Environmental Impacts Assessment (EIA) Study Report for the establishment of 2.5 MW Biomass Power Plant in Garissa County using *Prosopis juliflora* as feedstock

For

Northern Energy Ltd

P.O. Box **50492- 00100, Nairobi**

Prepared by

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DECLARATION

This EIA Study Report was prepared in accordance with Environmental Management and Coordination Act, 1999 and the Environmental Impact Assessment and Audit Regulations, 2003, for submission to National Environment Management Authority (NEMA).

The undersigned, submits to NEMA this Environmental Impact Assessment Study Report for the proposed Biomass Electricity Generation Project using *Prosopis juliflora* feedstock in Garissa County for the purpose of obtaining a license to undertake the work. All information contained in this report is accurate and truthful representation of all findings as relating to the project.

NAME.....

SIGNATURE.....

NEMA REGISTRATION No: 2815

DATE.....

On behalf of the Proponent:

Northern Energy Ltd. P. O. Box. 50492- 00100, Nairobi

Signed by:

Name	Signature	Date

PROPONENT

I,…….....on behalf of Northern Energy Limited submit this Environmental Impact Assessment Study Report for the Proposed Biomass power plant to be established in Garissa County. To my knowledge all information contained in this report is accurate and truthful representation of all findings as relating to the project.

Designation: ……

Signature: ……

Date: ……..

Disclaimer:

This Environmental Impact Assessment Study Report is strictly confidential to Northern Energy Ltd (the proponent). Any use of the materials thereof should be strictly in accordance with the agreement between the proponent and Dr. Joseph M. Maitima (the EIA Expert). It is, however, subject to conditions in the Environmental (Impact Assessment and Audit) Regulations, 2003 under the Kenya Gazette Supplement No. 56 of 13th June 2003.

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Acronyms

ASAL	Arid and Semi Arid Lands
BACT	Best Available Control Technology
CH_4	methane
CO_2	carbon dioxide
CO	carbon monoxide
DDP	District Development Plan
EMCA	Environmental management and Coordination Act
ESMP	Environmental and Social Management Plan
FIT	Feed In Tariff
HAP	Hazardous Air Pollutants
LAER	Lowest Achievable Emission Rate
MW	megawatts
NEMA	National Environment Management Authority
NGO	Non Governmental Organization
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
SO_2	Sulphur dioxide
VOCs	Volatile Organic Compounds
OSHA	Occupation Safety and Health Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
ppb	parts per billion
ppm	parts per million

Summary

The proposed project seeks to establish a biomass power plant to produce 2.5MW of electricity using *Prosopis juliflora (*SW) DC as a feedstock. The plant will be located in Garissa county about 1 kilometre from Garissa town in 46 acre piece of land that has been set aside for this purpose. The power generated will be fed into the national grid which passes close to the area the plant is to be located.

The term "biomass fuel" encompasses diverse fuels derived from timber, agriculture and food processing wastes that are combusted to produce gasses that run turbines to produce electricity. Burning plant materials harvested for use in electricity generating plants is considered renewable as the materials can be re cultivated again and again for the same purpose.

The need to generate sufficient and sustainable source of electricity is a national priority as is stated in the Kenya Vision 2030. Kenya needs to increase and diversify its sources for electricity given that most of its electricity comes from hydro power which in many cases is unable to supply enough for the country. Hydro power though being a green source of energy is affected by weather fluctuations where during the dry seasons the levels of rivers are too low to run the turbines to full capacity. As a result the country has been using diesel engines which are not only expensive but highly pollutants to the environment.

The government has been encouraging private investors to invest in alternative sources of energy especially in renewable green sources that cause less pollution to the environment. It is in this effort that several companies have ventured into generating energy from wind power, solar power and power from geothermal resources.

Energy from biomass in Kenya is largely untapped despite the high potential it has in the country given the high amounts of organic wastes from agriculture and the forestry sectors. A few county governments including Nairobi City County are in the process of using organic municipal wastes to generate electricity. The proponent of this project is applying the same principal but using prosopis plant materials as feedstock. Prosopis is an invasive species that has spread rapidly in Kenyan rangelands especially within the river and lake basins of Tana River, lake Baringo and Lake Turkana. The species found in Kenya is *juliflora* which is one of several species of prosopis growing worldwide.

Prosois juliflora (SW) DC is a fast-growing and drought resistant plant originating from South and Central America. It grows in all kinds of soil conditions, including wastelands, at altitudes ranging from 0 to 1,500 m above sea level, under mean annual temperatures of 14 to 34 °C and annual rainfall of 50 to 1,200 mm. Mature trees grow to 17 m in height. The species is characterised by its twisted, greenish-brown stem, with axial thorns on both sides of the nodes and branches. It is reported to dry out the soil and to compete with grasses, particularly in dry areas.

In areas where it has invaded, it has occupied lands that were formerly used for grazing displacing pastures with prosopis thickets that are unsuitable for livestock. Many efforts have

been made by government agencies, NGOs and communities to control the spread of the species but none has been successful.

The biomass power plant will generate electricity, create jobs and create many other opportunities for business within Garissa town and for many land owners from which the feed stock will be bought including transporters who will be contracted to ferry feedstock from the source areas to the power plant. The proposed power plant will provide a sustainable way of controlling the spread of the species in Garissa while making an economic gain from its presence.

This EIA Study Report explains the process of how prosopi*s* plants will be processed to produce electricity and outlines all environmental concerns associated with the entire process from harvesting of feedstock, transportation of feedstock to the power plant and the gasification process. The report includes an elaborate environmental and social management plan to guide the proponent and the contractors on how to avoid and minimize adverse impacts.

1. Introduction

This is an environmental impacts assessment report for establishing a biomass electricity power plant in the outskirts of Garissa town, Garissa County using *Prosopis juliflora* as a feedstock. The plant will be located in Garissa County about 1 kilometre from Garissa town between the town and River Tana. The feedstock will be harvested from an area measuring approximately 150 km^2 or more along River Tana where prosopis plant has invaded and established itself. The plants will be cut and transported to the power plant where they will be cut into small chips, dried and stored ready to be used in the power plant.

At the power plant the dry woody chips will be fed into a gasifier to produce electricity. The produced electricity will be connected to the National Grid for distribution across the country by the Kenya Power. The details of how a biomass power plant works are given in this report and all the by-products to be produced and how they will be handled are explained in the various sections of this report

Propsopis juliflora (SW) DC is an invasive plant species that was introduced in Kenya in 1960s to control soil erosion, but then turned out to be a noxious invasive species that consumed vast productive lands in the ASAL areas of Kenya. It has caused a lot of damage to pastoralists by reducing the areas covered by pastures from which livestock graze. Where prosopis grows no grass can grow because it forms a tree canopy that kills all the grass below it. The plant has some thorns that pierce the goats when they try to feed on the leaves. The goats that feed on the leaves of prosopis lose their teeth because of the poison from the thorns. The plant is therefore unwanted in the field due to its negative economic impacts to their livelihoods. Because of the negative impacts the communities have been fighting the spread by cutting down and burning charcoal. The other use of prosopis made by the local communities is to use them in construction. These two uses selectively pick the mature plants leaving the younger ones to grow. This unplanned method of harvesting may have contributed to the quick dispersal of the plant in the area. There have been a lot of government efforts to look for a solution to control the spread of the noxious invasive species but no lasting solution has been found.

Northern Energy Ltd. through technical support from Viability Africa and in partnership with FIRM (Financial Inclusive for Rural Microenterprises) a funds management arm of US AID, has put together a project to utilize *Prosopis juliflora* in Garissa County and Tana River County as a feedstock to a power plant to generate electricity. Initially the power plant is targeting to generate about 2.5 MW of electricity, but latter will be upscaled to a higher production capacity depending on the availability feedstock supplies.

The following is a summarized list of positive and negative effects of *Prosopis juliflora* on livelihoods based on study conducted in Baringo area of Kenya [11] (Mwangi and Swallow, 2005).

Positive effects on livelihoods;

1. Poles for fences, home construction and repair
2. Availability of fuelwood and charcoal for subsistence and sale, reducing travel time for women and removal of other trees
3. Pods for livestock fodder and as a snack for children
4. Ropes made from bark
5. Honey
6. Reduced dust storms

The negative effects include;

1. Invasion into crop fields and associated costs of clearing
2. Invasion into grazing areas and associated loss of grazing territory
3. Invasion into wetlands that reduces their value for watering and dry-season grazing
4. Invasion into the shores of lakes, wetlands, and riverbanks making use water and its resources more difficult
5. Damage to the tires of vehicles and bicycles
6. Consumption of the sweet pods causes damage to the teeth of goats
7. Sharp thorns causes wounds to goats and cattle

1.1. Project proponent

The proponent for the proposed project is Northern Energy Ltd a company in Kenya, Registration Number CPR/2014/133696 situated in Nairobi, P.O. Box 50492- 00100, Nairobi. The company was registered with a primary objective of generating energy, and the proposed biomass project in Garissa one of many project to be established by the company.

1.1.1. Activities for which the proponent seeks NEMA License for this project

The activities that the proponent seeks a license to undertake in order to fully implement the proposed project include but not limited to:

1. All activities associated with civil works required for building roads network including access roads and roads within the plant site, garages and warehouses, water reticulation, waste water management system, effluent water cooling pods, etc.
2. All activities associated with the harvesting and transportation of prosopis feedstock.
3. All constructions associated with installation of and operations of gasification and electricity development processes
4. Construction of a fence, gates and gatehouses as will be required
5. Construction of offices, warehouses, staff houses and workshops.

6. Project development

This project has undergone several stages of development from the initial planning stages to the level where feedstock (Prosopis) assessment has been completed, feasibility study prepared and a business plan drawn. Prior to the studies indicated above, arrangements for identifying a place to locate the proposed plant had been done and is proposed to be about 1km away from Garissa town within a 46 acre plot although the actual plant will occupy only a few acres.

The proponent is now at the point of procuring the machineries and equipments required for plant. The communities are aware of the proposed project and are looking forward to the project for two main reasons: 1) the project will create employment and many business opportunities for the local communities; 2) the project will help to contain the spread of prosopis invasion into the grazing lands and cultivation lands along River Tana. One of the business opportunities to be created by this project is as the participants in the public participation workshop held in Garissa on 12th November 2014 put is that prosopis will now become a cash crop for farmers to cultivate as a multipurpose tree crop. The same sentiments were independently echoed by Garissa County Director of forestry who during a stakeholder consultation with the EIA team welcomed the establishment of the plant because prosopis will now become a crop and people will grow it for cash. The forester envisaged establishment of nurseries of prosopis seedlings for distribution to farmers. Further to these highly valued reasons, the project will contribute to the national efforts to increase availability of clean energy in the county.

6.1.Project area

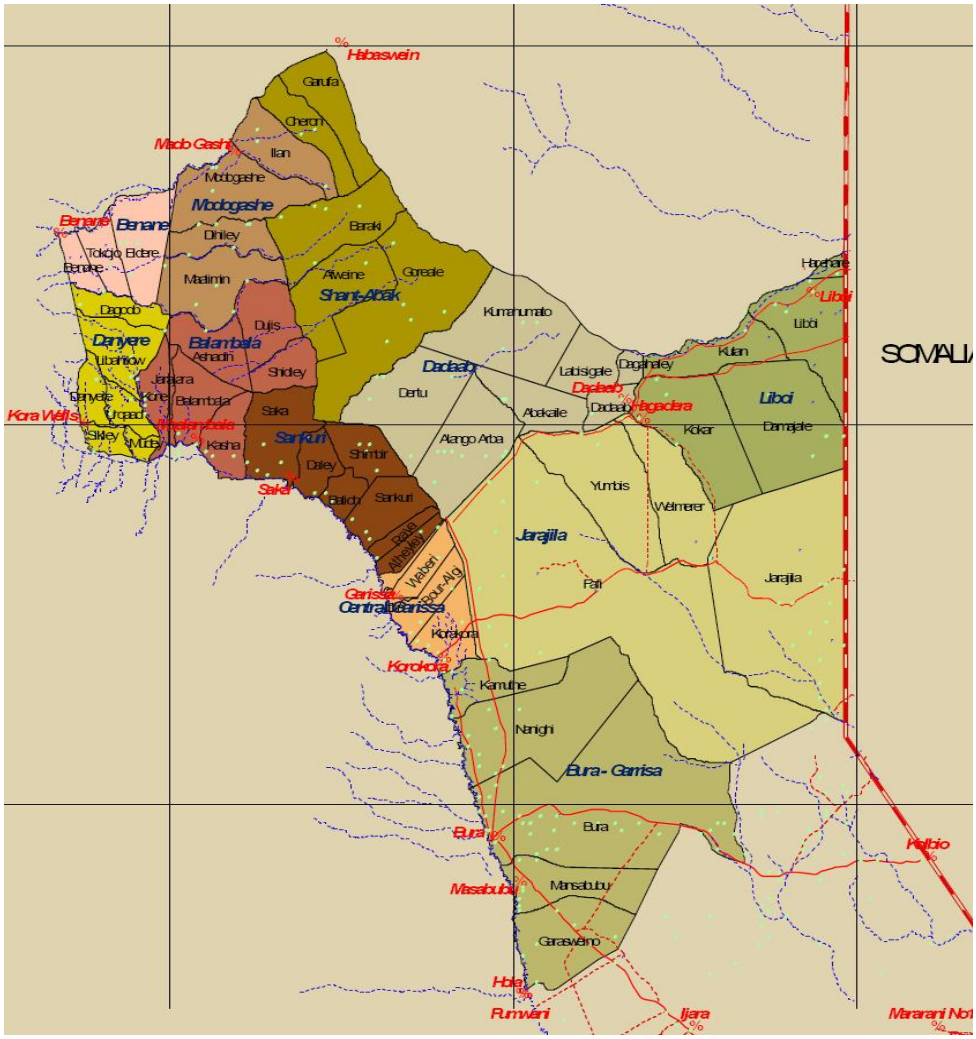

Figure 1 Map of Garissa County

The proposed Biomass power plant will be located in Garissa County, and the exact location of the place where the plant will be built is about 1 km from Garissa town towards River Tana. Harvesting of prosopis feedstock will include areas where prosopis is growing within garissa County and the neighboring in Tana River County. Garissa County lies between latitude 00 58 and 00 2'S and longitude 380 34'E and borders Wajir County to the North, Lamu, and Malindi to the south Tana River and Isiolo to the West and the Republic of Somalia to the East. Garissa County is about 370 kilometres north of Nairobi and covers an area of 44,174.1 Km^2 and is mainly inhabited by the Somali people, who constitute over 95% of the population. The County is basically flat and low lying land without hills, valleys and mountains, rising from a low altitude of 20m to a high of 400m above sea level. The major

physical features are seasonal *Lagas (*or *wadi)* and the Tana River Basin on the western side. The River Tana forms a ribbon of life that determines the climate, and influences the settlement patterns and economic activities within the county.

Garissa County is principally a semi-arid area with 275 mm of rain per year and temperatures ranging from 20^0C to 38^0C, and an annual average of 36^0 C. The hottest months are September and January to March, while the months of April to August are relatively cooler. Like most other regions in Kenya, the area has two rain seasons, the short rains from October to December and the long rains from March to May. Rainfall is unevenly distributed within the season where most of the times it falls in short torrential downpour making it unreliable for vegetation growth.

The southern parts of the County such as Hulugho, Masalani and Bura receive more rainfall than the northern parts. Balambala and Fafi Constituencies practice rain-fed agriculture on small scale. During the dry season, there is a general migration of livestock from the hinterland to areas near River Tana where water is readily available. However, some pastoralists move with their livestock to adjacent counties of Tana River and Lamu in search of pastures. Much of the County's livestock population are indigenous sheep, goats and cattle, found in the southern parts which receive more rain while camels occupy the drier north.

Garissa County has six sub-counties which include: Fafi, Garissa, Ijara, Lagdera Balambala and Dadaab. These correspond to constituencies in the County. The county has a total population of 699,534 according to the 2009 population census distributed as shown in Table 1. The county is sparsely populated with majority of the population being concentrated in areas with infrastructural facilities such as Garissa Township.

Table 1 Human population distribution in Garissa by Sub Counties

2009 Census			2012 Projections	
Constituency	Population	Density (Km2)	Population	Density (Km2)
Garissa Township	116,953	173	131,405	194
Balambala	73,109	15	82,143	17

Lagdera	92,636	14	104,083	16
Dadaab	152,487	22	171,329	25
Fafi	95,212	6	106,977	7
Ijara	92,663	9	104,113	9
Total	623,060	14	700,050	16

The power plant will be located in Garissa town close to the national grid where the power to be generated will be connected under the national Feed In Tariff (FIT) arrangements and the feedstock will be harvested both from Garissa county and Tana River County. See map below.

Figure 2 Proposed site for the power Plant [1]

Table 2 Coordinates of the proposed project location

Point	Latitude	Longitude
A (Nearest to Tana River)	S 00° 28.927’	E 039° 38.023’
B	S 00° 28.658’	E 039° 38.529’
C (Nearest to Grid)	S 00° 28.542’	E 039° 38.726’

7. Distribution of Prosopis in Kenya

Prosopis is widely distributed in Kenya’s rangelands. It’s distribution is in patches in Turkana basin, Lower River Tana basin, Ewaso Ngiro basin in Kajiado and in Madera around the Kenya Ethiopis border. The figure below shows the distribution

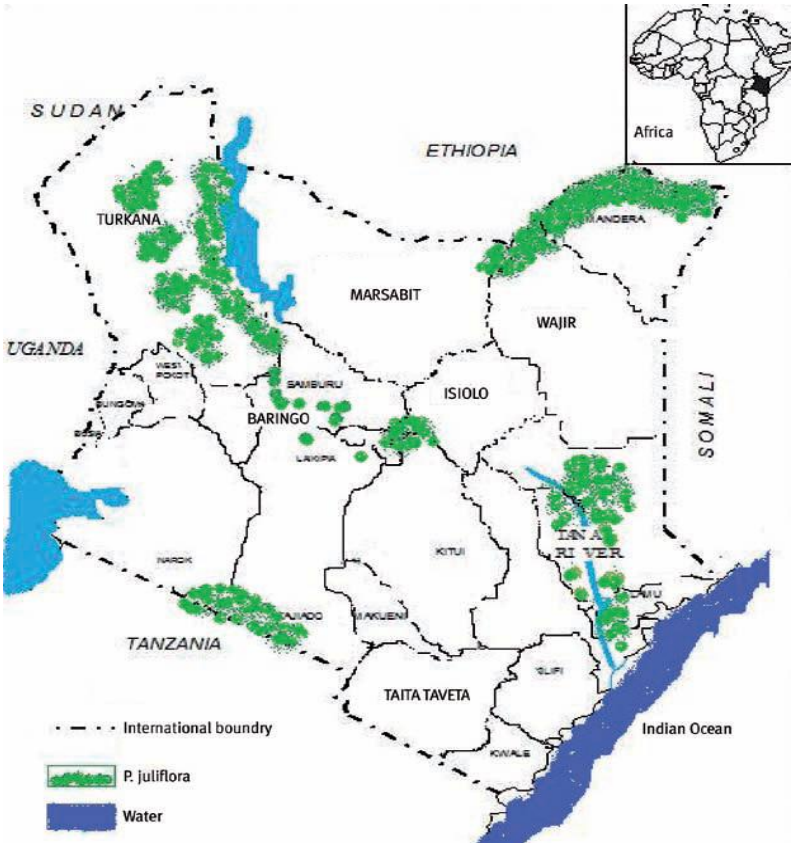

Figure 3 Distribution of Prosopis juliflora in Kenya

7.1. Distribution of Prosopis in Garissa and Tana River Counties

A study was conducted to determine the distribution of *Prosopis juliflora* in both Garissa and Tana River Counties and assess the quantities available for the power plant in the two counties. In Tana River prosopis grows only along the river as a riparian forest. The growth covers about a kilometre on either sides of the river except in places where the bank forms a flood plain. In the flood plain the river catchment widens and water spreads to a wider area. Prosopis and other riparian vegetation form a thicket wher prosopis is the major plant species in the flood plain.

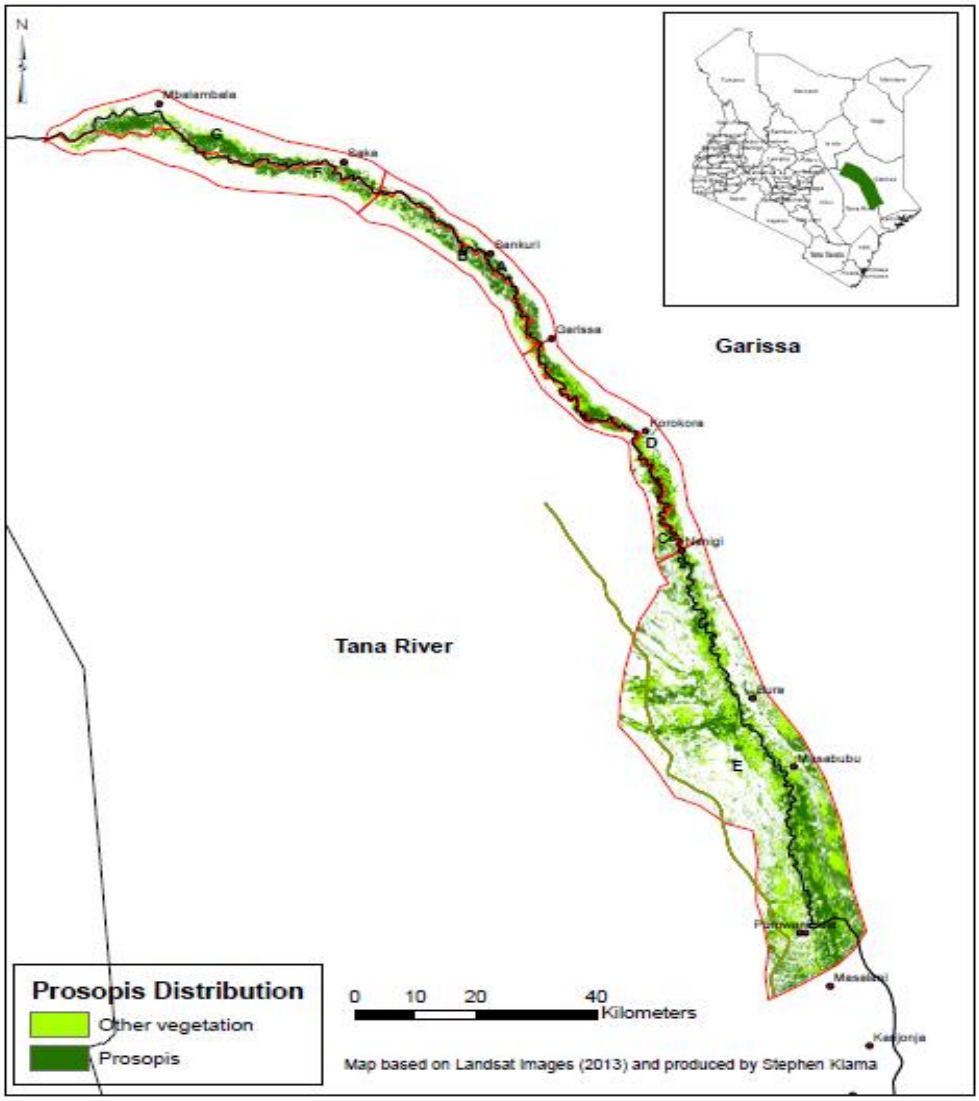

Figure 4 Distribution of Prosopis in the project area [1]

7.2. Available Quantity of Biomass Quantity

There is a wide variation in the number of trees per hectare in natural occurring *Prosopis* forests. Trees per hectare range from 1,440-3,520 in the five study areas and the mean dry weight and volume per hectare of the standing were estimated at 63.2 tonnes/ha and 109.9m3/ha respectively.

A study on prosopis biomass feedstock resources was done (Feedstock Assessment Study [1]) in the 5 zones around the project area that is NW of Garissa town, NW of Madogo area, SE of Garissa town, SE of Madogo area and Bura-Hola region and the results are here presented as blocks A to E

Figure 5 Location of Blocks A and B Prosopis distribution area

Figure 6 Prosopis thicket in Garissa Town

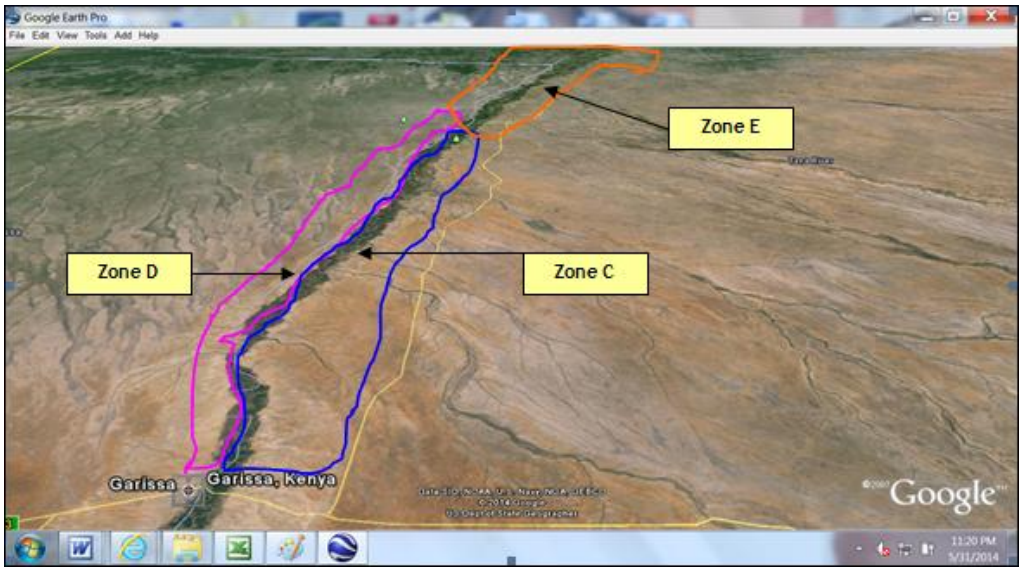

Figure 7 Location of Blocks C and D Prosopis distribution area

Table 3 Analysis of Prosopis Feedstock Study [1]

	***Prosopis* zone**					
Variable	**A**	**B**	**C**	**D**	**E**	**Mean**
Number of trees/ha	1,440.0	2,240.0	2,260.0	3,520.0	2,116.7	**2,307.7**
Stem density/ha	2,600.0	4,640.0	5,600.0	5,820.0	4,816.7	**4,700.0**
Fresh Weight (MT/ha)	180.6	169.2	50.8	126.1	93.2	**122.8**
Dry Weight (MT/ha)	97.7	88.1	23.9	63.3	46.3	**63.2**
Volume M^3/ha)	166.4	152.5	43.2	111.2	81.7	**109.9**

The study estimated the existing quantity of the standing *Prosopis* biomass at all the five zones to be 2,288,057 tonnes of dry weight and 3,979,216m^3 as shown in the table below.

Table 4 Prosopis biomass attributes [1]

	Variable			
***Prosopis* Zone**	*Prosopis* Area (Ha)	Estimated Total Fresh weight (MT)	Estimated Total Dry weight (MT)	Estimated Total Volume m^3
A	6,288	1,135,647	614,644	1,046,143
B	4,900	829,098	431,874	747,059
C	2,856	145,221	68,371	123,505
D	4,949	624,090	313,063	550,349
E	20,914	1,664,267	834,848	1,467,620

	Variable			
***Prosopis* Zone**	*Prosopis* Area (Ha)	Estimated Total Fresh weight (MT)	Estimated Total Dry weight (MT)	Estimated Total Volume m^3
Canal (Bura)	300	24,120	11,970	21,150
Bura-Hola Road	333	26,773	13,287	23,477
TOTAL	**40,540**	**4,449,216** ±402,550	**2,288,057** ±260,319	**3,979,216** ±312,215

The findings of a study to assess the abundance of prosopis around the project site has shown that the use of Prosopis for generation of electricity is feasible and viable by reasons of abundance and engineering characteristics of Prosopis trees. The standing biomass within a radius of 150 km from Garissa town, the proposed project site, is estimated at 2,288,057 tonnes dry weight or wet volume of 3,397,216 m^3. However, owing to the rising loss of Prosopis habitat along the River Tana basin brought about by crop farming and demand for charcoal, poles and firewood, about 50% may be available to Northern Energy. With the large raw material base, the company can reliably sustain the generation of 20 MW or more. However, it is suggested that the investment plan could begin a lower capacity plat so as to be be upgraded latter when supply and demand of feedstock stabilizes.

This proposal is for 2.5 MW biomass plant which is within the range of what can be sustained with the available feedstock

7.3. Potential for Prosopis production in irrigated lands

The distribution of prosopis in Garissa and Tan River as observed in the field and as shown in the distribution map shown above, is an indication that availability of water is the main factor limiting its growth. An analysis conducted on variability of soil types in Garissa shows no significant variability indicating that soil types is not a limiting factor in the distribution of prosopis in Garissa.

One other factor thought to limit distribution of prosopis is grazing pressure. Young shoots of the plant are browsed by livestock and wild animals before they establish themselves. They are fenced off to prevent herbivory at the young stage, livestock cannot kill them off because they develop sharp thorns that pierce the browsing animals. Besides is not a preferred fodder for animals, except the ponds that are sweet and liked by animals.

Prosopis is germinated in nurseries and transported to areas where they can be watered at least for 2 to 3 years; it is likely that they can be grown outside the areas they are growing now.

Tana River County

Tana River County, named after the name of the river itself, covers an area of about 38,800 km2 with a population of 240,075 according to the 2009 census. The population is currently growing at a rate of 2.4% per year (GOK, 2009). Nomadic pastoralism is the main occupation of the communities dominated by the Orma, Pokomo, Wardey and Malakote (Wailuana). The latter are fewer and they are largely sedentary agriculturalists cultivating along the river basins and flood plains. Most of the population is therefore found in the south of the district (Garsen, Galole and Bura) while the drier northern part is very sparsely populated (Bangale, Madogo) as shown in Table 2.

Table 5 Human population distribution in Tana River County

Division Division	**Population 1999***	**Population 2009***	**Headquarters**
Bura	28,848	38,284	**Bura**
Galole	34,948	46,380	**Hola**
Garsen	51,592	68,468	**Garsen**
Madogo	21,731	28,839	**Madogo**
Bangale	12,686	16,836	**Bangale**
Total	**149,805**	**198,807**	

Source: GOK, 2009

River Tana forms the eastern border of the County and is the main source of water for humans, livestock, wildlife and agriculture. The Tana River is Kenya's longest river, starting from catchments in Mount Kenya and the Aberdares Mountain range and flowing east and south before emptying into the Indian Ocean. The lower Tana River passes through semi-arid and arid plains, in which the river is solely fed from rain upstream in the highlands.

The river generally floods twice a year corresponding to Kenya's rainy seasons (May-June and November-December), creating a floodplain of up to 6 km wide, with floods failing in roughly 2 out of 10 years. However, the five upstream hydroelectric dams and irrigation have altered this flooding pattern, significantly increasing flow in the dry season and decreasing

the frequency of small magnitude flooding. This has resulted in the river's flood prone areas shrinking to less than 2 km in most areas in the recent past.

Towards the mouth, the river creates an extensive delta that is characterized by wetlands. The delta presents great potential for the development of the County and acts as a natural habitat for an enormously diverse fauna and flora as well as a fall back grazing area for dry season. The County is interspersed by seasonal rivers, popularly known as *lagas* or *wadi*. The *lagas* have large catchments with well-developed network of tributaries. These enable the pastoralist herds and flocks to utilize the vast arid and semi-arid expanses of the County.

Most of the County is dry with temperatures of 25^{o}C and erratic low rainfall ranging from 300-500 mm annually. The County has the lowest agricultural potential in Kenya and is mainly suitable for nomadic pastoralism only. The natural vegetation in the County is very sparse except for areas near the river where tall evergreen riverine forests are found. The thorny bushlands or wooded grasslands that characterize most of the County are dominated by Acacia spp and Commiphora spp. Mangroves can also be found within the estuaries near the mouth of the River Tana.

Prosopis trees are lately becoming dominant in many areas of the county having been introduced in mid 1960s at Hola Irrigation Scheme. Large scale plantings were carried out in Bura in early 1980s when Bura Irrigation scheme was established. The tree has since spread uncontrollably covering vast area

8. Equipment, Materials and Resources to be used

8.1.Equipment

At all times during the construction phase, the contractor will ensure that high quality construction and installation of materials and equipment is done. During this phase, a number of equipments to be used will include but not limited to the following: concrete mixers, vibrators, welding machines, simple hand equipments, electrical equipments, Lorries and excavators.

8.2.Materials

The materials that will be used shall be as per the Kenya Bureau of Standards and care will be taken to ensure that only sufficient materials and equipments are purchased to avoid wastage.

Materials will be sourced locally from local manufacturers, stockiest and wholesalers. Sand and ballast shall be sourced from recommended dealers. Materials will include plastics, cement, water, paints and hardcore stones, sand, ballast, reinforcement steel, wood and timber products, steel sections, water supply and drainage pipes, electrical wiring and PVC conduit pipes, concrete paving and slabs, electrical fitting, plumbing and drainage fittings, roofing, paints and varnish.

8.3.Project Resource Inputs

A large amount of capital and recurrent resources will be used throughout the project cycle. These will comprise:

- Land – will be needed for the project
- Water – for cooling the plant, site operations, dust control, for landscaping and domestic uses.
- Energy resources including electricity, petroleum fuels (diesel, heavy industrial oil, petrol) and engine oils for vehicles.
- Labour (skilled and unskilled) – causal workers will be employed as well as qualified personnel such as engineers and technicians.
- Funds – the proponent will require finances to implement the project.
- Construction materials and equipments are necessary.
- Policy and Legal documentation and enforcement instruments that are needed in terms of approvals and the relevant legislations on the project.

8.4.Waste that may be generated at construction and installation

There are likely to be a number of wastes in the construction process.

These would include:

- Soil and pebbles from excavation and construction debris.
- Dust emissions arising from excavations activities on site and the transport to site of construction materials.
- Polythene sheeting and nails from installation activities.
- Worn-out construction equipment parts, and
- Domestic solid and sewage waste from the workers
- Packaging materials removed from transported equipments

9. Project Benefits

The proposed project is a long term project expected to last several years after installation. Some of the benefits of this project include:

- Generating indirect employment in the region during site preparation and operations, supply of raw materials and auxiliary works.
- The commissioning of project would lead to improvement in transport facilities as loose or soft surface rural roads will be upgraded to facilitate movement of feedstock materials and staff vehicles.
- A boost in business for the local area as the plant personnel will increase demand for commodities.

10. Terms of Reference

To facilitate compliance with EMCA 1999, and the Kenya government regulations on environmental impacts assessment and the issuance of a license by NEMA, the proponent has contracted Dr. Joseph Mworia Maitima a lead EIA expert to conduct a full study for the establishment of the biomass power plant project. This will involve establishment of a base a site where the power plant be constructed. It is to be noted that the proponent has already undertake detailed studies on the availability of feedstock and conducted a feasibility study that show that the project is viable financially. What the proponent seeks now is A NEMA approval as required by EMCA 1999.

The consultant has the following terms of reference:

a) To meet the legislative requirement of the National Environmental Management Authority by carrying out an environmental impact assessment exercise for the proposed project
b) Compile an action plan for the prevention and management of foreseeable accidents and other works related to health and safety hazards during the operation of the project.
c) To collect and collate views from the local neighbourhood and stakeholders interested and affected by the presence and operations of the proposed facility.

d) To obtain sufficient baseline information on the bio-physical and Socio-economic environment.
e) To obtain data on significant environmental impacts, including health and safety of the workers, visitors to the project and surrounding environment.
f) To prepare project alternatives as provided in the act and the guidelines for environmental impacts assessment.
g) To collate and analyze findings of the specialist investigations and information gathered during the assessment, and thereof highlight the following:
    - Mitigation measures to avoid negative environmental impacts and if possible alternative activities that could be considered.
    - Measure to maximize positive impacts
    - Possible monitoring indicators for future use/reference.
    - Determine gaps in knowledge that were encountered during the course of the study.
    - Make recommendations.

In accordance with the National Environmental Management Authority (NEMA), Section 58 of the Environmental Management and Co-ordination Act (1999), and the Environmental (Impact Assessment and Audit) Regulations (2003). It is on this basis that, the proponent commissioned a NEMA lead expert as a consultant to prepare this Environmental Impact and Social Impact Project Study Report.

10.1. Responsibilities

The responsibilities are as follows:

The Proponent is to provide the following:

1. Site maps for the developments showing the location of the proposed biomass plant, background information on previous studies including records on feedstock studies, feasibility studies and other information needed.

2. Proposed measures intended for dealing with land owners of the land where prosopis is to be harvested.

3. To provide details on land ownership

The consultant is to provide the following:

1. A project brief describing the proposed activities for NEMA approval to undertake the full study
2. An Environmental Impacts Assessment Study draft report to the Client
3. An Environmental and social Management Plan (ESMP) to the client
4. Final Environmental Impact Assessment Study report to the proponent that will be submitted to NEMA for approval

10.2. Scope of EIA Study

The scope of study includes detailed characterization of existing status of environment around the proposed project site in Garissa County for various environmental components viz. air, noise, water, land, biological and socio-economic. Under the scope of EIA it is envisaged:

- To assess existing status of air, noise, water, land, biological and socioeconomic components of environment
- To identify and quantify significant impacts of the project site and the proposed site operations on various environmental components
- To evaluate proposed pollution prevention and control measures
- To prepare a pragmatic environmental and social management plan (ESMP) outlining control technologies and or practices to be adopted for avoiding and mitigating adverse impacts
- To delineate post-project environmental quality monitoring programme to be implemented.

10.3. Methodology for EIA

Keeping in view the nature of activities envisaged and environmental impacts assessment guidelines and regulations of 2003, the area around proposed site was studied for the purpose of environmental impact assessment studies. The work to be carried out for each of the environmental components is briefly reported below and described in details for the purpose of showing the extent the study report will cover.

Air Environment

- Collection of surface meteorological data like rainfall, ambient temperature etc.
- Design of ambient air quality monitoring network

Land Environment

- Collection and assessment of representative soil conditions within the study Area
- Assessment of land use within the project area

Biological Environment

- Collection of information on flora and fauna within the project area
- Collation of information on wildlife and forests if any in the vicinity of the project area

- **Socio-economic Environment**
- Collection of baseline data including demographic details, such as households, population, literacy, employment pattern, general health, trade, transport, communication & welfare facilities such as hospitals, educational institutions, project awareness amongst the public, infrastructure facilities, economic resources, cultural and aesthetic attributes etc. as per the requirements

Anticipated Environmental Impacts

- Identification of Environmental Impacts associated with biomass power production
- Prediction of adverse impacts due to activities related to biomass power plant operations
- Assessment of adverse impacts due to the proposed activity on air, land, water, biological and on human interests.

- **Mitigation Measures**

  It is recommended that all equipment are operated within specified design parameters during the preparation, construction, and decommissioning phases both within the plant site and the surroundings.

Environmental and Social Management Plan

Environmental and Social Management Plan (ESMP) will be drawn after identifying, predicting and evaluating the significant impacts on each component of the environment with a view to maximizing the benefits from proposed project. The following measures will also be included in ESMP:

- Recommend mitigation measures required to address environmental and social concerns such as wildlife and habitat protection, cultural and archaeological sites protection, terrain stabilization, maintaining water resource, debris disposal and conservation of natural resources, drainage and water flow patterns

- Provide a comprehensive and detailed plan covering environmental and social variables to be monitored, the location and timing of sampling and the use to be made of monitoring data to ensure compliance with the applicable environmental rules/regulations throughout the life of the project

11.Detailed project description

A layout of the proposed project

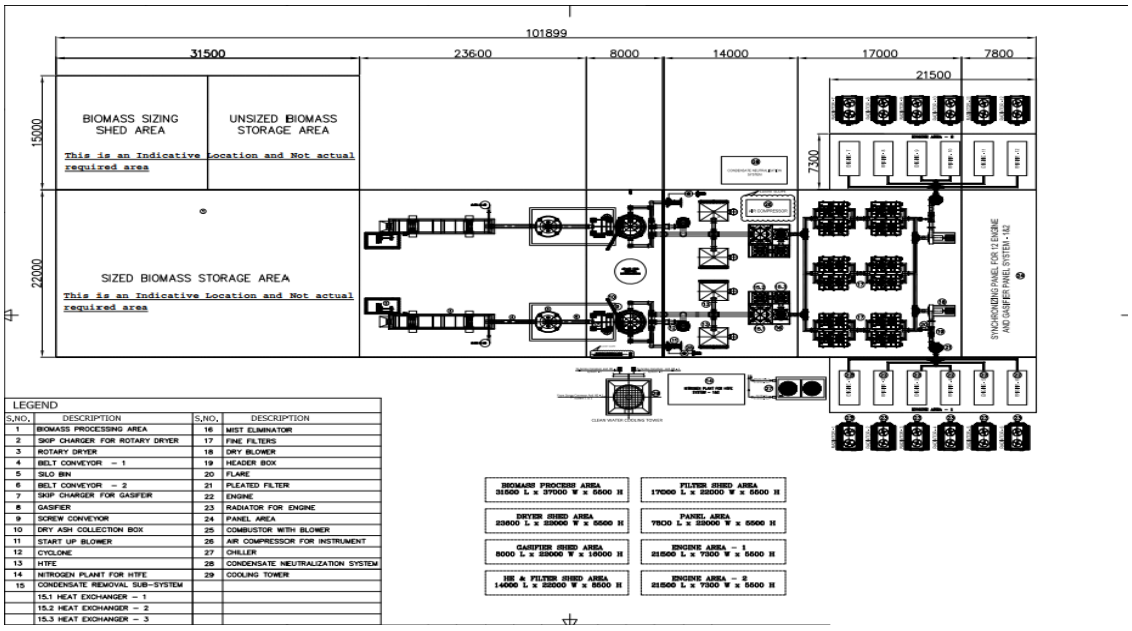

Figure 8 Layout of the proposed project

The project will use gasification method of electricity production from biomass. Prosopis woody parts will be harvested and transported by trucks from the fields to the power plant in Garissa town where they will be chipped, dried and stored for use in the plant.

Most of the details outlined in this section are derived directly from the feasibility report prepared for this project by the proponent.

Biomass gasification is a thermo decomposition of carbonaceous materials such as wood at high temperatures in atmosphere limited of oxygen; the target product being a gaseous fuel. The biomass (which consists of carbon, hydrogen and oxygen) is converted into an inflammable mixture of gases known as producer gas.

The reactor is called a gasifier and the product (the gaseous fuel) is known as producer gas. Producer gas is a mixture of combustible and non-combustible specific gases, liquids and solids (when coming directly from the reactor). The gaseous components from the producer gas are COH_2 CH_4 CH_6 C_2H_4 H_2O and N_2 (incase of air gasification).

The principle combustible gas components of the producer gas are carbon monoxide and hydrogen (CO and H_2): in the sense that they carry a larger fraction among the combustible specific gases. Others include methane, ethane (CH_4 C_2H_6 C_2H_4) and other higher hydrocarbons. Non-combustible gases in the producer gas in include carbon dioxide (CO_2), steam and nitrogen (N_2) (in case of gasification). The combustible gases can be used to run internal combustion engines (both compression and spark ignited) or as a substitute for furnace oil in direct & indirect heat applications.

11.1. Gasification Process

Four distinct processes takes place in a gasifier as the fuel makes its way from the top (feeding point) to the bottom of the gasifier (gasifier bottom), where it is reduced to ash/charcoal as a result of gasification. The four reactions that take place during the gasification process are as follows:

Stage 1: Drying

Moisture content of the biomass entering the gasifier is approximately 10-15%. The moisture content reduced in the drying zone part of the gasifier. Drying of the biomass takes place at about 100-200^{o}C. The rate of drying depends on temperature and moisture content of the dry gas i.e, gasifying agent, the external surface of the wood particle, the internal diffusivity of moisture in the particle, and the physical chemical nature of the bonding of the moisture to the particle. The amount of heat energy needed will depend on the moisture content of the fuel. Some organic acids (mainly acetic acid) are generated during the drying process which can lead to minimal corrosion in the reactor.

Stage 2: Pyrolysis/Devolatilization

Pyrolysis is the basic reaction of all thermal conversion processes of biomass. Pyrolysis stage is important in that it forms an integral and important part of gasification process. About 65% of the gasification products are evolved during this stage. It takes place at moderate temperature (200-500°C) and it is extremely fast.

Pyrolysis of biomass takes place in a sequential manner, with the least stable component i.e hemicelluloses, decomposing first at 200-280°C and lignin, the most stable component, decomposing last at 280-500°C. At low heating rate thermal decomposition of wood takes place in the following sequence:

1. Up to 200°C -: Moisture, volatiles search as acetic acid, formic acid, and gases such as CO and CO_2 are released.
2. Above 500°C (approx. 650^{o}C): devolatilization is complete. The residue char, forming approximately 31-35% of the dry wood weight, is predominantly carbon(C), approximately 89%; i.e. char. secondary reactions and char gasification begins.
3. Wood pyrolysis depends upon temperature, heating rate, and residence time, pressure and biomass properties (physical and chemical). The reaction rate, the products, and other thermal behavior of biomass pyrolysis are considered to be main products.
4. DRY BIOMASS + HEAT-----CHAR (predominantly C) + GASES (CO2, CO, CH_4, H_2, C_2H_4) + VOLATILES (tars, organic liquids, acids)

Stage 3: Char Gasification

The solid carbonaceous products of stage 2, (devolatilization) known as char; undergoes chemical reactions with gaseous products of stages 1& 2, to produce gases. Some of the reactions are endothermic while others are exothermic. Char gasification is generally accepted as the rate limiting stage in overall gasification of biomass. It occurs or takes place above 600°C.

The combustion reactions and other exothermic reactions provide the energy necessary to sustain the endothermic gasification and pyrolysis reactions within the reactor. The balance heat energy is carried by the final product gas; which is commonly at relatively high temperature. Hydro gasification of carbon i.e., methane fraction is slightly exothermic. The reaction is minimized at high temperature and low pressure conditions; it is favoured by low temperature and elevated pressures.

Stage 4- Secondary Reactions

Secondary reactions are categorized into two: -

1. Direct reactions between gaseous products (i.e., specific gases) of stage 1 to 3. These are known as homogeneous gas phase reaction
2. Conversion of liquid volatiles (product of stage 2) to specific gases and higher hydro-carbon to low molecular gases.

Sub stage 4(i): Homogeneous gas phase reactions

These are reactions between gaseous products of stage 1 to3

Water gas shift: $CO+H_2O=CO_2+H_2$

Methanation: $CO+3H_2=CH_4+H_2O$; $H_2+CO_2=CH_4$

Oxygenation: $CO+ ½ O_2=CO_2$+heat; $H_2+ ½ O_2=H_2O$ + heat:

The methanation reaction is highly exothermic, and methane formed by high pressure and low temperature.

Sub stage 4(ii) Other secondary reactions

Other important secondary reactions, which occur at appropriate conditions(e.g. high temperature, pressure of catalyst) involves the decomposition of any hydrocarbon(liquid volatiles) and tars to carbon and low molecular gaseous products

Long residence time and high temperature(>800°C) are necessary for near complete conversion of tars in absence of catalysts – tar conversion can be increased by adding steam – the main component of tar decomposition are predominantly C_2-C_4 hydrocarbons with traces of CO_2, CO, and CH_4

11.2. Gas Generation and Gas Cleaning System

Northern Energy will utilize a reactor and cleaning system integrated into one compact system. The different components of the gasification module include: reactor (gasifier), gas cleaning system and a control system.

Gasifier Reactor

A downdraft gasifier reactor will be employed, where the feedstock and air flow from the top sections to the downward sections. It will be built using high strength stainless steel, skid-mounted with the ability to recycle and reintroduce tar in the reactor to increase the calorific value of biomass/producer gas. The reactor has an inbuilt feed conveyor, safety airlock shut valve, built-in ignition heater and an integrated biomass stirring mechanism which are computer controlled with integrated level and temperature control sensors. The grate section has a cleaning, line ash collection chamber and an automatic ash removal system. The main jacket lining have high temperature insulation and cast high alumina refractory lining.

Figure 9 A Gasifier Reactor

Gas Cooling and Cleaning System

Gas cooling and cleaning is a multi-staged process where the gas is washed out of impurities and cooled before utilization. The process is computer controlled to recover tar and other impurities which are returned back to the reactor.

All the structures of the system are made of stainless steel for better durability. The different components of the gas cleaning system are:

Cyclone Separator: The raw producer gas coming from the gasifier reactor is sent to the cyclones, which efficiently separates most of the particulate matter, dust from the producer gas.

Scrubbing System: The system consists of spray tower systems with integrated sumps, heavy-duty stainless steel circulation pumps, tar collection and management systems, each with independent heavy duty tar pumps. Central tar collection and separation system with independent heavy duty reactor return tar pump. The system is computer controlled with integrated pressure, temperature and level sensors, automated valves, and include a heat exchanger and pump for connection to external cooling.

Wet Electrostatic Precipitator: Removes tar and liquid mists, yielding an exceptionally clean syngas. The system has a fully automatic computer control with integrated electrode heating system, variable high voltage control system and independent tar collection and return pumping system

Evaporation System: Although it is not directly involved in gas cleaning & cooling process, evaporation system plays a major role in eliminating any potential water accumulation in the system, thereby maintaining water equilibrium.

Pressurization System: This includes a twin regenerative blower that blows the producer gas from the gasifier reactor & delivers the pressurized gas to the utility point (gas genset). The blowers are made up of stainless steel to prevent any type of corrosion. The twin blowers are fully automated & computer controlled. The output pressure is between 150 – 200 mbar. The twin blower system also pulls atmospheric air into the gasifier reactor for gasification. Pressurization system maintains negative pressure for the reactor & all other cleaning equipment. The pressurization system is located just after the Wet ESP.

Instrumentation & Control System: The gasifier module consists of a cabinet which contains all the instrumentation & control systems. The cabinet houses the PLC based control system and its computer interface along with various sensor transmitters, electrical wiring and safety interface.

Power Generation System

The power generation system is a natural gas genset that operates on producer gas composed of relatively low calorific value as compared to other combustible gases like natural gas, biogas and land fill gas. The cleaned producer gas is pressurized using a special booster pump to meet gas gensets inlet standards. The pressure is increased to offset the large drop in static pressure from the gasification module to the genset. The genset is directly coupled to an alternator rated at an electric output of 1200KW when running of producer gas. The genset and alternator are mounted on the same common frame to minimize on vibrations. The generator and alternator and the auxiliaries are contained into a single unit. The auxiliary equipment that accompanies the generation set are:

Figure 10 Cummins QSV-91G Ultra Low -BTU Gas Engine

Radiator: A finned type radiator is used to cool the water for both LT (low temperature) and HT (high temperature) circuit of the engine.

Lubricating Oil System: The engine lubricating system includes a heat exchanger, engine-mounted lube oil filters and thermostatic valve. The lube oil system dissipates excess heat generated from the complete combustion of producer gas inside the internal combustion engine.

Gas Engine Starting System: Includes starter, 24V DC batteries, cables, lugs and a battery stand.

Gas Engine Exhaust System: Consists of exhaust silencer, gas ducting, insulation & temperature sensor to monitor the temperature of the exhaust gas which may be around 450 - 500°C, depending upon combustion conditions inside the gas engine. The gas engine exhaust system also contains gas analyzers to monitor the NO_x emission levels into the atmosphere.

Flame Arresters: Prior to the gas engine inlet, flame arrestors are provided in the gas train to prevent the system from any back-fire. Flame arrestors are fire safety devices that must be implemented to reduce the possibility of an engine spit-back event, igniting the flammable air-fuel mixture in the front of the engine. Under normal operating conditions there is no flammable air-fuel mixture inside the system, however since the system operates at negative

pressure behind the twin regenerative blowers, air can possibly enter the system through unwanted leakages & form a combustible mixture with producer gas, thereby increasing the risk of explosion in front of the gas engine.

12. Power Evacuation System

The power evacuation system deals with the overall control & distribution of electric power generated from the gas engine alternator to the point of interconnection. It mainly consists of two components:

Electrical & Control System: Consists of the power control center (PCC) panel used to synchronize engines, incoming/outgoing breakers and motor control center (MCC Panel) for power plant auxiliaries. The PCC is the main power control unit that governs the inflow & outflow of power from the power plant. The MCC units are responsible for controlling the overall function of all the electrical motors present in the power plant. The system also includes a load bank which stores the required electrical load and applies the load to an electrical power source and converts/dissipates the resultant power output. The purpose of a load bank is to accurately mimic the operational or "real" load that a power source will see in actual application. However, unlike the "real" load, which is likely to be dispersed, unpredictable and random in value, a load bank provides a contained, organized and fully controllable load.

Transformer & Circuit Breakers: The power is generated at 11 kVA and transformers may be required to step-up the power to meet the requirements of the utility`s infrastructure and has to be stepped-down (415V) to service the parasitic load (motors, lighting, processing equipment etc.). The step-up transformer is located after the PCC panel & transfers the power to the local grid through transmission lines via a circuit breaker. Circuit breakers are located between the 3 phase transformer and the local grid substation. A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow.

13.Project activities

The proposed activities of this project will comprise but not limited to:

i. Harvesting of Prosopis feed materials
ii. Transportation of feed resources to the power plant
iii. Chipping of wood feed resources into small pieces to feed into the gasifier
iv. Drying and storage of wood chips
v. Gasification process
vi. Electricity generation process
vii. Waste handling

Each one of these project activities will have environmental consequences that will be investigated and mitigation measures developed and incorporated in the Environmental and Social Management Plan (ESMP) during the full study along with other project impacts analysis.

13.1. Harvesting of Prosopis for feedstock

Prosopis will be harvested from farms surrounding the power plant. Initially the proponent is planning to harvest within a region of 100 km^2 from the power plant in Garissa. Latter when the power plant is up scaled to higher production of electricity the feedstock harvesting zone can be expanded. It is also envisaged that the places where Prosopis will be harvested re-planting of the trees will be done so that continuous replenishing of the feedstock will take place in such a way that Prosopis will become an agro-forestry tree crop. This project will develop land use plans to make sure that the land where Prosopis has been harvested is used sustainably to avoid land degradation. These plans will be done in consultation with the land owners, the relevant government agencies like KFS, Ministry of agriculture and livestock and local administration.

13.2. Transportation of feed resources to the power plant

The Proponent has a 46 acre land that is currently a thick forest of Prosopis to be used in the plant. However, the main source area of Prosopis is the 100km^2 extent where Prosopis is

growing in privately and communally owned land. Northern energy will procure prosopis from the owners of the land where it is growing cut it down, remove the small branches and leaves and transport the woody parts to the power plant in Garissa town.

Transportation will be done by trucks and due care will be taken to avoid negative environmental impacts due to movement of trucks. This report will prepare a comprehensive Environmental and Social management Plan that will include measures to mitigate impacts from transportation.

13.3. Chipping of wood feed resources into small pieces to feed into the gasifier

The transported woody materials will be off loaded from trucks and placed in a warehouse from where they will be chipped by a machine into small pieces approximately 4 x 4 cm chips that can be fed into a gasifier. The chips will first be dried in a drier to remove moisture before they are put in a bigger warehouse for storage waiting to be fed into the gasifier. The process of chipping is not expected to produce many wastes except for the few droppings that will fall off during the feeding into the chipper. The chipping machine is expected to run on electricity so the major pollution at this stage will be the wood dust produced in the process.

13.4. Drying and storage of wood chips

It is expected that wood chips will be stored in bulky so as to make sure the stock of feed resources is available to continue running the power plant for several month ahead of time. The storage of woody materials as feed stock in the form of dry chips is likely to cause several environmental issues from the risk of fire to collecting dust, hosting micro organisms like fungus and also attracting pests like rats and mice that can be a nuisance to people. The ESMP to be prepared in this study will address all these issues and propose mitigation measures to avoid or reduce the potential impacts.

13.5. Gasification process

Gasification process is a major operation in this project as it is the process that will convert the wood biomass into electricity. This process is explained into detail in another section of

this report. This part of the report will highlight only the environmental issues of concern in this particular process.

Gasification process is basically combustion of materials into gases. The types and amounts gases produced depend on the types of materials used as feedstock. The proposed feedstock will be woody plant materials and generally the gases produced are mainly n*itrous oxides*, variable amounts of *sulphur oxides*, *carbon oxides* and gaseous hydrocarbons like methane. These are the primary products in the process of producing electricity. This study will address the environmental and social impacts from each of these gases and suggest methods for mitigating the impacts.

A major by product of gasification process will be ash formed in the combustion of wood chips. The ash collected will be packaged and applied to farmlands to enhance soil fertility.

13.6. Electricity generation process

Because biomass technologies use combustion processes to produce electricity, they can generate electricity at any time, unlike wind and most solar technologies, which only produce when the wind is blowing or sun is shining.

The gas produced in the gasification process will be used to run a gas turbine to produce electricity. How this process works is explained elsewhere into detail in this report. The environmental and social impacts associated with this activity are the release of gases into the atmosphere after running the turbine.

13.7. Waste handling

The proposed project will have no wastes that are of serious concerns to the environment. For example there will be no wastes that are hazardous to the environment. Majority of wastes to be generated in this project are organic waste materials from Prosopis cuttings and leaves which will decompose and add to the much needed organic manures in the soils where they will be deposited. There is a possibility that some of the waste materials from Prosopis plants may be utilized by the local communities to make charcoal briquettes. The other major waste

by product will be ash produced during gasification process which as mentioned earlier will be recycled back into the soil to enhance soil fertility in the farmlands.

Water will be drawn from the river to cool the power plant. Some of the water will be discharged from the system and after cooling it to room temperature or temperature similar to that of the river water it will be returned back into the river

14.Environmental concerns of Biomass Power Plant operations

The term "biomass" encompasses diverse fuels derived from timber, agriculture and food processing wastes or from fuel crops that are specifically grown or reserved for electricity generation. Some biomass fuels are derived from trees. Given the capacity of trees to regenerate, these fuels are considered renewable. Burning crop residues or plant materials harvested for use in electricity generating plants is considered renewable as the materials can be re cultivated again and again for the same purpose.

At present, most biomass power plants burn timber and agricultural wood wastes. Direct Combustion power plants burn the biomass fuel directly in boilers that supply steam to generate electricity. With biomass gasification, biomass is converted into a gas - methane - that can then fuel steam generators, combustion turbines, combined cycle technologies or fuel cells. The primary benefit of biomass gasification, compared to direct combustion, is that extracted gasses can be used in a variety of power plant configurations.

14.1. What are the environmental impacts?

Prosopis juliflora can be a very aggressive invader and replaces native vegetation and takes over rangelands. Negative effects include complete loss of pasture and rangelands for both domestic and wild ruminants, losses due to access to water and the destruction of fishing nets by the thorns, and illness and death of livestock due to eating *P. juliflora* pods and being pierced by the sharp and stout thorns. Other impacts are loss of cropland, the costs of repairing tyres punctured or destroyed by thorns, and doctor's bills for treating thorn wounds. Dense stands of *P. juliflora* can block irrigation channels, obstruct roads and block smaller trails completely affecting access to pasture, croplands, water sources and fishing areas.

Prosopis species are salt and drought tolerant with deep roots which tolerate dry as well as waterlogged soils. Seed production is prolific. Trees rapidly form dense thorny thickets that reduce biodiversity[9]. Invaded grasslands are transformed to woodland and forests. Loss of grass cover under canopies may also promote soil erosion. It has massive impacts upon water resources. The tree re-sprouts easily after damage[9].

14.2. Environmental impacts of Prosopis as an invasive species

Invasive plant species are the second most important threat to global biodiversity loss after land-use change. Invasive species can modify native community composition, deplete species diversity and affect ecosystem processes. *Prosopis juliflora* is an important invasive plant species in an ecosystem. Seed germination is a critical stage in plant life cycles and is a major factor in the establishment and success of invasive plant species. Among the factors that affect seed germination and dormancy, coat-imposed seems to be the most important for *P. juliflora*. In *Prosopis* species, the ingestion of fruits by wild and domestic animals may promote and accelerate germination, enhancing the dispersal of seeds and fruits of these species. Germination rate, germination time and germination synchrony differed significantly with the length of the scarification treatments in H_2SO_4 for both seeds with endocarps and seeds without endocarps (non-endocarp seeds). Sulphuric acid affected plant survival more strongly than germination rate, particularly in non-endocarp seeds.

Crop farmers from Chemonke village, Kenya, have had to seek alternative settlement elsewhere because they have lost their land to *P. juliflora* invasions, often resulting in conflict with established communities[11]. Surveys of local communities around Lake Baringo revealed that 85-90% of respondents to a questionnaire favoured complete eradication of invasive *Prosopis* species [11]. In another study[10] found that 64, 79, and 67% of respondents interviewed in the Garissa, Loiyangalani, and Baringo areas of Kenya, respectively, said that life would be better without *Prosopis*. Over 90% of livestock owners in eastern Sudan regard invasive *Prosopis* as a liability and pastoralists in Ethiopia refer to *Prosopis* as the "Devil Tree".

P. juliflora has been included in the Global Invasive Species Database[12]. It has been listed as a noxious weed in all Australia states and in Hawaii.

Whether combusting directly or engaged in gasification, biomass resources do generate air emissions. These emissions vary depending upon the precise fuel and technology used. If wood is the primary biomass resource, very little SO_2 comes out of the stack. NO_x emissions vary significantly among combustion facilities depending on their design and controls. Some biomass power plants show a relatively high NO_x emission rate per kilowatt hour generated if compared to other combustion technologies.

High NO_x rate a top air quality concerns associated with biomass plants.

Carbon monoxide (CO) is also emitted - sometimes at levels higher than those produced by coal plants.

Biomass plants also release carbon dioxide (CO_2), the primary greenhouse gas. However, the cycle of growing, processing and burning biomass recycles CO_2 from the atmosphere. If this cycle is sustained, there is little or no net gain in atmospheric CO_2. An individual Prosopis plants take long time to grow and thus takes much more CO_2 from the atmosphere than what it releases during combustion.

The studies conducted in Peru by Coronado and Olcese, quoted by Azevedo (1960), show that *P. juliflora* pods present high digestibility, with the following values per component:

dry matter:	82,56%
protein:	80,13%
ether extract:	90,98%
raw fiber:	70,89%
non-nitrogen extracts:	83,19%

Biomass power plants share some similarities with fossil fuel power plants: both involve the combustion of a feedstock to generate electricity. Thus, biomass plants raise similar, but not identical, concerns about air emissions and water use as fossil fuel plants. However, the feedstock of biomass plants can be sustainably produced, while fossil fuels are non-renewable. The type of feedstock and the manner in which it is developed and harvested significantly affect land use and life-cycle global warming emissions impacts of producing power from biomass.

14.3. Water Use

Biomass power plants require large amounts of water for cooling, but actual water withdrawals and consumption depends on the facility's cooling technology. For biomass plants with once-through cooling systems, which take water from nearby sources, circulate it through the plants cooling system, and then discharge it. This system draws more water continuously as the same is discharged continuously. The proposed cooling system for the Garissa biomass plant will use wet-recirculating cooling systems, which reuse cooling water in a second cycle rather than immediately discharging it. The system withdraws approximately 2000 litres of water per megawatt-hour and consumes approximately 500 litters per megawatt-hour while the rest is recycled [8].

Most biomass plants around the world that require cooling uses wet-recirculating technology, but some use once-through cooling technology. In either case, when withdrawn cooling water is returned to its source, it is much warmer than when it was withdrawn, which often has a negative impact on plant and animal life in river system or the recipient reservoir. As is the case in all thermal plants, this impact will have to be closely monitored to avoid discharge of warm water into the river.

Water is also needed to produce some biomass feedstock especially if the feedstock will be grown or cultivated as some stakeholders have suggested. However, feedstock such as P*rosopis juliflora* which grows wild will require no watering except perhaps during germination in a nursery or for short period during transplanting. Water use efficiency of a given plant depends on a number of factors, including soil quality and temperature [9]. Even if Prosopis was to be planted to produce the feedstock, the plant is adapted to dryland areas and can grow where many other forest plant species cannot grow due to lack of sufficient amounts of water. Soils in places where *Prosopis* plants are growing have higher soil moisture content than other places due less evaporative potential as prosopis shades the soils from direct heating by the sun. At the same time places where *Prosopis* plants are growing experience less surface runoff and therefore less soil erosion. Growth of Prosopis plants in Garissa or Tana River benefits the water budget in the area by reducing evapotranspiration and conserving water in the soil for longer periods of time.

14.4. Air Emissions

Burning biomass to produce electricity can impact air quality. The level of air emissions associated with biomass power plants varies depending on the feedstock, combustion technology, and types of installed pollution controls, but the most common pollutants include nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter. The table below compares air emissions from different types of biomass, coal, and natural gas power facilities with pollution control equipment. In general, biomass facilities emit less SO_2 and mercury (a neurotoxin) than coal.

Direct air emissions from Wood residues by Boiler types

Table 6 Comparison of gas emissions from different biomass feedstock

	SO_X	NO_X	CO	PM-10[1]	Comments
Biomass Technology					
Stoker Boiler, Wood Residues (1,4)	0.08	2.1 (biomass type not specified)	12.2 (biomass type not specified)	0.50 (total particulates) (biomass type not specified)	Based on 23 California grate boilers, except for SO_2 (uncontrolled)
Fluidized Bed, Biomass (4)	0.08 (biomass type not specified)	0.9 (biomass type not specified)	0.17 (biomass type not specified)	0.3 (total particulates) (biomass type not specified)	11 FBC boilers in California
Energy Crops (Poplar) Gasification (a,b)	0.05 (**suggested** value based on SOx numbers for Stoker and FBC, adjusted by a factor of 9,180/13,800 to account for heat rate improvement)	1.10 to 2.2 (0.66 to 1.32 w/SNCR, 0.22 to 0.44 with SCR)	0.23	0.01 (total particulates)	Combustor flue gas goes through cyclone and baghouse. Syngas goes through scrubber and baghouse before gas turbine. No controls on gas turbine.
Coal Technology					
Bituminous Coal, Stoker Boiler (f)	20.2 1 wt% S coal	5.8	2.7	0.62	PM Control only (baghouse)
Pulverized Coal Boiler (d)	14.3	6.89	0.35	0.32 (total particulates)	Average US PC boiler (typically :baghouse, limestone FGC)
Cofiring 15% Biomass (d2)	12.2	6.17	0.35	0.32 (total particulates)	?
Fluidized Bed, Coal (f)	3.7 (1 wt% S coal Ca/S = 2.5)	2.7	9.6	0.30	Baghouse for PM Control, Ca sorbents used for SO_x
Natural Gas Technology					
4-Stroke NG Reciprocating Engine (g)	0.006	7.96-38.3 (depends on load and air:fuel ratio)	2.98-35.0 (depends on load and air:fuel ratio)	0.09-0.18 (depends on bad and air:fuel ratio)	No control except PCC at high-end of PM-10 range
Natural Gas Turbine (e)	0.009 (0.0007 wt% S)	1.72	0.4	.09 (total particulates)	Water-steam injection only
Natural Gas Combined Cycle (c,e)	0.004	0.91 (0.21 w/ SCR)	0.06	0.14 (total particulates)	Water-steam injection only

Nitrogen oxides from biomass are lower than those from coal but higher than natural gas. NO_x emissions causes ground-level ozone, or smog, which can burn lung tissue and can make people more susceptible to asthma, bronchitis, and other chronic respiratory diseases. Like SO_2, NO_x also contributes to increased acidity in rain water and the formation of harmful particulate matter. Biomass power plants also emit high levels of particulates (soot and ash) and carbon monoxide.

Readily available technologies, such as fluidized bed and electrostatic precipitators, can help reduce NO_x, CO, and particulate emissions associated with biomass power.

14.5. Land Use

Land use impacts from biomass power production are driven primarily by the type of feedstock and the way the feedstock is produced. The proposed feedstock sources do not require additional land for planting, rather than harvesting of the already existing feedstock. This method of harvesting is currently seen as a method to control the spread of the plant which is an invasive species that is autonomously or naturally colonizing new places. Harvesting of the feedstock is seen as way of making profitable use of land through sale of Prosopis to the power plant by the land owners. Areas where Prosopis will be harvested land will be available for either re-planting if found to be profitable, or for re-establishment of pastures for grazing livestock. The land owner will make a choice of how to use his land based on the most feasible option.

Important safeguards and best practices for harvesting of Prosopis are needed to ensure that sufficient plant residues are left behind to some carbon in the soil, maintain nutrient levels, and prevent erosion. Additionally, harvesting of the plant can be done sustainably done, but proper forest management practices need to be followed to ensure that critical wildlife habitats are not destroyed and that forest re-growth is continued if needed or any cropping in the area is feasible[13].

Effects of biomass power production and global warming

There are global warming emissions associated with growing and harvesting biomass feedstock, transporting feedstock to the power plant, and burning or gasifying the feedstock. Transportation and combustion emissions are roughly equivalent for all types of biomass. However, global warming emissions from the sourcing of biomass feedstock vary widely. Earlier considerations suggested that biomass had net zero global warming emissions, because of the thought that growing of biomass absorbed an equal amount of carbon as the amount released through combustion. However, it was later understood that some biomass feedstock sources are associated with substantial global warming emissions. Thus, it is important to distinguish between biomass resources that are beneficial in reducing net carbon emissions, those that have an ambiguous impact, and those that increase net emissions.

Forest feedstock is an example of a marginal biomass resource. The use of forest products for biomass feedstock can have net zero global warming emissions if forest managers harvest in a sustainable manner and replant with fast-growing tree species. However, even when following best practices, forest regeneration will not occur instantly, so there can be a long lag-time before the biomass resource achieves carbon neutral[14].

Due to a number of factors, the range for estimates for lifecycle global warming emissions of biomass energy is wide. Excluding global warming emissions from land use changes, most estimates are between 0.04 and 0.2 pounds of CO_2 equivalent per kilowatt-hour[9]. To put this into context, estimates of life-cycle global warming emissions for natural gas-generated electricity are between 0.6 and 2 pounds of carbon dioxide equivalent per kilowatt-hour and estimates for coal-generated electricity are 1.4 and 3.6 pounds of carbon dioxide equivalent per kilowatt-hour [15]

14.6. Biomass energy as a renewable energy

If developed properly, biomass can and should supply increasing amounts of bio power in Kenya. Sustainable, low-carbon biomass can provide a significant fraction of the new renewable energy we need to reduce emissions of heat-trapping gases like carbon dioxide to levels that will avoid the severe impacts of global warming. Without sustainable, low-carbon bio power, it will likely be more expensive and take longer to transform to a clean energy economy.

But like all our energy sources, bio power has environmental risks that need to be mitigated. If not managed carefully, biomass for energy can be harvested at unsustainable rates, damage ecosystems, produce harmful air pollution, consume large amounts of water, and produce net greenhouse emissions.

However, there is a wide range of biomass resources that can be produced sustainably and with minimal harm, while reducing the overall impacts and risks of current energy system. Implementing proper policy is essential to securing the benefits of biomass and avoiding its risks.

Biomass is a renewable energy source not only because the energy it produces comes from the sun, but also because biomass can re-grow over a relatively short period of time. Through the process of photosynthesis, chlorophyll in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates—complex compounds composed of carbon, hydrogen, and oxygen.

When these carbohydrates are burned, they turn back into carbon dioxide and water and release the energy they captured from the sun. In this way, biomass functions as a sort of natural battery for storing solar energy. As long as biomass is produced sustainably—meeting current needs without diminishing resources or the land's capacity to re-grow biomass and recapture carbon—the battery will last indefinitely and provide sources of low-carbon energy.

15. Types of beneficial biomass and alternative methods of energy production

There are a wide range of biomass resources that are categorized as "beneficial" because their use will clearly reduce overall carbon emissions and provide other benefits. Among other resources, benefits of biomass power plants include; (1) energy plants that don't compete with food crops for land, and (2) sustainably-harvested wood and forest residues.

Beneficial biomass use can be considered part of the terrestrial carbon cycle—the balanced cycling of carbon from the atmosphere into plants and then into soils and the atmosphere during plant decay. When bio power is developed properly, emissions of biomass carbon are taken up or recycled by subsequent plant growth within a relatively short time, resulting in low net carbon emissions.

Beneficial biomass sources generally maintain or even increase the stocks of carbon stored in soil or plants. Beneficial biomass also displaces carbon emissions from fossil fuels, such as oil or natural gas, the burning of which adds new and additional carbon to the atmosphere and causes global warming.

Among beneficial resources, the most effective and sustainable biomass resources will vary from region to region and also depend on the efficiency of converting biomass to its final application.

15.1. Direct combustion

As reported in the literature, the oldest and most common way of converting biomass to electricity is to burn it to produce steam, which turns a turbine that produces electricity (direct combustion). The problems with direct combustion of biomass are that much of the energy is wasted and that it can cause some pollution if it is not carefully controlled. Direct combustion can be done in a plant using solely biomass (a "dedicated plant") or in a plant made to burn another fuel, usually coal.

15.2. Biomass gasification

By heating biomass in the presence of a carefully controlled amount of oxygen and under pressure, it can be converted into a mixture of hydrogen and carbon monoxide called syngas. This syngas is often refined to remove contaminants.

Equipment can also be added to separate and remove the carbon dioxide in a concentrated form. The syngas can then be run directly through a gas turbine or burned and run through a steam turbine to produce electricity. Biomass gasification is generally cleaner and more efficient that direct combustion of biomass. Syngas can also be further processed to make liquid bio fuels or other useful chemicals.

The proposed project will utilize gasification method to produce electricity using gas turbine.

16.Biomass Energy Operations Impacts

Operation activities that may cause environmental impacts include operation of the biomass energy facility, power generation, biofuel production, and associated maintenance activities.

Typical activities during biomass facility operation include power generation or production of biofuels, and associated maintenance activities that would require vehicular access and heavy equipment operation when components are being replaced. Biomass power plants require pollution control devices to reduce emissions from combustion and large cooling systems. Water requirements vary greatly among the various biomass facilities. Potential impacts from these activities are presented below, by the type of affected resource.

The following potential impacts may result from biomass facility operations.

16.1. Acoustics (Noise)

Operations of heat recovery systems of a biomass power plant, chipping rooms and boilers of, and turbine generators would result in occupational noise that would exceed the Occupational Safety and Health Administration (OSHA) noise threshold limit. Personnel working in these areas would be required to wear hearing protection. Insulation of these areas would reduce noise levels so that hearing protection would not be required outside these areas. Noise levels in other parts of the facility would most likely be below the threshold limit established by OSHA.

Other noise sources would include exhaust stacks, mechanical-draft cooling systems, switchgear at substations, corona noise from transmission lines, vehicular traffic, and maintenance facilities.

No adverse community reaction would be expected as a result of noise levels below 50 A weighted decibels (dBA) at the nearest sensitive receptor (e.g., closest residence). Noise control equipment could be incorporated to achieve these levels.

16.2. Air Quality (including Global Climate Change and Carbon Footprint)

Operation of biomass facilities results in emissions of criteria air pollutants and hazardous air pollutants (HAPs). Criteria air pollutants include particulate matter, carbon monoxide, sulfur oxides, nitrogen oxides, lead, and volatile organic compounds (VOCs). HAPs are toxic chemicals.

The use of Best Available Control Technology (BACT) would minimize the potential for adverse air quality impacts from biomass facilities. A gas-fired *regenerative thermal oxidizer* would reduce VOCs by 95%. *Baghouses*, which are a type of dust collector using fabric filters, control particulate matter. Enclosing the processing equipment in a slight negative pressure envelope in addition to the use of baghouses could minimize fugitive dust emissions from milling operations.

The use of forest biomass feedstock (i.e., fuel specifically grown for energy production) in place of fossil fuels like coal, oil, and natural gas can result in a reduction in the amount of carbon dioxide that accumulates in the atmosphere only if the carbon released by combustion of biomass fuels is effectively recaptured by the next generation of feedstock plants. If the biomass source is not replaced by growing more plants, the carbon released in biomass combustion is not recaptured; therefore, these forms of biomass energy can only be considered to be carbon-free if the energy production cycle includes replanting of the feedstock. While the combustion of biomass fuels under these conditions can be considered to be carbon-free, in practice, any gains in terms of reduced carbon dioxide emissions are offset by carbon dioxide emissions associated with the use of fossil fuels in the cultivation, harvesting, and transportation of the biomass feedstock.

16.3. Cultural Resources

Impacts during the operations phase would result into unauthorized collection of cultural artefacts or cause some visual impacts in areas where such materials exist. The threat of unauthorized collection would also result from construction of access roads during the construction phase, or even by making remote lands accessible to the public. Visual impacts resulting from the presence of a biomass facility and transmission lines could affect some cultural resources, such as sacred landscapes or historic sites.

16.4. Ecological Resources

During operation, adverse ecological effects could occur from (1) disturbance of wildlife by equipment noise and human activity, (2) exposure of biota to oil spills and other contaminants, and (3) mortality of wildlife from increased vehicular traffic and collisions with and/or electrocution by transmission lines. Disturbed wildlife would be expected to get used to facility operations.

Intake structures for withdrawal of water from the river would result in impingement and entrainment of aquatic species. Proper design of these structures can minimize these impacts. Discharge of heated cooling water into the river or other water bodies could be beneficial or adverse, depending upon the design of the discharge structure and the temperature of the effluent.

16.5. Environmental Justice

Possible environmental justice impacts during operation include the alteration of scenic quality in areas of traditional or cultural significance to minority or low-income populations and disruption of access to those areas. Noise impacts, health and safety impacts, and water consumption in arid areas are also possible sources of disproportionate effect.

16.6. Hazardous Materials and Waste Management

Non-hazardous solid waste would be transported to an approved landfill. Industrial wastes are generated during routine operations (dielectric fluids, cleaning agents, and solvents). These wastes typically would be put in containers, sorted out and labelled, possibly stored briefly, and transported by a licensed waste handler to an appropriate permitted off-site disposal facility as a standard practice.

Ash produced from combustion could be sold for other uses (e.g., fertilizer or manure manufacturers or users), or it could be taken to a landfill for disposal. Impacts could result if these wastes were not properly handled and were released to the environment.

16.7. Human Health and Safety

Possible impacts to health and safety during operation include accidental injury or death to workers. Health impacts could result from exposures to chemicals and products used and produced in biomass facilities, air emissions, and noise. Chemicals used in biomass facilities could include anhydrous ammonia, sodium hydroxide, sulphuric acid, hydrochloric acid, phosphoric acid, and sodium methylate. Gasoline or diesel might also be stored on site. These chemicals need to be handled carefully especially during storage to make sure that they are kept in chemical safe facilities depending on the specification for each of them. Any spills of chemicals should be cleaned according to its specifications and warning signs should be placed in appropriate places with precautionary measures and actions to take in case of accidentally spilling on to people.

Dry dust produced from handling feedstock, plants or wood chips, may be combustible. All personnel involved with the operation would utilize appropriate safety equipment and would be properly trained in required OSHA practices.

16.8. Paleontological Resources

Impacts during the operations phase would be limited to unauthorized collection of fossils. This threat is present once the access roads are constructed in the construction phase, making remote lands accessible to the public. Upon observation of any fossil materials, the find should be reported to the relevant authorities at the national Museums of Kenya.

16.9. Socioeconomics

Direct impacts would include the creation of new jobs for operation and maintenance workers and the associated income and taxes paid. Indirect impacts are those impacts that would occur as a result of the new economic development and would include new jobs at businesses that support the workforce or that provide project materials, and associated income and taxes. The number of project personnel required during the operation and maintenance phase would be fewer than during construction, but the continuation of feedstock harvesting, transportation and chipping would create jobs for many people. Therefore, socioeconomic impacts related to jobs would be many throughout the project period.

16.10. Soils and Geologic Resources (including Seismicity/Geo Hazards)

During operation, the soil and geologic conditions would stabilize with time. Soil erosion and soil compaction are both likely to continue to occur along access roads. Within the project footprint, soil erosion, surface runoff, and sedimentation of nearby water bodies will continue to occur during operation, but to a lesser degree than during the construction phase.

16.11. Transportation

Increases in the use of local roadways and path ways would occur during operations. Biomass fuels for power plants would arrive daily by truck. The number of trucks to transport feedstock daily will be many and the number of kilometres of road to be used daily are also

many. Transportation of waste materials to the disposal site is also likely to involve many trucks on a regular basis. Such movements will result into blowing of many dusts into the atmosphere and also cause soil disturbance in addition to possible road accidents and gas emissions from exhausts.

Landfills would either be placed close to the sources of wastes to avoid long distance of trucking. Vehicles should be of good mechanical conditions, and water should be poured on dusty roads to reduce dust emissions

16.12. Visual Resources

The magnitude of visual impacts from operation of a biomass facility is dependent upon the distance of the facility from the viewer, the view duration, and the scenic quality of the landscape. Facility lighting would adversely affect the view of the night sky in the immediate vicinity of the facility. Plumes from stacks or cooling towers might be visible, particularly on clear days.

Additional visual impacts would occur from the increase in vehicular traffic.

16.13. Water Resources (Surface Water and Groundwater)

Withdrawals of river water are expected to continue during the operations phase of the biomass power plant. The amount of water needed depends upon the type of facility.

In a typical biomass power plant, the primary consumptive use of water will be to support the cooling system used to condense spent steam for reuse. Wet re-circulating cooling systems recycle cooling water through cooling towers where some portion of water is allowed to evaporate and must be continuously replenished. Wet re-circulating cooling systems also periodically discharge small volumes of water as blowdown and replace that amount with fresh water. Other consumptive uses of water at a biomass power plant include the initial filling and maintenance of the steam cycle, fresh water supplies to support the workforce, and a wide variety of incidental maintenance-related industrial applications.

Most uses of water at a biomass power plant will ultimately result in the generation of some wastewater. Blowdown from both the steam cycle and the wet re-circulating cooling system

will represent the largest wastewater stream and, because water in both the steam cycle and the cooling system undergoes some chemical treatment, the discharge will contain chemical residuals. Its temperature will also be elevated. All wastewater discharges from biomass power plants can be directed to a holding pond for evaporation, cooling, and/or further treatment, but are likely to be eventually discharged to surface waters.

17.Environmental and Legislative Framework

It is intended that this project will comply with all Kenyan legal requirements. In addition, guidance has been sought from, amongst others, the World Bank's safeguard policies on Environmental Assessment (OP 4.01), Natural Habitats (OP 4.04), and Involuntary Resettlement (OP 4.12); the AfDB's Involuntary Resettlement Policy (2003) and Integrated Environmental and Social Impact Assessment Guidelines (2003).

International treaties and agreements of relevance to the project are:

- United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Cleaner Development Mechanism
- Convention for Biological Diversity

Policy, Legal and Administrative/Institutional Framework

Overview

The economic recovery action plan takes cognizance of the need to achieve macro and micro sectoral objectives and targets without compromising the health of the environment. Kenya faces an environmental challenge due to degradation of the country's natural resources that form the Country's economic base. The Government has attempted to address these problems through the enactment if the Environmental Management and Coordination Act (EMCA) 1999 which provides for Environmental Impact Assessment (EIA) of proposed projects and environmental audit (EA) of existing enterprises.

EIA is a tool for environmental management and has been identified as key component for proposed projects, to ensure sustainable development with respect to environmental resources

and co-existence with socio-economic activities in the neighbourhood. At the national level, Kenya has put in place necessary legislation that requires EIA to be carried out on some specified projects, activity or programmes, and a report submitted to the National Environmental Management Authority (NEMA) for approval and issuance of relevant certificates.

To facilitate this process, regulations on EIA and Environmental Audits have been established under the Kenya Gazette Supplement No.56 of 13th June 2003. Besides, a number of other national policies and legal statutes have been reviewed to enhance environmental sustainability in national development projects across all sectors, which the proposed project must adhere to. This section discusses the environmental policies, legislation and institutional requirements impacted on by the proposed development. The proposed project impacts on several Government institutions mandates, policies and legal framework are explained here below:

17.1. Selected National Policies

National Environmental Action Plan (NEAP)

The NEAP for Kenya was prepared in mid 1990s. It was a deliberate policy effort aimed at integrating environmental considerations into the country's economic and social development. The integration process was to be achieved through a multi-sectoral approach to develop a comprehensive framework to ensure that environmental management and conservation of natural resources are integral part of societal decision-making. The NEAP also established the process of identifying environmental problems and issues, raising awareness, building national consensus, defining policies, legislation and institutional needs, and planning environmental projects. An Environmental Action Plan for Arid and Semi-arid Lands (ASAL) and District-specific Environmental Action Plans for 24 ASAL districts were also formulated and formed part of the building block to the NEAP.

The 2nd NEAP (2009) recognizes that a network of transport services including roads, airports, railways and waterways facilitate economic and social development. It has however cautioned that continued use of these modes of transport often causes negative impacts on the environment such as air, noise, clearance of vegetation, water pollution, solid and liquid

waste disposal resulting from operations and maintenance. The NEAP (2009) recommends control of air and noise pollution, and compliance to EMCA (1999) and its subsidiary legislations.

Environment and Development (Sessional Paper No. 6 of 1999)

The paper, is now a full policy on environment, presents broad categories of development issues that require sustainable approach. The paper harmonizes environmental and developmental objectives so as to ensure sustainability. The paper provides comprehensive guidelines and strategies for government action regarding environment and development. With regard to wildlife, the policy reemphasizes the aims of the Wildlife Policy of 1976 and especially the government's commitment towards involving local communities and other stakeholders in wildlife conservation and management, as well as developing mechanisms that allow them to benefit from the resource. The paper also advocates for the establishment of zones that allow for the multiple use and management of wildlife.

The Wildlife Policy (Sessional Paper No. 3 of 1975)

This is the policy that governs wildlife management in Kenya. Its goal is "to optimize returns from this resource, taking into account returns from other land uses". The policy not only recognizes economic benefits from tourism and consumptive uses but also the intangible benefits that include aesthetic, cultural, and scientific gains that accrue from conservation of ecosystems and biodiversity.

The National Biodiversity Strategy

The overall objective of the National Biodiversity Strategy and Action Plan (NBSAP) is to address the national and international undertakings elaborated in Article 6 of the Convention on Biological Diversity (CBD). It is a national framework of action to ensure that the present rate of biodiversity loss is reversed and the present levels of biological resources are maintained at sustainable levels for posterity. The general objectives of the strategy are to conserve Kenya's biodiversity to sustainably use its components; to fairly and equitably share the benefits arising from the utilization of biological resources among the stakeholders; and

to enhance technical and scientific cooperation nationally and internationally, including the exchange of information in support of biological conservation.

The National Poverty Eradication Plan (NPEP) and the Poverty Reduction Strategies Paper (PRSP)

The objective of the NPEP is to reduce the incidence of poverty in both urban and rural areas by 50% by the year 2015 as well as strengthening the capabilities of the poor and the vulnerable groups to earn income. Also it aims to narrow gender and geographical disparities and create a healthy, better educated and more productive population. The plan has been prepared in line with the goals and commitment of The World Summit for Social Development (WSSD) of 1995 and focuses on the four WSSD themes of poverty eradication, reduction of unemployment, social integration of the disadvantaged people and creation of enabling economic, political, and cultural environment. This plan is to be implemented by the Poverty Eradication Commission (PEC) formed in collaboration with government ministries; community based organizations, the private sector, non-governmental organizations, and bilateral and multilateral donors.

The NPEP emphasizes the empowerment of poor people and their communities to better manage their resources for collective advancement. The PRSP has the twin objectives of poverty reduction and economic growth. The paper articulates Kenya's commitment and approach to fighting poverty, with the basic rationale that the war against poverty cannot be won without participation of the poor themselves.

Vision 2030

Vision 2030 the country's new development blueprint aims to transform Kenya into a newly industrializing, middle-income country to all its citizens by the 2030. The Vision is based on three pillars, economic, social and political. Infrastructure is one of the foundations to anchor the three (3) pillars of Vision 2030. Vision 2030 aspires for a country firmly interconnected through a network of roads, railways, port, airports, waterways, and telecommunications are available to all. The Vision states that by 2030, it will become impossible to refer to any region of our country as remote. To ensure that the main projects under the economic pillar are implemented, investment in the nation's infrastructure will be given the highest priority.

The objectives of the proposed project are in line with Vision 2030. Any development project that incorporates these strategies in its plans is most welcome in Kenya.

Relevant International Agreements

Kenya's commitment to implement global and regional environmental agreements that influence land use can be ascertained by her acceptance, accessions and ratifications. The Multilateral Environmental Agreements (MEAs) are legal instruments that are utilized to enhance the global responsibility in the management of the environment and natural resources.

Other relevant International Agreements include Conventions on Biological Biodiversity, Climate Change, Desertification, Trade in Endangered Species of Wild Fauna and Flora, Wetlands and Vienna Convention for the Protection of the Ozone Layer. Kenya is also party to the major international human rights treaties specifically, the International Covenant on Civil and Political Rights and the International Covenant on Economic, Social and Cultural Rights.

Convention of Biological Diversity (CBD)

The purpose of this Convention is to ensure the conservation and sustainable use of biodiversity. The implementation of CBD impacts on land in many ways. For example, the designation of reserves or protected areas for preservation of flora and fauna restricts use of such land. EMCA, 1999 provides for conservation of biodiversity. The provisions of CBD are domesticated in the Wildlife Conservation and Management and Forest Acts.

The seed and Plant Varieties Act (Cap 326) regulates seed development, transfer, importation and use. The Acts scope includes seed testing, certification, cross-pollination and importation. The use of specific plants and seed varieties on land is regulated by the Act. The Plant Protection (Cap 324) aims to preserve plant varieties, by preventing and controlling pests and diseases that are likely to damage the faunal diversity.

17.2. Legal and Institutional Framework

Economic development is always accompanied by potential environmental degradation. There is the risk of utilization of natural resources in a manner that is not sustainable. The Government had to come up with legal framework to protect against these negative impacts of natural resources utilization. A sound legal and institutional framework for environmental protection and human health was necessary. The Table below shows how the proposed project will impact on and compliance to the relevant laws and regulations.

18. Legal Provisions and Compliance Aspects

The Legal Statute	Legal Provisions	Compliance Aspects
The Environmental Management and Coordination Act, 1999	Part II of the Environment Management & Coordination Act, 1999 states that every person in Kenya is entitled to a clean and healthy environment and has the duty to safeguard and enhance the environment. In order to ensure that this is achieved, part VII section 68 of the same Act directs that any operator of any undertaking should carry out an environmental audit and prepare an appropriate report for *submission* to the National. Environmental Management Authority (NEMA), who in turn may issue a license as appropriate. The second schedule of the same Act lists processing and manufacturing industries alongside that of electrical and infrastructure must undergo annual environmental audits. Part V section 42, subsection 1 directs that no person shall among others deposit any substance in a lake, river or wetland or under its bed if the substance will have adverse environmental effect on the river, lake or wetland. Section 44 requires that NEMA develop, issue and implement regulations, guidelines and measures for sustainable use of hill sides, hill tops and mountain area to control harvesting natural resources located in such areas among other activities. According to section 51, NEMA will in consultation with relevant Lead Agencies	Disposal of wastes into the environment during the project implemention would be contravening the law, Interference with steep slopes is not allowed by law, Interference with water sources and watersheds would be against the law.

Environmental Management and Coordination Act	The environmental impacts assessment and audit guidelines require that assessment be conducted in accordance with the issues spelt out in the second and third schedules of the regulations. These include coverage of the aspects on schedule 2	
(Environmental Impact Assessment Regulations)	(ecological, social, landscape, land use and water considerations) and general guidelines on schedule 3 (impacts and their sources, project details, national legislation, mitigation measures, a management plan and environmental auditing schedules and procedures. To facilitate implementation of the law, regulations on Environmental Impact Assessment (EIA) and Environmental Audits (EA) have been established under Legal Notice 101, of Kenya Gazette Supplement No. 56 of 13th June 2003. Besides this, a number of other national policies and legal statutes have been reviewed to enhance environmental sustainability in	Undertaking environmental impact assessment for the project before commencement (accomplished by this report)
Environmental Management and Coordination Act (Environmental Management Regulations) **Waste Management Regulations,**	*Water Quality Management Regulations, 2006 (Legal Notice No. 120)* These regulations were drawn under section 147 of the Environmental Management and Coordination Act 1999. In accordance with the regulations, every person shall refrain from acts that could directly or indirectly cause immediate or subsequent water pollution and no one should throw or cause to flow into water resources any materials such as to contaminate the water. The regulation also provides for protection of springs, streams and other water sources from pollution.	The proponent avoid discharging of any form of industrial effluent associated with Biomass gasification activities into the environment without appropriate treatment to meet the laid down standards

2006 (Legal Notice No. 121)	Waste Management Regulations, 2006 (Legal Notice No. 121). The regulations are formed under sections 92 and 147 of the Environmental Management and Coordination Act, 1999. Under the regulations, a waste generator is defined as any person whose activities produces waste while waste management is the administration or operation used in handling, packaging, treatment, conditioning, storage and disposal of waste. The regulations requires a waste generator to collect, segregate and dispose each category of waste in such manners and facilities as provided by relevant authorities. Regarding transportation, licensed persons shall operate	Disposal of all materials for the works including solid wastes and debris should be in accordance with the standards outlined in this regulation

	Noise and Excessive Vibration Pollution Control Regulations, 2009. Part II section 3(I) of these Regulations states that: no person shall make or cause to be made any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment and section 3(2) states that in determining whether noise is loud, unreasonable, unnecessary or unusual. Part II Section 4 also states that: except as otherwise provided in these Regulations, no person shall (a) make or cause to be made excessive vibrations which annoy, disturb, injure or endanger the comfort, repose, health or safety of others and the environment; or (b) cause to be made excessive vibrations which exceed 0.5cm per second beyond any source property boundary or 30m from any moving source. Part III, Section 11(1) states that any person wishing to (a) operate or repair any machinery, motor vehicle, construction equipment or other equipment, pump, fan, air-conditioning apparatus or similar mechanical device; or (b) engage in any commercial or industrial activity, which is likely to emit noise or excessive vibrations shall carry out the activity or activities within the relevant levels prescribed in the First Schedule to these Regulations. Any person who contravenes this Regulation commits an offence. Section 13(1) states that no person shall operate construction equipment (including but not limited to any pile driver, steam shovel, pneumatic hammer, derrick or steam or electric hoist) or perform any outside construction or repair work so as to emit noise in excess of the permissible levels as set out in the Second Schedule to these Regulations. These purposes include emergencies, those of a domestic nature and /or public utility construction. Section 14 relates to noise, excessive vibrations from construction, demolition, mining or quarrying sites, and states that: where defined work of construction, demolition, mining or quarrying is to be carried out in an area, the Authority may impose requirements on how the work is to be carried out including but not limited to requirements regarding (a) machinery that may be used, and (b) the	**Ensuring noise and vibration generated from plant machinery does not exceed the guidelines under these regulations.** **The assessment may also generate increased traffic and associated noise to the immediate receptors.**

	Air Quality Regulations Under the general prohibitions (Part II), section 5 states that no person shall act in a way that directly or indirectly causes immediate or subsequent air pollution. Among the prohibitions are priority air pollutants (as listed under schedule 2 of the regulations) that include general pollutants, mobile sources and green house gases. Odours are also prohibited under section 9 of the regulations (offensive emissions). Emissions into controlled areas such as schools, hospitals, residential areas and populated urban centers are also prohibited. Part VII on occupational air quality limits in section 29 states that an occupier of premises shall ensure that exposure of indoor air pollutants does not exceed the limits stipulated under the Occupational Safety and Health Act rules or under any other law. Other sources are recognized at sections 32 and 33 are those arising from construction equipments and materials as well as particulate matter from demolitions of structures and buildings as well as stockpiled dry materials.	**Ensuring controlled emissions** **Control emissions from trucks to be used in ferrying prosopis julifora from the fields to the plant.**

	Biodiversity Regulations Part II of Regulations, section 4 states that no person shall engage in any activity that may have adverse impacts on ecosystems, lead to introduction of exotic species or lead to unsustainable use of natural resources without an EIA licence. The regulation puts in place measures to control and regulate access and utilization of biological diversity that include among others banning and restricting access to threatened species for regeneration purposes. It also provides for protection of land or river declared to be protected natural environmental system accordance to section 54 of EMCA, 1999.	**Interference with the biodiversity must be at minimal. The proponent is required to ensure that only the required plant (prosopis juliflora) is cut down as set down in this report.**

The Water Act (Cap. 372)	This Act regulates abstraction of water from all sources. In addition, it prohibits pollution of water. Part II, Section 3 states "every water resource is hereby vested in the state, subject to any rights of use granted by or under the Act or any other law". Section 18 provides for national monitoring and information systems on water resources. Following on this, sub-section 3 allows the Water Resources Management Authority to demand from any person, specified information, documents, samples or materials on water resources. Under these rules, specific records may be required to be kept and the information thereof furnished to the authority on demand. "The right to the use of water from any water resource is vested in the Minister except to the extent that is alienated by or under the Act or any other written law (Section 5)". Consequently, a water permit must be obtained before using any water resource. Section 29 (1), (2), and (3) stipulates the procedure for obtaining a water permit, while Section 4 states "except as provided in Section 33, an application for a permit shall be a subject of public consultation and where applicable, of environmental impact assessment in accordance with the requirements of the Environmental Management and Coordination Act, 1999". Section 32 requires that in issuing an abstraction permit, among other considerations, will be an assessment of the existing lawful use of the water as well as the efficient and beneficial use of the water in the public interest. Other aspect considered would be the likely effect of the water use to water resources and users as well as the strategic importance of the proposed water use. Subsection 3 states that the nature and degree of water use authorized by a permit shall be reasonable and beneficial in relation to others who use the same sources of supply or source of water. The Fourth Schedule on abstraction of ground water requires the person constructing a well within 800m of an	**Disruption of natural drains and streams channels along the project road sections should be minimized,** **Proponent must ensure minimal or no discharge of silt and debris into River Tana to the extent possible.** **Proponent must to apply for water abstraction permit for construction purposes and abide to the conditions thereof.** **Ensure no pollutants from the construction areas or from construction is discharged into any of the springs and streams in the project area.**

Water Resources Management Rules (2007)	In addition to the Water Act 2002, the main document outlining the regulations is the Water Resource Management Rules 2007. The rules set out the procedures for obtaining water use permits and the conditions placed on permit holders. Sections 54 to 69 of the Water Resources Management Rules 2007 impose certain statutory requirements on dam owners and users in regard. These provisions address: Technical design report in respect of the water use permit; • Operational information to be lodged with WRMA; • Dam safety measures and requirements for inspections; Requirements for procedures to notify downstream communities in the event of unexpected releases. Section 104 of the Water Resource Management Rules requires certain water permit holders to pay water use charges. The intention of the water use charges was to:	**Apply and obtain a water abstraction permits for construction water and abide by the conditions established under the rules.**
The Public Health Act (Cap. 242)	Part IX section 115 of the Act states that no person/institution shall cause nuisance or condition liable to be injurious or dangerous to human health. Any noxious matter or waste water flowing or discharged into a watercourse is deemed as a nuisance. Part XII Section 136 states that all collections of water, sewage, rubbish, refuse and other fluids which permits or facilitate the breeding or multiplication of pests shall be deemed nuisances. The Act addresses matters of sanitation, hygiene and general environmental health and safety	**Obtain a public health certificate for the construction operations and particularly the plant site.**

LAND: Constitution and Land Act 2012 (No.6 of 2013)	Guidelines as to the management of community land are enshrined in Article 63 of the constitution. Further to the set principles the Land Act requires the proponent to acquire a License from the community in order to perform an Act of profit and/or easement otherwise lack of it would amount to trespass.	**The proponent is required to liaison with the local community; this will be extremely beneficial in dispute resolution/prevention.**
Public Roads and Roads of Access Act (Cap. 399)	Sections 8 and 9 of the Act provides for the dedication, conversion or alignment of public travel lines including construction of access roads adjacent lands from the nearest part of a public road. Section 10 and 11 allows for notices to be served on the adjacent land owners seeking permission to construct the respective roads.	

The Wildlife Conservation and Management Act (Cap 376)	The Act provides for protection, conservation and management of wildlife in Kenya. Introduced in 1976, the Act empowered the Director of Wildlife to protect animals and vegetation, both inside and adjacent to national parks and reserves. An amendment of the Act was enacted in 1999 establishing the Kenya Wildlife Services with the principal objective of managing the protected areas in arid and semi-arid lands (ASAL), to ensure conservation of the flora and fauna; and utilization of wildlife resources on a sustainable basis. Section 15 empowers the Minister to ensure the security of animals and plant life in national parks, reserves and surrounding ecological zones. Areas could also be declared protected, prohibited or restricted and appropriate regulations developed.Section 29 prohibits any hunting on any private land unless a game license has been issued and endorsed accordingly, and only by the land owner or a legal leaser. Under the same Act, sections 30 and 31 allows the killing or injuring of wild animals for protection of human life and property, while section 62 provides for the compensation procedures for any person who suffers any bodily injury or is killed by wild animals so long as no offence was being committed during the incident or if it happens during normal wildlife utilization activities. Section 63 indicates that an application can be made for livestock	**This will apply in the interaction of wildlife.**

Transport Licensing Act	Section 4 provides that no person shall, except under and in accordance with the terms of a license use a motor vehicle on a road for the carriage of goods for or in connection with any trade or business carried on by him. The act provides that all authorized goods vehicles shall be maintained in a fit and serviceable condition. The licensing authority may attach to a license of any class a condition that the authorized vehicle shall or shall not be used in a specified area or over a specified route or a condition that certain classes or description of goods shall or shall not be carried.	**This will apply for the material haulage trucks The operators have an obligation to observe traffic regulations and rules at all times**

Physical Planning Act (Cap286)	Section 24 of the Physical Planning Act gives provision for the development of local physical development plan for guiding and coordinating development of infrastructure facilities and services within the area of authority of County and for specific control of the use and development of land. The plan shows the manner in which the land in the area may be used. Section 29 of the physical Planning Act gives the county governments power to prohibit and control the use of land, building, and subdivision of land, in the interest of proper and orderly development of its area. The same section also allows them to approve all development applications and grant development permissions as well as to ensure the proper execution and implications of approved physical development plans. On zoning, the act empowers them to formulate by-laws in respect of use and density of development. Section 30 states that any person who carries out development within an area of a local authority without development permission shall be guilty of an offence and the development shall be invalid. The act also gives the local authority power to compel the developer to restore the land on which such development has taken place to its original conditions within a period of ninety days. If no action is taken, then the council will restore the land and recover the cost incurred thereto from the developer. In addition, the same section also states that no person shall carry out development within the area of a local authority without development permission granted by the county authority. At the same time, sub-section 5, re-enforce it further that, no licensing authority shall grant under any written law, a license for commercial use for which no development permission had been granted by the respective local authority. Section 36 states that if in connection with development application a local authority is of the opinion that, the proposed activity will have injurious impact on the environment, the applicant shall be required to submit together with the application an Environmental	**The County Authorities in the respective project areas may require compliance with certain conditions in line with physical planning of the respective areas.**

The Land Planning Act (Cap. 303)	Section 9 of the subsidiary legislation (The development and use of land regulations 1961) requires that before the local authorities submit any plans to the Minister for approval, steps should be taken as may be necessary to acquaint the owners of any land affected by such plans. Particulars of comments and objections made by the landowners should also be submitted. This is intended to reduce conflict with other interests such as settlement and other social and economic activities.	

Occupational Safety and Health Act, 2007	The Occupational Safety and Health Act, No. 15 of 2007 as revised in 2010, provides for the safety, health and welfare of workers and all persons lawfully present at workplaces. Employer must ensure the safety, health and welfare of all employees at work working in their workplace. The responsibilities of the employer as per section 6 include to: • Provide and maintain the plant and systems and procedures of work that are safe and without risks to health. • Make arrangements for ensuring safety and the absence of risks to health in connection with the use, handling, storage and transport of articles and substances. • Provide for information, instruction, training and supervision as is necessary to ensure the safety and health at work of every person employed. • Maintain the workplace in a condition that is safe and without risks to health and provide and maintain necessary means of access to and egress (outlet) from it that are safe and without risks to health. • Provide and maintain a working environment for every person employed that is safe, without risks to health, and adequate as regards facilities and arrangements for the employees' welfare at work. • Inform all employees of any risks from new technologies and imminent danger. • Ensure that every person employed participates in the application and review of	**The Proponent must ensure that workplaces are registered in compliance with Part V(ss.43-46) of the Act** **The proponent is required to employ a foreman with knowledge on health, safety and environment regulations** **Injuries/Near miss accidents that occur on site are required to be recorded in an accident register. Necessary corrective measures should be undertaken to prevent future accidents.** **Statistical records on accidents are required to**

	safety and health measures. • Carry out appropriate risk assessments in relation to the safety and health of employees and, on the basis of these results, adopt preventive and protective measures to ensure that under all conditions of their intended use, all chemicals, machinery, equipment, tools and process under the control of the employer are safe and without risk to health and comply with the requirements of safety and health provisions in the Act. • Send a copy of each risk assessment report to the area occupational safety and health officer. • Take immediate steps to stop any operation or activity where there is an imminent and serious danger to safety and health and to evacuate all persons employed as appropriate. • Register their workplace unless such workplace is exempted from registration under the Act. Further required prepare a Health and safety policy statement with respect to the health and safety at work of his employees and further to bring the policy statement and any revision of it to the employees	**be recorded on a monthly basis and forwarded to supervising consultant and/or displayed on a notice board at the workplace.**

19. Institutional Framework

EMCA (1999)

In order to make the Act operational, the EMCA has established various administrative structures. These include the National Environment Committee (NEC), the National Environment Management Authority (NEMA), the Public Complaints Committee (PCC), the NEMA Board, Provincial and District Environment Committees, the National Environment Tribunal (NET). The apex body under the Act is the NEC, which amongst other things is charged with the responsibility of developing the national environment policy in Kenya as well as to set annual environmental goals and objectives.

NEMA is the organ that has been established to exercise general supervision and coordination over all matters relating to the environment in Kenya. Further NEMA is the Government's principal instrument in the implementation of all polices relating to the environment. The PCC was formed to investigate environmental complaints against any person, submit their findings/recommendations to the NEC and to submit periodic reports of its activities to the NEC.

All project proponents must comply with the following administrative requirements:

- The projects to be subjected to EIA/EA are specified in the second schedule of the Environmental Management and Coordination Act. Besides the scheduled activities, the Act empowers the Minister to prescribe for EIA/EA appraisal of any other activity, which in his view carries significant environmental impacts

NEMA administers the EIA/EA on behalf of the Minister responsible for the environment. EIA/EA is applicable to both public and private sector development projects and programmes

- NEMA provides a framework for dispute resolution

- A scheduled activity cannot receive the necessary authorization from NEMA to proceed or continue operating, until all EIA/EA requirements have been fulfilled and accepted by NEMA and its lead agencies
- EIA/EA licenses are granted when NEMA and the Minister are satisfied that EIA has been satisfactorily conducted and realistic and achievable Environmental Management Plan of an activity has been sufficiently developed (vi) All formal submissions under the EIA guidelines are made to NEMA. NEMA keeps a register of all projects and programmes currently being appraised under the EIA/EA guidelines
- The undertaking of all EIA/EA and subsequent reporting are the responsibility of the project proponent. NEMA on behalf of the Government, provide the procedures and technical advice to project proponents on how to comply with the EIA/EA requirements.
- The EIA/EA studies are carried out by experts or teams of experts recognized and registered by NEMA.

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- The Public Complaints Committee (PCC): The PCC was formed to investigate environmental complaints against any person, submit their findings/recommendations to the NEC and to submit periodic reports of its activities to the NEC.
- The NEMA Board
- NEMA County Offices
- National Environment Tribunal (NET).

20. Baseline on biophysical characteristics of the project area

20.1. Climate

The project area lies within the Sahelian Climatic region, characterized by dry spells and short rainy seasons and is classified as 100% Arid and Semi Arid Land (ASAL). The area experiences high temperatures and low unreliable rainfall throughout the year. The hottest season falls between November and April with temperatures soaring up to 38°C. Cooler months of July and August have mean temperatures of between 25 – 30°C. Rainfall is generally low and unreliable in the area but when it rains, it falls in sudden heavy storms often causing unpredictable sheet wash and flash floods.

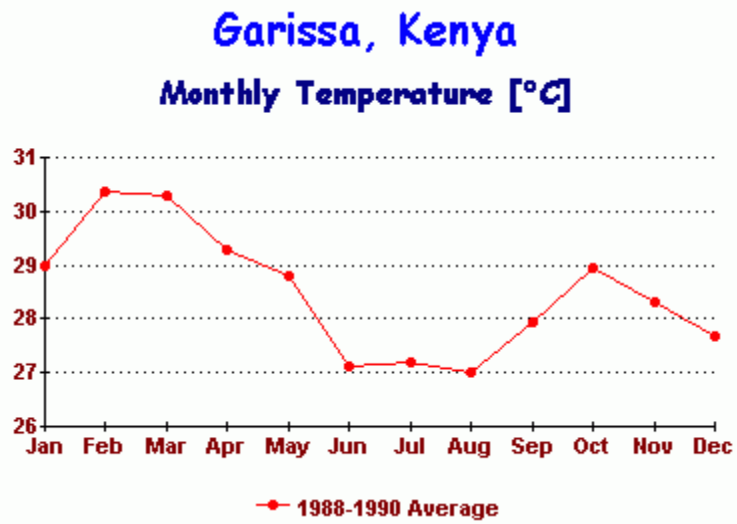

Figure 11 Garissa average temperatures 1988 - 1990

Based on 1988 to 1990 averages the months of highest temperatures in Garissa are the months of February and March which have on average about 30^{o}C and the months with the lowest on June, July and August which have on average about 27^{o}C. It is important to note that even during the months with the lowest the temperatures are still very high based on comparisons with most other parts of Kenya.

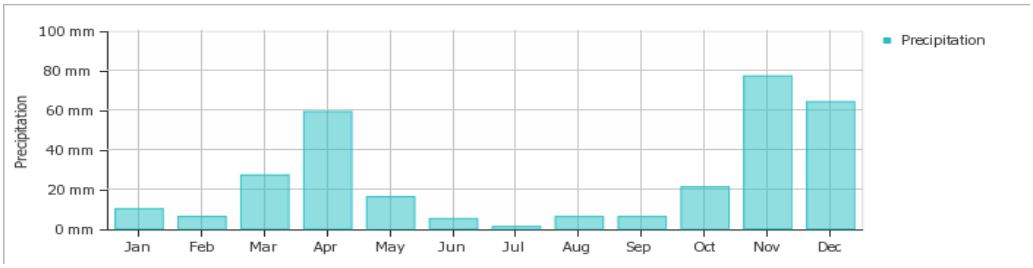

Figure 12 Average monthly precipitation in Garissa

Garissa has a bi- modal rainfall pattern falling in two main seasons – March April and may with monthly precipitation ranging from average of 20mm to 60 mm. Higher rainfall fall in the months of October, November and December rage from 20mm to 80mm. During the months of November and December the rains range from 60mm to 80 mm and these are the wettest months in Garissa.

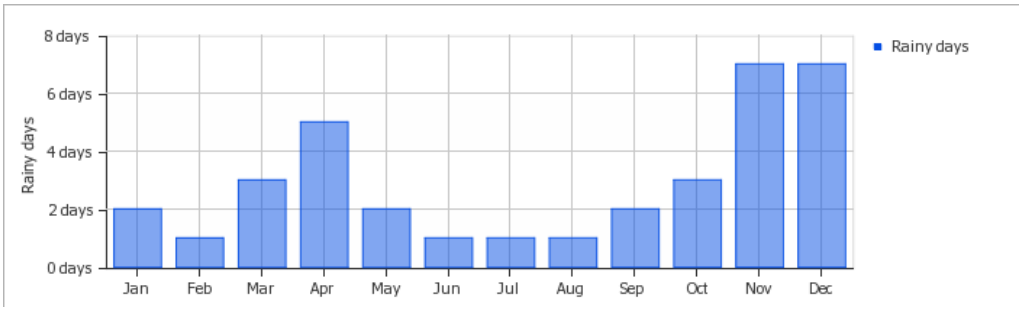

Figure 13 Average rainy days in Garissa

The highest number of rainy days per month in Garissa are very few. It is only during the months of April, November and December, the number of rainy days are above 4 days. Rainfall in Garissa is generally low with some months with no rain at all or with very low rainfall. The area has a bi-modal pattern of rainfall with the long rains falling from Feb. to May and the short rains falling in the months of October and November.

20.2. Topography

The topography around the proposed site lacks any significantly conspicuous features. The area is generally flat with some point rising to the 600m.asl to as low as 400m.asl. along the Uwaso Nyiro-Lorian swamp plains. The project site is therefore in the low-lying flat land area within the dry Nyika plains of the country.

20.3. Baseline information

Description of the project area

Garissa County covers an area of 44,174.1 Km^2. The County is basically flat and low lying without hills, valleys and mountains, rising from a low altitude of 20m to 400m above sea level.

The major physical features are six major river basins of which Tana River Basin on the western side is the only perennial river basin. The River has tremendous effect on the climate, settlement patterns and economic activities within the county.

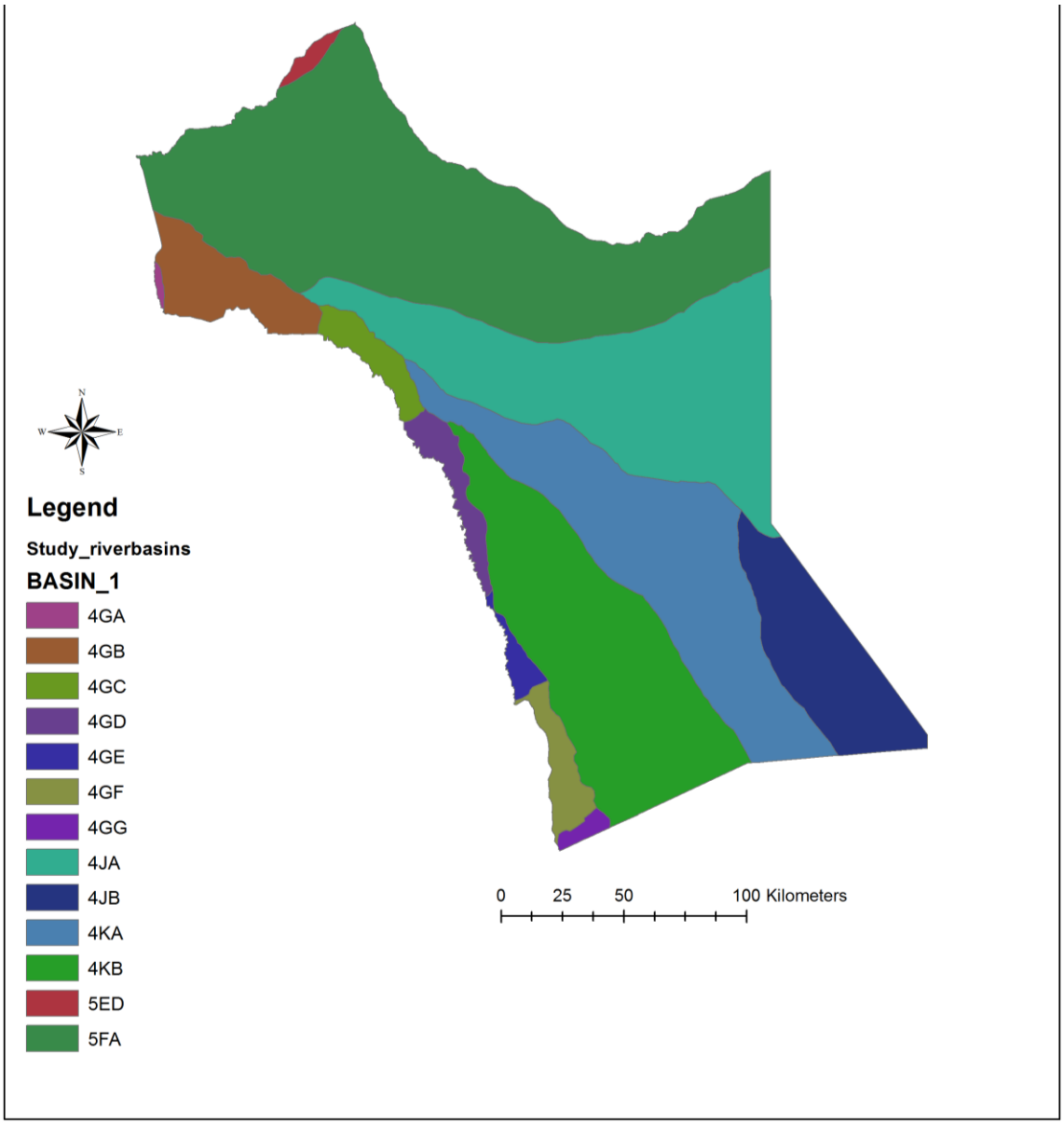

Figure 14 River basins in Garissa

20.4. Environment and Social Conditions

Garissa County is principally a semi-arid area and receives an average rainfall of 275 mm per year. Given the arid nature of the county, temperatures are generally high throughout the year and range from 20^0 C to 38^0 C. The average temperature is however 36^0 C.

The county has a total sum of ninety two sub locations and five constituencies. It has a total population of 699,534 according to the 2009 population census and is sparsely populated with majority of the population being concentrated in areas with infrastructural facilities such as Garissa Township.

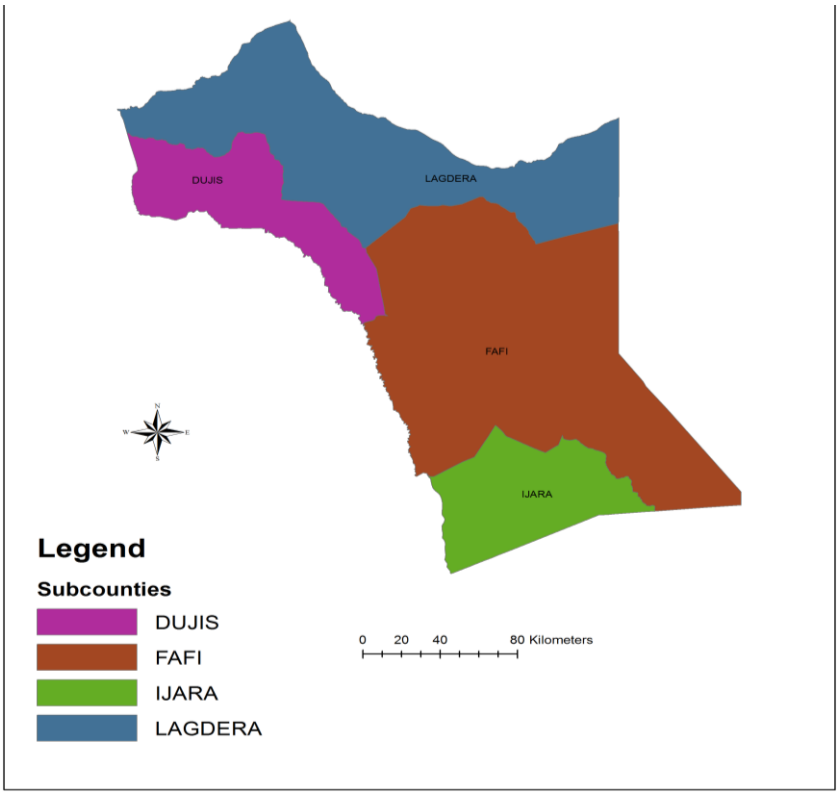

Figure 15 Map of Sub Counties in Garissa

20.5. Agricultural profiles – crops & livestock

In terms of land use, the county's population is predominantly pastoralists based on the vegetation characteristics of the area. Much of the area (over 70%) comprises of bushland with grassland forming the next big percentage. Forest covers only a small section along the Tana river basin whereas woodland covers a significant percentage at the delta towards the south side of the study

areas. These form two non-gazetted indigenous forests in the county, namely Boni and Woodlands. Most of these are woody trees and shrubs which are mainly browsed by camels and goats and to some extent by grazers. Some species provide forage long into the dry season in form of fallen leaves and seed pods. This implies that the main land use is nomadic pastoralism. There are farming activities along River Tana with an average farm size of 1.3 hectares owned by individual groups. The land has however not been planned and is characterized by demarcating different sections for different activities. The main crops grown are: watermelons, mangoes, vegetables, tomatoes, paw paws, bananas, cowpeas, sim sim, maize, beans and green grams. These are usually produced on a small scale under irrigation along the river.

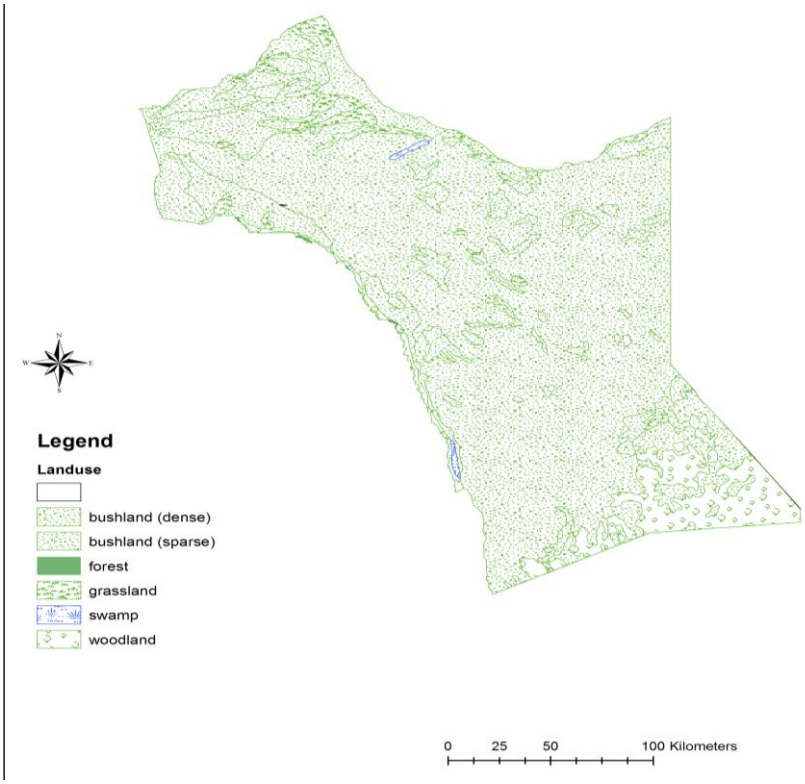

Figure 16 Map of Land use in Garissa

20.6. Geological characteristics

Geologically, the area generally comprises of the sedimentary formations with only a small section occupied by the basement system which comprise of metamorphosed rocks consisting of granites, and biotite gneisses part of a wider metamorphic rock system commonly referred to as Mozambican belt. The geology could be described as mainly comprising to the tertiary

age. In terms of landform, the area is characterised by alluvial plains, delta plains and a bit of what is commonly referred to as badlands.

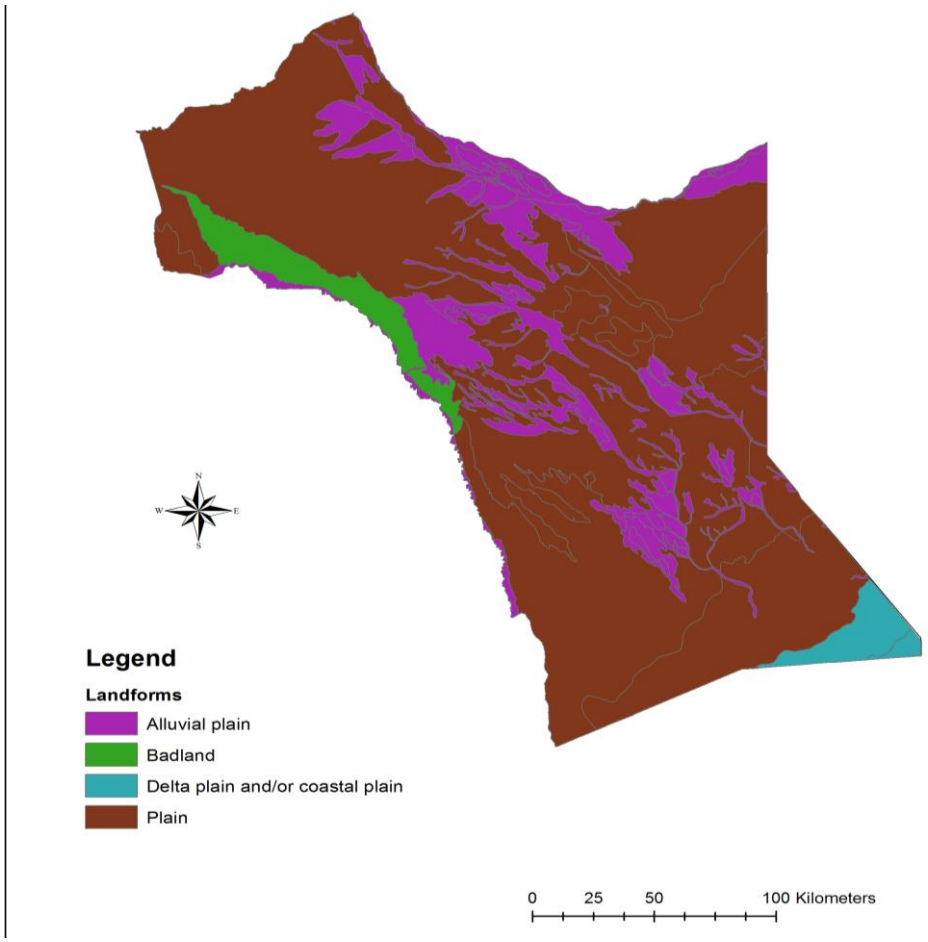

Figure 17 Map of Land forms in the study area

Soils

The area comprised of many soil classes ranging from Calcaric Fluvisols to Vertic Gleysols all with different potentials in supporting different vegetation growths and different levels of erodability. It is believed that Geology and geomorphology processes have had an influence in the soils of the area in that both are concerned with the processes of erosion in the current landscape and with deposition on the land of the products of that erosion.

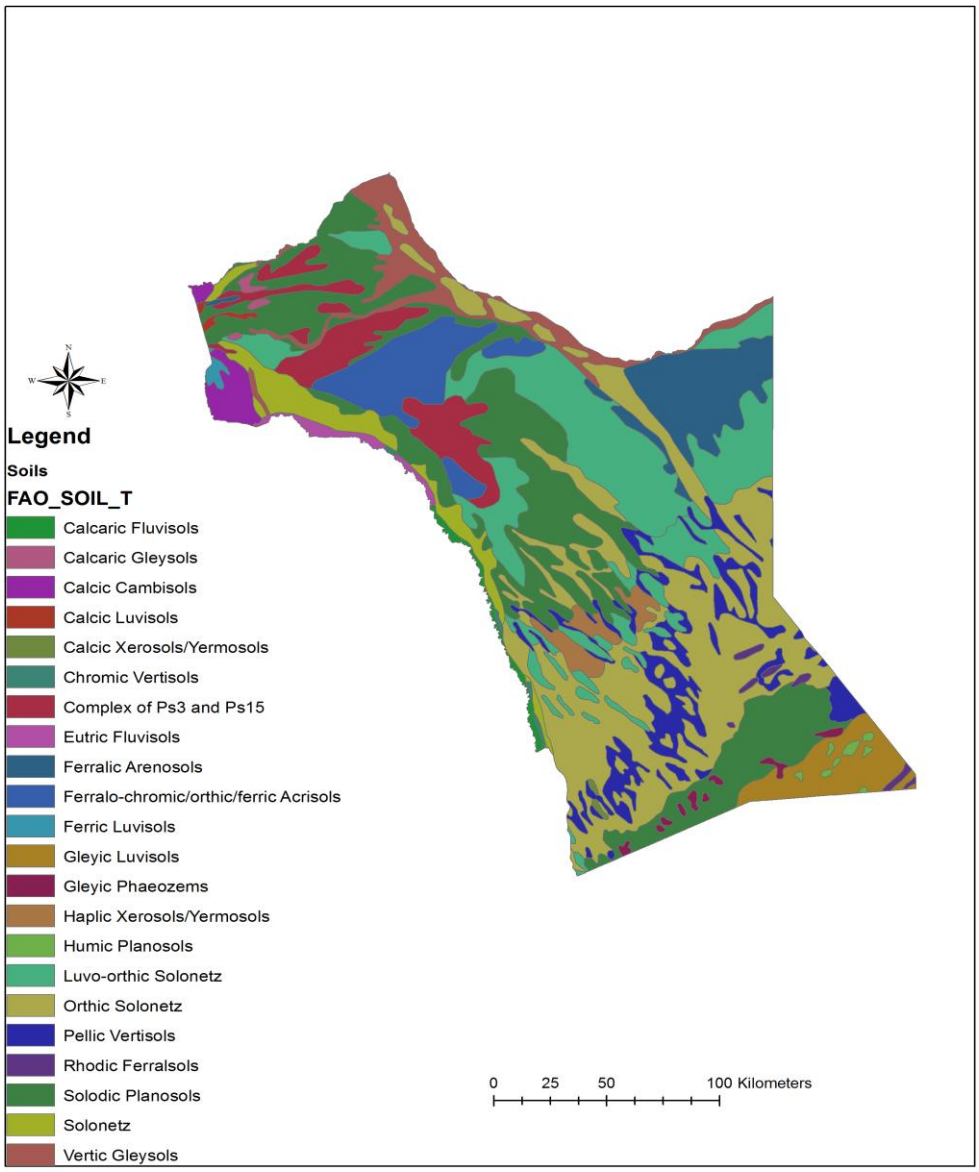

Figure 18 Map of soils in Garissa

20.7. Biodiversity

20.7.1. Flora and Fauna

The County's vegetation is mainly scrubland interspersed with Acacia trees. The vegetation in the area is generally thin in density and poor in diversity. These are dominated by tall elephant grass that grows mainly during rainy season and dries up during the long dry spells. Scattered thorny trees and bushes are found on the plains while the dry river beds (laggas) are covered by green umbrella shaped acacia trees and other thorny shrubs.

Animal species identified include Giraffes, Somali ostriches, and a few cheetahs along the dry savannah; rodents (mice), birds mainly along the river valleys, dikdik antelopes, mongrels and domestic livestock including zebu cattle, goats sheep and camels The area is generally flat terrain with sandy soils and is colonized by scattered thorny trees. See the desert wind erosion features; hummocks.

20.7.2. Ecology of Prosopis juliflora

Invading *Prosopis juliflora* tends to form dense, impenetrable thickets, associated with unfavourable impacts on human economic activities. Thousands of hectares of rangelands have already been invaded, and the process is still occurring,

Land use changes, competitive ecological advantages, and climate change are key factors thought to influence the probability of invasion. Invasions into riverine areas and degraded rangelands of Africa,

Whatever the trigger for invasion, the principal factor in this process is the rapid and prolific seeding of mature *Prosopis* plants. Seed production is estimated at 630,000 to 980,000 seeds per mature tree per year. Those seeds are most likely to germinate when the sugary pods are consumed by domestic livestock, the seeds scoured while passing through the animals' digestive tract, and the scoured seeds dropped into moist faeces.

For over fifty years, ranchers in south-western USA and Argentina tried a range of techniques to eradicate or control *Prosopis*. Despite the high costs of eradication, a cost effective program is yet to be found. South Africa and Australia are experimenting with biological control methods, using seed-eating beetles[16]. Because eradication efforts have been neither cost-effective nor technically successful, it seems the best option might be to adapt land use to its management and use [18].

20.7.3. Chemical properties of Prosopis

Prosopis juliflora wood has a number of chemicals. These include flavonoids, one of the most bioactive compounds naturally existing in the plant kingdom. A total of 21 flavonoids were found in *Prosopis in general*, and twelve of these have been identified in prosopis juliflora. The flavonoids were identified are: 6 flavones--apigenin, luteolin, apigenin 6,8-di-Cglycosides, chrysoeriol 7-O-glucoside, luteolin 7- O- glucoside, and 6 flavonols--kaempferol 3-Omethyl ether, quercetin 3-O-methyl ether, isorhamnetin 3-O-glucoside, isorhamnetin 3-Orutinoside, quercetin 3-O-rutinoside, and quercetin 3-O-diglycoside (glucose, arabinose). The table below shows the percentage of occurrence of these chemicals in prosopis juliflora samples amongst all the

Table 7 Percentage of ocuurence of Flavonoids in Prosopis juliflora

S.N.	Chemical type	*Prosopis juliflora*
1	Apigenin	100
2	Luteolin	75
3	Apigenin 6,8-di-*C*-glycosides	100
4	Apigenin 6,8-di-*C*-glycosides	100
5	Chrysoeriol 7-*O*-glucoside	100
6	Luteolin 7-*O*- glucoside	50
7	Kaempferol 3-O-methyl ether	100
8	Quercetin 3-O-methyl ether	75
9	Isorhamnetin 3-O-glucoside	100
10	Isorhamnetin 3-O-rutinoside	100
11	Quercetin 3-O-rutinoside	100
12	Quercetin 3-O-diglycoside (glucose, arabinose	25

A chemical characterization of *P. juliflora* has indicated an arabinogalactan protein with potential uses for beverages and pharmaceutical products, while fatty acids and free sugars in the seeds and pods enhance its use as a food supplement. Antifungal and plant growth inhibiting alkaloids have been isolated from its leaves and associated with its allelopathy. Bark and bark extracts have been shown to exhibit antifungal properties. *P. juliflora* wood has been described as a source of lumber and firewood. There is considerable potential for *P. juliflora* as a source of fibre for the paper, paperboard and hardboard industry. The heartwood of different *Prosopis* species contains significant amounts of wood extractives and polyphenol compounds. A reddish amber gum, with properties similar to the gum arabica produced by *Acacia senegal*, often exudes from the stem and older branches.

20.8. Water Sources

Garissa County is water scarce with only 23.8 per cent of the population having access to safe water. Access to piped water is limited to the sub - county headquarters where

approximately 27,725 households have connection. The main source of water in the county is River Tana and seasonal Laghas. The average distance to the nearest water point is 25Km. However, for residents of Garissa Town, this distance has reduced considerably.

Sanitation

The proportion of the population of the county that uses pit latrines as a means of sanitation is 46.76 per cent while 2.6 per cent use VIP latrines. A majority of the population at 50.63 per cent use other means of sanitation such as bushes. There is only one sewerage connection that is currently being constructed in Garissa town. However, other towns in the county do not have sewerage connections.

20.9. Hydrology

Garissa is part of the expansive ASAL of Kenya, the area characterized by dry riverbeds usually collecting water only during the rainy days as a result of surface runoff. Ground water is the main source of water for domestic purposes. The water table in Garissa is very high. The town is close to River Tana that dominates the hydrology of the county and the neighbouring Tana River County.

20.10. Archaeology

Desk analysis at the National Museums of Kenya has established that there are no archaeological sites in the area proposed for this exploratory site. However, the proponent and the contractor will be observant of any exposure of prehistoric cultural or palaeontological materials and if found relevant authorities at the National Museums of Kenya will be contacted for advice on how to handle them.

21.Baseline social and economic conditions

21.1. Population Distribution in the project area

The inhabitants are concentrated in small pockets around water points and centres where markets, hospitals, schools and other services are found. Garissa is the major urban centre of the county and is a destination for migrants who are seeking employment, including people

driven off the land by drought and other shocks as well as Somali immigrants. Roads in the area are of low quality and are usually inaccessible during the rainy seasons.

The communities in this area are predominantly ethnic Somalis, with small minority communities, mainly the Malakote and Munyoyaya. The region is defined by Somali culture, characterized by strong Islamic and oral traditions and livestock as central to the way of life. The minority communities share the Islamic religion; however they have traditionally incorporated farming to a greater extent than the Somalis. Many households are polygamous, consisting of one male head of household with several wives. As such, household size tends to be larger than the national average. According to local government data, poverty levels are high in Garissa County, with estimates of households classified as poor ranging from 63%.

There are two major livelihood zones in Garissa County: the agro-pastoral zone in the western part of the county, which is a strip of land 1-2 km in width along the River Tana, and the pastoral zone, which covers the rest of the county. Across both zones, livestock production is the most important livelihood strategy, sometimes combined with crop production in the agro-pastoral zone. Other sources of income include unskilled labour, trade and commerce, salaried jobs, remittances and charcoal production. Communities rely on communally owned land for livestock grazing, farming and other livelihood resources including firewood, non-timber forest products, charcoal, honey and medicinal products.

21.2. Education and Literacy

Garissa County has 184 Early Childhood Development Education (ECDE) Centres with a total enrolment of 24,091 consisting of 13,285 boys and 10,806 girls. There are 229 teachers hence a teacher pupil ratio of 1:105. The pre-school net enrolment rate is 9.6 per cent and the completion rate is 89.34 per cent while the retention rate is 11 per cent. This is due to the nomadic lifestyle of the people. In addition to formal schooling there are also Madarasa where young children are taught religious studies.

The county has 131 primary schools with a total enrolment rate of 41,474 consisting of 24,939 boys and 16,535 girls. The enrolment rate is low in the county. There are 672 teachers giving a teacher pupil ratio stands at 1:61. The primary school net enrolment rate is 23.5 per

cent while the completion rate is 62.7 per cent. The transition rate stands at 58.3 per cent. This is due to the nomadic lifestyle of the people and early marriages among the girl child.

The proportion of the population that is able to read stands at 39.7 per cent while that of the population who cannot read and write is 57.9 per cent. On average the literacy level in the county is 8.2 per cent. Men are more literate than women.

21.3. Employment

The employment level in the county is 30,214. Of those employed, 62.2 per cent are male while 37.8 per cent are female. The major sources of employment are government departments, Non Governmental Organizations, donor agencies and business organizations. Most of these wage earners are in formal employment. A small number of the county population is self employed. This represents three per cent of the total population with urban centres having two per cent while one per cent is in the rural area. The self employed are mainly engaged in milk vending, jua kali, hawking and livestock selling among others.

The county has a labour force of 345,299 persons consisting of 183,049 male and 162,250 female. This represents 49.4 per cent of the total population in the county. Unemployment rate in the county stands at 28.4 per cent. It is therefore imperative that the county invests more in activities that will create employment for the un-employed.

21.4. Land- use

The mean holding size is not known since the land is communally owned. Less than one per cent of the population have title deeds. In terms of land use, the county's population is predominantly pastoralists. This implies that the main land use is nomadic pastoralism. There are farming activities along River Tana with an average farm size of 1.3 hectares. The farms are owned by individual groups. The land has however not been planned and is characterized by demarcating different sections for different activities

21.5. Energy Access

About 78.8 per cent of the county's population use firewood as a source of energy for cooking purposes while 18.2 per cent of the population use charcoal. Electricity is only available in Garissa, Ijara, Dadaab, Bura East and Modogashe, and their environs with only 0.7 per cent of the population having access to electricity. In Dadaab, plans are under way to install two generators to supply power. In addition the Ministry of Energy has installed solar systems in health facilities, schools and watering points. Other sources of energy such as biogas and solar are used on a limited scale.

21.6. Religion and Culture

The dominant religion in the proposed project site is Islam. The religion determines the local people's way of life including culture which among others include – worship, dressing and food. The local people are also very wary of outsiders intruding in their way of life.

21.7. Gender and Children Affairs

There are clear gender roles in livestock rearing in pastoral communities. Herding the livestock is typically seen as the responsibility of men, who care for the livestock, move with them to water sources, slaughter the animals and take them to market. Older women may take responsibility for smaller animals and poultry, but this is generally limited to activities within the homestead. Younger women may be tasked with collecting fodder and occasionally with taking small animals to water points. The women of the household are usually in charge of milking cattle, sheep and goats (but not camels). They may also take livestock products such as milk, meat and butter to market.

Gender issues are deeply rooted in culture and tradition. Education disparities have a ration of 1:2 girls to boys in both primary and secondary education. Literacy levels are therefore lower for women and stand at 8.1% for women against 21% for men. Access to economic resources is also low for women owing to the traditional division of labour which places women at the household level for domestic chores. Female Genital Mutilation (FGM) rates are high in the area under study with over 97% of the women having gone through it.

Girl child is seen as an investment for which the father expects to receive some dowry and often girls are married off at the tender age of 14 years, which forces them to drop out of school. This practice has also contributed to low enrolment of girls to school. Inadequate

education infrastructure in the area under study also accounts for the low literacy levels. According to the District Development Plan most of the missing structures include classrooms, toilets and desks.

21.8. Youth Employment

Youth comprise the largest part of population in the two (2) locations. The highest number of the youth remains unemployed. The ages of 1-24 comprises of a 60% of the population (DDP, 2008-2012). This is economically active age group whose increase will require economic empowerment. Over 75% of those youth are currently involved in livestock subsector.

21.9. Levels of Poverty

Although the levels of poverty in the county as a whole is considered high like other ASAL areas, an average Somali in Garissa should not be considered poor especially when we take into account wealth from livestock . However, according to the DDP and Vision 2030 (2008-2011), a number households are not able to supply themselves with the basic needs of food, clothing and shelter. Causes of poverty include, unreliable rainfall, high levels of illiteracy, poor infrastructure, and natural disasters like floods, droughts and poor market systems. Environmental degradation associated with climate change- severe and more frequent droughts have aggravated poverty levels.

21.10. Housing

Majority of the local people live in semi-permanent grass thatched ‘manyattas’ made of grass stall walls and grass thatch. The type of housing is suitable for the hot and dry climate of the area. They however are quite inconvenient to live in, during the rainy seasons. The semi-permanent housing materials are ferried from place to place during the pastoralist’s migration. The houses made up of tree twigs are semi permanent and when families migrate to other areas for pasture, they leave behind the twigs and cut others where they eventually settle. This cutting of the already stressed tree resources contributes to environmental degradation.

Figure 19 A typical human settlement

Figure 20 a typical homestead

21.11. Health

Health Access: Garissa County has a total of 126 health facilities. Out of these, 68 are level two facilities, seven are level four, 21 are private clinics, 19 are level three facilities and one is a level five facility based in Garissa Town. There are also three Non Governmental Organization dispensaries and five mission health facilities which are included in the above figure. Good health care services are mostly in the urban areas. The average distance to the nearest health facility is 35Km. Most of the health facilities are along the river where there

are settlements. The number of trained health personnel is also very low with the doctor population ratio being currently 1:41,538 while the nurse population ratio is 1:2,453.

The five most prevalent diseases in Garissa County are Malaria, Upper Respiratory Tract Infections, Stomach - ache, Diarrhoeal diseases and Flu; with a prevalence of 46.6 per cent, 5.2 per cent, 6.6 per cent, 2.7 per cent and 3.7 per cent respectively. HIV and AIDS prevalence rate is low at one per cent as compared to 5.6 per cent at the national level. This however is a sharp increase from zero per cent recorded during the Kenya Demographic Health Survey of 2003. This rise can be attributed, among other reasons, to the fact that only 10 per cent of the population has comprehensive knowledge on HIV prevention as per the Multiple Indicator Cluster Survey (MICS) of 2007.

21.12. Livestock production

Livestock production is the major economic activity in the area under study. An estimated 90% of the local people are engaged in this activity, making it the major source of employment. The sector has also faced challenges that include erratic rainfall, insecurity and poor infrastructure. The main livestock in the area include cattle, sheep, goats, camels, donkeys and poultry keeping at small scale.

Figure 21 (a) Camels **(b) Camels fetching water**

Figure 22 Camels, Cows and Donkeys

Figure 23 Small Ruminants

21.13. Trade, Tourism and Industry

Trade in livestock and their products make up the key commodities for trade and dominate the economy. Hundreds of traders trek to the project areas to buy animals for slaughter. Meat products from the region supply most major towns in Kenya and also find their markets outside the country and particularly the Middle East.

The county has a high potential for tourism development. The potential include a wide range of wildlife species such as, Hirola, lions, giraffes, tigers and zebras, a rich Somali traditional culture and a highly developed hospitality industry in Garissa Town. The proximity of the county to the tourist coastal town of Lamu makes it ideal for linkage through a tourist circuit. This coupled with the rich traditional culture of the Somali people would boost tourism in the region. Garissa County heavily relies on domestic tourism from the many local and international Non Governmental Organizations operating in the area throughout the year.

Figure 24 Giraffes.

Figure 25 Roads and bushes

22. Physical Infrastructure

This sector comprises of telecommunications, roads and transport, energy and piped water. Garissa County is well networked with mobile telephone network but in a few place away from major towns the network may be weak.

22.1. Telecommunications and Road Transport

The township area and most of the areas where prosopis will be harvested has good mobile telephone network. Poor communication in the many other places in Garissa County makes communication difficult.

Most of the roads in the area are unclassified. They are loose surface roads which are impassable during the rainy seasons. The poor conditions of the roads cause relatively high wear and tear of vehicles. It also limits the type of vehicles used to trucks and 4 wheel drive vehicles. The poor conditions of the roads are a major hindrance to the development in the vast area of North Eastern Province.

23. Energy

Most of the county residents especially in the rural areas depend on wood fuel. In Garissa town there is electricity and therefore people have a choice to use it for cooking as well as other needs for power.

24.Public Participation

Figure 26; Public Participation in Garissa County

Public participation was held in a baraza where we called residence of the area informed them about the project its activities and the proposed area of location. We also consulted department of forestry in Garrisa County on the impact of use of the *prosopis* (mathenge) for electricity production and it current uses. For the public participation we had 32 participants as seen in the list of names attached to this report. We had representatives from the national government, county administration, local business men and women and other residents. This has been illustrated below.

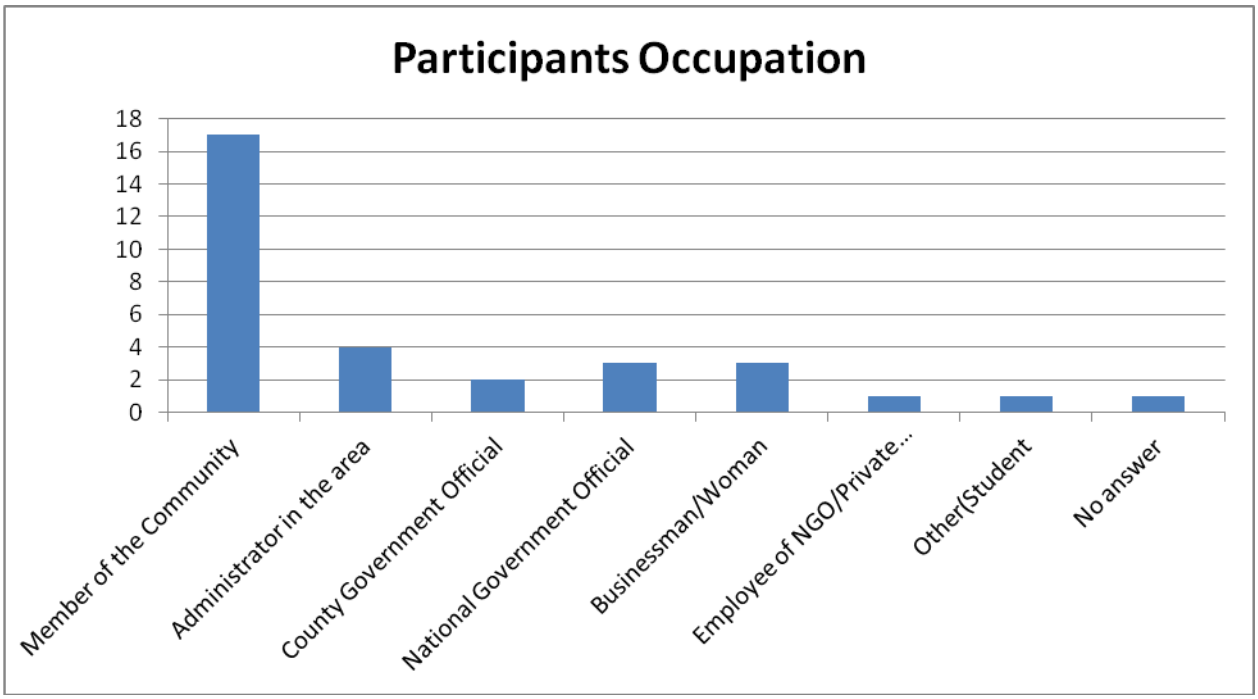

Figure 27 Composition of workshop participants

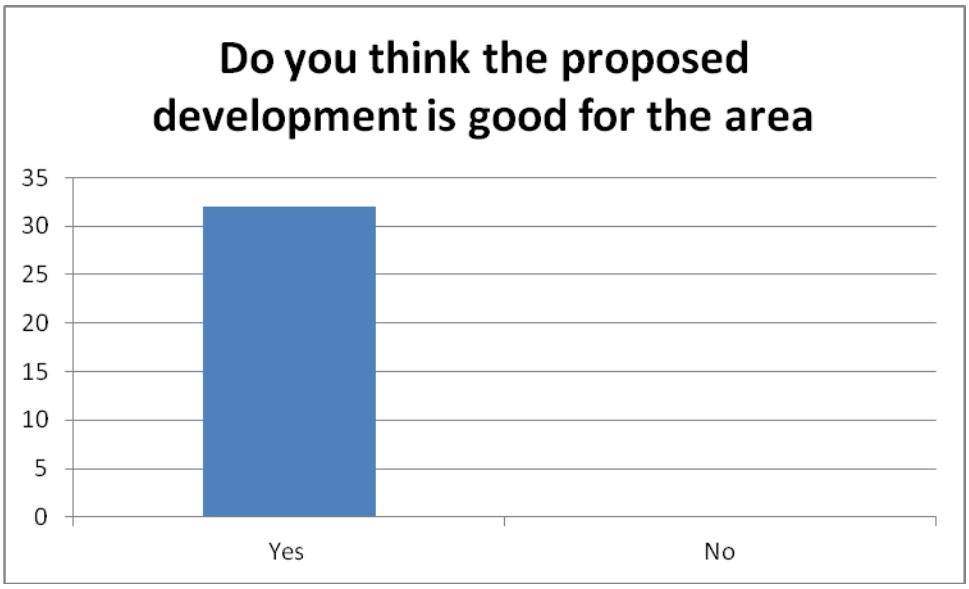

Figure 28 Perceptions on the usefulness of the project

All the 32 participants did not oppose the project they were all for the project, as evidenced form the table above.

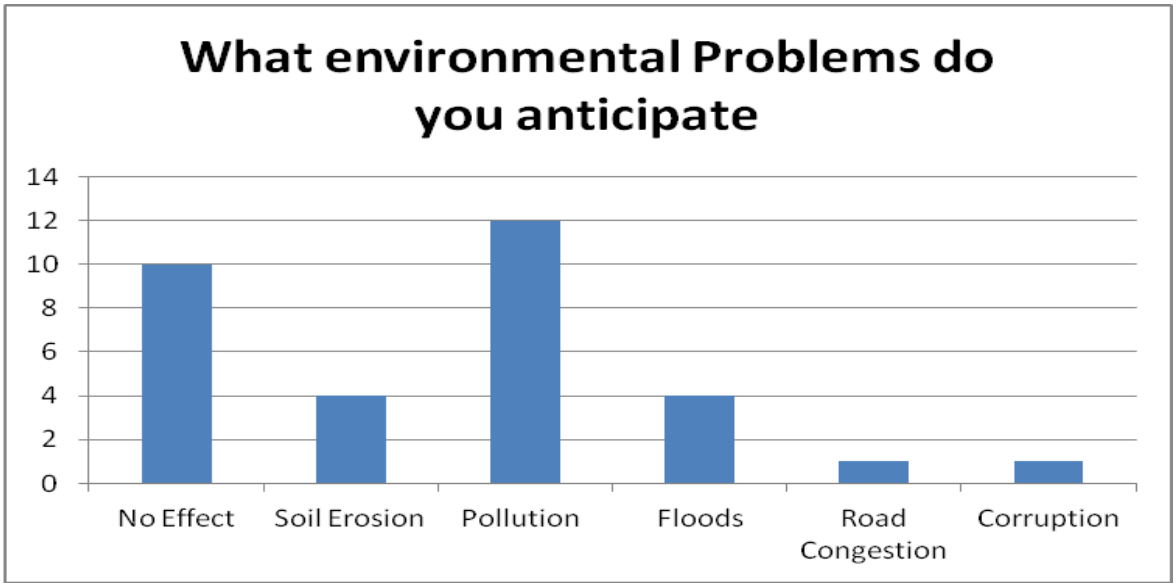

Figure 29 Perceptions on the anticipated environmental problems

Majority of the residence in the county feared that pollution will be a very big problem in the area they were comparing it to that of charcoal makers who are the other competing users of the Mathenge plant in the county. The fact that it grows close to and next to the river means that if harvested the Tana River during rainy seasons will burst its banks and flood the town and equally lead to a lot of soil erosion. The residence also feared that between the harvesting company and electricity generation plant there will be a lot of road congestion leading to large traffic jam in the area. Majority of other residence could not come up with an anticipated problem.

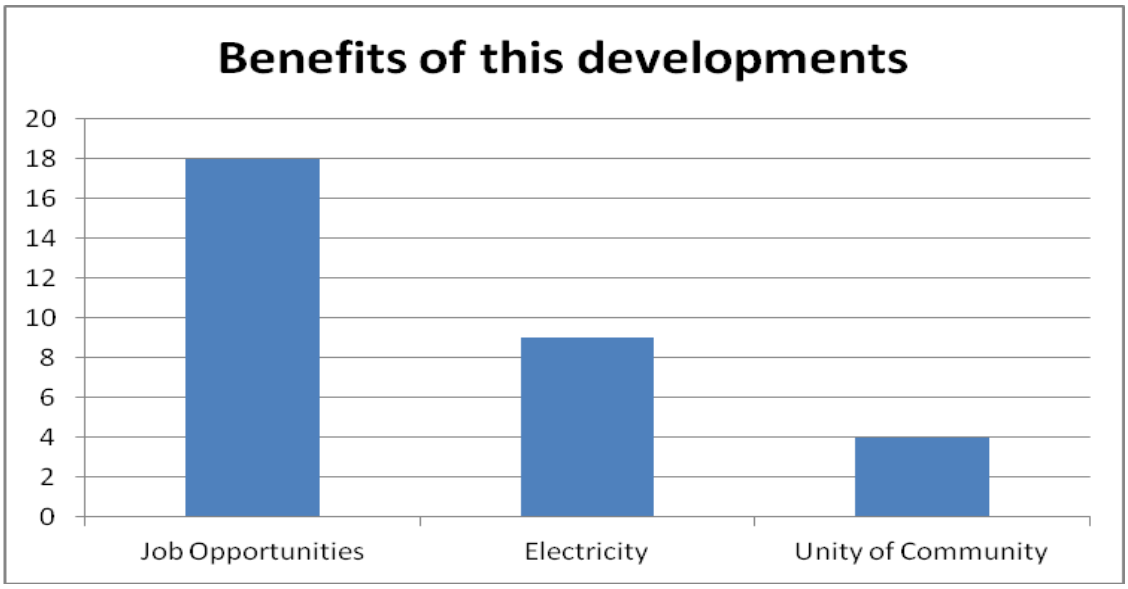

Figure 30 Perceptions on the anticipated benefits

The residences were very optimistic about the project. Majority of Garrisa residence stated that the project would create the much needed job opportunities in the County. They also cited continuous sustainable power supply. The area depends on Kengen generators to power the town. Other respondents believed the project will bring the communities closer with each other.

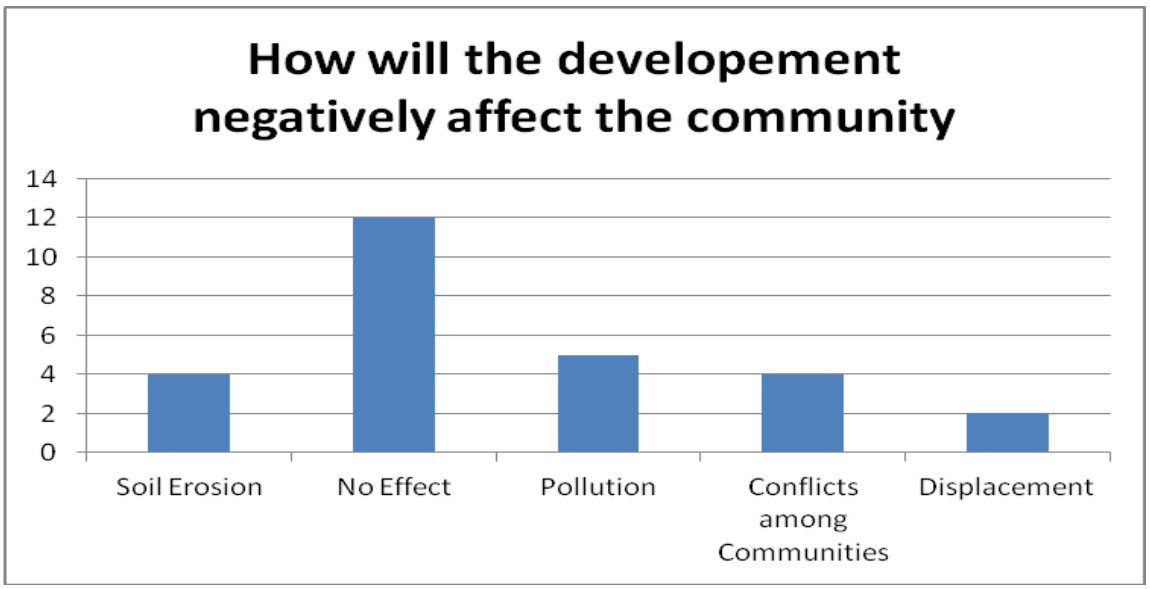

Figure 31 Community perceptions on the negative environmental effects

With respect to the community majority of the respondents could not find a negative to the project though others expressed their worry of pollution from the gases that will come from the facility, soil erosion after harvesting the land will be left bare hence potential of erosion from wind, water or animal and conflict among communities as they try to each secure their land to be harvested for economic gain. Other worries were that of displacement from the facility site as well from the harvesting areas. Mathenge is wild hence areas of harvest will most likely be in and around their homesteads.

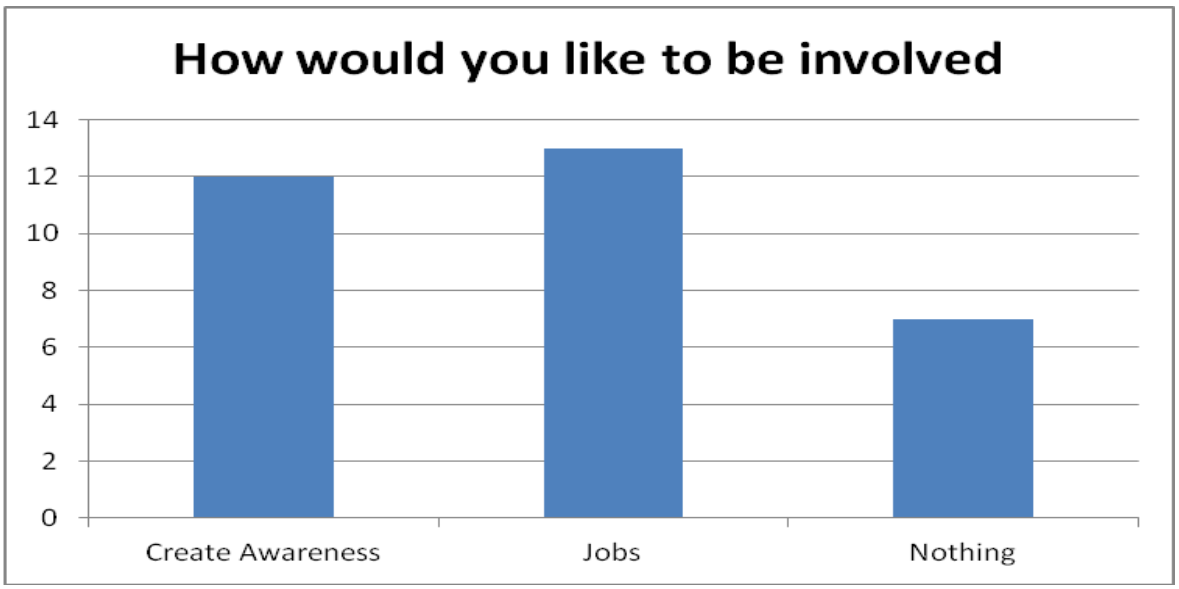

Figure 32 Responses on how the communities would like to be involved

The proponents stated that they would like to be involved in sensitizing the wider community through creating awareness; other hoped the project will give them jobs when it commences. Others had no immediate desire in relation to the project.

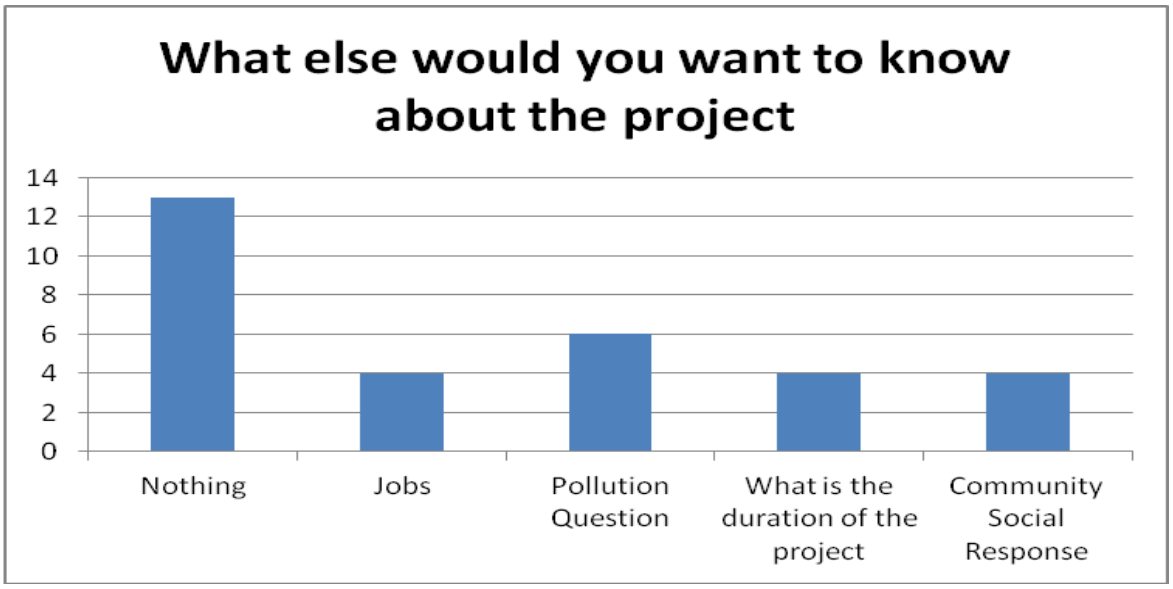

Figure 33: The need for further information about the project

The majority of the respondents stated that they have fully understood the project activities. Other respondents felt the pollution issue needs to be fully understood and how it will affect them and their livestock's. Respondents also were not sure on the duration of the project and the job opportunities that will arise from the project. A few of the respondents were not sure of the response from the community in relation to the project.

The participants of the public consultations generally were for the project and as stated above had very few worries other those of pollution and soil erosion, The meeting was held in Kora View Hotel conference hall on 5th November 2014. Below see photos of the participants;

25.Project alternatives

Project alternatives a set of options to justify and validate and make sure that the best choices were made in planning, designing, and locating the project as outlined in the project document. The alternatives considered give emphasis on environment, economics, and social dimensions of the project design, operations and location. The following are the project alternatives for the proposed activities.

25.1. Alternative Sources of Energy

The project proposes to use biomass gasification process to generate electricity and feed it to the national grid. The location of this plant is planned to be in Garissa County and the feedstock will be Prosopis woody parts harvested from both Garissa County and Tana River County.

Biomass produces clean energy especially from a source such as Prosopis that is a fast growing forest plant that is already known to be a nuisance invasive species causing havoc in the country. Producing electricity from Prosopis will not only help in controlling the spread of the invasive species but also will make an economical use of the plant. Energy from biomass is known to be the best source of renewable energy compared to wind energy that can produce electricity only when wind is blowing or from solar that produces power only when the sun is shining. Biomass can provide a continuous source of energy both day and night and at all seasons of the year.

Discussions with residents of Garissa County about the use of prosopis to produce electricity shows that the land owners of Prosopis feedstock are very enthusiastic to start supplying the plant materials and to start growing the plant commercially in their farms.

25.2. Alternative location of the biomass Power Plant

The proposed biomass power plant will be located in Garissa close to town and also close to the national grid power line where the generated electricity will be connected. The power plant will be close to the massive River Tana that will provide the needed water for cooling the plant without impinging of domestic water supplies for Garissa town residents. The water to be discharged from the plant will be cooled down first cleaned of any impurities and re-cycled for other uses or returned back to the river.

In Garissa County Prosopis grows along the River Tana where it interferes with the flow of the river, reduces the indigenous riverine vegetation including biodiversity, and prevents access to the river by the residents. Riparian forests however, prevent siltation and soil erosion. The project will make sure the riverbank is not left bare and all surface runoff water ways are not exposed to erosion.

The location is close to town where there is already a good number of people unemployed. At this location the plant will not have a shortage of labour nor will the proponent be required to build housing facilities for the workers.

Garissa is located in the dry ASAL areas where land has low potential uses and using it to produce electricity will be a big opportunity not only for the local communities but also for Kenya as a country.

25.3. Alternative Source of Feedstock

Biomass power plants can use a wide range of biomass resources to generate electricity. These range from municipal organic wastes, agricultural wastes, vegetation harvested from wild sources or grown commercially as a power plant feedstock.

Prosopis is an invasive plant species that grows in dryland areas where not many forest species can grow. The plant spreads naturally establishing itself in new places. It is therefore an ideal plant to use for power generation as the process will provide a means for controlling the spread of the plant.

25.4. Alternative uses of Prosopis

Prosopis is widespread in Garissa and Tana River counties and where it grows nalong River Tana forming a thick riparian forest. Initially the residents had a problem in controlling the plant as it took up their grazing lands and blocked their access to the river. Afterwards the residents came to discover that the plant is a good source of firewood, charcoal and building materials. From this the time of this discovery the plant has been the main source of firewood, charcoal and building materials. However, amid these uses, the plants continuous to spread very rapidly as the harvesters are not coordinated and their methods of harvesting seem to enhance the spreading. They selectively pick certain individual mature plants leaving others to grow. This method increasing sprouting and germination of seeds along the pathways or tracts they use.

25.5. Alternative energy production techniques

The proposed project will use gasification technique to produce electricity as opposed to direct combustion where electricity is produced from steam turbines. Gasification process uses less water than direct combustion and produces less gaseous wastes than gasification process where electricity is produced from gas turbines.

The proposed project will use re circulating water cooling system that uses less water for cooling.

It is important to keep to these energy production techniques as these have been developed through years of improvements in the countries where biomass has been in use as a source of energy.

25.6. No Project alternative

The no project Scenario in this case will mean loss of a much needed opportunity for increasing the amount of electricity supply in Kenya to spur industrial growth. In view of Vision 2030 this commodity is needed to drive the national and global economies. Not taking up this opportunity will mean:

- The country socio- economic developments will lag behind for lacking electricity that is a driver to economic development.
- This country's industrial sector will keep paying heavily for electricity that is currently subsidized by diesel generators that do not only pollute the environment but make electricity very expensive.
- If the project started very many local people would get jobs and this will improve the social welfare of the region that does not have many employment opportunities.
- Poverty begets more poverty. With alternatives sources of livelihoods, the local people will continue relying on natural resources which is not sustainable development.

26. Potential Environmental and Social Impacts

Biomass power plant operations have the potential for a variety of impacts to the environment. These 'impacts' depend upon the type of feedstock and the mode production of the feedstock, the size and complexity of the project, the nature and sensitivity of the surrounding environment and the effectiveness of planning, pollution prevention, mitigation and control techniques.

The impacts described in this section are potential impacts for the proposed biomass power plant to produce 2.5 MW of electricity in Garissa using Prosopis as feedstock. With proper

care and attention, these potential impacts may be avoided, minimized or mitigated. The biomass production practices have been proactive in the development of management systems, operational practices and engineering technology targeted at minimizing environmental impact, and this has significantly reduced the number of environmental incidents in the countries where the technology has been practiced. Various initiatives have been made to improve on the efficiency in production and environmental protection, and preparation of this report has made reference to these initiatives as much as they can apply to the environmental conditions in Garissa and the feedstock source areas.

Several types of potential impacts are discussed here. They include human, socio-economic and cultural impacts; and atmospheric, aquatic, terrestrial and biosphere impacts.

Setting up the projects may take only a few months although the process may be longer in certain situations. In this case impacts associated with construction occur for a short time but once production of electricity commences, the impacts associated with operations changes to be of a longer period running into years. Proper planning, design and control of operations in each phase will avoid, minimize or mitigate the impacts.

26.1. Human, socio-economic and cultural impacts

Power plant construction operations are likely to induce economic, social and cultural changes in Garissa. The extent of these changes is especially important to local groups, who may have their traditional lifestyle affected. The key impacts may include changes in:

- land-use patterns, such as agriculture, and grazing as a direct consequence or as a secondary consequence by providing new access routes, leading to new businesses and exploitation of natural resources;
- local population levels, as a result of immigration (labour force) and in-migration due to increased availability of opportunities;
- socio-economic systems due to new employment opportunities, income differentials, inflation, differences in per capita income, when different members of local groups benefit unevenly from induced changes;
- socio-cultural systems such as social structure, organization and cultural heritage, practices and beliefs, and secondary impacts such as effects on natural resources, rights of access, and change in value systems influenced by foreigners;

- Availability of, and access to, goods and services such as education, healthcare, water, transport, and consumer goods brought into the region;
- Aesthetics, because of increase in the number of people or noisy facilities; and
- Transportation systems, due to increased road infrastructure and associated effects (e.g. noise, accident risk, increased maintenance requirements of change in existing services).

Some positive changes will probably also result, particularly where proper consultation and partnerships have developed. For example, in the rural areas where feedstock will sourced, improved infrastructure, trade, health care and education are likely to follow. However, the uneven distribution of benefits and impacts and the inability, especially of local leaders, to predict the consequences of an equitable distribution employment opportunity for example, may lead to unpredictable outcomes.

26.2. Atmospheric impacts

Atmospheric issues are attracting increasing interest from both industry and government authorities worldwide. This has prompted all industrial development projects to focus on procedures and technologies to minimize emissions.

In order to examine the potential impacts arising from biomass power plant operations it is important to understand the nature of the emissions and their relative contribution to atmospheric impacts, both local and those related to global issues such as stratospheric ozone depletion and climate change.

The volumes of atmospheric emissions and their potential impact depend upon the nature of the process under consideration. The potential for emissions from biomass power plant activities to cause atmospheric impacts is generally considered to be low.

26.3. Aquatic impacts

The principal aqueous waste streams resulting from biomass power plant operations are:

- Discharged water from cooling systems;
- Changes in aquatic organisms due to removal of riparian forest after feedstock is harvested;
- process, wash and drainage water;

- Increased pressure on Garissa municipal wastes due to increased number of town dwellers;
- spills and leakage; and
- dusts from transportation of feedstock to the plant.

Again, the volumes of waste produced depend on the stage and method of the process used. In biomass power plant operations the main aqueous effluent are discharge of hot cooling water, whilst in production operations—after the installations are completed—the primary aqueous effluent is cooling system discharge of water. Other aqueous waste streams such as leakage and discharge of drainage waters that may result in pollution of riverine ecosystems ground and surface waters. Impacts may result particularly where ground and surface waters are utilized for household purposes or ecologically important areas are affected.

Indirect or secondary effects on local drainage patterns and surface hydrology may result from poor construction practice in the development of roads.

26.4. Terrestrial impacts

Potential impacts to soil arise from three basic sources:

- physical disturbance as a result of construction;
- contamination resulting from spillage and leakage or solid waste disposal; and
- Indirect impact arising from opening access and social change.

Potential impacts that may result from poor design and construction include soil erosion due to soil structure, slope or rainfall. Left undisturbed and vegetated, soils will maintain their integrity, but, once vegetation is removed and soil is exposed, soil erosion may result. Alterations to soil conditions may result in widespread secondary impacts such as changes in surface hydrology and drainage patterns, increased siltation and habitat damage, reducing the capacity of the environment to support vegetation and wildlife.

In addition to causing soil erosion and altered hydrology, the removal of vegetation may also lead to secondary ecological problems, particularly in situations where many of the nutrients in an area is held in vegetation (such as tropical rainforests); or where the few trees present are vital for wildlife browsing (e.g. tree savannah); or in areas where natural recovery is very

slow (e.g. Arctic and desert ecosystems). Clearing by operators may stimulate further removal of vegetation by the local population surrounding a development.

Due to its simplicity, burial or land-filling of wastes in pits has been a popular means of waste disposal in the past. Historically, pits have been used for burial of inert, non-recyclable materials; evaporation and storage of produced water; emergency containment of cooling system; and the disposal of stabilized wastes. However, the risks associated with pollutant migration pathways can damage soils and usable water resources (both surface and groundwater), if seepage and leaching are not contained.

Soil contamination may arise from spills and leakage of chemicals and oil, causing possible impact to both flora and fauna. Simple preventative techniques such as segregated and contained drainage systems for process areas incorporating sumps and oil traps, leak minimization and drip pans, should be incorporated into facility design and maintenance procedures. Such techniques will effectively remove any potential impact arising from small spills and leakage on site. Larger incidents or spills offsite should be subject to assessment as potential emergency events.

26.5. Ecosystem impacts

Plant and animal communities may also be directly affected by changes in their environment through variations in water, air and soil/sediment quality and through disturbance by noise, extraneous light and changes in vegetation cover. Such changes may directly affect the ecology: for example, habitat, food and nutrient supplies, breeding areas, migration routes, vulnerability to predators or changes in herbivore grazing patterns, which may then have a secondary effect on predators. Soil disturbance and removal of vegetation and secondary effects such as erosion and siltation may have an impact on ecological integrity, and may lead to indirect effects by upsetting nutrient balances and microbial activity in the soil. If not properly controlled, a potential long-term effect is loss of habitat which affects both fauna and flora, and may induce changes in species composition and primary production cycles.

If controls are not managed effectively, ecological impacts may also arise from other direct anthropogenic influence such as fires, increased hunting and possibly poaching. In addition to changing animal habitat, it is important to consider how changes in the biological environment also affect local people and indigenous populations.

26.6. Potential emergencies

Plans for all industrial operations should incorporate measures to deal with potential emergencies that threaten people, the environment or property. However, even with proper planning, design and the implementation of correct procedures and personnel training, incidents can occur such as:

- spillage of fuel, chemicals and hazardous materials;
- explosions;
- fires (facility and surrounds);
- unplanned plant upset and shutdown events;
- natural disasters and their implications on operations, for example flood, earthquake, lightning.

Planning for emergency events should properly examine risk, size, nature and potential consequences of a variety of scenarios, including combination incidents.

27. Potential Environmental and Social impacts and mitigation measures

The proposed project is likely to alter both the biophysical and socio-economic salient environmental features of the area as outlined below.

27.1. Positive impacts

27.1.1. Employment and Income

Job opportunities will be created for the local communities and the rest of Kenyans at large. This embraces both permanent and temporary staffing as per contract duration. Indirect services during construction and operation phases are likely to generate more income/job opportunities. This would raise the standards of living to the people of Garissa. A number of workers from the local community will be employed by this project either directly or indirectly. This will provide income and thus improve the living standards of the local people. The government will also gain in revenue collection through taxes and the local county government will benefits from increased property rates and levies.

27.1.2. Trade

Due to increased demand for household goods during the proposed plant operations, there will be increased trade of agricultural goods and consumables by those working at the project

area. A number of materials, input and products will be purchased for use during the construction phase. The demand for materials during construction will provide trade in the sourced supplies and thus creating and generating employment and income for suppliers, stockiest and transporters within the project area.

27.1.3. Growth of the Informal Sector

All new projects tend to attract informal sector activities by providing food and other essential goods to the project employee and casual workers.

27.2. Potential Negative Impacts

Negative impacts are likely to occur from activities associated with all the main phases of the project, all of which cumulatively have potential negative impacts on the biophysical and social environment. The potential negative environmental and social impacts will include the following; noise and dust pollution, loss of biodiversity, landscape interference and possible effects on water resources.

There will also be increased consumption of water, natural water systems contamination, higher risks to HIV/AIDS, occupational fire and accidents from the machinery, disruption of land use pattern, solid and sewerage generation in addition to occupational health and safety risk. The proposed project will also generate increased traffic flow of motorized machinery and equipments. These impacts are categorized and then grouped under the various project phases.

28. Impact categorization

The possible negative impacts and mitigation measures are listed below. Their **significance is categorized according to the Legend shown.**

Table 8 Legend of negative impacts categorization

Nature of Impact	Symbol	Significance Categories scale 1 = Low significance; 5 = High significance
Temporary	t	S=1-5
Permanent	T	S=1-5
Short term	St	S=1-5
Long term	Lt	S=1-5
Specific or localized	w	S=1-5
Widespread	W	S=1-5
Negligible or Zero	O	S=1-5
Reversible	R	S=1-5
Irreversible	IR	S=1-5

28.1. Impacts at Construction Phase

The main activities in this phase will involve the construction of the service roads infrastructure in the plant site, offices, road pavements and plant installations, and parking for vehicles.

28.1.1. Biophysical Impacts

Vegetation loss and Soil erosion (t, St, w, R S=2)

Some site clearance and opening up of roadways will lead to loss of vegetation and displacement of associated fauna. Localized erosion of the cleared site and compaction by trampling on the ground by heavy vehicles will reduce percolation capacity of soil. Iron roofing and hard cast paving will increase the risk of runoff.

Mitigation:

Following the completion of site preparation and construction activities, the proponent will undertake grass planting as the construction progresses to avoid the soil being washed or carried by wind. Places of least vegetation cover will be identified for the plant site and only

construction points will be completely cleared to ensure minimum vegetative disturbance around the factory site. Proper roof catchments and gutters will be put in place to control the possible increased runoff. Temporary storage tanks may be supplied to trap this water for irrigating planted vegetation.

Soil surface removal and translocation (TWR **)**

Excavation could lead to the risk excessive soil removal and disturbance and possible over saturation of the overburden soil. Scattered trenches and mounds of top soil and tailings from screening could be a common feature, not in keeping with the natural flood plans and the seasonal streams that cross the site as drainage leads to the river.

Mitigation:

The stripped topsoil and tailings from the screening process will be used to progressively backfill the dugout trenches immediately behind the abandoned areas. This combination of and backfilling leaves only minimal sized pit opening at any given time. Care will be taken not to interfere with the course of the seasonal streams, by leaving clearance of at least 30m from the operations points from the streams. This is in keeping with the Legal Notice 120 – Water Quality Regulations 2006.

Alteration of soil geochemistry (t w O R)

The excavations during construction may bring to the surface a mixture of clay and sandstone from the layers below surface, which may be rich in chemicals. These are bound to alter the soil geochemistry of the surrounding area location. Besides, prolonged human activity, the intensive transport system around the power plant site may lead to break up of soil texture that may lead to changes in the soil's physical chemistry.

Mitigation:

Beneficial use will be made of these chemical dynamics by investing on plant species that can utmost benefit from the availed chemicals through efficient absorption. Assistance will be sought from Kenya Forestry Service and other soil and botanical experts. Otherwise, backfilling will recognize the depth origin of the overburden and tailings, where the latter will go in first.

28.2. Impacts during the Operation Phase

28.2.1. Biophysical Impacts

Soil surface disturbance and Landscape interference (t w O R)

Track movement within the factory area could lead to the risk of digging gullies due to earth surface disturbance and lead to water collecting in pools or over saturating in temporary locations in the site. Scattered trenches and mounds of top soil and tailings from screening could be a common feature, not in keeping with the natural environments and the seasonal streams that cross this project site.

Mitigation:

The stripped topsoil and tailings from the screening process will be used to progressively backfill the dugout trenches immediately behind the abandoned pit. This combination of and backfilling leaves only minimal sized pit opening at any given time. Care will be taken not to interfere with the course of the seasonal steams,

Ponding Risk from construction (t, St, w, R, S=3)

Excavation leaves open pits which could trap water and form stagnant ponds. Loose soil could block free flow of surface water leading to pools of water at excavation points.

Mitigation:

The Proponent will do landscaping, and fill the depressions including burrow pits and disused open areas. Sporadic torrential rains may fill up pits still in use with water. In such cases supplemental pumping into suitably designed drainage outlets into the seasonal stream will be ensured. The quality of the discharged water will be monitored in keeping with the Legal Notice 120, of 2006.

Loss of Plant Life and associated bio-communities (T, Lt, w, S=3)

The site preparation activities will clear off much of the Prosopis shrubs and acacia vegetation within operation areas. Direct impact will result from a disturbance that causes changes in root stability, temperature, light, soil structure, and moisture and nutrient levels.

These interfere with the natural soils and fauna. The clearing of vegetation will lead to loss of plant life, associated birds, rodents, earthworms, microbes as well as larger animals spotted on the riparian forests in the site such as dik-diks. It will also lead to increased soil erosion as a result of unstable soil structure and uncovered ground.

Mitigation:

Although plant diversity is low at the proposed site, the proponent will incorporate greater species diversity in their rehabilitation and landscaping programmes. Close collaboration and assistance will be sought and built with the Kenya Forest Service at their nearest station and the Kenya Forestry Research Institute, for supply of appropriate seeds and establishing tree nurseries in the rehabilitation programme.

Increased surface runoff and soil erosion (T, Lt, w, S=2)

The built up area and bare ground such as road tracts will lead to increased volume and velocity of storm water run-off across some points of the area covered by the proposed area. This will lead to increased amounts of runoff entering drainage systems that could result in over flow and clogging in lower laying flat parts and neighbouring plots. Loose soils and debris could be carried and deposited in the process at places where they could create siltation.

Mitigation:

Since the areas is arid and semi-arid the amount of continual runoff will be minimal and therefore of little impact. However, the proponent will construct surface rainwater trap pits and cut-off drains to check occasional runoff. Roof catchment's gutters connected to tanks will harvest excess rainwater. The water would also be used for irrigating planted vegetation and for outdoor cleaning such as of vehicles and toilet cleaning, thereby reducing demand on water supply.

Air pollution from Dust and Engine exhaust gases (t, St, W, R, S=2)

Excavations during construction and demolition activities will generate dust particles that are potential hazard to the workers, neighbourhoods and passers-by. During windy days, dust

may emanate from the cleared spots. This may also cover the photosynthetic tissues of nearby plants.

Exhaust fumes from vehicles transporting the feedstock materials may cause air pollution especially if the tracks used will not be in good mechanical conditions.

Mitigation:

Prompt compaction of loose soils and aggressive grass replanting will be implemented. The distance to the nearest population concentration is about 1km. The impact of the dust on the surrounding people is therefore unlikely. Water will be sprinkled on to the disturbed off-pit soil to reduce flying dust. However, the power plant operation will produce no dust since most of the operations will be in a closed system.

Employees/construction workers will be provided with personal protective equipment (PPE), to reduce possible dust and noxious gas inhalation.

Vehicles will be of good mechanical condition and will be maintained regularly to make sure no excessive exhaust fumes are emitted.

Obstruction by disposed Excavated Soil (t, Lt, w, R, S=2)

The soil and tailing mounds will cause both visual and movement obstruction.

Mitigation:

Public movement through the operational area will generally be of a limited nature. However, emergency responses, which might be hindered by the obstruction, will be provided for by clear operating procedures. Most of the excavated materials will be used for backfilling and some will be applied in landscaping.

Waste into the Environment (T, St, w, IR, S=2)

The operations will generate both solid and liquid waste namely:

- Lavatory waste, and used oil.

- The solid waste will encompass office and packaging refuse, oil plastic containers, small amounts of vehicle parts and kitchen refuse.

Mitigation:

If at all there will be some staff or workers residing on site they will use appropriate sized potable septic tanks that will be installed at their dwelling places and places of work to keep with the movement of operations. Quality standards will be adhered to through initial testing and periodic monitoring in line with the requirements of NEMA contained in the Legal Notice 120, of 2006. The proponent will ensure that it enlists a licensed private company specialized in the handling oil and solid waste. Biodegradable wastes will be composted on site to produce tree planting manure. A *Good Housekeeping* practice as part of the company policy will be implemented at the facility.

Solid Wastes (t,w,S,R)

Garissa town is a fast growing town with the volume of solid waste increasing rapidly. The higher the population of a town, the more is the amount of solid waste generated. The town has no solid waste management plan as wastes may occasionally transported to landfills outside the town.

The proposed development may increase the number of town residents and commuter vehicles and thus more waste generation.

Mitigation measures

We recommend that all wastes generated during construction and operations of the plant should be collected and disposed off to the designated waste disposal sites. The contractors should put in place waste bins or receptacles in appropriate sites where garbage collectors can pick them and dispose accordingly. This should use only NEMA licensed garbage handlers who know how garbage is collected and transported safely.

Alternatively, the town generates a substantial amount of solid wastes that can be re-cycled into other forms of products like compost manures.

In general the solid wastes generated from the project should be managed in the 4R approach as outlined here below in figure 8

1. Reduce production of wastes
2. Re-use the wastes
3. Re-cycle the wastes
4. Recover

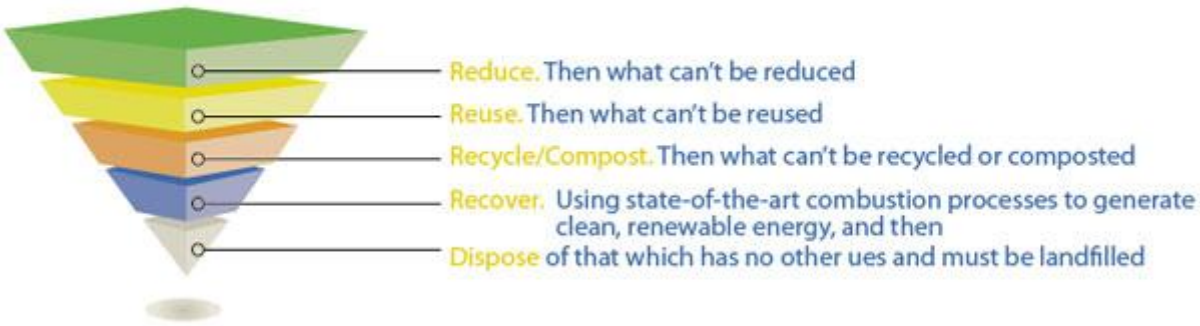

Figure 34 Schematic diagram of 4 R waste management

Liquid Wastes (Lt,W,S,IR)

In an urban set up, liquid wastes are generated from kitchens, bathrooms and sewerage. Other forms of liquid wastes come from oil changes in areas where service vehicles are kept. With the increase of people in the town and the number of vehicles in the town, the amount and types of liquid wastes should be expected to increase.

Mitigation Measures

Management of liquid wastes is a challenge for every municipality. Meru town has a functioning sewerage but by far too small to cover the large and growing town. The existing system is too old and covers a very small part of the town.

We recommend that the town management should consider developing an adequate sewerage with a better plant for treating liquid wastes from the town. It is recommended that pipes for drainage of liquid wastes be laid along the roads being constructed so that when the management plan is done connection will be done.

Surface and Ground Water Contamination (T, Lt, W, iR, S=3),

Discharges from cleaning and washes could be a source of pollution to water bodies during very wet conditions. Flowing leachate and run-off washings could proceed to pollute the riparian area within the operation area and seasonal streams.

Mitigation:

The project area borders with River Tana a permanent all weather large and flowing water body that is fed on by all the surface drainage from the surrounding areas. However, the seasonal streams and surface drainages are dry for most of the year only holding water occasionally during the wet rainy season. The project will have an adequate drainage on site containment to minimize uncontrolled storm water. Well-documented procedures for maintenance of the drainage system will be implemented and staff will be trained accordingly. Oil waste and spills will never be allowed into the environment; proper containment and accidental spill absorption regime will be implemented at all time. Vegetative pollutant traps and continual monitoring of the waters on site and surrounding areas will form part of the pollution control efforts by the company.

28.2.2. Socio-economic Impacts

Disease transmission through social interaction (t, Lt, W, R, S=2)
The activities related to factory operations and tracking of feed resources will attract the informal sector business and unemployed people, and this will lead to increased interactions of people which might lead to spread of communicable diseases such as HIV/AIDs.

Mitigation:
Special trainings will be conducted for employees on communicable diseases such as HIV, and the related social health risks. The company, through its social responsibility, will extend community education into the surrounding areas.

Noise pollution nuisance (t, Lt, w, R, S=2)
The use of machinery and vehicle movement will generate noise.

Mitigation

The contractor will ensure that the operations of most of the machinery such as excavator, loader shovel and graders are concentrated within the factory site and that all workers are provided with and using PPE such as earmuffs. Although the there are no residential dwellings in the vicinity of the factory site noise surveillance instruments will be availed periodically to check on any excesses.

Traffic congestion and accidents (t, St, w, R, S=1)

During operations, there will be a lot of movement of Lorries to and from the site transporting feedstock materials thus increasing vehicular flow, and congestion especially along the main road in the district and outside.

Mitigation;

Logistical procedures will be put in place to ensure ease of movement. Materials will be packed properly in specialized carrier trucks to reduce chances of fallout on the road. Assistance will be sought from Traffic Department where and when necessary.

Road sign will be placed in specific areas to direct the traffic and control movement of trucks to designated areas during delivery and personal cars to designated parking areas where they will not block smooth flow of the traffic.

28.2.3. Health and safety impacts

Increased Occupational and safety hazards (t, Ltd, w, R, S=3)

The operations of the biomass power plant production will not be directly associated with occupational health. However the proponent should ensure health and safety of the people in and outside the project area.

Mitigation:

Safety rules and warning signs including emergency procedures, evacuation mechanism in case of fire will be displayed at strategic open places within the factory premises. Relevant trainings and drills on fire and first aid will be conducted for employees. Relevant fire fighting and safety systems, including reliable written operating procedures will be put in

place. A standby ambulance will be availed on site to respond to emergencies, besides keeping close touch with other health and emergency institutions in Garissa township ambulances and health facilities. A specially trained manager will be in charge of environment, health and safety matter of the project.

Health deterioration of facility workers (t, Lt, w, R, S=2)
Prolonged exposure to dust contaminants and factory fumes (during operations) may lead to poor health incidences of those permanently stationed at specific high-risk workstations.

Mitigation
Dust containment and suction systems will be installed. Use of PPEs will be strictly enforced. Machine operators will be provided with respirators, eye protections and dustcoats to minimize inhalations. Regular medical checks will be done and records maintained of the employees. Staff working at the plant will have medical cover. Sanitation related education and practice would form part of the facility's regular routine, to avoid incidences of infections such as cholera, bilharzias and malaria. Swapping of work stations for staff will reduce level exposure.

Hazardous Materials
In addition to the common gases emissions, biomass combustion can also emit substances considered to be hazardous to the environment and human health. While the type of hazardous compounds depends on the biomass fuel type, several toxic by products are universal to burning. These materials are primarily products of incomplete combustion and include VOCs, PAHs, and dioxins.

VOCs are organic gases emitted directly from combustion of VOC-containing materials; these include methylene chloride, benzene, and formaldehyde, among others. VOCs are also emitted naturally from trees and vegetation. VOCs in the atmosphere are of concern because when mixed with NO_x and sunlight, they create ground level ozone.

PAHs are colourless, white, or pale yellow-green solids. They are formed by the incomplete combustion of wood or other organic materials. PAHs commonly enter the air as emissions from forest fires and volcanoes. PAHs are ubiquitous in the environment. In air, they are typically

attached to dust particles. Biomass power plants are known to emit low quantities of PAHs, though the exact amount depends on combustion practices and emission controls used in the plant. In high concentrations, PAHs are toxic to aquatic life and birds.

Noxious Odours

Noxious odours are a potential concern because if large amounts of biomass fuel are allowed to accumulate, they may begin to ferment. Operations without odours control can be especially troublesome when piles are allowed to age for one year or more. Power plant management must employ a strict plan for wood storage and handling. Piles must be monitored, limited in size, and arranged in long, narrow rows to prevent odour production and smouldering.

Visual and Sound Impacts

Daily site operations at biomass power plants can have visual and sound impacts for nearby residents. As many power plants operate continuously, effects could be noticeable at all hours of the day.

Visual impacts might include:

- Outdoor lighting
- Visibility of the facility
- Steam emitting from facility smokestacks

Sound impacts could include noise associated with (Negraran et al., 2007):

- Periodic steam release from boilers
- Loading and unloading of fuel
- Wood chipping operations (including vibrations)
- Minor plant operations
- Delivery truck braking systems

Particulate Matter (PM)

Biomass combustion also contributes to PM emissions. PM is comprised of small particles, dust, soot, and ash, as well as condensation of combustion gases. PM can be directly emitted from wood combustion as smoke and ash. PM is divided according to particle size; $PM_{2.5}$ is less than 2.5 microns in diameter and PM_{10} is less than 10 microns in diameter. Quantitative information about the amount of PM emitted from biopower plants is limited. However, biomass has been shown to emit relatively low levels of PM.

28.3. Impacts at Decommissioning Phase

28.3.1. Biophysical Impacts

Un-aesthetic derelict land (t, St, w, R, S=3)

Construction at the site may alter the natural scenic view of the landscape by digging trenches, and heaping soil materials in places that may have been relatively flat. This may lead to some areas being neglected by users

Mitigation

Proper site restoration or reconstruction measurers will be carried out in the event of complete phase-out of the project. Landscaping and plant enrichment will be done at phase-out. Environmental, health and safety legal requirements will be followed.

28.3.2. Socio-economic Impacts

Loss of jobs and livelihoods (T, Lt, w, R, S=2)

There may be some layoffs due to redundancy or alterations of operations plans.

Mitigation:

If layoffs become necessary there should be a lay off procedure and includes adequate time for the staff to prepare and payment compensation in accordance to labour laws.

Noise pollution (t, St, w, R, S=2)

Noise may interfere with neighbours and rouse their objections

Mitigation:

The contractor will ensure that the required noise levels are observed during the construction, operation and decommissioning phases. Noise surveillance instruments will be availed periodically to check on any excesses.

28.3.3. Health and Safety Impacts

Loss of hearing (T, L, w, IR, S=1)

There may be elevated noise levels at demolition works that may interfere with workers' hearing in addition to related disturbance.

Mitigation:

Use of PPE like earmuffs will be enforced.

Bodily injuries and accidents (T, Lt, w, IR, S=2)

These may be due to increased equipment mishandling, faulty workmanship, inappropriate equipment and protective gear, poor visibility, flying debris and falls.

Mitigation

The contractor will ensure supervision of work and handling of equipment is restricted to only skilled and experienced personnel to prevent accidents. Debriefing on safety procedure for site workers will precede any such works. Both the contractor and proponent will observe work ethics and worker's compensation in case of injury or loss. PPE like helmets, overall, nose and eyes protection hand gloves and boots, all of suitable and reliable quality will be used.

29.Impact Valuation Matrix

Table 9 Impacts Valuation

Impact	**Categorization**	**Valuation S= value**
Vegetation loss and Soil erosion	t, St, w, R	2
Ponding Risk from construction	t, St, w, R,	3
Loss of Plant Life and associated bio-communities	T, Lt, w,	3
Increased surface runoff and soil erosion	T, Lt, w,	2
Air pollution from Dust and Engine exhaust gases	t, St, W, R,	2
Obstruction by disposed Excavated Soil	t, Lt, w, R,	2
Waste into the Environment	T, St, w, IR,	2
Surface and Ground Water Contamination	T, Lt, W, IR, ,	3
Disease transmission through social interaction	t, Lt, W, R,	2
Noise pollution nuisance	t, Lt, w, R,	2
Traffic congestion and accidents	t, St, w, R,	1
Increased Occupational and safety hazards	t, Ltd, w, R,	3
Health deterioration of facility workers	t, Lt, w, R,	2
Un-aesthetic derelict land	t, St, w, R,	3
Loss of jobs and livelihoods	T, Lt, w, R,	2

Noise pollution	t, St, w, R,	2
Loss of hearing	T, Lt, w, IR,	1
Bodily injuries and accidents	T, Lt, w, IR,	2
Average Valuation		**39/18 = 2.17**
Overall score is 2.17 implying low impacts		
Comment: With an impact valuation of 2.17 the overall impacts of the project are within the acceptable ranges		

30. Environmental and Social Management Plan

Table 10 ESMP for the Design and Construction Phase

Possible Negative impact	Recommended Mitigation Measures	Monitoring	How to monitor	Responsibility	Time schedule and Monitoring frequency	Estimated cost
Biophysical impacts and Mitigation						
Lack of statutory permits and licenses	All statutory regulations must be complied with before the project is started. All licenses and permits required by the national government and the county government must be obtained prior to commencement of the project	Checking to make sure that all permits and licenses have been obtained and are renewed as required	Regular spot checking and developing a calendar for renewal dates for permits	Proponent	At the planning phase	5.0 Million
Proof of land ownership or permission to use the land	The proponent has to make sure that there is a proof of land ownership or permission to set up the proposed development on the site proposed	Acquiring the necessary documents to show land ownership	Checking	Proponent	at the beginning	2.0 Million
Resource availability and	The proponent must assess the availability and adequacy of the	Making a needs assessment of	Assessing	Proponent	at the	2.o Million

adequacy	resources and inputs required for successful implementation of the project	resources needed, amounts needed and assessing their availability in the required amounts			beginning	
Inadequate Public participation in the planning	The proponent must consult with relevant stakeholders during planning to seek their inputs in the planning process especially on the selection of the site for the project	holding stakeholder consultations	Meetings	Proponent	at the beginning	500,000
Working with un-qualified personnel	Professional services should be provided by qualified and certified personnel in their fields of specialization	Hiring of professionally qualified personnel	Checking on qualifications	Proponent	all the time	-
Using insufficient site plans for all sectors of operations and services	The proponent must consult professionals during site planning to make sure that the sitting of activities are procedural stage by stage with all inputs and outputs (e.g., wastes) are handled carefully.	Good site plans are made	Checking	Proponent	all the time	500,000
Use of sub-standard materials during construction	All construction materials must be approved by the authorized standards body (KEBS) and are from a known approved source.	Checking on the standards of the materials in use	Checking	Proponent	all the time	500,000

	The materials must be produced sustainably without negative impacts to the environment. The suppliers of construction materials must be licensed by a qualified approving authority.					
Vegetation loss and Soil erosion	The developer will undertake grass planting as the construction progresses to avoid the soils being washed or carried by wind. Places of least vegetation cover will be identified and only construction points will be completely cleared to ensure minimum vegetative disturbance. Wherever possible vegetation within the biomass plant site should be preserved and where plants must be uprooted they should be recycled into use as construction materials, firewood or converted into soil manure	Inspection of exposed places to make sure that	Observe and keep records of vegetation cover	Proponent	As project progresses, Audited annually	500,000/=
Soil disturbance through vehicle movements, digging of pits	During construction movement of vehicles carrying materials is likely to be comparatively high. The contractor can minimize	Frequent inspection	Observe movement of vehicles and keep records of	Contractor	Regularly	300,000

and scooping of surface soil	vehicle movement outside the designated areas as much as possible. Alterations of soil surface should be avoided as much as possible		damages to the roads			
Preservation of archaeological materials	The contractor should be observant when excavations are made during the construction to note presence of archaeological materials and other materials of cultural value buried in the soil. Where such materials are found the contractor should liaise with the National Museums of Kenya in Nairobi on how they can be removed or preserved.	Observing materials exposed during excavations	Present any suspicious materials with experts at NMK	Proponent and contractor	Proponent	200,000
Air pollution from moving vehicles	Pour water on vehicle paths to reduce dust When possible vehicles should be used when most people and livestock are indoors	Assess the amount of dust particles in the air	Observe dust blown off by moving vehicles	Contractor / Site engineer	Site engineer	100,000
Noise from movement of Vehicles	Use vehicle and machinery equipment that are of good mechanical conditions Ensure the machines used are	Mechanical checks of the vehicles and servicing regularly	Inspection	Contractor or site engineer	Engineer in charge	500,000

	adequately serviced					
Interference with livestock when grazing	Keep livestock off the project area. When trucks are moving keep the drivers should be observant of livestock grazing in the feedstock source areas	Movement of vehicles and livestock	Make sure livestock are not in the area of construction	Site engineer and contractor	regularly	50,000
Vibrations on the ground	The contractor should avoid using heavy equipment that causes vibrations on the ground. If such machineries should be used mechanisms to reduce transmission of vibrations to the ground should be employed. There should be no vibrations at night when people and most of animals are asleep.	Vibrations and stability of objects and installations	Monitor movement of objects and cracks on buildings Impacts on building	Site engineer and proponent	Regularly	100,000
Dust	Trucks to avoid driving off road and contractor to pour water on the road during dry seasons to reduce dust	Movement of vehicles and the dust they emit.	Record dust particles in the air	Site engineer and proponent	regularly	100,000
Flooding	Drainage of surface water must be done to avoid water collecting on the surface. Drainage channels should lead the water to the neighbouring River Tana	Make sure no surface water stagnates in the compound	Monitor blockages on drainage charnels	Site engineer and proponent	During rainy seasons	300,000

Contamination of water resources	Proper roof catches and gutters will be put in place to control the possible increased runoff. Temporary storage tanks will be supplied to trap this water for irrigating planted vegetation.	Chemical and biological properties of water within and outside the power plant area.	Chemical analysis of the water to determine chemical and biological composition	Site engineer and proponent	During rainy seasons	200,000
Water pollution during construction	Avoid releasing waste water directly into the river or surface temporary water pools	Checking on water quality before releasing to the environment	Checking	Proponent	Always	-
Solid wastes during construction	All solid waste must be collected into waste bins and sorted out before taken to landfills	Ensuring that all solid wastes are disposed properly	Checking	Proponent	Always	500,000
Liquid wastes during construction	All liquid waste must be disposed to pits for evaporation.	Ensuring that all liquid wastes are disposed properly	Checking	Proponent	always	500,000
Provision of sanitary facilities during construction	All workers must be provided with toilets for use at all times	seeing that sanitary facilities are in place	Checking	Proponent	always	200,000
Destruction of archaeological materials	All archaeological materials recovered must be reported to the National Museums of Kenya	making sure that no archaeological materials are	Checking	Proponent	Regularly	300,000

		destroyed				
Socio-economics						
Interference with movement patterns of people	The development should not interfere with movement patterns of people. Where paths and roads have been blocked, alternative routes must be created.	Changes in movement of people. Record and respond to complaints from residents.	maintain records of infrastructural changes and alterations to roads and paths	Site engineer and proponent	Occasionally	200,000
Cultural conflicts between locals and the incoming workers	The incoming workers of different cultural backgrounds should not interfere with the local cultures Incoming workers should be instructed to respect the local cultures	Conflicts between the plant workers and the local residents	Maintain records of conflict with locals	Site engineer and proponent	Occasionally	100,000
Competition on the supplies in the local markets	The incoming workers should not compete with locals in doing business in the local markets and providing supplies in the construction site.	Local residents should be given priority when service tenders are given buy the company	Keep records of the places of origin of all doing people doing business with the company.	Site engineer and proponent	During hiring	200,000

Table 11 ESMP for the Operations Phase

Negative impact	Proposed Mitigation Measures	Monitoring	How to Monitor	Responsibility	Time schedule and Monitoring frequency	Estimated costs for mitigation K.Sh.
Biophysical impacts and Mitigation						
Soil disturbance Interference with visual aesthetics	The stripped top soils and tailings from the site leveling and clearing process will be used to build and strengthen the perimeter wall. Care will be taken not to interfere with the course of the seasonal streams, by leaving clearance of at least 30m from the operations points. This is in keeping with the Legal Notice 120 – Water Quality Regulations 2006.	Soil condition and dislocation soil perimeter wall	Observations on the soil surface, exposures, stream blockages undisturbed flow of surface runoff	Site Engineer	Daily monitoring and Annual Audits	200,000/=
Poding risk from construction	The proponent will do landscaping, and fill the depressions including burrow pits. Sporadic torrential rains may fill up pits still in use with water. In such cases supplemental pumping into suitably designed drainage outlets into the	surface soil conditions Quality of discharge water	Observe soil translocation	Proponent	Monthly	500,000

	seasonal stream will be ensured. The quality of the discharged water will be monitored in keeping with the legal Notice 120, of 2006.					
Emission of hazardous materials	All hazardous materials generated and emitted from the plant must be handled by a competent and licensed handler	taking records of hazardous materials emitted	Checking	Proponent	Regularly	300,000
Loss of plant life and associated bio-communities	Although plant diversity is low at the proposed site, the proponent will incorporate greater species diversity in their rehabilitation and landscaping programmes. The services of knowledgeable curator/botanist will be employed to implement this feature. Close collaboration and assistance will be sought and built with the Kenya Forest Service and for supply of appropriate forbs seeds and establishing tree nurseries in the rehabilitation programme	Vegetation cover around the camp	Site Engineer and the proponent	Proponent	Monthly	350,000/=
Increased surface runoff and soil erosion	The proponent will construct surface rainwater trap pits and cut-off drains to check occasional runoff. Roof catchment's gutters	Surface water movements and Soil trans location	Note changes in volumes of surface runoff. Amounts of soil	Proponent or contractor	Quarterly inspection and Annual Audit	510,000/=

	connected to tanks will harvest excess rainwater in the site. The water would also be used for irrigating planted vegetation, outdoor cleaning such as of vehicles and toilet cleaning, thereby reducing demand on water supply.		deposition by surface water			
Air pollution from dust and engine exhaust gases	Prompt compaction of loose soils and aggressive grass replanting will be implemented. Water will be sprinkled onto the disturbed soil to reduce flying dust. Employees/ constructers or workers will be provided with personal protective equipment (PPE), to reduce possible dust and noxious gas inhalation.	Presence of dust on the roads and the exposed surfaces within the camp	Observe for the presence of dusts on the roads	Contractor / proponent	Occasionally	500,000/=
Obstruction by disposed excavated Soil	Public movement through the factory site will generally be limited. However, emergency responses, which might be hindered by the obstruction, will be provided for by clear operating procedures. Most of the excavated materials will be used for fill-ups and some will be applied in landscaping.	Presence of excavated soils on the surface, paths and movement areas	checks and observations	Proponent and contractor	Regularly	Cost combined as above

Alternation of Soil geochemistry	All materials retrieved from the construction site may alter the geochemistry of the soil, will be mixed with surface soils and buried in a pit to make sure they are not exposed	Checking and observing	Note presence contaminated soils	Proponent	Annual Audits	300,000
Disposal of Waste into the Environment including solid wastes	The construction site will be equipped with toilet and washing facilities fully connected to septic tanks. The proponent will ensure that it enlists a licensed private company specialized in the handling oils and solid wastes. Biodegradable organic wastes will be composted on site for tree planting manure. A Good housekeeping as part of the company policy will be implemented at the facility.	Inspection	Noting any improper waste disposal	Proponent	Regular	500,000/=
Surface and Ground Water Contamination	The project area is close to a permanent river system. The seasonal streams on site are dry beds only holding water occasionally during the wet rainy season. The project will have an adequate	Checking and inspection of surface water and ground water	sampling water for testing	Proponent	Regularly	200,000

	drainage containment plan to minimize uncontrolled storm water. Good procedures for maintenance of the drainage system will be implemented and staff will be trained accordingly.					
Air pollution	The amount of dust getting into the air will be minimized by pouring water during the dry days. Air pollution by gaseous wastes from machineries will be minimized by making sure that machines in operation are in good mechanical order and are serviced.	dust particles gaseous emissions from machineries	the amount dust particles in the air the gaseous emissions from machineries	Proponent Contractor	Regularly	300,000
Movement of vehicles and individuals	People should be instructed to walk, and drive vehicles only on the designated routes.	Movement of vehicles	Checking on the paths used by vehicles	Proponent	always	100,000
Chemical Discharge and emissions	Machine operators should be instructed to discharge chemicals only in the designated places or constructed containers.	monitor chemical discharges and emissions	Checking and testing chemical discharges	contractor /site manager	Regularly	500,000
Disposal of waste water from washings	Waste water should be collected into one place where it can evaporate or be treated and recycled	Monitor the flow of waste water from kitchens and washing	Checking where waste water is disposed	proponent	Regularly	100,000

	into agricultural use	areas				
Barriers to wildlife movement	The biomass plant should not be located in unique habitats where rare wildlife inhabit is or go to feed or breed	Presence and movement of wildlife	Observe and inquire from residents the presence and movement of wildlife.	Proponent	Before setting up the camp	100,000
Threats on biodiversity	The plant workers should not disturb wildlife outside the biomass plant area during the day and at night	Monitoring the movement of camp users outside the site	Checking the movement of people outside the site	Proponent	Regularly	100,000
Contaminated soil	Contaminated soils should be labelled, containerized and sent off-site for further handling/disposal	movement of soils should be to designated areas	Observations on the where contaminated soils are put	Proponent	regularly	100,000
Effects from emitted gasses	Gasses will be flared through a conventional burner. Large quantities from extended operations may be collected and recycled off-site for other uses	The disposal of gasses produced from plant operations	Check to make sure excess gases are flared	Proponent / site Manager	Regularly	50,000
Used medical wastes	Collected, labelled as biomedical waste, and sent offsite for disposal. Review possibility of safe incineration for readily combustible	Monitor the handling and disposal of medical wastes	make sure they are always incinerated outside the plant	Proponent and contractor	Regularly	50,000

	items		site			
Energy conservation	Buildings must have provisions of adequate natural lighting to minimize use of electricity in lighting rooms during the day.	Making sure that energy is conserved adequately	Checking	Site Engineer	Regularly	-
Water conservation	Modern taps and toilets that use minimal water to be installed to avoid excessive use of water	making sure that there is enough water conservation	Checking	Site Engineer	Regularly	100,000
Improperly designed feedstock storage warehouses and processing rooms	The warehouses or feedstock storage facilities must be built with wire mesh that regulates entry by pests like rodents	Make sure that warehouses are well designed to prevent pests	Checking	Site Engineer	Regularly	200,000
Fire hazards in the power plant	Fire fighting equipments must be installed in all buildings and placed at strategic places within the power plant site	Checking that enough fire extinguishers are installed.	Checking	Site Engineer	Regularly	100,000
Dangers of exposed live electricity wires	The site engineer should make sure there are no un insulated live electricity wires that may affect people, livestock and wildlife	Inspection of wire transmission cables	Checking	Site Engineer	Regularly	100,000
Improper handling of electrical installations and power connections	People employed to handle electricity production and interconnections to the main grid should be trained and qualified	All employees handling electricity are well trained	Checking	Site Engineer	when hiring	-

	electricians					
Emission of noxious odours	Aging fuel for no more than one year. Organize wood in long, shallow piles. Prevent piles from getting wet and allow air flow. Allow for adequate drainage surrounding fuel piles. Enclose fuel piles. Monitor fuel pile temperatures	checking on feedstock conditions and storage state	Checking	Site Engineer	Regularly	200,000
Emission of particulate matter into the air	Use of appropriate air filters	Checking on particulate matter emissions	sampling on the particulate matter emitted	Site Engineer	Regularly	200,000
Disposal of ash from combustion	Ash piles to be covered until they are disposed off for recycling back into the soil or put into other uses.	Making sure no ash particles are accumulating in the compound	Checking	Site engineer	Regularly	200,000
Deterioration of buildings and infrastructure	The condition of buildings and all infrastructure to be inspected regularly	Inspecting the conditions of all buildings	Inspecting	Site Engineer	annually	
Socio-economic Impacts and Mitigation						
Disease transmission through social	Special trainings will be conducted for employees on HIV, and related	staff are trained	checking	Site Engineer	Quarterly and	100,000/=

interaction	social health risks. The company, through its social responsibility, will extend community education into the surrounding areas				at Annual Audit	
Noise pollution nuisance	The contractor will ensure that the operations of most of the machinery such as loaders, graders are well serviced and that all workers are provided with and using PPE such as earmuffs. Although there are no residential dwellings in the project area noise surveillance instruments should be made available periodically to check on any excesses.	Inspection on all the mitigation measures suggested	Inspection	Proponent	Annual Audit and Daily monitoring	In-house
Traffic congestion and accidents	The earth road network is not a busy one. Logistical procedures will ensure ease of movement. Materials will be packed properly in specialized carriers to reduce chances of falls on the road. Assistance will be sought from Traffic Department where necessary		Site Engineer		Daily monitoring	-
Cultural conflicts with foreigners	Proponent should instruct the workers at the plant not to interfere	Monitor the interactions between	Make sure all workers have	Proponent and contractor	Regularly	100,000

	with the cultural practices and religious beliefs of the local people.	the workers and the locals	received the instructions and training			
Impacts on local infrastructure	Make sure the local infrastructure is not constrained by activities of the proposed project Construction of infrastructure should use locally available materials as much as possible	monitor efficiency operations of the local infrastructure e.g. roads, mosques, recreation centers etc.	Check or inquire from local to identify and rectify and constraints arising from the presence of the project in the area	Proponent	at the beginning of the project	200,000
Health and Safety Impacts and Mitigation						
Health deterioration of facility workers	Dust containment and suction systems will be installed on the plant site. Use of PPEs will be strictly enforced. Welders will be provided with respirators, eye protections and dustcoats to minimize inhalations. Regular medical checks will be done and records maintained of the employees. Staff working at the plant will have medical cover. Sanitation related education and practice would form part of the	Inspection on all the mitigation measures suggested	Inspection	Regularly	Proponent	Progressive, Annual Audit

	facility's regular routine, to avoid incidences of infections such as cholera, bilharzias and malaria. Swapping of work stations for staff will reduce level exposure.					
Challenges for foreign disease	The proponent should make arrangements with health providers in Garissa to make sure that workers who get sick are treated promptly.	Make sure all ailments are treated promptly	Disease screaming and tests	Proponent	regularly	500,000
Insecurity due to presence of many people	The proponent should organize with local administration to make sure that presence of the site occupants (workers) in the area does not cause insecurity inside and outside the camp.	Monitor security situation in and around the camp	Inquiries from the local administration Checking with site managers	Proponent	Regularly	300,000
Exposure of foreigners to zoonotic diseases or similar outbreaks or vise versa – foreigners passing zoonotics to local livestock	Contacts with local livestock should be minimized and if it has to happen disinfection should be done beforehand	monitor occurrences of zoonotic diseases	discussions and checking with local Vets	Proponent	Regularly	200,000
Over working of staff	Checking that factory staff work for 8 hours a day except where there may be exemptions to work for less	Checking	inspecting working hours	Proponent	Regularly	300,000

Table 12 ESMP for the Decommissioning Phase

Negative impact	**Proposed Mitigation Measures**	**Monitoring**	**How to monitor**	**Responsibility**	**Time schedule and**	Estimated cost of mitigation Ksh**.**
Biophysical Impacts and Mitigation						
Un-aesthetic deserted land drainage	Proper site restoration or reconstruction measures will be carried out in the event of complete phase-out of the project site. Landscaping and plant enrichment will be done at phase-out. Environmental, health and safety legal requirements will be followed	Checking on restoration status and progress	Checking	Site Engineer	Post-check evaluation	200,000/=
Soil chemical composition and poisoning	The contractors will immediately identify areas in the site where soils have been contaminated, scoop it and bury it in a pit where it is not exposed to people, livestock and wildlife including the below ground organisms as explained in the oil spill contingency arrangements	Checking on contamination of soils in the compaound	Checking	Proponent	Yearly	200,000

Re-vegetating the abandoned land	The contractor will take the responsibility of re-vegetating the abandoned camp site only with indigenous plant species.	Checking on vegetation cover in the compound	Observations	Proponent	During site abandonment	300,000
Ground leveling	Before deserting the site, the ground should be leveled by spreading heaps of soil and the soil fence	Checking on the levels of the ground	Make sure the ground is level – no heaps of soil left behind	Proponent	During site abandonment	200,000
Burying of pits and dumps	The pits used in the site for various purposes should be buried and covered with clean soil.	checking on the condition of pits	make sure no pits are left open	Proponent	During site abandonment	200,000
Socio economic Impacts and Mitigation						
Loss of jobs and livelihoods	The company will implement a comprehensive layoff and severance package for those who may not be redeployed.	Make sure that lay off are done in accordance to the law	Check how the law has been applied	Proponent	during site abandonment	In-house
Noise pollution	The contractor will ensure that the required noise levels are observed during the decommissioning phase. Noise surveillance instruments will be availed periodically to check on	Make sure that noise levels are within the required levels	Checking	Site Engineer	During site abandonment	In-house

	any excesses.					
Health and safety Impacts and Mitigation						
Loss of hearing	Use of PPE like earmuffs will be enforced	Checking for use of PPE	Checking	Site Engineer	Spot-checks	20,000
Bodily injuries and accidents	The contractor will ensure supervision of work and handling of equipment is restricted to only skilled and experience personnel to prevent accidents. Debriefing on safety procedure for site workers will precede any such works. Both the contractor and proponent will observe work ethics and worker's compensation in case of injury or loss. PPE like helmets, overall, nose and eyes protection hand gloves and boots, all of suitable quality will be used. Use of PPE like earmuffs will be enforced.	Checking on the skills of the affected personnel	Checking	Site Engineer	Spot-checks	

31.Conclusions and Recommendations

When done well, biomass energy brings numerous environmental benefits—particularly reducing many kinds of air pollution and net carbon emissions. Biomass can be harvested in ways that protect soil quality, avoid erosion, and maintain wildlife habitat. However, the environmental benefits of biomass depend on developing beneficial biomass resources and avoiding harmful resources, which having policies that can distinguish between them.

In addition to its many environmental benefits, beneficial biomass offers economic and energy security benefits. By growing our fuels at home, we reduce the need to import fossil fuels from other countries, and reduce our expenses and exposure to disruptions in that supply. Many countries that import coal or electricity from other countries could instead use local biomass resources.

With increasing biomass development, farmers and forest owners can gain valuable new markets for their crop trees, and we could substantially reduce our global warming emissions. Growing our use of beneficial biopower plants will require policy to guide industry to the right kinds of resources, public confidence that biomass can be a sustainable and beneficial source of income and energy, and the use of appropriate biomass conversion technologies and applications.

However, both growing of feedstock, transporting them to the power plant and combusting them to produce electricity has some environmental impacts. These environmental and social impacts have mitigation measures to avoid or reduce the impacts to manageable levels. There is some degree of best management practices adopted by countries where bio power plants have been used for a long time to generate electricity. In attainment areas, BACT is required, and in nonattainment areas, LAER is required. To achieve BACT or LAER, a variety of measures may be implemented, a modification to plant processes, and add-on controls.

Other best management practices specific to reducing biomass power plant emissions include:

- Fitting the boiler with flue gas recirculation (controls combustion temperatures and reduces NO_x formation).
- Optimizing stack height (control emissions).
- Optimizing combustion temperatures (ensures high efficiency and minimizes NO_x emissions).

- Using high efficiency fabric filters (controls particulate emissions).
- Using state of the art emission monitoring equipment and source tests for applicable pollutants.
- Monitoring emissions on a continuous basis rather than a periodic basis.

Best management practices pertaining to concerns of water quality include:

- Reducing Water Usage and Controlling Wastewater Disposal
- Requiring wastewater quality to be equal to or greater than that of drinking water.
- Requiring discharge water be the same temperature and pH as the receiving body of water.
- Utilizing a recirculating cooling system or dry cooling system to cut down on the amount of water used. This also lessens the number of fish, shellfish and fish eggs that are caught in the intake screen.

Reducing Noxious Odours

- Aging fuel for no more than one year.
- Organizing wood in long, shallow piles.
- Preventing piles from getting wet and allow air flow.
- Allowing for adequate drainage surrounding fuel piles.
- Enclosing fuel piles.
- Monitoring fuel pile temperatures.

Reducing Visual and Sound Impacts

- Landscaping in key areas to minimize visual impact
- Enclosing area where fuel is unloaded.
- Maintaining equipment properly.
- Restricting yard operations and deliveries to daytime hours.
- Installing a silencer on the stack.
- Disallowing emergency brakes on trucks.

32. References or Footnotes

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Appendices

Appendix: 1. Questionnaire administered in Garissa Power plant Public Participation

Ecodym Africa

Environmental Consultancy and Research

Sustainable Environment, Livelihoods and Development

Questionnaire for Community Participation in EIA Studies

Name of the Project: **Establishment of a 2.5 MW Biomass Power Plant in Garissa County**

Name of Participant ---------- Tel: November 12th 2014

Sex (Male/Female) ---------- Location: ----------

Sub-location ..... Other (stakeholders) .....

The EIA expert explains to the participants in a summary form the proposed development and the potential environmental and socio economic effects associated with implementation of the project including the extent or magnitude and boundaries of the proposed development.

The EIA expert then explains the purpose for public consultations in the proposed development as a requirement by EMCA 1999, and requests them to feel free to answer questions according to their feelings emphasizing that they will not be identified with the responses. Their answers will be used only for statistical purposes. Their identity will only remain in the list of participants and NOT in the answer to questions.

1. What is your occupation (**Tick one** if other specify in the space provided)
    a. A member of the community

b. An administrator in the area
c. A County Government official
d. A National Government official
e. A businessman resident in the area
f. An employee with NGO / Private business in the area
g. Other (**Specify**)

2. Do you think the proposed developments are good for the area?
   a. Yes ……

   b. No ----------

   If No Please explain

3. Apart from what you have heard so far about the development, is there anything you would like to know about the proposed development and the environmental effects that will occur as result of the development? **Write down your questions**

4. From what you have heard about the proposed development (from the EIA Expert) and your own experiences of the environment around this area, list the environmental problems that you think the proposed development will bring about?
   List in the space below

5. How do you think this development should benefit your community and others around it now and in the future? **List the benefits you expect**

6. How do you think the development will negatively affect your community and others around it? **List the potential negative effects**.

7. How do you think the completion of the proposed project will affect your;

   a. Cultural activities

b. Access to natural resources like water, firewood, pastures, etc.
c. Social facilities like religious institutions, educational facilities, etc.
d. Effects on access to markets for domestic products and household supplies
e. Other (Name it)

8. As a member of the community living around, how would you like to be involved in the development as an individual or the community in general?

9. Is there anything else you like to ask in relation to environmental and social impacts of the proposed project?

Thank you for your information. Your views and suggestion will be considered.

Please remember to sign the list of participants and to take a GROUP photo both of which will appear in the report to be submitted to NEMA