SWEDISH TRADE COUNCIL

KNOWLEDGE TRANSFER IN BIOMASS SUITABILITY & SUSTAINABILITY FOR VARIOUS TECHNOLOGIES

Report Prepared by

SAWA CONSULTING

P.O Box 20802

00202 Nairobi

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1 STUDY OBJECTIVES

UNIDO is planning the implementation of three (3) projects follows:

a. Biogas facility in Homa Bay that will generate biogas from municipal sewage
b. Micro Hydro Plant for fuel substitution in a tea factory, probably in Kericho
c. Community Power Centres (CPCs) for renewable off-grid electricity production (three communities, sites in Western Kenya, Baringo District and Coast Province)

In order to assist UNIDO in planning and implementing these projects, the Swedish Trade through Hifab has commissioned this study and corresponding workshops focusing on renewable energy, energy efficiency and methods for ensuring that the energy production and use is socially and environmentally sustainable in each of the chosen project sites and communities. All three projects are in very early stages of development.

Specific objectives of this biomass study and corresponding workshops are to:

a. Quantify availability of selected biomass streams
b. Determine suitability and sustainability of biomass streams and technologies for production of fuel streams – electricity, charcoal and biomass briquettes
c. Review practicality of projects proposed by UNIDO
d. Identify general technical options and identification of relevant legal requirements, environmental regulations, land tenure status, construction standards and planning regulations etc.
e. Identify crucial capacity needs for local level stakeholders.
f. Recommend to UNIDO, the local authorities and the communities on steps required to achieve their goals
g. Identify lessons and points of concern based on best practice case studies

2 BIOMASS AVAILABILITY

This section provides an overview of the availability of selected biomass streams in Kenya and especially in the UNIDO project target regions. The information presented is based on existing documented information, field surveys as well as communication with biomass producers. As per the terms of reference five biomass streams namely: *Prosopis Juriflora* (Mathenge), Bagasse, Sisal, Coconut and Cashew have been considered; Key elements of the assessment include availability, seasonality, competition and pricing in Kenya.

2.1 Bagasse

Western Kenya is the main Sugar cane production zone with seven sugar cane milling factories serving the cane growing areas of Nyanza and Western provinces of Kenya. Rehabilitation of the Kwale Sugar (formerly Ramisi Sugar) in Kwale District Coast province is ongoing while Mumias Sugar is planning additional large scale plantations and factory in the Tana River basin.

Existing factories produce about 167,000 tons of bagasse per month, for an average of 10 months per year. Table 2.1 below summarizes the historical availability of bagasse. Data for Kibos Sugar which began operations in 2008 is unavailable.

Table 2.1: Bagasse availability (tonnes) in Kenya: 2000 -2005

Company	2000	2001	2002	2003	2004	2005	Average
Chemelil	256,959	196,068	270,674	197,192	243,005	193,186	226,181
Muhoroni	67,295	6,027	180,477	171,174	142,100	144,377	118,575
Mumias	725,116	729,625	799,166	785173	877433	888,604	800,853
Nzoia	160,289	122,850	234,046	207,682	247,182	241,898	202,325
S. Nyanza	185,297	179,945	205,546	196,321	256,318	268,533	215,327
West Kenya	45,776	55,273	85,099	85,830	86,111	114,239	78,721
Total	**1,440,732**	**1,289,788**	**1,775,008**	**1,643,372**	**1,852,149**	**1,850,837**	**1,641,981**

Source: KSB; 2008: 19-25

In spite of using the most inefficient combustion, steam and power production systems, only 60% of the vast quantities of bagasse are effectively utilized as boiler fuel while the rest is disposed of. With the exception of Mumias, other factories cogenerate only enough power to satisfy their internal requirements while at times relying on utility supplies to meet peak demand.

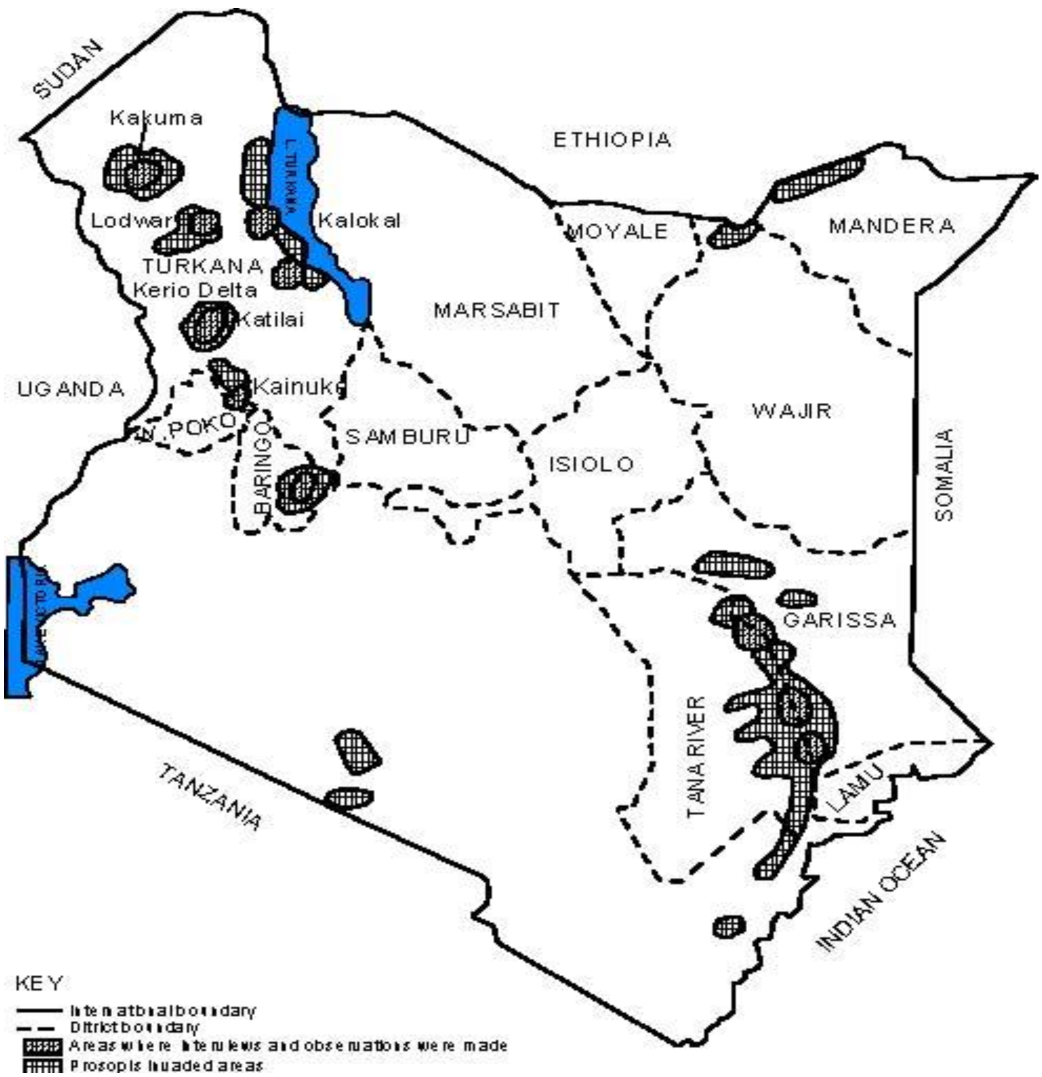
Initially a very attractive due to high volumes available, bagasse is increasingly becoming unattractive for long term alternative fuel supply investment due to the ongoing shift by the sugar industry to cogeneration for export of electricity to the grid and the simultaneous CDM benefits. This means that in 2-3 years availability of excess bagasse will be extremely limited if not all together unavailable. This period however depends on among other factors the privatization program of the sugar industry. Estimates from independent studies have pointed to a significant potential to enhance cogeneration capacity in the country from the installed 35 MW to between 100 and 300 MW in the short- to long- term.

2.2 Prosopis Juriflora (Mathenge)

The first documented introductions of Prosopis juliflora and Prosopis pallida to Kenya was in 1973 for the rehabilitation of quarries in Mombasa by Bamburi Cement, with seed sourced from Brazil and Hawaii. Introductions into the semi-arid districts of Baringo, Tana River and Turkana districts in the early 1980s was part of the government of Kenya anti desertification programme to ensuring self-sufficiency in wood products, making the environment habitable and safeguarding the existing natural vegetation from overexploitation by the rising human populations (Choge et al, 2002).

A report by the Kenya Forestry Research Institute and Forestry Department (Choge et al, 2002) shows pockets of large-scale colonization across the semi-arid areas of Kenya, with large-scale invasions indicated in the Tana River area of eastern Kenya and in the Lake Tana and Pokot areas in northwestern region of the country. Schematic 2.1 show the distribution of Prosopis Juriflora in Kenya.

Schematic 1: Distribution of prosopis in Kenya



Source: Choge et al., 2002

Detailed surveys are needed to establish and update estimates of acreage and quantities of standing *prosopis juriflora* biomass stocks. P*rosopis juriflora y*ields are estimated at about 25 to 30 tons of biomass/ha/year at a short rotation age of 4 to 5 years.

In Baringo district alone, more than 300 square kilometers or 12,000 hectares has been invaded by Prosopis. This translates to an estimated biomass yield of 360,000 tons per year. Invading Prosopis tends to form dense, impenetrable thickets, associated with unfavorable impacts on human economic activities.

2.3 Sisal

Large scale Sisal production in Kenya is undertaken manly in the rift valley and Coast provinces. Major plantations are found in Mogotio, Kibwezi, Taita and Vipingo. Biomass waste from sisal can be obtained bogas - waste from processing of green leaf and boles - standing stock left after complete harvesting sisal leaves.

Sisal fiber is only about 4% of the entire green sisal leaf, which also comprises 60% water, 35% Bogas (Decorticator waste) and 1% Tow (low grade fiber. It is estimated that from the 552,400 tons of sisal leaf harvested in 2006, about 102,470 tons (Air dry) of bogas was generated. Most of this fibrous material is dumped in the field to dry. Some of it is used as cattle feed and as fertilizer.

2010 data shows that REA Vipingo the largest single producer in Kenya and commanding more than 50 % of the national sisal output generates approximately 40,000 tons (air dry) of boles per year from its estates in Kibwezi and Vipingo. The Total national availability of boles can therefore be estimated to be 80,000 tons per year.

2.4 Coconut

Coconut production in Kenya is concentrated in coast province up to distance of 50 km inland. Kwale and Kilifi districts are the main areas of coconut production in Kenya. Production stood at 61,000 tons in 2006 up from 57,000 tons in 2003; this would have produced a total of 34,038 tons (air dry) of husk. Increased competition for land use (real estate) at the coast and depressed prices of coconut oil, have seen the acreage under coconut trees decline over the last 2-3 years.

There is currently no competition for the coconut husks and shells, but collection and delivery infrastructure remain a key challenge. Delivered cost will largely be affected by the cost of transport. If these are to be utilized, then the development of a sustainable and cost effective collection system must be given priority.

2.5 Cashew

Cashew is grown for local and export markets mainly in Coast province with Kwale and Kilifi districts being the main production areas. Production capacity has declined over the years mainly due to ageing trees which is also a major concern with respect o the sustainability of the cashew industry. Neither the government nor the existing processors - Kenya Nuts (Thika), Wondernuts (Kilifi) and Millennium (Kilifi) have made any meaningful investments in extension services for the development and planting of new crop over the past 10 years. Consequently cracking capacity is on the decline and is currently estimated at 3,500 tons of cashew nuts per annum, 75 % (2,600 tons) of which ends up as kernels.

This high energy density biomass fuel though available in relatively small quantities has attracted competition from small furnace operators especially in Nairobi and to a smaller extent Mombasa. Demand for cashew kernels in Mombasa has reduced significantly since Bamburi Cement which was the major consumer terminated utilization of cashew kernels in their cement kilns in Mombasa. Current ex factory prices range between KES. 3,000 to 5,000 per ton.

Table 2.2 summarizes the annual availability of biomass wastes.

Table 2.2: Annual Biomass Availability

Biomass Stream	Availability (tons/Year)	Calorific Value (kcal/kg)	Competition
Bagasse	1, 642,000	2,820	Low, but expected to increase with privatization of sugar industry
Prosopis Juriflora	High, but un-quantified	4,216	Low, but rapidly increasing interests for power generation and charcoal production
Sisal waste	182,000	3,525	Low , due to low density
Cashew shells	2,600	5,925	High especially in Nairobi due to its high calorific value.
Coconut husk	34,000	3, 991	Low due to distributed nature of waste

3 SUITABILITY AND SUSTAINABILITY OF BIOMASS STREAMS

The trend by industries to switch to biomass fired furnaces and boilers continue to have an impact on availability and pricing of biomass streams. The overall availability of some biomass streams have declined significantly while utilization as fuel has increased significantly over the last 5 years.

Production of charcoal and generation of electricity offers new opportunities to communities that live in areas under prosopis "invasion". Bagasse and cashew kernels among other agri-wastes are increasingly being used by a number of industries and households as fuel. Demand for agri-wastes exceeds supply rendering these materials largely unavailable for alternative use.

Suitability and sustainability of the five (5) biomass streams was assessed from four (4) perspectives;

a. *Availability* - in terms of total quantity available, degree of centralization, absence of annual or seasonal variation in supply, clarity of ownership and limited pre-existing or competing uses.
b. *Conversion potential*- suitability for processing into higher value fuels such as briquettes, charcoal or electricity
c. *Fuel quality- energy* value and performance of the higher value fuels.
d. *Enterprise potential*- based on clarity of ownership and waste owners' capacity and interest in collaborating in utilization venture.

3.1 Bagasse

Bagasse is the crushed outer stalk material formed after the juice is squeezed from sugar cane, in sugar mills. Bagasse characteristics vary in composition, consistency, and heating value depending on the climate, type of soil, variety of cane, harvesting method, amount of cane washing, and the efficiency of the milling plant. In general, bagasse has low density (190kg/m3) and a high calorific value 4400 Kcal/kg1 on a wet, as-fired basis. Most bagasse has moisture content between 45 – 55% percent by weight.

Availability of bagasse for processing will be determined by whether the sugar factory is undertaking cogeneration for export into the grid or not. Typically sugar factories consume 60% of the bagasse for self generation. Bagasse is suitable for cogeneration of steam and electricity or production of biomass briquettes for use in industrial boilers and kilns. Briquetting bagasse substantially increases the energy density while at the same time reducing the moisture content.

Currently it is easier to develop project with privately owned sugar factories due to the clarity and certainty of their development plans. Publicly owned sugar factories are not willing to make any commitments regarding the bagasse feedstock given the uncertainty of the privatization timelines.

3.2 Prosopis juriflora

Invading Prosopis tends to form dense, impenetrable thickets, associated with unfavorable impacts on human economic activities. It produces good quality fuel of high quality calorific value - 4,216 kcal/kg which burns well even when freshly cut due to its high carbon content and levels of lignin. Prosopis produces high quality charcoal - 7,000 kcal/kg and its heartwood is strong and durable.

A study by the World Agro forestry Centre ‘Invasion of prosopis juliflora and local livelihoods: Case study from the Lake Baringo area of Kenya’ (2005) drew the following conclusions on perceptions regarding prosopis:

a. Pastoralists and farmers are likely to incur higher costs due to pasture depletion and farmland clearing. People pursuing livelihood strategies such as trading of Prosopis products accrue greater benefits.
b. Women, who are heavily dependent on Prosopis for fuel wood, are likely to enjoy greater benefits from Prosopis than men.
c. The distribution of costs and benefits are likely influence the perceptions of individuals. Those who incur higher benefits relative to costs will more likely to favour the invasive species, while those whose costs are higher than benefits strongly disfavour the species.
d. In the absence of joint community rules for management and control of *Prosopis,* individuals are unlikely to invest in controlling and/or eradicating *Prosopis* in the communal grazing lands.
e. Individuals are more likely invest in the control, management and/or eradication of *Prosopis* in their own private land.

Most land in Baringo and other Arid and semi Arid (ASAL) districts where prosopis exists are currently held under the communal tenure regime of the Group Ranch, an institution established via the Land (Group Representatives) Act of the 1960s. This may pose ownership challenges when developing and implementing initiatives to utilize the feedstock to produce higher value fuels on a sustainable basis.

3.3 Sisal

Sisal waste is available in large quantities at centralized locations making them attractive for processing into higher value fuels. Current limited competition for the boles and bogas further makes them attractive for development. The bogas and boles can be combusted directly to generate electricity or be pelletized to increase the energy density (from 3,525 kcal/kg to up to 5,000 kcal/kg) and reduce moisture content. The juice can also be squeezed from the boles to produce biogas which can be used to generate electricity. Private or corporate ownership of the sisal plantations make it easy to enter into agreements to develop the resource.

3.4 Coconut

While current lack of competition for coconut husks make it attractive, the distributed nature of the wastes and the difficulty in pelletizing the husks make it unattractive for use as solid biomass. The limited quantities make it unattractive for combustion or gasification to generate electricity.

3.5 Cashew

Despite having a high calorific value, the limited quantities and the physical and chemical characteristics of the Cashew kernels make them unattractive for processing into higher value pellets. The kernels are better utilized as they are for industrial applications, but are not suitable for household use.

Table 3.1 summarizes the suitability and availability of the selected biomass streams.

Table 3.1: Suitability and availability of the selected biomass streams

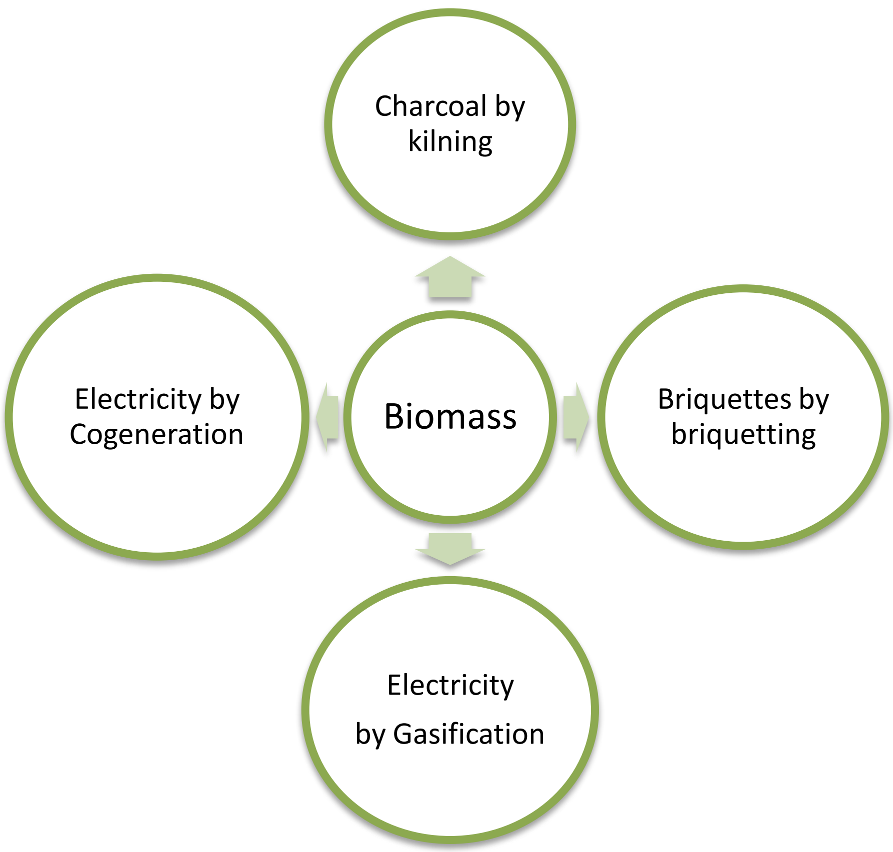
Biomass Stream	Availability	Conversion potential	Enterprise potential	Sustainability	Opportunity for community participation
Bagasse	Large volumes, centralized, clear ownership. Anticipated high competition	Electricity and steam generation as well as conversion to higher value briquettes	High - Ownership is by a single entity whether public or private, easier to develop commercial enterprise	sustainability of briquettes depends on whether factories chose to cogenerate for export to grid	Limited - both as producers and users of energy / fuel streams
Prosopis Juriflora	Large volumes, centralized. Limited, but increasing competition. Ownership depends on land tenure.	Electricity generation through direct combustion or gasification and charcoal production	Ownership may pose challenges to enterprise investment models	Sustainable with proper management of feedstock	High - both as producers and users of energy / fuel streams. Excellent opportunity for community empowerment.
Sisal	Fairly large volumes, centralized, clear ownership.	Electricity generation through direct combustion or gasification and as conversion to higher value pellets/briquettes	High -Ownership is by a single private entity, easier to develop commercial enterprise	Depends on sustainability of the sisal industry	Limited - both as producers and users of energy / fuel streams
Coconut	Limited volumes, distributed	Electricity generation through gasification and as conversion to pellets	Low – distributed nature of stocks may be a barrier	Increased pressure from land use change	High - both as producers and users of energy / fuel streams
Cashew	Small volumes, centralized , clear ownership	Best used in raw form due to physical and chemical characteristics.	High	Sustainability threatened by ageing crop	Limited - both as producers and users of energy / fuel streams

4 TECHNOLOGY OPTIONS AND SUSTAINABILITY

4.1 Technology

The four main options of improved biomass energy utilization involve: a) Gasification for electricity production b) Cogeneration c) Charcoal Kilning and; d) Briquetting/ pelletizing. The schematic below summarizes the general biomass conversion options.

Schematic 4.1: Biomass Energy Conversion Options and technologies



Under the UNIDO Community Power Centers (CPC) initiative, factors critical to the choice of energy conversion option and technology include:

- Feedstock type and availability
- Technology availability and ease of adoption including operation and maintenance
- Equipment capital (CAPEX) as well as operation and maintenance (O&M) costs
- Markets/Marketing
- Competitive market pricing of final product - electricity , charcoal and briquettes

- Overall value addition including secondary commercial activities - jobs, bee keeping, animal feeds etc

There are several well documented experiences of best case community based and commercial projects utilizing the various technologies these are highlighted in Section 6 of this report.

4.1.1 Gasifiers

Biomass gasification involves partial combustion of biomass under controlled air supply, leading to generation of producer gas constituting the combustible gases H2 (20%), CO (20%) and CH4 (1–2%). The energy value of producer gas is about 5.0 MJ/m3. The producer gas can be used as fuel for internal combustion engine for mechanical and electrical applications. There are three types of gasifiers Downdraft, Updraft and Cross draft. The choice of one type of gasifier over other is dictated by the fuel, its final available form, its size, moisture content and ash content.

Several small plant designs based on different biomass fuels and of different capacities feasible to meet the electrification needs of a large number of villages have been developed and disseminated in India. Plant capacities range between 3 kW- and 1MW. Capital cost of the power plant is in the range of US$ 1,200 per 100 kWe*. Biomass gasifier systems based on woody biomass, raised on wastelands, have been shown to have the largest potential to meet rural electricity needs including domestic, agricultural pumping and rural industrial (such as milling) activities in most parts of India.

4.1.2 Cogeneration

Cogeneration is the simultaneous production of electricity and heat from combustion of biomass such as bagasse, wood or other combustible fuels. Steam generated from combustion of solid biomass is used to drive a turbine to generate electricity while excess or low temperatures steam is used to provide process heat. Cogeneration units are typically available in the MW range, but smaller units are also available.

In Kenya all sugar factories with the exception of Mumias cogenerate power for own consumption. Mumias exports 27 MW of excess electricity to the national grid. There are no known existing examples of small scale community cogeneration projects in Kenya.

4.1.3 Charcoal Kilns

Charcoal kilns are used to carbonize biomass under limited oxygen supply. Charcoaling improves the energy density and reduces moisture. Charcoal burns cleaner and is therefore more attractive especially for urban households. The most common kiln used in Kenya is the earth mound kiln operating at efficiencies of 9-12% and requiring no capital investment. More efficient kilns that include: a) Masonry / Brazilian type kilns such as those used by Kakuzi with an efficiency of about 28% b) Retort kilns with an efficiency of 35-45% - these are not common c) the Katugo kiln developed in Uganda and used in Tanzania on a large scale by Sao Hill industries with an efficiency of 33 %.

4.1.4 Briquettes

Briquetting involves the densification and moisture reduction of raw solid biomass by subjecting the biomass to heavy mechanical pressure to form compact cylindrical form known as briquettes.

Owing to high moisture content direct burning of loose bagasse is associated with very low thermal efficiency and widespread air pollution. In addition, a large percentage of unburnt carbonaceous ash has to be disposed off. Briquetted bagasse has low moisture content and densified form which overcomes problems associated with direct firing of bagasse. Thus briquetted bagasse can be used as a potential fuel to substitute the fossil fuels. The benefits of briquetting include: a) High calorific value - 3,500-5,000 Kcal/Kg; b) low moisture - 2 to 5%; c) high density - 1.2 g/cm^3 compared to bulk density 0.1 to 0.2 g / cm^3 d) easy in handling and storage due to its size f) consistent quality.

The two techniques of briquetting bagasse/biomass are the binder less and charred binder briquetting techniques. In the binder less technique the biomass is finely divided to uniform size and subject to heavy mechanical pressure to form briquettes. The lignin5 in the agro waste acts as a natural binder, there is no need to add chemicals or any other foreign substance to the process.

In the charred briquetting technique the biomass is finely divided and charred to increase the carbon concentration and reduce the moisture. The charred material is then subjected to heavy mechanical pressure to form briquettes. Due to the absence of the binding properties in char, binding agents like starch are added to form briquettes.

Binder less technique is usually used for fuel briquettes for industrial boilers while charred briquettes are used for domestic application.

4.2 Sustainability

According to the UN Commission for Sustainable Development there are 58 sustainability indicators: Social (19); Environmental (19); Economic (14) and; Institutional (6). Table 4.1 summarizes the sustainability considerations critical for the success of biomass projects. The Sustainability Criteria represent a clear, transparent list of matters that any proposal is assessed against in order that a development is considered.

Table 4.1: Sustainability considerations critical for project success

Sustainability Criteria	Detail
Technical	Technology availability , technology support , operating skills , skills transfer etc
Economic	Investment, cost , competition (other energy prices) , commercial viability/profitability of project etc
Social	Ownership, incomes, jobs, education, health etc
Environmental	Land use, biodiversity conservation, GHG reduction, soil rehabilitation, effect on ground water etc

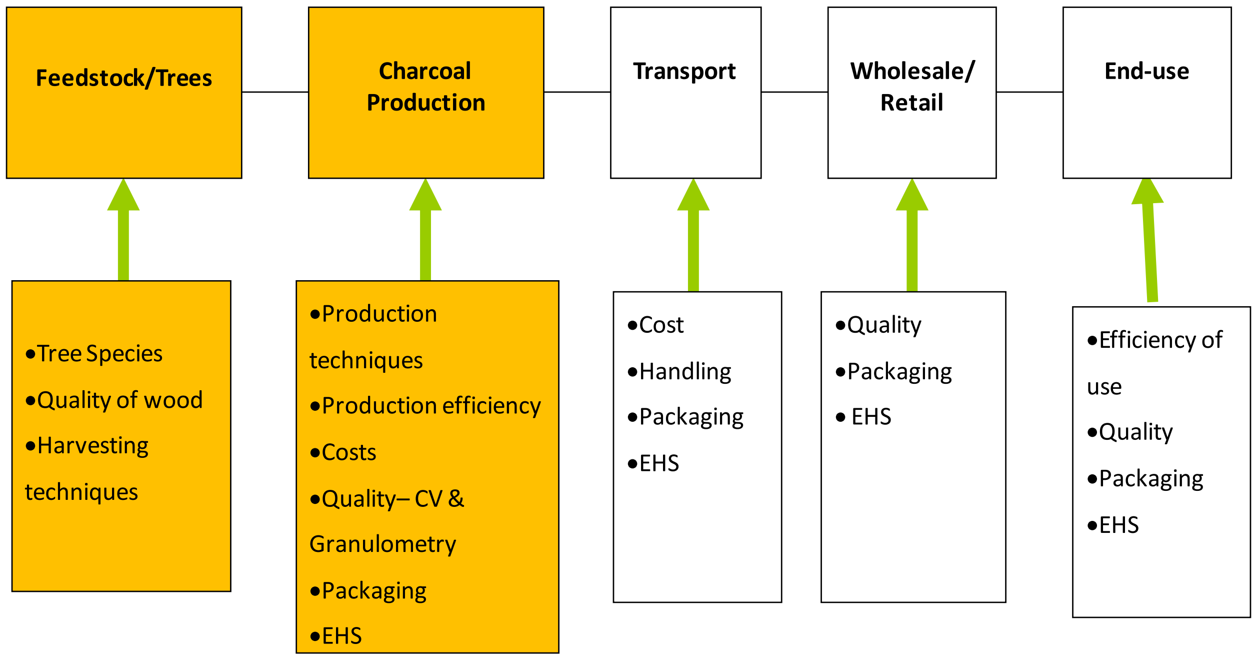
It is useful to subject proposed projects under the UNIDO CPC project to the full sustainability test using all relevant indicators while conducting feasibility studies for the individual projects. Table 4.2 summarizes the project development requirements to achieve sustainability.

Table 4.2: Biomass Project development requirements

Requirement	Detail
Feasibility	Technical /Environmental (EIA) / Financial/ Economic/ Social analyses - CDM potential , Project socio economic baselines, Ownership structure, Sustainability plan
Legal and Regulatory	EIA License , licenses (local authority etc), permits etc , ▪ Electricity generation regulations and licensing (Energy Act 2006) ▪ Charcoal regulations and licensing (Forest (Charcoal) regulations 2010
Investment	Financing - local community and external (equity, loans etc)

While developing a Charcoal kilning project, the charcoal value chain presented in schematic 4.2 should be taken into account to ensure sustainability.

Schematic 4.2: Charcoal Value chain



*EHS – Environment, Health and Safety

5 ANALYSIS OF PROJECT SITES

Visits were made to two of the project sites - Baringo and Kakamega, to make a rapid assessment of the proposed project options. Discussions were held with the selected target community groups to understand the opportunities, expectations, legal issues and potential capacity building requirements of the proposed projects. The following section provides a summary of analyses of the sites based on field visits and discussion with UNIDO staff.

5.1 Baringo - The Salabani Community

During the visit to Salabani discussion were held with officials of Salabani prosopis charcoal producers Association who included: Simon Kitol (secretary), Samuel Otarasi Lenturur (Chairman), Lillian Parsalat (Treasurer) and Tom Sikamoi (Vice secretary).

The target project area in Baringo is the Salabani community which is one of the initial sites where *prosopis juriflora* was introduced in the in the late 1970s and early 1980s to address concerns about deforestation, desertification, soil degradation and fuel wood shortages manage in the Baringo area. The community has been engaged for some time now in approaches to find innovative methods to address prosopis invasion more effectively. The community formed Salabani prosopis charcoal producer group in May 2010 to champion the management of prosopis through production of charcoal. The group admits that since the initiation of the group, they have not received any kind of training in the management of the plant.

The plant though effective in managing erosion has led to increased flooding in the area. The prosopis, traps the soil and raises the river beds and in the process allows run offs to flow freely in the open spaces. In addition, the plant has poisonous thorns, produces pods with high sugar content affecting the animals and its invasive characteristics has led to many villagers vacating their homes.

Factors considered in selecting the Salabani Community for the CPC include:

- Recommendation by FAO and KEFRI based on their initial experience in working with the community around the area to manage prosopis
- Easy accessibility afforded by a good road network
- Domination of the area by prosopis which provides the required feed stock for the sustainable biomass production

The Salabani Charcoal producers group has 20 individual producers producing and selling charcoal individually to brokers from Nairobi, Limuru, Kiambu, Naivasha, Kisumu and Eldoret among other towns in Kenya. The group currently produces about 800 -1000 bags of charcoal every week using inefficient Earth mound kilns.

Current challenges include:

- Low charcoal yields resulting from use of inefficient earth mould kilns
- Poor occupational safety and health practices evidenced by non use of proper personal protection equipment/clothing (PPE).
- Low returns on sales due to poor or lack of a collective bargaining position and poor linkage to end user markets and existence of charcoal cartels
- Insufficient knowledge on environmental friendly and functional technologies for managing prosopis
- Insufficient knowledge of potential commercial opportunities such as bee keeping, animal feed, building materials and production of briquettes.

Table 5.1 below summarizes the opportunities, threats, legal issues and the capacity building requirements identified during the discussions.

Table 5.1: Opportunities, threats, legal issues and the capacity building

Opportunities	Threats	Legal issues	Capacity building requirements
▪ Availability of large stock of prosopis suitable for commercial firewood and charcoal production ▪ Shortage of charcoal in the national market ▪ Secondary commercial activities – bee keeping, animal feed production, production of poles and timber etc ▪ Lack of electricity for domestic and productive uses	▪ Planned 30 MW power by Tower Power generation in Ngambo and Loboi could lead to competition for feedstock ▪	▪ Both charcoal production and electricity generation supported by legal and regulatory framework. ▪ See Forest (charcoal) Regulations 2010 and Energy Act 2006.	▪ Development and Management of prosopis ▪ Kiln Construction & Maintenance of kilns ▪ Production , Storage & Transport ▪ Marketing and Sales ▪ business , development and management, brick making

5.1.1 Observation and recommendations

Based on the discussions the following observations were made:

- The group appreciates the value of prosopis as a commercial crop and is keen to develop its exploitation especially the commercialization and efficient production of charcoal.
- The energy centre can be developed with an efficient charcoal production facility as the centre piece, but it is still important to develop electricity supply alternatives – Solar PV or small gasifier unit to support other value added services within and around the market centre such as mobile phone charging, ICT services and electricity for health clinic and school.
- Development of efficient brick kilns for charcoal production also provide an opportunity for secondary business such as brick production which should lead to improved housing
- Building of capacities and skills on areas outlined in table 5.1 will be essential.

A detailed feasibility study will be essential to establish the best project approach to ensure sustainable commercial charcoal production while at the same time addressing the energy and social economic needs of the community.

5.2 Kakamega – Kamjisu for Development (KAFODE)

During the visit to Kamjisu discussion were held with officials of Kamjisu for Development Group a legally registered Community Based Organization. The community has put up a health facility as the center piece of their development agenda. The total catchment for the facility is 15,000 inhabitants. Their key development priorities are access to health, jobs for the youth, supply of energy which is very scarce in the area. Further discussions with the group confirmed acute biomass energy poverty in the area. The objective of the health facility is to provide basic health care and preventive medical services which mean that it requires reliable energy supply. The facility currently uses kerosene lamps and stoves which have negative impacts on air quality and poses health and fire risks. Lack of electricity also means that the facility cannot offer immunization and laboratory services.

Energy supply for domestic use is mainly through firewood which is extremely expensive at KES. 200 per 10 kg bundle. Sawdust, sugarcane trash and sugarcane roots are used as alternatives. Charcoal is used to a limited extent and costs KES. 850 per 30 kg bag.

The community power centre is expected to be near the health facility. A structure has also been constructed by the group to provide shops and work areas. The nearest grid connection is 5 km. KAFODE is mobilizing community members to connect the facility and household to the national grid under the *Umeme Pamoja* initiative. 98 applicants willing to pay various amounts have so far signed up.

Current challenges include:

- Lack of electricity at the facility
- Acute shortage of domestic cooking fuels (charcoal and firewood)
- Lack of jobs for the youth resulting from limited business opportunities and poor skills.

The community is proximate to two sugar factories -West Kenya and Butali Sugar which are 15km and 20 Km away respectively. West Kenya Company currently manages 14,000 ha. of sugarcane plantations and is in the advanced stages of expanding its factory and incorporate a cogeneration unit. Average bagasse production over the last ten years is about 73,000 tonnes.

Butali Sugar a recently completed new company of capacity similar to West Kenya is awaiting licensing by the Kenya Sugar Board to begin operations. There are already concerns regarding competition for cane between the two companies given that they are targeting the same catchment area.

Table 5.2 below summarizes the opportunities, threats, legal issues and the capacity building requirements identified during the discussions.

Table 5.2: Opportunities, threats and the capacity building

Opportunities	**Threats**	**Capacity building requirements**
▪ Availability of bagasse ▪ Shortage of domestic biomass fuels in the area ▪ Many Jobless , unskilled youths ▪ Lack of electricity for the health facility and productive uses	▪ Competition for bagasse for cogeneration by the sugar factories ▪	▪ Development and Management of tree plantations ▪ Briquette production ▪ Marketing and Sales ▪ business , development and management

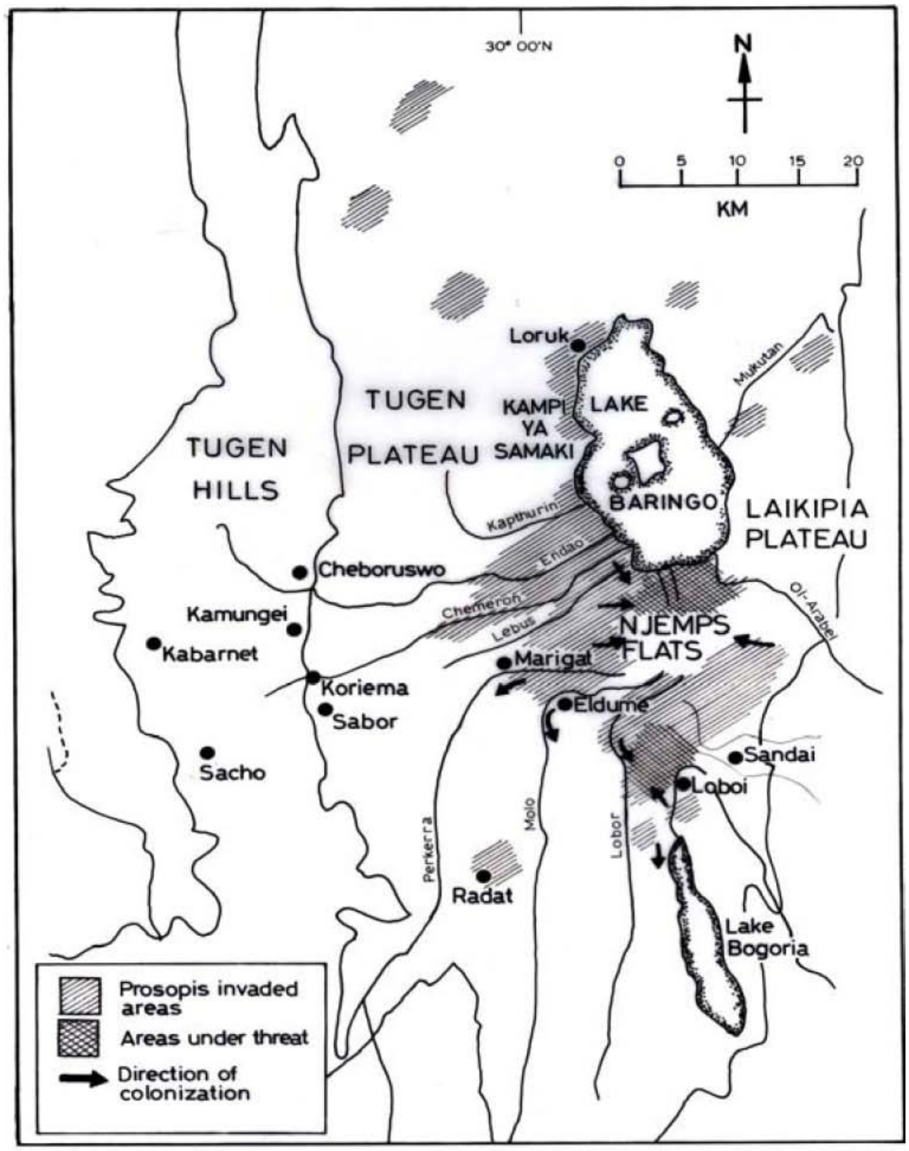
5.2.1 Observation and recommendations

Based on the discussions the following observations were made:

- The group has a clear development plan for the area centred around the health facility and a community business centre which fits very well with the concept of the community power centre.
- The energy centre can be developed around a bagasse briquetting facility targeting production of briquettes for domestic use. Electricity supply alternatives for the business park and health facility are grid electricity, solar PV or small gasifier unit utilising bagasse. An analysis should be conducted on which option would provide the overall best value in terms of investment, quality of service and jobs created. Grid electricity is likely to emerge the best option.
- Production of briquettes should be accompanied by sale of appropriate stoves creating further business opportunities and jobs.
- Building of capacities and skills on areas outlined in table 5.2 will be essential.

A detailed feasibility study will be essential to establish the best project approach to ensure sustainable commercial production of bagasse briquettes and supply of electrical energy to the community business centre and health facility.

6 ANNEX 1: STATUS OF PROSOPIS SPP. INVASION IN BARINGO



7 ANNEX 2: SCOPE OF WORK

The consultant will conduct a desk study of the selected biomass sites and conduct workshops at the selected sites by the end of 15th Dec 2010. The specific tasks will cover, but not limited to the following:

- Present at the UNIDO Nairobi workshop and lead discussions on Suitability and Sustainability of biomass based on different technologies.

- Provide brain picking to the UNIDO staff
- Conduct workshops at specific sites and lead the local communities in discussing;
    - Their energy needs and how they can be achieved with the existing biomass resource.
    - The available technological options for the type of biomass available to them.
    - Issues to consider in briquette making.
    - How to make the existing biomass sustainable for the preferred technology
    - Legal issues associated with biomass harvesting
    - Any other issues raised by the community relating to the presentation
- Produce a report entitled “Best Practices and Technology Suitability for Energy Generation using Biomass”. The report shall include but not limited to;
    - Introduction
    - Best practices for sustainable development and technology suitability of biomass.
    - Sustainability criteria and considerations for utilizing prosopis, bagasse, cashew nut shells and sisal as feedstock for biomass power generation, with their technological implications.
    - Findings from the responses at the workshops.
    - An outline of crucial components required in the feasibility study pointing to the specific CPC sites.
    - Recommendations based on the workshop and desk study findings.

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