forest plantations; 2013

Stratum	Exploitable areas [1]	Volume of standing trees par ha	Volume of standing trees total	Annual exploita-ble volume [2]
	(ha)	(m³/ha)	(m³)	(m³/year)
Gallery forest	741,594	71.12	52,742,178	1,758,073
Sparse forest	24,974	42.25	1,055,134	35,171
Planted forest	1,760,563	19.60	34,507,032	1,150,234
Shrubby savan-nah	4,457,444	14.60	65,078,679	2,169,289
Grassy savannah	199,802	10.30	2,058,402	68,613

Planted steppe	186,462	8.14	1,517,604	50,587
Shrubby steppe	2,096,405	8.75	18,343,486	611,450
Grassy steppe	1,240,168	0.98	1,221,187	40,706
Total	**10,707,411**	**10.03**	**176,523,702**	**5,884,123**

Source *Obou, 2013*

Explanations:

C = Carbon density = ABD * 0.5 (Brown, 1997)
ABD = Biomass density on soil (t/ha) = VOB * WD * BEF (Brown, 1997)
VOB = volume on standing tree (m^3/ha)
WD = average wood density (t/m^3) = 0.7 t/m^3
BEF = Biomass extension factor = Exp. (3.213 – 0.506 * Ln (BV)) si BV < 190 t/ha; BEF = 1.74 si BV > 190 t/ha
BV = VOB * WD
CO_2 = CO_2 density (t/ha) = C * 3,667

Potential carbon sequestration of trees outside forests; 2013

Stratum	C	CO_2	Area	Total C	Total CO_2
(number)	(t/ha)	(t/ha)	(ha)	(t)	(t)
Pluvial crops	22.95	84.15	8,703,345	199,724,188	732,388,599
Agroforestry areas	33.44	122.62	2,612,230	87,350,738	320,315,158
Agricultural areas with presence of natural areas	45.03	165.13	3,621,692	163,089,604	598,049,578
Average/total	33.81	123.97	14,937,267	450,164,531	1,650,753,334

Source *Obou, 2013; Internet capture*

Explanations:

C = Carbon density = ABD * 0.5 (Brown, 1997)
ABD = Biomass density on soil (t/ha) = VOB * WD * BEF (Brown, 1997)
VOB = volume on standing tree (m^3/ha)
WD = average wood density (t/m^3) = 0.7 t/m^3
BEF = Biomass extension factor = Exp. (3.213 – 0.506 * Ln (BV)) si BV < 190 t/ha; BEF = 1.74 si BV > 190 t/ha
BV = VOB * WD
CO_2 = CO_2 density (t/ha) = C * 3,667

Annex 8: Standards and Principles “Individual Village Reforestation” (IVR) – Energy Reforestation of bare land

Principle 1:	Adaptation to climate change;
Principle 2:	Conservation of biological diversity;
Principle 3:	Maintenance of population and productivity;
Principle 4:	Political integration;
Principle 5:	Extension and integration in a spatial plan (RUSPWE /PCD);
Principle 6:	Voluntary participation without direct financial allocation;
Principle 7:	Support to local good governance;
Principle 8:	Effective organizational skills;
Principle 9:	Women and peasants “landless” have priority access to land;
Principle 10:	Guarantee of individual rights of use;
Principle 11:	Taking into account economic efficiency in decision -making ;
Principle 12:	Recognition of the role of the market;
Principle 13:	Creating a “green” economic value chain;
Principle 14:	Fight against market imbalance through good governance and compliance with standards;
Principle 15:	Mixing community and individual aspects;
Principle 16:	Supervision by certified providers;
Principle 17:	Keep it simple;
Principle 18:	Application efficient processing technology;
Principle 19:	All RVI lands are recorded continuously in a database system.

Source *Andriamanantseheno et al., 2013*

Annex 9: Explanation of differential taxation

On the basis of the charcoal value chain, the principle of differential taxation is presented below using an example for better illustration. Amounts of money appearing in the diagrams refer, in their chronological order, with direct costs for the production of one kilogram of charcoal in currency unit (CU) and are only to be considered as an example.

A. Status quo

Currently, most of the charcoal comes from illegal logging. Wood raw material is free. Only labor costs for cutting and carbonization are taken into account. Transportation costs are estimated to be rising, since the regions where charcoal is illegally exploited are further away from consumption centers. Production costs of around 100 CU/kg in the example are incurred in the sustainable management of natural forests. It is assumed that improved kiln technique is used and logging from natural forests is therefore more efficient.

	Production	Coupe & carbonisation	Transport	Prix Marché
Filière incontrôlée	0	120	40	160
Filière durable	150	80	20	250

Impact: The sum of the production costs in the sustainable value chain leads to a higher market price, compared to an illegal value chain. Thus, sustainable production systems such as sustainable forest planning and reforestation cannot compete in the market with illegal channels. As long as the price of wood does not reflect the operating cost, sustainable planning or reforestation must be subsidized.

B. Introduction of regulatory measures

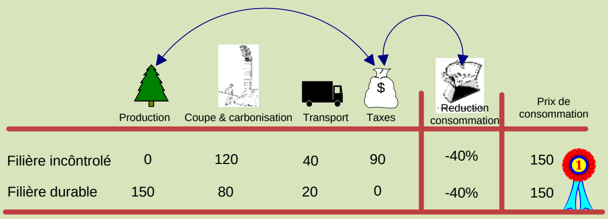
To limit the waste of natural resources during uncontrolled exploitation, differential taxation must be introduced to obtain compensation between the instigators of harmful behavior to the environment and citizens investing in a sustainable exploitation of their natural resources. Differential taxation must be calculated in a way that reflects the costs of sustainable use of forest resources. Given that these additional taxes are conveyed from producers to consumers, the market price of wood energy increases.

	Production	Coupe & carbonisation	Transport	Taxes	Prix Marché
Filière incôntrolé	0	120	40	90	250
Filière durable	150	80	20	0	250

Impact: With the increase in the wood energy price, sustainable production systems become profitable and then are an interesting alternative land use for the rural population as an energy supplier. The consent of the rural population to invest in incentives encouraging increases in productivity quickly increases and the amount of unregulated logging decreases accordingly. The urban consumer, who must rely on a significant price increase of wood energy, is then disadvantaged.

C. Introduction of improved cookstoves to absorb the energy price increase

Significant increases in the price of basic energy sources such as fuelwood and charcoal create the risk of falling standards of living; especially for the poor, and a risk of social unrest. This is why it is extremely important for people to be prepared for price increases at the same time as the regulatory measures, through awareness and measures to facilitate access to improved cookstoves that are sufficient to meet the demand of consumers.



	Production	Coupe & carbonisation	Transport	Taxes	Reduction consommation	Prix de consommation
Filière incôntrolé	0	120	40	90	-40%	150
Filière durable	150	80	20	0	-40%	150

Impact: The introduction of improved cookstoves results in a saving of about 30% to 40% at the consumer level. Price increases induced by sustainable production of resources automatically get absorbed. The investment costs for a new improved cookstove are often absorbed within just a few weeks. The market penetration of improved cookstoves will gradually increase.

Source *GTZ, 2007*