# DETAILED FEASIBILITY REPORT

## Bamboo Charcoal Manufacturing Unit

**in conformity with**

**The Royal Government of Bhutan's Vision of Achieving**

**Economic Self-Reliance**

**June 2015**

**Ministry of Economic Affairs**

**Royal Government of Bhutan**

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# ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| ARI | Acute Respiratory Infection |
| BEP | Break Even Point |
| BHU | Basic Health Units |
| BTL | Bhutan Telecom Limited |
| CAGR | Cumulative Average Growth Rate |
| CUSP | Caltech- USGS Seismic Processing |
| DSCR | Debt Service Coverage Ratio |
| EA | Environment Assessment |
| EDI | East Development Initiative |
| EI | Environmental Information |
| EMP | Environment Management Plan |
| EPI | Expanded Program on Immunization |
| ETP | Effluent Treatment Plan |
| GC | Gewog Connectivity |
| IMNCI | Integrated Management of Neonatal and Childhood Illness |
| IRR | Internal Rate of Return |
| ISP | Internet Service Provider |
| KWH | Kilo Watt Hour |
| MRP | Maximum Retail Price |
| MT | Metric Ton = 1000 Kilogram |
| NACP | National HIV/AIDS & STIs Control Program |
| NEC | National Environment Commission |
| NHDCL | Narmada Hydroelectric Development Corporation Limited |
| NPPF | National Pension & Provident Fund |

| | |
|---|---|
| NTCP | National Tuberculosis Control Program |
| OHS | Occupational Health & Safety |
| ORC | Out Reach Clinics |
| RPM | Revolutions per Minute |
| RUB | Royal University of Bhutan |
| RWSS | Rural Water Supply & Sanitation Program |
| SPM | Suspended Particulate Matter |
| TICL | Tashi Info Comm Limited |
| TSPM | Total Suspended Particulate Matter |
| TSS | Total Suspended Solid |
| VDCP | Vector Borne Disease Control Program |
| VHW | Village Health Workers Program |
| WFP | World Food Program |

# 1.0 EXECUTIVE SUMMARY

This report is a detailed feasibility study on the production of bamboo charcoal in Bhutan conducted by the Department of Industry under the Ministry of Economic Affairs, Royal Government of Bhutan.

The demand for charcoal in Bhutan is in excess of domestic production with the surplus being met through imports from India. The import of charcoal has a CAGR of10.64% and 23.24% for quantity and value of imports respectively.

Bamboo can be an important source of charcoal in Bhutan. This is because Bhutan grows several different species of bamboo. As a source of charcoal, bamboo provides some key advantages over wood. Primarily, since bamboo can be harvested, bamboo charcoal, unlike wood charcoal, does not run the risk of precipitating deforestation.

The report presents in detail the justification of the project, market analysis of charcoal, resources required, technology used in the plant, plant location, environmental aspects, implementation of the project, cost presentation and financial analysis.

(i) **Justification of the project:** A large amount of charcoal is imported every year in Bhutan for industrial use. Bhutan grows volumes of different species of bamboo.

(ii) **Market Analysis:** Charcoal is extensively used in Bhutan for industrial purpose and in households as well. There is a great scope of marketing for bamboo charcoal as well as vinegar in Bhutan.

(iii) **Resources required**: The only raw material for bamboo charcoal is bamboo, which is available in plenty. Apart from this, the unit requires electricity, which is also available in Bhutan.

(iv) **Technology required:** Low cost wood fired brick kilns have been proposed over more complex mechanical carbonization furnaces. However technical details about such furnaces have been provided along with necessary financial analysis in the annexure

(v) **Plant Location:** Considering the availability of bamboo in the region, Samdrup Jongkhar has been proposed as the ideal location for the plant.

(vi) **Environmental Aspects:** The production of bamboo charcoal may cause air pollution, but this can be reduced to a great extent at a later stage by installing environment friendly kilns.

(vii) **Implementation of the Project:** The implementation of the project will take 12 months including pre-project activities.

(viii) **Cost Presentation and Financial Analysis**

**Table 1a: Cost Presentation and Financial Analysis with brick kilns**

| | |
|---|---|
| **Plant Capacity:** | 360 tons of Bamboo charcoal and 72 tons of Bamboo vinegar |
| **No. of Cycle:** | 12 (25 days a cycle) |
| **Working Days in Year:** | 300 |
| **D.S.C.R.:** | 3.06 |
| **B.E.P.:** | 9.91% |
| **IRR:** | 43.2% |
| **NPV:** | Nu 12.5 million |

**Summary of Cost Benefit Analysis:**

The total cost of the project is Nu. 8.36 million and the projected revenue at 100% capacity utilization is Nu. 23.77 million. Internal Rate of Return of the project is 43.2%, which is much higher than the bank rate of 13%. The NPV of Nu 2.58 million at a rate of 13% indicates that the project generates sufficient surplus over the long term.

**Table 1b: Cost Presentation and Financial Analysis with Mechanical Kilns**

| | |
|---|---|
| **Plant Capacity:** | 300 tons of Bamboo charcoal |
| **No. of Cycles:** | 300 |
| **Working Days in Year:** | 300 |
| **D.S.C.R.:** | 1.82 |
| **B.E.P.:** | 14.09% |
| **IRR:** | 20.93% |
| **NPV:** | Nu 3.26 million |

**Summary of Cost Benefit Analysis:**

The total cost of the project is Nu. 10.82 million and the projected revenue at 100% capacity utilization is Nu. 17.01 million. The Internal Rate of Return of the project is 20.93%, which is much higher than the bank rate of 13%. The NPV of Nu. 3.26 million at a rate of 13% indicates that the project generates sufficient surplus over the long term.

# 2.0 JUSTIFICATION OF THE PROJECT

## 2.1 The Need for the Project:

**General Scenario**

There is a broad consensus that Bhutan's comparative advantage exists in energy. Production of bamboo charcoal as an alternative fuel source would tend to strengthen this natural competitive advantage.

Bamboo charcoal can be used as household fuel for heating and cooking, as well as in a range of purification and absorption applications, such as purifying drinking water, in air filters, in mattresses and pillows as a deodorizer, and for certain industrial purification uses. Bamboo vinegar, a by-product of the manufacturing process, is also used as an ingredient in health products.

Bamboo is an excellent resource for charcoal because of its high surface area (up to 385 $m^2/g$) and the ability to reach high temperatures (the surface temperature of bamboo charcoal can reach 700°C). Bamboo grows naturally because of the country's largely undisturbed forests and the limited agriculture practiced in areas where bamboo proliferates. Four dzongkhags have a significant production of bamboos. These are Samtse, Samdrup Jongkhar, Tsirang and Zemgang. The following table gives the production figures for 2014 per the INBAR Report on Bamboo Construction in Bhutan (February 2015).

**Table 2: Dzongkhag-wise Production of Bamboo in Bhutan**

| Dzongkhags: | Samtse | Samdrup Jongkhar | Tsirang | Zemgang |
|---|---|---|---|---|
| Parameters: | | | | |
| Total bamboo area (ha) | 982.12 | 101.20 | 248.54 | 156.32 |
| Total vol. by culm (m3 ) / ha | 96.31 | 255.70 | 152.57 | 9.67 |
| Total weight of culms(tons) | 37,835 | 10,350 | 15,167.90 | 604.64 |

Bhutan has possibly the greatest variety of bamboo species of all the Himalayan countries, with contributions from Chinese-Japanese origins, and some Southeast Asian and South Indian locations. Possibly as many as 50 more species exist, but have yet to be identified. Most of the bamboos are sympodial (clumping or clump forming type). This is primarily used for making charcoal.

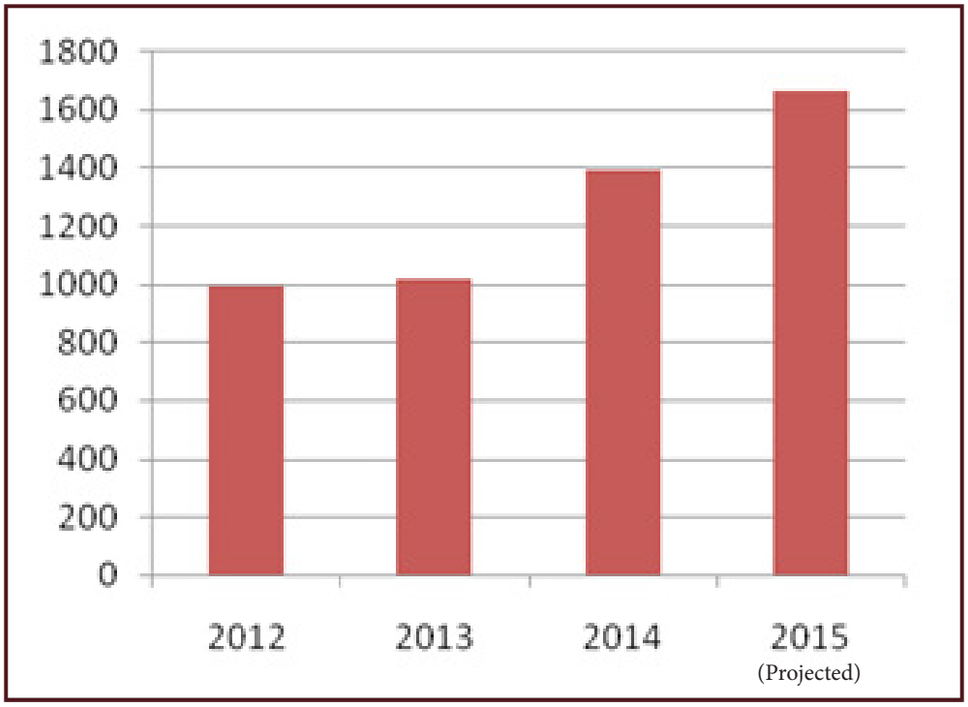
As bamboo is a fast-growing and sustainable resource, it is an ideal and profitable raw material for charcoal production and an excellent substitute for wood-based charcoal as Bhutan has quite a huge production of bamboo. As a source of charcoal, bamboo obviates the need to fall back upon wood as a source of charcoal, which has the potential to precipitate afforestation.

Per the Bhutan Trade Statistics, wood charcoal is consistently among the top ten imported items in Bhutan. The import figures are given in the following table.

**Table 3: Import of wood Charcoal**

| S. No. | Year | Amount Spend for Importing Charcoal (Nu) |
|---|---|---|
| 1 | 2012 | 994,346,990 |
| 2 | 2013 | 1,014,708,467 |
| 3 | 2014 | 1,387,314,599 |

**Chart 1: Amount spend for importing Charcoal (Nu in millions)**




From Table no. 1 (Import of wood Charcoal) we can see that charcoal is in the top ten import list for the last three years and the value of import is also increasing significantly. The projected import for 2015 using extrapolation stands at 1,661,449,135 Nu. Given the abundance of bamboos, it is possible to foresee an abundant potential for the industry in Bhutan.

## 2.2 Competition Analysis

Mountain Charcoal, based in Phuentsholing, is the only major manufacturer of bamboo charcoal in the organized sector. Given the huge market potential, the competitive pressures posed by this single entity is unlikely to be significant. The main competition lies in imports. However, if the unit offers comparable quality and price, consumers and buyers are unlikely to show any undue preference for imported charcoal as long as the supply meets the demand.

# 3.0 MARKET ANALYSIS

## 3.1 Structure of the Industry:

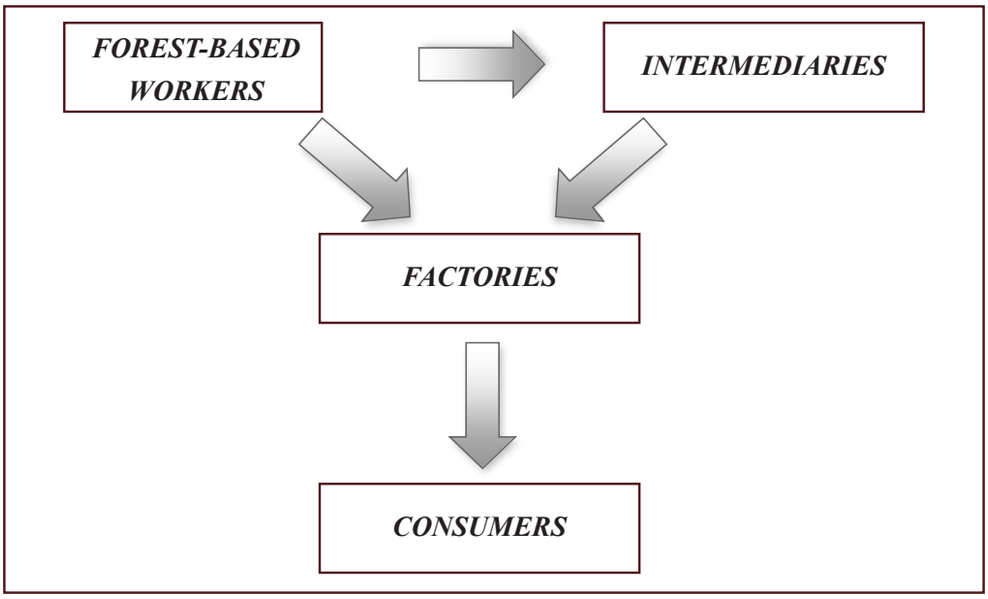



**Figure1: The Key Stakeholders**

**Key stakeholders**: For Bhutan, the bamboo charcoal manufacturing systems can be said to comprise of the following stakeholders:

**Forest-based workers:** Persons working in forest-based industries or community members who are tasked with looking after bamboo plants, cutting the culms and harvesting them.

**Intermediaries:** They buy the culms from the forestry, transport and sell them to factories after cutting them properly.

**Factories:** They undertake the manufacturing process**.**

**Consumers:** Consumers are of two types – industries and households.

## 3.2 Demand and Supply

There is a sustained demand for bamboo charcoal in Bhutan. The main assumption of this work hinges upon the observation that there is a growing demand for charcoal over time both as a source of household and industry end uses. A very clear picture of demand- supply relationship can be drawn based on data from FAOSTAT (Table 4).

**Table 4: Charcoal Production, Import and Export**

| Year | Production | Export | Import | Consumption |
|---|---|---|---|---|
| 2006 | 6,554 | 1.0 | 1.0 | 6,544 |
| 2008 | 6,900 | 8,000 | 47,000 | 45,900 |
| 2010 | 7,000 | 13,922 | 71,621 | 64,699 |

The surge in consumption post-2008 is primarily a result of the establishment of several large ferro alloys industries in Bhutan, which use wood charcoal as a major input. Given the newness of the ferro alloys industry itself in Bhutan, the opportunity to develop new businesses on the value chain is a major impetus for establishing a bamboo charcoal industry.

## 3.3 Pricing & Marketing Strategies:

This marketing effort will call for a strategy based on segmenting, targeting & positioning.

**Segmenting:** The act of dividing the market into distinct groups of buyers who might require separate offerings in terms of product attributes, pricing, promotion and distribution. Typically the domestic market of bamboo charcoal can be segmented into **individual consumers and institutional consumers.**

**Individual consumers** can be further classified under three groups:

1.1 High Income

1.2 Middle Income

1.3 Low Income

Similarly, institutional buyers would be primarily manufacturing units in the following industry segments:

2.1 Chemical e.g. Carbide

2.2 Metallurgical e.g. Ferro Silicon

2.3 Cement

**Targeting:** This is the act of choosing some of the segments identified from considerations of commercial attractiveness. While some focus may be given to catering to individual buyers, the primary target buyer for this product is medium and large industries.

**Positioning:** This is the act of providing a viable competitive positioning of the firm and its offer in each target market. It should ideally communicate uniqueness that adds value.

Some viable positioning statements could be

- A quality product
- Affordably priced
- Readily available
- Environment Friendly – saves forests (unlike wood charcoal)

The marketing mix should accordingly be defined to highlight aspects such as product attributes (quality and packaging), pricing strategy, promotion and distribution and logistics all carefully designed to ensure a high level of consumer satisfaction.

**Product:** The product can be differentiated from others based on the strength of its quality. The company can make a conscious attempt to source bamboo with the right moisture content so that they are able to produce Grade 1 charcoal with a higher calorific value.

**Price:** The price could be more or less at par with the domestic prices prevalent in the market. A slight premium may be considered keeping in mind the price value perception and the desire to position the product as superior.

**Promotion:** The promotional strategy for individual buyers could be as follows. For individual consumers, the company would target dealers, wholesalers and consumers to convey to them the benefits of the products through proper media channels like print, radio and television. There should be attractive performance recognition schemes and contests for dealers – particularly for the first year of operation. For institutional buyers, the sales team would ensure that the segment is well covered by initiating cold calls and staging product presentations to spread awareness and generate interest.

**Table 5: Promotional Activities**

| Serial No. | Promotional Activity |
|---|---|
| 01 | Occasional TV and radio advertisements to make industries and households aware about the activities of the organization |
| 02 | Distribution of leaflets, pamphlets, stickers; Wall paintings & hoardings wherever possible |
| 03 | Promotional gifts to the industries and retailers |
| 04 | Promotional & discounted sales campaigns to departmental stores, institutional buyers, retailers and overseas buyers |

**Place:** Superior distribution & logistics is key to success in a geographical area where rural roads as well as transportation facilities are in a constant state of development. As and when the market grows - the company can open storage units in and around the new industrial estates being established in eastern and southern Bhutan. The sales office should be located in Thimphu or Phuentsholing, where the majority of industries and institutional buyers continue to operate.

## 3.4 Technological Changes that Could Impact Costing

The difference in technology between brick laid kilns and mechanical ones has a major implication for the industry. The brick laid kilns that are proposed in this study can be replaced by mechanical kilns, which have a higher capacity of 1-3 metric tons. Prices for these kilns range from Nu. 0.25 million and higher. Though these kilns consume electricity, the production cycle can be reduced from 25 days to one day. Unit costs can be reduced drastically through economies of scale. However, a separate feasibility study needs to be undertaken to assess the availability of increased raw material and market demand.

## 3.5 Competitiveness of the Project

The project advocates the setting up of brick kilns, which would be cheaper compared to the cost of sophisticated mechanical furnace.

The major raw material namely bamboo would be locally sourced, which would be available at competitive rates. The company aspires to provide the product as well as its by-product at prices that are competitive with prevailing market prices.

Keeping in mind the large volume of imports, it is not expected that the unit would experience competitive pressure from existing units, especially since only one other entity is currently in operation. Furthermore, the proposed capacity for this business is 360 metric tons, a small fraction of the total market size.

## 3.6 Special Attributes Desired by Target Customers:

In general customers would prefer the following:

1. High quality, hygienic and graded properly

2. They would prefer an affordable price; some may prefer to have a credit period

3. Some would look forward to promotional offers

4. Timely delivery in good condition

5. Bamboo vinegar should have therapeutic value and cleansing property

6. Should be environment friendly

However the customer needs and wants may vary from one customer segment onto the other. For example, the household consumers are not bothered so much about the quality but the industrial consumers are very much quality conscious.

## 3.7 Terms & Conditions and Product Specifications Desired by Target Customers:

The microstructure of bamboo charcoal effectively serves as a unique and natural absorption system, like a 'hard' sponge which can trap impurities, harmful matters and gases. The proposed plant would produce 1st grade bamboo charcoal (Table 6).

**Table 6: Technical Specifications**

| | Unit | Bamboo Charcoal | |
|---|---|---|---|
| | | 1st Grade | 2nd Grade |
| Moisture Content | % | ≤ 7.00 | ≤ 9.00 |
| Dash Content | % | ≤ 2.5 | ≤ 3.5 |
| Solid Carbon Value | % | ≥ 90.00 | ≥ 85.00 |
| Volatile Ratio | % | ≤ 7.50 | ≥ 9.00 |
| Heating value of solid carbon | J/g | ≥ 33400 | ≥ 32300 |

Bamboo charcoal can be used for a wide range of different purification and absorption application.

**Reduce indoor air pollution** - Bamboo charcoal absorbs harmful chemicals in the air. It is especially useful for absorbing formaldehyde, ammonia, benzene from paints and strong adhesives, or when antifreeze is kept indoors. It also reduces smog as it absorbs carbonic oxide, ammonia, formaldehyde, benzopyrene, nicotine, and tar.

**Purifying drinking water** - As bamboo is naturally anti-bacterial and anti-fungal, bamboo charcoal also possesses similar properties. Bamboo charcoal also absorbs 2, 4-dichloro-hydroxybenzene, a major harmful pollutant in

drinking water. Bamboo charcoal also eliminates harmful substances such as surplus chlorine, chloroform, and contains rich natural mineral, like, potassium, magnesium, sodium, calcium etc. Water quality is improved when bamboo charcoal is used in cooking and boiling.

**Adjusting humidity -** Bamboo charcoal is both an effective natural humidifier and dehumidifier, a result of the pores present in its substructure which can trap and release moisture.

**Promote metabolism and blood circulation -** As bamboo charcoal absorbs and emit far infrared rays, it promotes blood circulation. Bamboo charcoal in mattresses, cushions and comforters help to warm the body faster. Due to its absorbent properties, bamboo charcoal is often used in refrigerators, trash cans, shoe insoles, etc. to absorb odor. "Stale air" in office buildings which causes depression and exhaustion comes from recycling pollutants in the air. Infrared rays emitted constantly from bamboo charcoal reduces moisture in the air into fine particles that naturally change into negative ions, which promote better metabolism and blood circulation. Bamboo charcoal products are not only functionally sound, but also good for protecting the environment.

## 3.8 Packaging and Transportation

The main purpose of packaging is to ensure that the product is inside a container along with packing materials to prevent the movement and for protection. It needs to satisfy three basic objectives. These are to:

1. Contain product and facilitate handling and marketing by standardizing the number of units or weight inside the package.

2. Protect product from injuries (impact, compression, abrasion and wounds) and adverse environmental conditions (temperature, relative humidity) during transport, storage and marketing.

3. Provide information to buyers, such as type, weight, number of units, grade, producer's name, country, area of origin, etc. Recipes are frequently included such as nutritional value, bar codes or any other relevant information on traceability.

**Figure 2: Packaging of Bamboo Charcoal**


**Figure 3: Packaging of Bamboo Vinegar**

While considering the fact of packaging one has to focus on two types of packaging: one for charcoal and another for vinegar.

Depending upon the size of the charcoal, jute bags can be used. Wooden boxes can also be used for the packaging of bamboo charcoal.

The vinegar is packed in plastic bottles. The bottles should be sealed properly so that the chemical property of the vinegar does not get spoiled. The packaging materials need to satisfy the following requirements:

i) Be easy to handle.

ii) Stackable by one person; have the appropriate dimensions so that they fit into transport vehicles.

iii) Materials should be constructed with biodegradable, non-contaminating and recyclable materials.

Heavy vehicles are needed for the transportation of bamboo charcoal. Bamboo vinegar is acidic, so careful handling during transportation is required.

## 3.9 Assessment of Comparative Advantage

Two factors combine to provide a distinct comparative advantage for setting up a bamboo charcoal manufacturing unit.

**a) Availability of Bamboo:**

The main raw materials for producing bamboo charcoal are bamboo and firewood. Bamboo grows naturally in Bhutan because of the country's largely undisturbed forests and the limited agriculture practiced in areas where bamboo proliferates. The Kingdom probably has the greatest variety of bamboo species of all the Himalayan countries. Bhutan's great range of altitudes and climates account for this diversity. Bhutanese bamboo is principally of Himalayan and Chinese-Japanese origins, with some Southeast Asian and South Indian contributions.

**b) Availability of firewood:**

Over 70% of Bhutan's total land areas is under forest cover, which provides an abundant source of firewood.

## 3. 10 Potential for Marketing Collaboration:

It is recommended that the sales teams operate as two divisions: industry sales and consumer sales. The industry sales team would sell charcoal directly to institutions. The consumer sales team would sell vinegar and charcoal to consumers through a network of dealers. Collaboration with foreign marketing agencies can also be pursued – particularly for wood charcoal vinegar. In Bhutan, charcoal is currently used in the following sectors:

(i) Chemical industry

(ii) Metallurgy

(iii) Cement industry

(iv) Households: Ordinary lump charcoal is still the consumer's preferred form of charcoal since it is easy to handle and to ignite. The steady growth of population and the rising price of oil and gas based energy causes the demand for charcoal to expand constantly. Apart from these, bamboo charcoal is also used in the form of briquette charcoal.

(v) Miscellaneous: Bamboo charcoal is also used in several economic activities such as animal feed additives, soil conditioners, tobacco curing, fruit drying, arts and printing industry, fireworks and black powder explosives.

To address both industrial and household demand, bamboo charcoal can be extensively marketed in Bhutan through print, radio, television, live demonstrations and B2B connections.

# 4.0 RESOURCES

## 4.1 Sources of Inputs including Water

**Electricity**

Electricity is required to run the production machinery and to provide lighting for the plant. The vast majority of Bhutan's energy is provided by hydroelectric power stations and is highly reliable.

## 4.2 Comparative Analysis of Critical Inputs

**Bamboo:** Transportation of bamboo adds to costs. Kilns for charcoal production from bamboo should be located in an area where bamboo is available in plenty. Raw materials can be sourced from plantations or forested areas, or collected from homestead plantations.

## 4.3 Sources of Raw Materials

Bamboo grows naturally in Bhutan because of the country's largely undisturbed forests and the limited agriculture practiced in areas where bamboo proliferates.

There are two principle types of bamboos: the woody variety and the herbaceous variety. The woody variety is used to make bamboo charcoal, and are found in abundance in parts of Bhutan. Some of the bamboo species pertaining to the woody variety are listed in the Table 7.

**Table 7: Information on Bamboo in Bhutan**

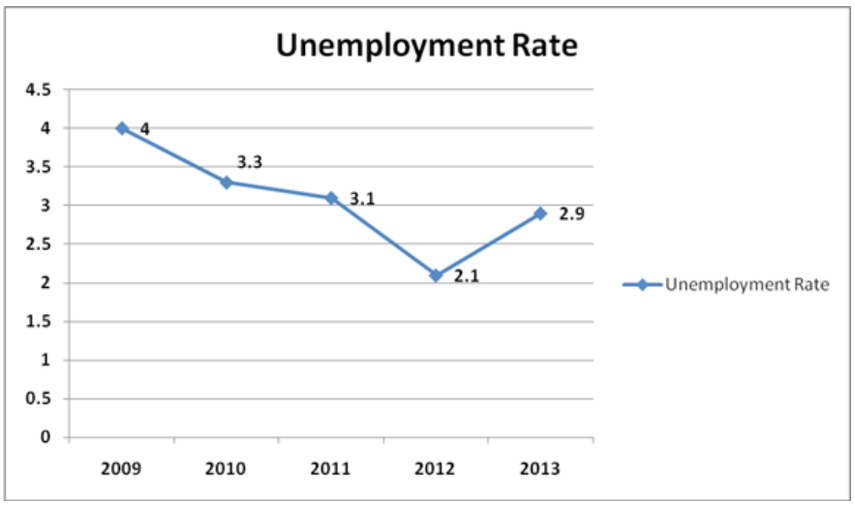
| Botanical name | Local name | Distribution | Parts used |
|---|---|---|---|
| *Arundinaria* spp. | Maling bans | Chimithangka and Thimphu<br>Selephu/Paro<br>Diafam/Samdrup Jongkhar<br>Bhangtar/Samdrup Jongkhar<br>Nganglam/Samdrup Jongkhar<br>Deothang/Samdrup Jongkhar<br>Pemagatshel | Stems<br>Leaves |
| *Arundinaria maling* | Hima | Begana/Thimphu<br>Helela/Thimphu<br>Lamperi/Thimphu | Stems |
| *Bambusa* spp. | Bhalu bans | Sarpang<br>Samdrup Jongkhar<br>Samtse | Stems |
| *Dendrocalamus* spp. | Mal bans/Choya bans | Sarpang Zhemgang Samdrup Jongkha Pemagat-shel | Stems |
| *Dendrocalamus stricta* | Bejuli bans | Sarpang | Stems |

## 4.4 Availability of Manpower and Skills

The Labour Force Survey Report 2013 finds that the agriculture sector employs over 55 percent of total employed persons, while 17 percent are employed in public administration & defense, education, electricity, gas & water supply sectors, and the remaining 28% in real estate, construction, hotels & restaurants, and mining & quarrying sectors.

The survey finds that a total of 335,870 individuals were employed and 9,916 were found to be unemployed out of a total projected population of 745,939 in 2013, making unemployment rate at the national level by 2.9%.

**Chart 2: Unemployment Rate in Bhutan**




The Labour Force Survey Report 2012 indicates that by 2020 there will be 267,000 students seeking jobs. A variety of skills are available from the various training institutions to support any service enterprise. However, higher technical courses for engineering & technology, international law and finance are required to meet the requirements of the imminent future.

## 4.5 Need for Skill Development

As the workforce is not so much skilled there is a need to develop their skills according to the need of the industry. Workshops or on-site short term trainings may be organized by the suppliers of machineries on how to control the temperature, operate machineries etc. The training should be a combination of theory sessions, on the job coaching sessions and on the job supervision. For people joining with no relevant experience, training on their respective functional area would be mandatory. There should be a periodic skill assessment done by the management on the basis of observation of on the job performance. Based on the findings, a training calendar needs to be drawn up.

# 5.0 THE PLANT

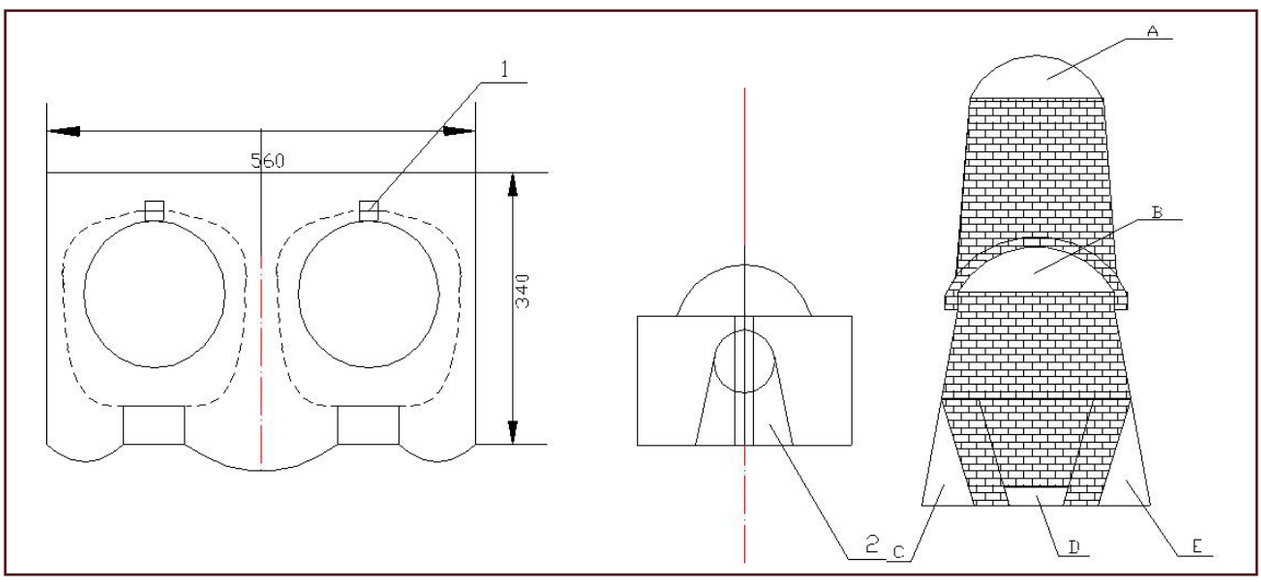
## 5.1 Choice of Technology

Raw bamboo charcoal is made of bamboo culms, which were cut into a certain length and then loaded into a kiln to dry, heat and pyrolyze under the condition of little or no oxygen. There are two broad technology options – Brick layered kilns and Mechanical carbonization furnaces. Basic comparatives are given below:

| Factor | Brick layered kilns | Mechanical carbonization furnaces. |
|---|---|---|
| Capital Cost | Low | High |
| Degree of Engineering Complexity | Low | High |
| Cycle time | High | Low |
| Pollution | High | Low |

Keeping in mind low capital cost, ease of construction and maintainability – the technology recommended is **Brick Layered Kilns** to start with. Mechanical furnaces may be considered as potential choice in the medium to long term.

A typical double brick kilns are shown in Fig.4.




(a) (b)(c)

1. fuel 2 sidewall A.B firewood intakes C, D, E air intakes

**Figure 4: Diagrammatic sketch of the structure of a typical double brick kilns**

The vertical and lateral views of the double kilns are shown in Fig.4 (a) and (b), and the dimension measures 3.8 meters in length, 2.8 meters in width and 2.5 to 2.7 meters in height with wall 24 cm thick. The building process is as follows: First of all, 15 to 20 cm thick stones are levelly paved on the ground, covered by a layer of loess 20 cm thick. Then bricks are laid on the loess. After building the kiln with bricks a layer of loess 20 cm thick are laid on the top, which serves to keep out the moisture and preserves the heat. The flue of 100 × 100 cm is situated at the back.

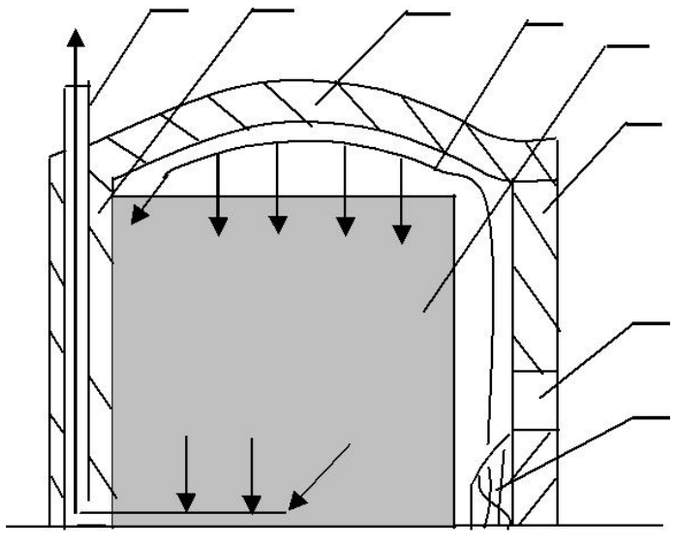


**Fig. 5 sketch map of a brick kiln heating bamboo charcoal**

1. Firewood 2. Entrance of firewood 3. Front wall 4. Bamboo sticks 5.Smoking track

6. Roof made of brick 7. Back wall 8. Chimney

Fig.4 (c) depicts an explicit illustration of a kiln gate, which is 1.5 meters high, with 50 cm wide at the bottom and 40 cm wide on the top. There are five intakes on the kiln gate. Intakes A and B serve not only to add firewood, but also to observe flame and burning situation. Intakes C, D and E, mainly used to control the increase rate of interior temperature by adjusting their opening. This type of kiln has a capacity of four to six tons of bamboo and consumes two tons of firewood in a cycle.

**Production Process**

The entire production process centers around bamboo pyrolysis. This process along with its four distinctive stages has been explained below.

## Bamboo Pyrolysis

Bamboo pyrolysis, including bamboo carbonization, bamboo destructive distillation, bamboo activated carbon and bamboo gasification, etc is a manufacturing method which provides for heating bamboo to form many pyrolyzed products under the condition of letting in little or no air in.

a. **Bamboo carbonization:** Bamboo is heated in brick kilns or mechanical kilns with little air by means of the heat energy generated by burning firewood to pyrolyze bamboo and produce bamboo charcoal.

b. **Bamboo destructive distillation:** bamboo is heated in a pyrolyzing kettle isolating air to produce bamboo charcoal and bamboo vinegar and so on.

c. **Bamboo activated carbon:** the bamboo material is heated in a brick kiln and activated kiln to get bamboo activated carbon.

d. **Bamboo gasification:** bamboo or bamboo residues resulting from the processing are heated to get bamboo gas in a gasification kiln.

**Stages of Bamboo Pyrolysis**

Bamboo pyrolysis can be divided into four stages according to temperature and the chemical composition of the products in a kiln or a pyrolyzing kettle.

**First stage - drying:** the temperature is below 120°C and the speed of pyrolysis is very slow in this stage. The external heat vaporizes the water in bamboo, the chemical composition of the bamboo is still intact.

**Second stage - pre-carbonization:** the temperature is in the range of 120°C to 260° C and there is a distinct pyrolysis reaction in bamboo during this stage. The unstable chemical compounds in bamboo (i.e. hemicelluloses) begin to decompose into carbon dioxide, carbon monoxide, acetic acid, etc. This stage is an endothermic reaction.

**Third stage - carbonization:** the temperature is in the range of 260°C to 450°C, and the bamboo rapidly decomposes into many liquid and gaseous products. Liquid products contain acetic acid, methanol and bamboo tar. The gaseous products are methane and ethylene in increasing volumes and carbon dioxide in gradually decreasing volumes. Because a lot of heat emits from bamboo, this stage is an exothermic reaction.

**Fourth stage - calcinations (refining stage):** the temperature is over 450°C. The bamboo becomes charcoal by providing heat; the volatile substances in the charcoal are got rid of. Refining stage is the key to upgrade the quality of bamboo charcoal. Based on the temperature in this stage, the bamboo charcoal can be divided into three groups (low-temperature charcoal, middle-temperature charcoal and high-temperature charcoal).

**Production of Bamboo Charcoal:**

Bamboo charcoal is produced in the following basic steps:

1. Bamboo culms are cut into segments
2. Segments are heated under controlled conditions to carbonize them.
3. Charcoal pieces are checked and packed

Production process:

A Charcoal production process is shown in the following figure.

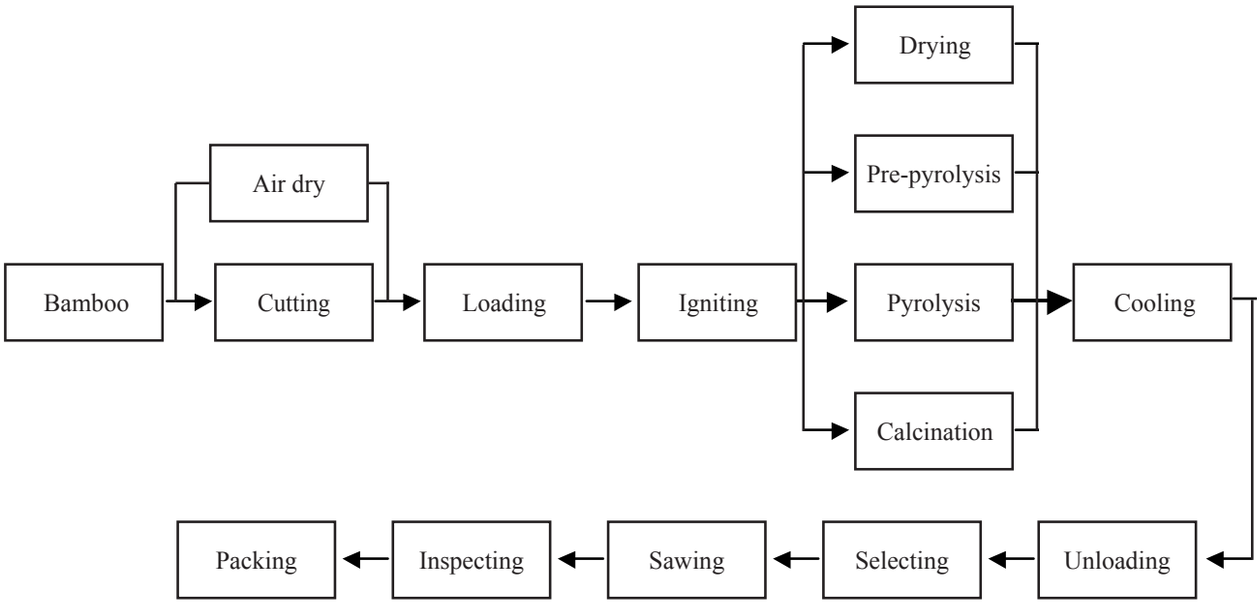



**Figure 6: Production process flow chart of bamboo charcoal**

The classical method for making bamboo charcoal would be as follows. The pit is dug up to a certain depth as the base of carbonization room and then build the carbonization room with stick soil. After that, the burning room is built in front of carbonization room and then air-dry the kiln. When loading, all bamboo culms stand in the kiln with base portions up. To make bamboo charcoal one has to carry out a series of procedures such as igniting, heating and drying, pre-carbonizing, carbonizing, calcining, sealing kiln, cooling, and unloading. One of the shortcomings of this method was the difficult in ensuring the quality of bamboo charcoal.

Because of the development of environment protection and health care function of bamboo charcoal, its products attract attention of people and the demand is increasing. To improve and enhance its quality, the production process and equipment are much better after years of improvement. At present, there are two main kilns or furnaces e.g. pear type brick kiln, which is used to manufacture bamboo charcoal, and mechanical furnace, which is usually used to produce bamboo briquette charcoal. The description of each stage is given below:

**Loading:**

Bamboo culms are cut into segments or pieces according to inner height of the kiln and loaded into the kiln. The bamboo segments are arranged vertically with the tip downward. Loading begins from tail of the kiln towards the gate, leaving 0.5 m of gap between the bamboo stack and kiln gate for combustion of firewood. Then the door is sealed with bricks and clay, leaving the arc intake for igniting and feeding firewood.

**Figure 7: Sealing the gate of the kiln**

**Igniting:**

The firewood lying behind the kiln gate is ignited and then the top two intakes on the gate are closed. When the firewood is burned two intakes at the bottom of the gate are kept open to keep the hot flow circulating in the kiln to go out through the flue at the tail of kiln. At the beginning, a small hole at the top of gate is necessary to let the smoke out and allow the firewood to burn easily.

**Heating (dry and pre-carbonization stages):**

It is the process of raising the temperature inside the kiln by dismounting the arc-feeding intake on the gate every day and feeding in firewood to keep fire going. Once the feeding is over, the feeding intake gets sealed once again. To avoid feeding firewood at midnight, it is necessary that not only should the feeding intake be sealed but even the air intakes should be partially sealed after last feeding in the evening every day. The bamboo in the kiln would crack if the temperature escalates quickly. The temperature in the kiln should be controlled under the self-igniting point of bamboo in seven to eight days after igniting. Firewood feeding should be decreased or stopped if the temperature is becoming high. Blocking the intakes and flue rim with bricks can regulate the temperature in the kiln.

**Carbonization:**

When the temperature in the kiln reaches 260□, bamboo will decompose rapidly and give out a plethora of products and heat from the chemical reaction. When it is over 450□, bamboo pyrolysis enters into refining or calcining stage. In fact, it is a contracting process of high temperature pyrolyzation for improving the quality of bamboo charcoal and enhancing its hardness as well. At the end of heating open the intakes of the gate and feed more firewood quickly to raise the temperature inside the kiln. In this process, the intakes of kiln gate shouldn't be opened wholly in a short time, and they are to be opened gradually within twenty-four hours or so to make the bamboo charcoal contract absolutely. At the end of refining stage, all the intakes should be opened again for one or two hours to raise the temperature of the charcoal in the kiln to 1000□ or more. The beginning and ending of refining process will be controlled according to the temperature on the curve. In practice, workers, especially in small plant, determine the carbonization stages by watching the color and smelling the smoke coming out from the flue. At the beginning of drying, the smoke shows white color containing a lot of steam, and then develops a slight acid smell. Beginning carbonization, the smoke turns slightly yellow accompanied by a tar smell. When smoke color turns blue, it indicates the end of carbonization and the start of refining.

**Sealing for cooling and unloading:**

The kiln gate must be fully sealed with brick and mud pile at the end of refining, and the bamboo charcoal in kiln should cool naturally. If the kiln is not sealed well, bamboo charcoal inside will be easily oxidized. The cooling time depends on weather. Usually it takes five to six days. When temperature in the kiln is lower than 50□, it is time to take out the bamboo charcoal.

**Factors Influencing Bamboo Pyrolysis Process**

- **The terminal temperature of bamboo pyrolysis**

The terminal temperature of bamboo pyrolysis has great influence on the output and composition of bamboo pyrolysis products. The results of experiments demonstrated that the output of bamboo charcoal decreases as

the pyrolysis temperature goes up. The yield rate of bamboo charcoal decreases while the pyrolysis temperature goes up, but the relative content of fixed carbon in bamboo charcoal increases. The yield rate of the liquified and gaseous products are increased with the temperature raising. The specific surface area of the bamboo charcoal is the maximum (385$m^2$/g) at pyrolysis temperature 700□.

**The speed of pyrolysis**

The speed of pyrolysis influences the productivity of pyrolysis equipment. In other words, high pyrolysis speed and low processing time can increase the utilization ratio of the pyrolysis equipment. The speed of pyrolysis is influenced by the speed of heating, the dimension and quality of raw material, the pyrolysis method and the carbonizing equipment, etc. The bamboo vinegar's output increases and the bamboo charcoal's output decreases in high-speed pyrolyzing process. When the exothermic reaction of raw material is taking place rapidly, a large quantity gas emits abruptly from the bamboo causing cracks that would reduce the mechanical strength of bamboo charcoal (Huang 1996).

- **The moisture content of bamboo**

The moisture content of bamboo directly influences the pyrolysis time and the consumption of fuel. The drying period of bamboo pyrolysis will prolong if the moisture content is too high, and as a result, the carbonizing process will extend with more fuel consumption. On the other hand, the bamboo culms can get cracked easily because of not getting heated uniformly in the pyrolyzing kettle when drying rapidly, and this degrades the quality of bamboo charcoal produced. At the same time, the concentration of bamboo vinegar becomes lower and will increase the consumption of fuel while the bamboo vinegar is further treated. The lower moisture content of bamboo speeds up the bamboo pyrolysis process. But the output of bamboo charcoal will be less and its mechanical strength reduced by the vigorous exothermic reaction if the moisture content of bamboo is too low. So suitable moisture content of bamboo is important for pyrolysis, and the 15%~20% moisture content of bamboo is favorable for carbonization in an outside-heating pyrolyzing kettle

- **Bamboo dimensions**

Because of low thermal conductivity, the bigger the dimension of bamboo pieces, the longer period of time it will be taken for the gas compounds emitting. Due to much subsidiary reaction that can cause loss during the pyrolyzing process, the output of bamboo charcoal will be reduced. It should be mentioned that bamboo material's conductivity value is low, and should consider how to speed up the heating process uniformly.

## 5.2 Source

**Plant and Machinery**

1a. Brick kiln using firewood

Capacity 1 ton

Cycle time 25 days

**Details of Supplier**

To be constructed taking the help of local contractors as per approved INBAR Design

1b. At a later stage mechanical furnaces may also be considered

One can consider two furnaces having a capacity of 500 kg/8 hour

The unit can in 300 days produce 300 tons of bamboo charcoal consuming about 4 tons of bamboo every day.

The manufacturing unit would consume 3 kw of power during manufacturing.

But there is no dependence on firewood and emissions are much better controlled as compared to brick kilns.

However costs for installation, commissioning, training, trouble shooting and maintenance would be high because of dependence on a third party.

At the same time number of hands would be lesser by 50%.

**Details of suppliers**

1. **Zhengzhou Furui Machanical Equipment Co., Ltd**

Brand Name: Furui

Model Number: FR -2-1, FR – 2-2, FR -2-3

Parameter of bamboo charcoal carbonization furnace

| **Model No.** | **FR-2-1** | **FR-2-2** | **FR-2-3** |
|---|---|---|---|
| Productivity(kg) | I000 | I500 | 2000 |
| temperature(°C) | 430°C | 430°C | 430°C |
| Motor power | 1.5kw | 1.5kw | 1.5kw |
| Weight | 4800kg | 6000kg | 7500kg |
| Size (mm) | 2800*1800*2500 | 3070*1800*2800 | 3500*2000*3000 |

**2. Zhengzhou Wanqi Mechanical Equipment Co Ltd**

The charcoal carbonization furnace is equipped with superheated stream cooling system. Thus the cooling process can be speeded up for 4-12 hours, and the production cycle time can be shortened to 24-48 hours. The furnace can produce around 200 kg charcoals every 1-2 hours, The efficiency of this type is 4 times more than the old-type, which greatly reduce the expenses spent in a great amount of old-type equipments when target capacity is high.

**Technical Parameters of continuous carbonization furnace:**

| Model | Tech spec |
|---|---|
| THL-4 | Output: 500kg/8hours<br>Carbonizing time:8hours<br>Carbonizing rate:99%<br>Overall size: 2.8*1.8*1.8(m)<br>Weight(t):3.5 |
| THL-8 | Output: 1000kg/8hours<br>Carbonizing time:8hours<br>Carbonizing rate:99%<br>Overall size: 4*2*2(m)<br>Weight(t):5T |

The detailed workings about this option is provided in the Annexure.

## 5.3 Rate of Consumption of Power, Fuel, Utilities & Consumables

**Requirement of Power**

For this project electricity is required for meeting the lighting loads. The brick kiln does not require any electric power.

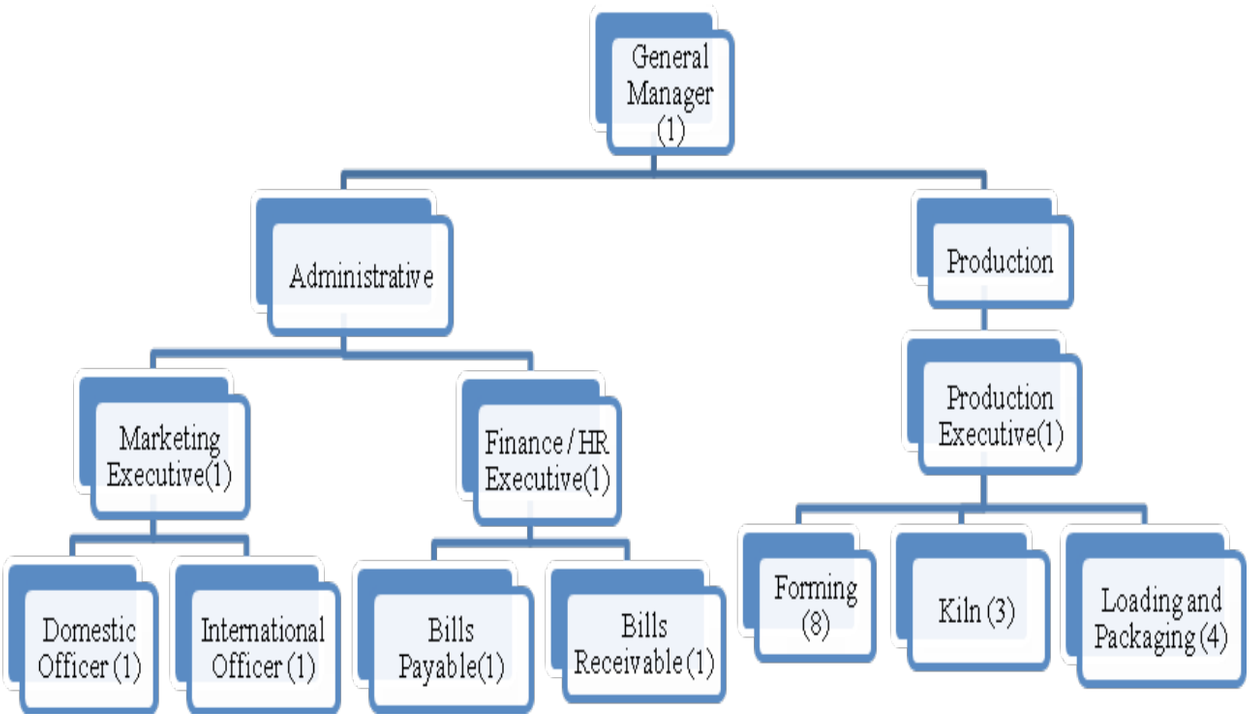
## 5.4 Raw Materials Requirement

To enhance quality and productivity of bamboo charcoal, the bamboo culms must be matured (growing over 4 years) and fresh. Punk culms can't be used as raw material because the bamboo charcoal made from punk culms is loose and brittle and apt to self-ignite. Moreover, the density, cavity structure and tissue composition of bamboo culms are different from bottom portion to tip. Meanwhile, the quality of bamboo is influenced by its age, land and soil condition, and climate. So it is reasonable to divide the culms into three parts (the upper, the middle and the lower) for processing. If possible, the culms may be divided with the consideration of age and soil conditions. There are abundant nutrient substances in bamboo, so it is apt to be moldy. Therefore the storage time of bamboo materials should be strictly controlled, especially in summer. The newly cut bamboo culms should be processed and dried rapidly and loaded into kiln as soon as possible to protect their quality. The moisture of bamboo influence bamboo production. The drying period of bamboo pyrolysis will prolong if the moisture content is too high, and as a result, the carbonizing process will extend with more fuel consumption. On the other hand, the bamboo culms are easy to cause cracks because of not being heated uniformly in the kiln when drying rapidly, and this degrades bamboo charcoal. Natural dry and manual dry are usually adopted. In small plants, the natural or air dry is popular, e.g. place bamboo culms on the bases and let them air dry in a certain time to the moisture content of 15% to 20%

## 5.5 Manpower Requirement and Organization Chart

The plant requires both production workers and administrative personnel. The plant should have a strength of 23 in all out of which eight persons would be engaged in administrative work and the rest in production. An organization chart is given below:

**Chart 3: Organization Chart**




For mechanical kiln number of hands would be lower by 50%

## 5.6 Specification of the Product with the Byproduct

**Bamboo Charcoal:** Bamboo Charcoal is made up of pieces of bamboo, which are taken from plants five years or older and burned inside an oven at temperatures over 120□ to 850°C. It benefits environmental protection by reducing pollutant residue.

It is an environmentally functional material that has excellent absorption properties.

**Figure 9: Bamboo Charcoal**

**Bamboo Vinegar:** A liquid byproduct is extracted through the carbonization process which is one of the most pure substances for both healing and sanitizing. This is known as vinegar as it contains similar level of acetic acid as normal vinegar.

The main difference between real vinegar and bamboo vinegar is that the latter contains far more organic compounds because it goes through little or no filtration.

**Figure 10: Bamboo Vinegar**

The end result is a therapeutic and cleansing agent that works for body and home.

**Use of Bamboo Vinegar**

- It's medicinal: Our bodies absorb toxins everyday but don't release them easily. Nutrients in bamboo vinegar aid this process. Also, rubbing bamboo vinegar on inflammations and rashes provides much needed relief because it has anti-inflammatory and anti-fungal properties.

- It deodorizes: The acetic acid found in bamboo vinegar gives it the ability to kill unwanted odors quickly. In other words it's a natural way to keep you smelling respectable throughout the day without putting undesirable chemicals on skin.

- Its skin friendly: Bamboo vinegar is an ingredient in many cosmetics and personal care products because it softens skin and dry or damaged hair. It is applied either directly or by pouring it into a tub of water when taking a bath.

- Bamboo vinegar's acidic nature also makes it ideal for household cleaning in the following ways:

- It Refreshes: Bamboo vinegar acts as a deodorizer for the bathroom, kitchen and elsewhere in the home.

- It disinfects: After being slightly diluted in a spray bottle it makes an excellent choice for sanitizing and cleaning tough spots including stains from leaky dirty diapers, rotting garbage bag spills, and even pet cages.

- It repels: Insects have a strong sense of smell and detest scents from herbs like mint, citronella, and lavender. Bamboo vinegar falls into the same category and makes a useful tool for keeping pests at bay.

## 5.7 Extent of Technical Assistance Needed Including Training

Though bamboo charcoal making does not need much more technical knowledge, knowledge in some specific areas are needed like controlling the temperature of the kiln, operating the kiln, putting the bamboo properly inside the kiln, closing the door of the kiln, timely releasing the charcoal and the like. Knowledge on safety measures is also needed. For that purpose, workshops by the producer may be arranged. On the job training may also be given.

# 6.0 PLANT LOCATION & INFRASTRUCTURE

The location recommended for setting up the plant are based on the following considerations

- Proximity to raw materials

**Bamboo:**

As per FAO Report on Non Wood Forest Products of Bhutan, the following dzongkhags grow bamboos significantly. These are Thimpu, Paro, Samdrup Jongkhar, Pemagatshel, Sarpang, Samtse and Zhemgang. Seeing the potential for growing bamboos in the Southern and Eastern part of the country, CFC (Common Fund for Commodities) in 2012 had launched a project for Bamboo development in four dzongkhags – namely Samtse, Samdrup Jongkhar, Tsirang and Samtse Dzongkhags.

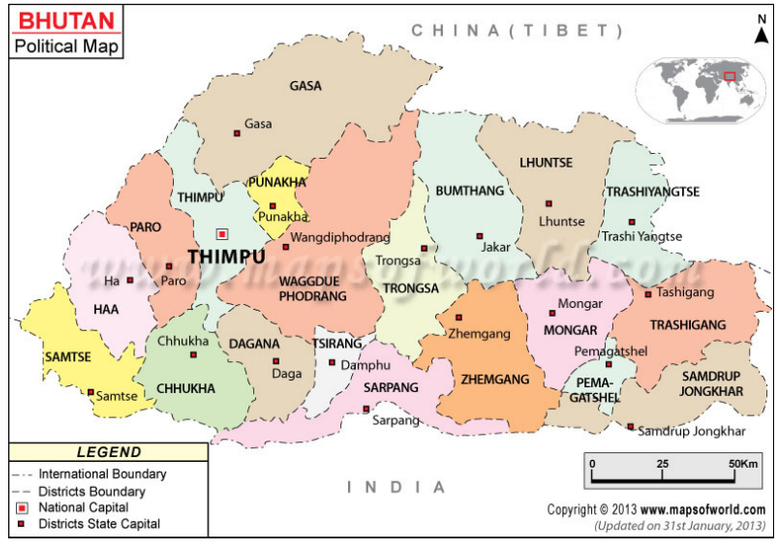



**Figure 11: Map of Bhutan**

**Firewood:**

The following table gives a distribution of forestland dzongkhag wise. It may be noted that the Southeastern part comprising of Samdrup Jongkar, Trashigang, Mongar and Zhemgang have thick forest.

**Table 31: Forest cover dzongkhag wise**

| Dzongkhags | Forest Area | Total Area |
|---|---|---|
| Bumthang | 134.62 | 271.48 |
| Chhukha | 152.90 | 180.24 |
| Dagane | 110.29 | 138.89 |
| Gasa | 82.48 | 441.25 |
| Ha | 106.18 | 171.17 |
| Lhuentse | 174.48 | 288.85 |
| Mongar | 168.48 | 194.73 |
| Paro | 75.55 | 128.60 |
| Pemogats | 27.48 | 51.78 |
| Punakha | 81.95 | 97.50 |
| S.Jongkhar | 175.32 | 230.84 |
| Samtse | 124.02 | 158.81 |
| Sarpang | 187.92 | 230.42 |

| | | |
|---|---|---|
| T.Yangtse | 97.36 | 143.81 |
| Thimpu | 88.30 | 190.94 |
| Trashigang | 149.63 | 228.27 |
| Trongsa | 140.27 | 180.73 |
| Tsirang | 48.29 | 63.88 |
| Wangdue | 265.89 | 406.44 |
| Zhemgang | 182.15 | 212.55 |
| | **2,573.57** | **4,011.16** |

Samdrup Jongkhar Dzongkhag is situated in the southeastern part of Bhutan, sharing its western border with Pemagatshel Dzongkhag and northern border with Trashigang Dzongkhag. The Indian states of Assam and Arunachal Pradesh are in the south and east respectively. A broad leaf subtropical evergreen forest covers roughly 85% of the land area. *(Source:* http://www.samdrupjongkhar.gov.bt/).

Motanga in Samdrup Jongkhar dzongkhag, where an industrial estate is to be established, is recommended as the ideal location for the establishment of the bamboo charcoal plant. The RGOB has proposed a work plan to establish an industrial estate with 145.5 acres of land in Motanga. The site is located at about 7 km to the east of Samdrup Jongkhar town and falls under Dewathang Gewog. Currently, there are two existing industries – viz., one ferro silicon factory and one plaster of paris factory. The unit can sell charcoal to this ferro silicon factory. The dzongkhag also has a centralized location through which the unit can connect to every dzongkhags.

**Table 8: Distance to Other Dzongkhags from Samdrup Jongkhar**

| S. No. | From | To | Distance (Km.) |
|---|---|---|---|
| 1 | Samdrup Jongkhar | Thimphu | 731 |
| 2 | Samdrup Jongkhar | Trashigang | 180 |
| 3 | Samdrup Jongkhar | Pemagatshel | 100 |
| 4 | Samdrup Jongkhar | Mongar | 271 |
| 5 | Samdrup Jongkhar | Lhuentse | 346 |
| 6 | Samdrup Jongkhar | Gelephu | 248 |
| 7 | Samdrup Jongkhar | Phuentsholing | 370 |

## 6.1 Raw Material Availability

Bamboo grows naturally in Bhutan. Species wise distribution of bamboo in Samdrup Jongkhar is presented in the following table:

**Table 9: Distribution of Bamboo in Samdrup Dzongkhag**

| Botanical name | Local name | Distribution |
|---|---|---|
| *Arundinaria* spp. | Maling bans | Diafam/Samdrup Jongkhar<br>Bhangtar/Samdrup Jongkhar<br>Nganglam/Samdrup Jongkhar<br>Deothang/Samdrup Jongkhar |
| *Bambusa* spp. | Bhalu bans | Samdrup Jongkhar |

## 6.2 Availability of Electricity

Electricity supply to the Dzongkhag is from Kurichu Hydro power project. The coverage is fairly good as shown below (as on 2005).

**Table 10: Availability of electricity**

| S. No. | Details | Nos. |
|---|---|---|
| 1 | Towns Electrified | 4 |
| 2 | Villages Electrified | 30 |

(*Source:* Dzongkhag wise Inventory of Resources, Bhutan, 2006)

As of 2013, Bhutan has 5,021.27 km & 104.41 km of overhead and underground high-tension lines respectively. (*Source:* Statistical Yearbook of Bhutan, 2014)

## 6.3 Topography, Hydrology & Seismology Data Requirements

Topography, Hydrology & Seismology of the location must be checked before setting up the manufacturing plant.

**Topography:** Topography is a detailed map of the surface features of the land. It represents a particular area in detail, including everything natural and manmade- hills, valleys, roads or lakes.

An objective of topography is to determine the position of any feature or more generally any point in terms of both a horizontal coordinate system such as latitude, longitude, and altitude. Identifying (naming) features and recognizing

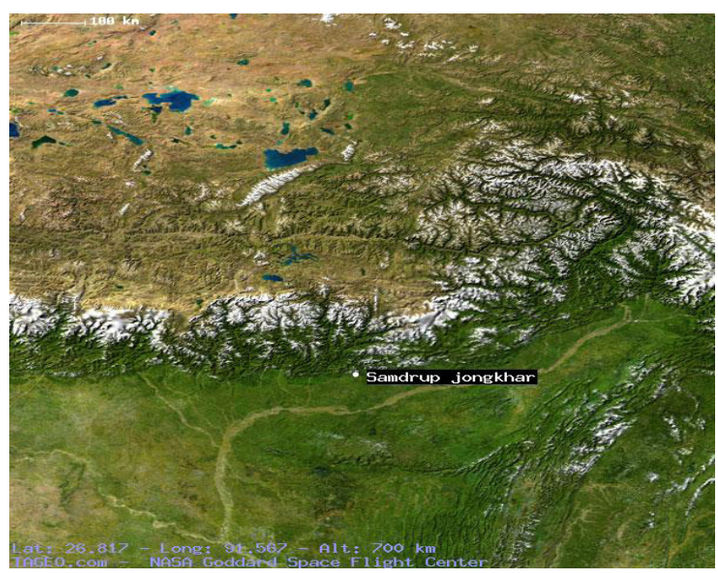



**Figure 12: Topography of Samdrup Jongkhar**

typical landform patterns are also part of the field. A topographic study may be made for detailed information about terrain (vertical & horizontal dimension of land surface) and surface features is essential for the planning and construction of any major civil engineering, public works, or reclamation projects.

**Hydrology:** Hydrology is the scientific study of the movement, distribution and quality of water on Earth including the hydrologic science, water resources and environmental watershed sustainability. Hydrology is subdivided into surface water hydrology, groundwater hydrology (hydrogeology), and marine hydrology.

Application of Hydrology

- Determining the water balance of a region.
- Determining the agricultural water balance.
- Mitigating and predicting flood, landslide and drought risk.
- Real-time flood forecasting and flood warning.
- Assessing the impacts of natural and anthropogenic environmental change on water resources.
- Assessing contaminant transport risk and establishing environmental policy guidelines.

**Seismology:** Seismology is the scientific study of earthquakes and the propagation of elastic waves through the Earth or through other planet-like bodies. The field also includes studies of earthquake environmental effects, such as tsunamis as well as diverse seismic sources such as volcanic, tectonic, oceanic, atmospheric, and artificial processes (such as explosions). Seismic waves are elastic waves that propagate in solid or fluid materials. They can be divided into body waves that travel through the interior of the materials; surface waves that travel along surfaces or interfaces between materials; and normal modes, a form of standing wave.

Seismological instruments can generate large amounts of data. Systems for processing such data include:

- CUSP (Caltech-USGS Seismic Processing)
- RadExPro seismic software
- SeisCom

## 6.4 Availability of Land

Major portions of the Dzongkhag fall within the sub-tropical belt with elevations ranging from 200 - 3,500 metres above sea level. The total area earmarked for Motanga SEZ development is 145.52 acres.

- Total wet land of the dzongkhag is 1,721 acres
- Total dry land is 21,499 acres and
- Tseri is 29,561acres

## 6.5 Availability of Transportation Facility

Due to lack of adequate road network, most places remain isolated and remote. Rugged terrain and scattered settlements make delivery of services difficult and costly. However, their are several initiatives to develop the transportation infrastructure.

The EDI (East Development Initiative) has identified and prioritized road infrastructure development for socio-economic development that would connect all the regional growth centers and industries.

The EDI report states that despite numerous gewog connectivity and farm roads being built in Eastern Bhutan, much still needs to be done especially in terms of its usability, long-term sustainability, maintenance and safety. Most roads are narrow with numerous hairpin bends and steep gradient. These roads can be used only during dry seasons. To solve this issue all gewog connectivity, roads will be taken over from Dzongkhags by Department of Roads for improvement and regular maintenance works.

The Government will explore the possibility of constructing link roads like connecting Lhuentse Dzongkhag to Trashiyangtse Dzongkhag without having to detour via Mongar. The other possibilities of linking Kangpara to Jomotsangkha, Gomdar & Wangphu to Martsala, etc. would be explored.

In addition to improving Yongphula airport and making it ready by 2015, the government will also explore the potential of more airports in the east.

The government will also prioritize the construction of Southern East-West highway. Of the 665 km distance except for the three missing stretches of coming to a total of 225 km roads connect all the others. The EDI states that the RGOB accords high priority for the completion of the 225 km stretch.

The government that the government will prioritize and complete the double laning of Samdrup Jongkhar – Trashigang highway and Construction of Gyalpoishing – Nganglam highway. (Source: The Bhutanese, 29th August, 2014)

## 6.6 Availability of Ancillary Units

Ancillary unit is an industrial unit which manufactures parts or intermediaries, or provides services. A large chunk of its production or services is used by another industrial taking. An ancillary unit is typically small - whose investment in fixed assets in plant and machinery, does not exceed Nu. 7.5 million. So, a bamboo orchard, a bamboo cutting unit nearby the plant could be an ancillary unit for bamboo charcoal unit.

## 6.7 Availability of housing, schooling and hospital facilities

**Housing**

Housing facilities in Samdrup Jongkhar are in demand but there is a fair degree of housing development activity that is taking place. As reported in the official newsletter of NHDCL (Volume II, Issue II), construction of three buildings with a total of 24 units of housing in Samdrup Jongkhar was planned for 2014.

The National Pension and Provident Fund has constructed around 7 buildings comprising 69 apartments and plans to add more as detailed in their annual report for 2013-14. Private builders are also active players in the region.

**Schooling:**

The comprehensive modern education system in Bhutan was introduced with the initiation of economic development plans in 1961. The monastic form of education however existed and continues even today. There are now extensive network of schools and other educational institutions spread throughout the country. The school-based education structure in Bhutan comprises of 11 years of free basic education from classes PP to X, divided into 7 years of primary education (PP-VI), which starts at the age of 6, and 4 years of secondary education (VII-X). Beyond the 10th standard students either continue their general education in classes XI and XII in higher secondary schools or join the vocational training institutes or enter the labour market. After completing class XII, graduates either continue their studies at the tertiary level under one of the institutes under the Royal University of Bhutan (RUB) for diploma or bachelor's degree, or on the job market.

Many schools provide boarding facilities for students living in areas far from the school with meals provided through the support of World Food Programme (WFP). The WFP also supports mid-day meals for day scholars who come from distant communities.

Samdrup Jongkhar has a total of 32 schools ranging from Extended Classroom to Higher Secondary Schools. The table below shows the number of schools in Samdrup Jongkhar:

**Table 11: Number of Schools, Institutes & Centres, Bhutan, 2012**

| S. No. | Type of School | No. |
|---|---|---|
| 1 | Extended Classroom | 7 |
| 2 | Primary School | 15 |
| 3 | Lower Secondary School | 4 |
| 4 | Middle Secondary School | 4 |
| 5 | Higher Secondary School | 2 |

(*Source:* Statistical Yearbook of Bhutan 2014)

**Hospital Facilities:**

Health Care is delivered in a totally integrated three-tiered system with National Referral Hospital at the apex, regional referral hospitals, district hospitals, and Basic Health Units (BHUs) at the

community Level. BHUs serve remote populace and are staffed by well-trained health personnel who are equipped to treat minor ailments and advice on preventive measures to avoid the spread of communicable diseases. Extended Health Centres such as Out Reach Clinics (ORCs) and Sub-posts support these BHUs. There are also numbers of special health programs in Bhutan administered by the Ministry of Health. These mainly cover Expanded Program on Immunization (EPI), Reproductive Health (RH), Acute Respiratory Infection (ARI) later upgraded to Integrated Management of Neonatal and Childhood Illness (IMNCI), National HIV/AIDS & STIs Control Program (NACP), National Tuberculosis Control Program (NTCP), National Leprosy Program, Rural Water Supply & Sanitation Program (RWSS), Village Health Workers Program (VHW), Vector Borne Disease Control Program (VDCP), Mental Health Program, among others.

**Table 12: Health Facilities**

| S. No. | Facility Type | No. |
|---|---|---|
| 1 | Hospital | 2 |
| 2 | BHUs | 15 |
| 3 | ORCs | 31 |

(*Source:* Statistical Yearbook of Bhutan, 2014)

## 6.8 Communication Facilities

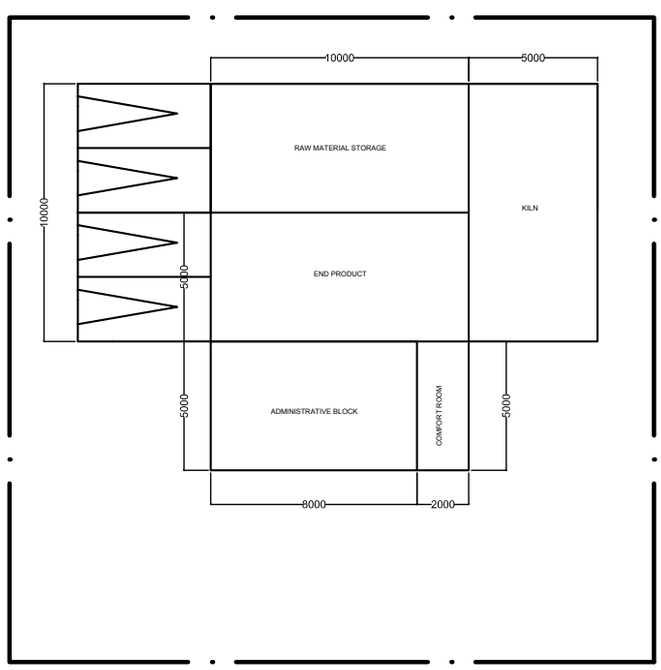
Bhutan Telecom Limited (BTL), Tashi InfoComm Limited (TICL), Samden Tech and Drukcom are the four Internet Service Providers (ISPs) in the country. Bhutan Telecom Limited is the sole provider of fixed-line telecommunication services while cellular mobile services are provided by B-Mobile (Bhutan Telecom Limited) and Tashi-Cell. With the exception of Bhutan Telecom, all other ISPs are private sector ventures.

## 6.9 Presence of approach road

Presence of approach road from and to the plant must be taken into consider before setting up the plant.


**Figure 13: A typical approach road to Samdrup Jongkhar**

## 6.9 Factory layout plan




BAMBOO CHARCOAL MANUFACTURING UNIT
TOTAL AREA : 625 SQM
BUILT-UP AREA: 400 SQM

# 7.0 ENVIRONMENTAL ASPECTS

Charcoal is one of the most environmentally unfriendly fuels; it is also a source of dangerous indoor pollution in developing countries. According to FAOSTAT about 45 million tones are produced world-wide every year. Of that, about a quarter is produced sustainably (from recycled wood) and cleanly (with filters and afterburners to reduce emissions of dangerous gases). The rest is produced in traditional kilns and mounds, using wood cut from rain forests, and with unchecked emissions spewed into the atmosphere.

Though bamboo charcoal has so many benefits the production of bamboo charcoal impacts negatively on the environment. The impact of charcoal production cuts across the physical and biological environment. i.e., it affects the living and the non-living parts of the environment or summarily the entire environment and its component. The production of charcoal mostly impacts on deforestation and air pollution. In almost all countries where charcoal is produced there have been reports highlighting concern about deforestation and forest degradation linked to charcoal production.

1. **Impact on Deforestation**

A huge amount of bamboo culms need to cut down every year for the industrial production of bamboo charcoal. In some cases bamboo is taken illegally from state land and producers are under pressure to harvest the wood to make the charcoal as fast as possible. Due to this reason those who are engaged in handicrafts and small-scale industries are lagging behind.

2. **Air Pollution**

Emissions during charcoal production are significant and contribute heavily to global climate change impact. Charcoal is produced via pyrolysis or thermal degradation of biomass, this result in formation of product of incomplete combustion such as $CH_4$ $CO_2$ alkanes, alkenes, oxygenated compound and particulate matter.

**Figure 14: Air Pollution due to the Production of Bamboo Charcoal**

3. **Effect on human health**

The effect of charcoal production on human health cut across the production cycle of bio char. The most deleterious impact emanate from the carbonization stage, which is the stage where most gaseous emission takes place. Long term Exposure of Human to gaseous emission during burning leads to respiratory problem and ultimately disease such as acute respiratory infection (ARI), Lung cancer, Otitis media (middle ear infection), low birth weight (Ezzati and kammen, 2002). Others include Asthma, cough, breathlessness, wheezing and difficulties to inhale or exhale, Hearing impairment, loss of hearing during sawing of wood with very high decibel of sawing machine

But there are some high technology kilns available in the market, which can reduce pollution to a great extent. Keeping in mind the benefits of bamboo charcoal the company can go for these high technology kilns.

This chapter covers the environment management aspects for the project. The degree of detail is based on the Reference Document, Environment Assessment Act, 2000 and the Regulation for the Environmental Clearance of Projects, 2002.

Reference has also been made to the Procedures for Project Review in the NEC guidelines and rules and regulations for establishment and operation of Industrial and commercial ventures in Bhutan, 1995. In accordance to these, for this project an Environment Assessment (EA) document including Environment Management Plan (EMP) and a monitoring plan shall be required. Since the impacts of the project are known, an Initial Environmental Evaluation is not required.

This report however includes characterization of environmental consequences due to various project activities, both during the construction phase as well as the operational phase and measures to mitigate them. The elaboration of these features shall meet the requirements of EA document. The environmental elements considered for this purpose are shown in the following table.

**Table 13 : Elements considered for environmental impacts**

| Sl # | Element | Sl # | Element | Sl # | Element |
|---|---|---|---|---|---|
| 1 | Land Use | 2 | Soil | 3 | Ecology |
| 4 | Subsidence and Landslide | 5 | Noise Quality and Ground Vibration | 6 | Vehicular Movement |
| 7 | Water Resources | 8 | Hydrology | 9 | Water Quality |
| 10 | Air Quality | 11 | Solid Waste | 12 | Human Settlement |
| 13 | Socio-economic Conditions | 14 | Aesthetics | 15 | Site of Cultural Heritage and Scenic Importance |

Mitigation measures based on the systems & practices foreseen in plant design, for addressing each environmental component has been described.

It is to be understood that this report meets the requirements of initial Environmental Information (EI), as per the prevalent norms in Bhutan.

**During Construction Phase**

**Table 14: Environmental impacts during construction phase**

| S. No. | Attributes | Problem Impacts Due to Plant |
|---|---|---|
| 1 | Land Use | Degradation in land values due to construction waste & construction silt runoff. |
| 2 | Soil | Loss of soil due to clearing, excavation, soil removal, road construction, etc. |
| 3 | Ecology | Encroachment in ecology; loss of flora and fauna. |
| 4 | Water Resources | Depletion of ground water resources, if used. |
| 5 | Water Quality | No effect of domestic waste, if a sewage treatment plant will be installed for the labour camp as well as the plant. |
| 6 | Air Quality | Fugitive emission and dust impair air quality. |
| 7 | Noise Quality | Increase in noise levels. |
| 8 | Vehicular Movement | Traffic congestion/accidents and adverse effects on air quality & noise levels |
| 9 | Solid waste | Increased excavated soil, debris, garbage, etc., at the construction site. |
| 10 | Aesthetics | Depreciation of environmental aesthetics by project structures. |
| 11 | Site of Cultural, Historical and Scenic Importance | Impact on the site of Cultural, Historical and Scenic Importance, if available |

**During Operation Phase**

**Table 15: Environmental impacts during operation phase**

| S. No. | Attributes | Due to Plant |
|---|---|---|
| 1 | Land Use | Area is industrial/agricultural land. |
| 2 | Soil | Positive impact due to horticulture and plantation. |
| 3 | Ecology | No major impact due to vegetation and plantation in the surrounding area. |
| 4 | Subsidence and Landslide Problems | No impact. |
| 5 | Water Resources | Depletion of water resources due to water withdrawal. |
| 6 | Water Quality | Discharge of sewage and storm water run-off may cause deterioration of water quality. |
| 7 | Air Quality | Increase in TSPM and RPM levels and impairment of ambient air quality. |
| 8 | Noise Quality | Increase in noise level in the surrounding area. |
| 9 | Vehicular Movement | Traffic congestion/accidents in conjunction with loss in air quality. |
| 10 | Solid Waste | Inappropriate disposal of garbage/ sewage could be hazardous. |
| 11 | Aesthetics | Loss in environ-aesthetics to some extent. |
| 12 | Site of Cultural, Historical and Scenic Importance | Impact on the site of Cultural, Historical and Scenic Importance, if available |
| 13 | Human Settlement | No impact as no relocation/resettlement required if industrial area. |
| 14 | Socio-Economic condition | Increased economic activities in the region resulting in additional jobs. Improvement in quality of life of people. |

**Environmental Management**

The mitigation measures including prevention and control for each environmental component have been delineated in the sub-sections that follow.

**During Construction Phase**

**Table 16: Mitigation measures during construction phase**

| S. No. | Attributes | Mitigation Measures Proposed at Plant |
|---|---|---|
| 1 | Land Use | Plantation and green belt development shall commence. |
| 2 | Ecology | Plantation and vegetation shall commence |
| 3 | Water Resources | Controlled use of water resources |
| 4 | Water Quality | Debris shall be isolated from waste water and disposed off separately. All waste shall be treated in septic tanks and ETP. |
| 5 | Air Quality | Regular water sprinkling at the construction site. Construction materials shall be totally covered during transportation. |
| 6 | Noise Quality | Use of silencers, noise isolators etc. in machines. Use of equipment, which keep noise levels within limits prescribed by regulatory agencies. |
| 7 | Solid Waste | Sewage treatment plant will be installed in the colony as well as at the plant. |
| 8 | Vehicular Movement | Proper metallic access road will be constructed upto the site. |
| 9 | Aesthetics | Construction activities commensurate with landscaping in the area. |

**During Operation Phase**

**Table 17: Mitigation Measures During Operation Phase**

| S. No. | Attributes | Mitigation Measures Proposed at Plant |
|---|---|---|
| 1 | Land Use | Development of green belt in and around the plant. |
| 2 | Soil | Tree plantation all around the plant. |
| 3 | Ecology | Development of green belt in and around the plant. |
| 4 | Water Resources | There shall be a perpetual demand on water resources. There will not be any substantial requirement of water at the plant other than for sanitation and general cleaning purposes. The water requirement in the plant will have no adverse effect on the water source and the water required at the plant can be adequately met from the current allocation to the plant from the community. |
| 5 | Hydrology | The plant shall take into consideration the local geological, geomorphological and hydro-geological settings. |
| 6 | Water Quality | There will be substantive generation of waste water at the plant premises besides the use at the staff quarters for sanitation purposes. This waste water will be collected in septic tanks. |
| 7 | Air Quality | Provision of suitable bag filters for dust control. Provision of leak proof and properly covered transport equipment to prevent dust from being airborne. Adequate dust suppression and extraction facilities at material handling and transfer points. Provision of green belt around the plant. Provision of a well-equipped workshop for regular maintenance of vehicles in order to control emissions. |

| | | |
|---|---|---|
| 9 | Vehicular Movement | Provision of wide tar/concrete road. Provision of a well-equipped workshop for regular maintenance of vehicles in order to control emissions. |
| 10 | Solid Waste | No solid waste will be generated besides from the staff quarters. Proper disposal of the waste based on terrain, landscaping, drainage & aeration. Septic tanks will be constructed at the staff quarters. |
| 11 | Aesthetics | Landscaping and use of vegetation. |
| 12 | Human Settlement | Not applicable. |
| 13 | Socio-Economic Conditions | Maintaining good communication with local communities before, during and after construction. Training of local personnel for specific (skilled) positions. Welfare measures for local populace. |

**Solutions Adopted in the Technical Concept**

The guidelines for various industrial units stipulate "limiting values" for water quality, air quality and noise quality.

For the project, adequate pollution control equipment has to be considered. The general requirement and measures to be considered for arresting the pollutants is tabulated in the following table.

**Table 18 : Estimated release of pollutants**

| Sl # | General Requirement | | Measure Considered |
|---|---|---|---|
| 1 | Water Quality | | |
| A | For plant | | |
| | Treated Effluent discharges should have a pH in the range of 6-9. | | Sewage treatment plant of adequate capacity to control the pH and TSS. |
| 2 | Air Quality | | |
| A | For Plant | | |
| | The air quality should conform to the limiting values of SPM, limiting values of SPM, | | Bag Filters & modern burner with precise fuel dosing system should be considered for the air quality. |
| 3 | Noise Quality | | |
| | For Plant | | |
| | A maximum increase in background levels of 3 dB (A) or the following levels: | | The plant should be designed not to generate more than 60 dB (A) maximum. All high noise emitting machinery such as the roller mills will be enclosed in a housing (lined with a 2 inch glass wool) so as to minimize sound emissions outside the plant. The walls of the structure housing the machinery will be made of mud bricks to absorb the sound |
| | Residential | 55/45 dB (A) | |
| | Industrial | 75/70 dB (A) | |
| | Commercial | 65/55 dB (A) | |

Furthermore, the major change between the current plant and the proposed new grinding plant is that all material conveyance will be enclosed so that there will be no emission of dust in the atmosphere and spillage of materials will also be avoided. Bag filters and dust suppression systems will also be installed within the grinding plant to ensure that the dust emission into the atmosphere will be lesser than the prescribed minimum norms. The company targets to maintain a Suspended Particulate Matter (SPM) level of lesser than 50 $\mu g/m^3$ in the vicinity of the plant.

There will be no emission of toxic gases such as $SO_2$, $NO_X$, etc, as no furnaces will be used in the operation of the plant.

Within the plant premises, all open spaces will be blacktopped/ concreted to ensure minimal fugitive dust emissions arising from movement of machinery, vehicles and wind.

In addition to the above mitigation measures, the company will install sound and air quality monitoring equipment from vendors as advised by the National Environment Commission Secretariat to instill self monitoring and ensure that the minimum threshold values for these parameters are complied with at all times.

### Occupation Health and Safety

All workers in the plant will be provided with and shall be mandated to use protective gear and equipment to ensure their personal safety. Safety boots, gloves and other protective equipment will be provided by the company. Trainings on safety for all new recruits as well as refresher courses on safety for the regular staff will be conducted regularly from time to time in order to ensure that safety procedures are followed at all times.

A safety inspector shall be appointed (plant manager) and an OHS committee comprising of employees shall be formed to monitor and ensure compliance to safety norms and procedures.

# 8.0 PROJECT IMPLEMENTATION SCHEDULE

The key factors that would facilitate successful and timely project implementation are –

- Proper choice of technology and machinery suppliers.
- Adequate diligence in formulating the technical concept and system design.
- Proper choice of contractors for civil construction and erection of equipment.
- Formulation of an effective project team led by an experienced Project Manager.
- Establishment of an efficient system for project planning & monitoring including reporting procedures for progress review & co-ordination.

**Implementation Strategy**

Typically any project has four core dimensions, which are as follows –

- Engineering: this directly impacts the smooth operations of the plant over its entire life.
- Procurement: is critical on account of the impact that it has on investment and performance benchmarks and also in ensuring the choice of appropriate technology.
- Construction: is critical in terms of its impact on completion quality and the duration of the project phase.
- Project Management: other than its obvious impact on project timeliness it also contributes to risk minimization for the promoter.

**Implementation Schedule**

The project implementation will take 12 months out of which six months will be allotted for pre project activities. And the rest should be done within the next six months from the date the project is approved by the Ministry of Economic Affairs.

Pre-project Activities include:

1. Hydrological investigations for ensuring the availability of the requisite quantum of water.
2. Receipt of requisite clearances from competent authorities with respect to :
    - Environmental clearance
    - Sanction and supply of power
    - Sanction and supply of water
    - Tying up sources of funds for the project to achieve financial closure
    - Procurement of land

- Topographic & Seismologic survey for plant area

Floating tender inquiries, evaluation of order for main machinery

3. Site Preparation and Levelling of land

The table given below shows the project schedule:

**Table 19. A: Implementation Schedule**

| Sl.No. | Activity | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Site Preparation & Leveling of Land | | | | | | | | | | | | |
| 2 | Construction of factory shed & Civil Infrastructure | | | | | | | | | | | | |
| 3 | Hiring of People | | | | | | | | | | | | |
| 4 | Installation of Machineries | | | | | | | | | | | | |
| 5 | Hiring of more people | | | | | | | | | | | | |
| 6 | Training & Commissioning of People | | | | | | | | | | | | |
| 7 | Trial Production Runs | | | | | | | | | | | | |

**Table 19. B: Legend**

| Color Coding | |
|---|---|
| | Site Preparation |
| | Construction & Civil Infrastructure |
| | **Manpower Hiring** |
| | Installation of Machineries |
| | Hiring of more manpower |
| | Training & Commissioning |
| | Trial Production Runs |

# 9.0 COST PRESENTATION

The table given below shows the financials of the project.

**Table 20a: Project Financials**

| | |
|---|---|
| **Plant Capacity:** | 360 tons of Bamboo charcoal and 72 tons of Bamboo charcoal vinegar |
| **No. of Cycle:** | 12 ( 25 days a cycle) |
| **Working Days in Year:** | 300 |
| **D.S.C.R. :** | 3.06 |
| **B.E.P. :** | 9.91% |
| **IRR :** | 43.2% |
| **NPV :** | Nu 12.5 million |

## 9.1 Capital Cost

The total cost of the project is estimated at Nu. 9.11 million as per the particulars given in the following table

**Table 21: Cost of Project**

| S. No. | Particulars | Value (Nu. In Million) |
|---|---|---|
| 1 | Land 1,000 sq. meters (On lease) | |
| 2 | Building & Civil Construction | 3.25 |
| 3 | Plant and Machinery | 2.27 |
| 4 | Misc. Fixed Assets | 1.75 |
| 5 | Preliminary Expenses | 0.10 |
| 6 | Pre Operative Expenses | 0.82 |
| 7 | Margin Money for Working Capital | 0.19 |
| 8 | Contingencies 10% of Fixed Assets | 0.73 |
| **Total** | | **9.11** |

**Table 22: Means of Finance**

| S. No. | Particulars | Value (Nu. In Millions) |
|---|---|---|
| 1 | Promoters' Equity | 3.64 |
| 2 | Term loan from FIs | 5.47 |
| | **Total** | **9.11** |

The term loan has been arrived based on the breakup of individual investment item and bank's financing pattern as given in the table Term Loan Requirement

**Plant and Machinery**

The cost of plant & machinery is estimated at Nu. 2.27 million including installation and commissioning. The installed production capacity is 30 Ton per cycle. The cost estimates for plant & machinery have been worked out based on the cost figures available from budgetary offers and/or orders placed for similar items in the recent past, duly updated to cover the price escalation in the intervening period.

**Table 23: Estimated Fixed Investment Cost**

| Item | Quantity | Unit Price (Nu.) | Amount of Money (Nu. in Millions) | Remarks |
|---|---|---|---|---|
| Kiln Construction | 30 Units | 75,600 | 2.27 | Cost of equipment including auxiliary unit |
| **Total** | | | **2.27** | |

**Building and Civil Work**

Building & Civil Works: The cost is estimated at Nu 3.25 millions taking construction cost per square feet to be Nu 13,000/square meter – taking covered area to be 250 square meters.

The mechanical kilns need about 150 sq meter of additional covered space,

**Misc. Fixed Assets**

Nu 1.75 millions has been estimated under the heading of MFA. The details of electrical installations for power distribution have been considered commensurate with the power load and process control requirements. Other miscellaneous fixed assets including furniture, office machinery & equipment, equipment for water supply, laboratory, workshop, firefighting equipment, etc have been provided on a lump sum basis as per information available with the consultants for similar assets. The details of miscellaneous fixed assets and their associated costs are been shown in table below:

**Table 24: Misc. Fixed Assets**

| S. No. | Particulars | Qty. (No.s) | Rate (Nu. In Millions) | Amount (Nu. In Millions) |
|---|---|---|---|---|
| 1 | Office Equipment | - | | 0.10 |
| 2 | Furniture and Fixture | | | 0.30 |
| 3 | Electrical Accessories | | | 0.30 |
| 4 | Electrical cabling, ducting & earthing | | | 0.60 |

| | | | | |
|---|---|---|---|---|
| 5 | Computer System | | | 0.40 |
| 7 | Fire Fighting | 10 | 0.005 | 0.05 |
| | | | **Total** | **1.75** |

**Table 25: Preliminary Expenses**

| S.No. | Particulars | Estimation (Nu. In Millions) | Amount (Nu. In Millions) |
|---|---|---|---|
| 1 | Company Formation Expenses, Legal & Liaisoning | 0.1 | 0.1 |
| **Total** | | | **0.1** |

**Pre-Operative Expenses**

Expenses incurred prior to commencement of commercial production other than that incurred for company formation, legal and liasoning purposes are covered under this head that total Nu. 0.82 million . These are estimates based on experience in similar projects.

**Table 26: Pre-Operative Expenses**

| S. No. | Particulars | Estimation | Amount (Nu. In Millions) |
|---|---|---|---|
| 1 | Interest up to Production on Term Loan of 3.81 @13% p.a. | for 1 year on Term Loan | 0.71 |
| 2 | Insurance during Construction Period | 0.25% of Fixed Assets | 0.02 |
| 3 | Electricity Charges during Construction Period | | 0.01 |
| 4 | Marketing Launch Expenses | | 0.02 |
| 5 | Technology Know-how and Consultancy Fees | | 0.02 |
| 6 | Training Expenses | | 0.02 |
| 7 | Travelling Expenses | | 0.02 |
| **Total** | | | **0.82** |

It may be noted that the cost of Technical consultancy, training and travel for mechanical kilns would be in excess of ten times the corresponding costs for brink laid kilns.

## 9.2 Operating Cost

**Cost of Raw Material**

For producing one ton of charcoal - four tons of bamboo and 2 tons of firewood would be needed. Based on the processing capacity of 30 Ton per cycle considering 300 days in a year the annual raw material consumption would be 1440 Ton of bamboo and 720 ton of firewood. The cost for the same will be Nu.2160 x 3000 = 6,480,000 i.e. 6.48 million – taking an average cost of Rs. 3,000 per ton for both the raw material.

The price has been considered keeping in mind prevalent prices in Thimphu.

**Table 27: Raw Materials Requirement**

| S. No. | Particulars | Qty. (Ton) | Rate Per Ton (Nu) | Total Value (Nu in Millions) |
|---|---|---|---|---|
| 1 | Bamboo | 1440 | 3,000 | 4.32 |
| 2 | Firewood | 720 | 3,000 | 2.16 |
| | | | **Total** | **6.48** |

**Land Lease Charge**

Required land is 1,000 sq. meter (10764 sq. ft.), which has been considered on lease @ Nu.4.00 per sq. ft. per annum for first three years and @ Nu 6.00 per sq feet for the fourth year and subsequently @ 3% increase every year.

**Table 28: Land Lease Charges**

| S. No. | Year | Lease Rate Per Sq. Ft Per Year (Nu.) | Lease Charges Per Annum (Nu. In Millions) |
|---|---|---|---|
| 1 | 1st Year | 4.00 | 0.04 |
| 2 | 2nd Year | 4.00 | 0.04 |
| 3 | 3rd Year | 4.00 | 0.04 |
| 4 | 4th Year | 6.00 | 0.06 |
| 5 | 5th Year | 6.20 | 0.07 |
| 6 | 6th Year | 6.40 | 0.07 |
| 7 | 7th Year | 6.60 | 0.07 |
| 8 | 8th Year | 6.80 | 0.07 |
| 9 | 9th Year | 7.00 | 0.08 |
| 10 | 10th Year | 7.20 | 0.08 |

**Sales Realization**

It is assumed that 60% capacity utilization will be achieved during first year of operation, 70% in the second year and 80% from the third year onwards. The selling price is considered on the basis of the retail prices of these produce in the similar period.

**Table 29.A: Sales Realization**

| S. No. | Particulars | Production Per Annum (MT) | Rate Per Ton | Total Amount Per Annum (Nu. In Millions) |
|---|---|---|---|---|
| 1 | Bamboo charcoal | 360 | 56,700 | 20.41 |
| 2 | Bamboo charcoal vinegar | 72 | 46,612 | 3.36 |
| | | | Total | 23.77 |

**Table 29.B: Sales Realization**

| | Nu. in Millions |
|---|---|
| Total sales realization at 100% | 23.77 |
| First year 60% | 14.26 |
| Second Year 70 % | 16.64 |
| Third Year 80% | 19.01 |

**Salary and Wages**

Salaries & wages (including benefits) for different categories of employees have been considered based on present day expenses being incurred by other industries in the vicinity. Adequate adjustments have been considered for expatriates. The breakdown of manpower and incidence of salaries & wages are detailed in Table 30(Salary & wages) are increased @ 5% every year.

**Table 30: Salary and Wages**

| S. No. | Description | Requirement | Salary Per Annum (Nu in Millions) |
|---|---|---|---|
| A | Administration | | |
| 1 | General Manager | 1 | 0.47 |
| 2 | Marketing Executive | 1 | 0.26 |
| 3 | Production Executive | 1 | 0.26 |
| 4 | Finance / Admin Executive | 1 | 0.26 |
| 5 | Marketing Officer | 2 | 0.26 |
| 6 | Finance Executive | 2 | 0.26 |
| | | | 1.77 |
| B | Production | | |
| 1 | Labor | 15 | 1.08 |
| | | | 1.08 |
| | | | 2.87 |

**Electrical and Water Consumption Charges**

Power & water charges are increased @ 5% every year.

The electricity and water charges would be primarily on account of usage for office &personal purposes. A notional amount of Nu 100,000 per annum is assumed.

**Term Loan Requirement from Financial Institutions**

**Table 32: Term Loan Requirement**

| S. No. | Particulars | Amount (Nu. in Millions) | Promoters Contribution (Nu. in Millions) | Bank Loan (Nu. in Millions) |
|---|---|---|---|---|
| 1 | Land 1000 sq. meters | | | |
| 2 | Building and Civil Construction | 3.25 | | |
| 3 | Plant and machinery | 2.27 | | |
| 4 | Other Misc. & Fixed Assets | 1.75 | | |
| 5 | Preliminary Expenses | 0.1 | | |
| 6 | Pre-operative Expenses | 0.82 | | |
| 7 | Margin Money for Working Capital | 0.19 | | |
| 8 | Contingencies | 0.73 | | |
| | **Total** | **9.11** | **3.64** | **5.47** |

A debt equity ratio of 60:40 has been considered for the above calculation

**Working Capital Requirement**

Working capital requirements have been worked out in the following table:

**Table 33: Working Capital Requirement**

| S. No. | Particulars | Period | Margin | Amount (Nu. In Millions) | Promoters Contribution (Nu. In Millions) | Bank Loan (Nu. In Millions) |
|---|---|---|---|---|---|---|
| 1 | Raw Material | 15 days | 25% | 0.16 | 0.04 | 0.12 |
| 2 | Receivables | 15 days | 25% | 0.59 | 0.15 | 0.45 |
| **Total** | | | | **0.76** | **0.19** | **0.57** |

**Estimated Cost of Production & Profitability**

The profitability projections have been worked out for 10 years; at 60% capacity utilization during first year of operation, 70% in second year and 80% from third year onwards and following assumptions and basis as relevant and applicable to Bhutan have been considered while preparing the profitability.

- Repairs & maintenance have been taken as @4% p.a. on fixed assets.
- Bank interest rate has been calculated @13% p.a. on term loan & working capital loan.
- Insurance charges @0.25% on all assets in first year, then @5% decrease every year.
- Power charges are increased @5% every year.
- Administrative expenses have been increased @5% every year.
- Debt equity ratio has been taken to be 60:40 for term loan.
- Margin money on bank loan has been considered @25% on working capital
- Bank loan has been considered for repayment in 8 years with one year moratorium
- Preliminary exp. will be written off @10% every year in next 10 years.
- Pre operative exp. will be written off from II year @10% every year in next 10 years.
- Straight Line Depreciation has been charged taking useful life for buildings to be 30 years with a residual value of 10%; 7 years on other fixed assets and 6 years on machinery with no residual value.
- Insurance, lease rent & interest has been taken as fixed cost for calculating B.E.P.
- Income tax has been charged @30% every year as per Bhutan's tax rates.

# 10.0 FINANCIAL ANALYSIS

## 10.1 Profitability

**Table 34: Profitability**

| Heads | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RM | 3.89 | 4.54 | 5.18 | 5.18 | 5.18 | 5.18 | 5.18 | 5.18 | 5.18 | 5.18 |
| Utilities | 0.01 | 0.01 | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.13 | 0.13 | 0.14 |
| Salary | 2.87 | 3.01 | 3.16 | 3.32 | 3.49 | 3.66 | 3.85 | 4.04 | 4.24 | 4.45 |
| Fringe benefits | 0.43 | 0.45 | 0.47 | 0.50 | 0.52 | 0.55 | 0.58 | 0.61 | 0.64 | 0.67 |
| Insurance | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Repair & maintenance | 0.29 | 0.30 | 0.32 | 0.34 | 0.35 | 0.37 | 0.39 | 0.41 | 0.43 | 0.45 |
| Land Lease Rate | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| Other Admin expenses | 0.11 | 0.12 | 0.13 | 0.13 | 0.14 | 0.15 | 0.15 | 0.16 | 0.17 | 0.18 |
| Production Cost | 7.74 | 8.58 | 9.43 | 9.65 | 9.88 | 10.11 | 10.35 | 10.61 | 10.87 | 11.16 |
| Sales | 14.26 | 16.64 | 19.02 | 19.02 | 19.02 | 19.02 | 19.02 | 19.02 | 19.02 | 19.02 |
| S&D Cost | 2.14 | 2.50 | 2.85 | 2.85 | 2.85 | 2.85 | 2.85 | 2.85 | 2.85 | 2.85 |
| Cost of Sales | 9.88 | 11.08 | 12.28 | 12.51 | 12.73 | 12.96 | 13.20 | 13.46 | 13.73 | 14.01 |
| PBIDT | 4.38 | 5.56 | 6.74 | 6.51 | 6.29 | 6.06 | 5.81 | 5.56 | 5.29 | 5.01 |
| Interest on TL | 0.71 | 0.67 | 0.58 | 0.49 | 0.40 | 0.31 | 0.22 | 0.13 | 0.04 | 0 |
| Interest on Loan for WC | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Interest | 0.79 | 0.74 | 0.65 | 0.56 | 0.47 | 0.39 | 0.30 | 0.21 | 0.12 | 0.07 |
| Heads | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
| PBDT | 3.59 | 4.82 | 6.09 | 5.95 | 5.81 | 5.67 | 5.52 | 5.35 | 5.17 | 4.93 |
| Depreciation | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.42 | 0.10 | 0.10 | 0.10 |
| PAD | 2.88 | 4.11 | 5.37 | 5.23 | 5.10 | 4.96 | 5.10 | 5.25 | 5.07 | 4.84 |
| Write off POE | 0 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| Write off PE | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| PBT | 2.78 | 3.93 | 5.19 | 5.05 | 4.92 | 4.78 | 4.91 | 5.07 | 4.89 | 4.65 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Tax @ 30% | 0.83 | 1.18 | 1.56 | 1.52 | 1.48 | 1.43 | 1.47 | 1.52 | 1.47 | 1.40 |
| PAT | 1.95 | 2.75 | 3.63 | 3.54 | 3.44 | 3.34 | 3.44 | 3.55 | 3.42 | 3.26 |
| Accumulated Profit | 1.95 | 4.70 | 8.33 | 11.86 | 15.31 | 18.65 | 22.09 | 25.64 | 29.06 | 32.32 |

## 10.2 Calculation of Interest on Term Loan

**Table 35: Interest on Term Loan**

| Year | Opening Balance (Nu. in Millions) | Repayment ( Nu. in Millions) | Closing Balance (Nu. in Millions) | Interest (Nu. in Millions) |
|---|---|---|---|---|
| 1 | 5.47 | 0.00 | 5.47 | 0.71 |
| 2 | 5.47 | 0.68 | 4.79 | 0.67 |
| 3 | 4.79 | 0.68 | 4.10 | 0.58 |
| 4 | 4.10 | 0.68 | 3.42 | 0.49 |
| 5 | 3.42 | 0.68 | 2.74 | 0.40 |
| 6 | 2.74 | 0.68 | 2.05 | 0.31 |
| 7 | 2.05 | 0.68 | 1.37 | 0.22 |
| 8 | 1.37 | 0.68 | 0.68 | 0.13 |
| 9 | 0.68 | 0.68 | 0.00 | 0.04 |

## 10.3 DSCR Calculation

**Computation of Net Operating Income**

**Table 36: Net Operating Income**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| PAT | 1.95 | 2.75 | 3.63 | 3.54 | 3.44 | 3.34 | 3.44 | 3.55 | 3.42 | 3.26 |
| Dep | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.42 | 0.10 | 0.10 | 0.10 |
| Int | 0.79 | 0.74 | 0.65 | 0.56 | 0.47 | 0.39 | 0.30 | 0.21 | 0.12 | 0.07 |
| NOI | 3.45 | 4.20 | 5.00 | 4.81 | 4.63 | 4.44 | 4.16 | 3.85 | 3.64 | 3.43 |

**Computation of Debt Services**

**Table 37: Debt Services**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Repayment | 0.00 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | |
| Lease | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| Interest | 0.79 | 0.74 | 0.65 | 0.56 | 0.47 | 0.39 | 0.30 | 0.21 | 0.12 | 0.07 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DS | 0.83 | 1.46 | 1.37 | 1.30 | 1.22 | 1.13 | 1.04 | 0.95 | 17.76 | 13.23 |

**Computation of DSCR (Net Operating Income/Debt Services)**

**Table 38: DSCR**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| DSCR | 4.17 | 2.88 | 3.64 | 3.69 | 3.81 | 3.93 | 3.99 | 4.04 | 0.20 | 0.26 |

## 10.4 Break Even Point

**Table 39: Break Even Point**

| Calculation of B.E.P | 1st Year | 2nd Year | 3rd Year |
|---|---|---|---|
| Sales | 14.26 | 16.64 | 19.02 |
| Variable Cost | 9.82 | 11.02 | 12.22 |
| Fixed Cost | 0.85 | 0.80 | 0.71 |
| Break Even Point (B.E.P) | 11.42% | 9.96% | 8.36% |
| Average B.E.P | 9.91% | | |

**Note on unit Costing & Pricing**

**Table 39: Unit Costing and Pricing**

| Heads | Average % |
|---|---|
| Raw Material Costs | 27.28 |
| Sales & Distribution Costs | 15.00 |
| Overheads | 19.50 |
| Margin | 38.22 |
| **Total** | **100.00** |

## 10.5 NPR and ROI

**Table 40: NPR and RI**

| Ratio | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year |
|---|---|---|---|---|---|---|---|---|---|---|
| Net Profit Ratio | 1.22 | 1.83 | 2.42 | 2.35 | 2.29 | 2.22 | 2.29 | 2.36 | 2.28 | 2.17 |
| Return on Investment | 0.71 | 0.67 | 0.58 | 0.49 | 0.40 | 0.31 | 0.22 | 0.13 | 0.04 | 0 |

## 10.6 Cash Flow Statement (Nu. In Millions)

**Table 41: Cash Flow Statement**

| S. No. | Years | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Inflows | | | | | | | | | | | |
| 1.1 | Net Profit After Tax | 0.00 | 1.95 | 2.75 | 3.63 | 3.54 | 3.44 | 3.34 | 3.44 | 3.55 | 3.42 | 3.26 |
| 1.2 | Depreciation | 0 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.42 | 0.10 | 0.10 | 0.10 |
| 1.3 | Preliminary Expenses Write Off | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 1.4 | Pre Operative Expenses Write off | 0 | 0 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 |
| 1.5 | Total Cash Inflows | 0 | 2.76 | 4.03 | 4.92 | 4.82 | 4.73 | 4.63 | 4.43 | 4.22 | 4.09 | 3.92 |
| 2 | Outflows | | | | | | | | | | | |
| 2.1 | Investment in Fixed Assets | 7.27 | | | | | | | | | | |
| 2.2 | Investment in Working Capital | 0.19 | | | | | | | | | | |
| 2.3 | Interest on Term Loan and WC | | 0.79 | 0.74 | 0.65 | 0.56 | 0.47 | 0.39 | 0.30 | 0.21 | 0.12 | 0.07 |
| 2.4 | Total Outflows | 7.46 | 0.79 | 0.74 | 0.65 | 0.56 | 0.47 | 0.39 | 0.30 | 0.21 | 0.12 | 0.07 |
| 3 | NET CASHFLOW | -7.46 | 1.97 | 3.29 | 4.26 | 4.26 | 4.25 | 4.24 | 4.13 | 4.01 | 3.97 | 3.85 |
| 4 | Net Present Value | -7.46 | 1.75 | 2.58 | 2.96 | 2.61 | 2.31 | 2.04 | 1.76 | 1.51 | 1.32 | 1.13 |

Net Present Value (NPV) at 13% is Nu.12.5 million

IRR: 43.2%

**Project Viability: -** Internal Rate of Return of the project is 43.2%, which is much higher than the bank rate of 13%.Hence the project is financially viable. The NPV of the project is positive (Nu. 12.5 million) at the discount factor of 13% during the first 10 years of operation considered. This implies that the project generates sufficient funds to cover all its cost, including loan repayments and interest payments during the period.

For mechanical kiln based operations, the IRR is 19.27% and the NPV is 2.5

We can safely conclude that the project is continues to be viable with mechanical kilns.

The detailed financial workings for the mechanical kiln based operations are provided in the annexure.

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# ANNEXURE

**A. Project cost/Total Investment/Returns with mechanical kilns in lieu of brick laid ones**

**Table A1:Project Summary**

| | |
|---|---|
| **Plant Capacity:** | 300 tons of Bamboo charcoal |
| **No. of Cycles:** | 300 |
| **Working Days in Year:** | 300 |
| **D.S.C.R.:** | 1.82 |
| **B.E.P.:** | 14.09% |
| **IRR:** | 20.93% |
| **NPV:** | Nu 3.26 million |

## Capital Cost

**Cost of Project:**

The total cost of the project is estimated at Nu. 10.82 million as per the particulars given in the following table

**Table A2: Cost of Project**

| S. No. | Particulars | Value (Nu. In Million) |
|---|---|---|
| 1 | Land 1,000 sq. meters (On lease) | |
| 2 | Building & Civil Construction | 5.1 |
| 3 | Plant and Machinery | 1.2 |
| 4 | Misc. Fixed Assets | 1.75 |
| 5 | Preliminary Expenses | 0.10 |
| 6 | Pre Operative Expenses | 1.62 |
| 7 | Margin Money for Working Capital | 0.13 |
| 8 | Contingencies 10% of Fixed Assets | 0.82 |
| **Total** | | **10.82** |

**Table A3: Means of Finance**

| S. No. | Particulars | Value (Nu. In Millions) |
|---|---|---|
| 1 | Promoters' Equity | 4.33 |
| 2 | Term loan from FIs | 6.49 |
| | **Total** | **10.82** |

The term loan has been arrived based on the breakup of individual investment item and bank's financing pattern as given in the table Term Loan Requirement

**Plant and Machinery**

The cost of plant & machinery is estimated at Nu. 1.2 million including installation and commissioning. The installed production capacity is 0.5 Ton x 2 per cycle i.e. per day. The cost estimates for plant & machinery have been worked out based on the cost figures available from budgetary offers and/or orders placed for similar items in the recent past, duly updated to cover the price escalation in the intervening period.

**Table A4: Estimated Fixed Investment Cost**

| Item | Quantity | Unit Price (Nu.) | Amount of Money (Nu. in Millions) | Remarks |
|---|---|---|---|---|
| Mechanical kiln | 02 units | 6,00,000 | 1.2 | Zhengzhou Wanqi Mechanical Equipment Co Ltd<br>Model No. : THL 4<br>Output: 500kg/8hours<br>Carbonizing time:8hours<br>Carbonizing rate:99% |
| **Total** | | | **1.2** | |

**Building and Civil Work**

Building & Civil Works: The cost is estimated at Nu 5.2 millions taking construction cost per square feet to be Nu 13,000/square meter – taking covered area to be 400 square meters.

**Misc. Fixed Assets**

Nu 1.75 millions has been estimated under the heading of MFA. The details of electrical installations for power distribution have been considered commensurate with the power load and process control requirements. Other miscellaneous fixed assets including furniture, office machinery & equipment, equipment for water supply,

laboratory, workshop, firefighting equipment, etc have been provided on a lump sum basis as per information available with the consultants for similar assets. The details of miscellaneous fixed assets and their associated costs are been shown in table below:

**Table A5: Misc. Fixed Assets**

| S. No. | Particulars | Qty. (No.s) | Rate (Nu. In Millions) | Amount (Nu. In Millions) |
|---|---|---|---|---|
| 1 | Office Equipment | - | | 0.10 |
| 2 | Furniture and Fixture | | | 0.30 |
| 3 | Electrical Accessories | | | 0.30 |
| 4 | Electrical cabling, ducting & earthing | | | 0.60 |
| 5 | Computer System | | | 0.40 |
| 7 | Fire Fighting | | | 0.05 |
| | | | **Total** | **1.75** |

**Preliminary Expenses**

**Table A6: Preliminary Expenses**

| S.No. | Particulars | Estimation (Nu. In Millions) | Amount (Nu. In Millions) |
|---|---|---|---|
| 1 | Company Formation Expenses, Legal & Liaisoning | 0.1 | 0.1 |
| **Total** | | | **0.1** |

**Pre-Operative Expenses**

Expenses incurred prior to commencement of commercial production other than that incurred for company formation, legal and liasoning purposes are covered under this head that total Nu. 0.82 million. These are estimates based on experience in similar projects.

**Table A7: Pre-Operative Expenses**

| S. No. | Particulars | Estimation | Amount (Nu. In Millions) |
|---|---|---|---|
| 1 | Interest up to Production on Term Loan of 3.81 @13% p.a. | for 1 year on Term Loan | 0.71 |
| 2 | Insurance during Construction Period | 0.25% of Fixed Assets | 0.02 |
| 3 | Electricity Charges during Construction Period | | 0.01 |

| | | | |
|---|---|---|---|
| 4 | Marketing Launch Expenses | | 0.02 |
| 5 | Technology Know-how and Consultancy Fees | | 0.02 |
| 6 | Training Expenses | | 0.02 |
| 7 | Travelling Expenses | | 0.02 |
| **Total** | | | **0.82** |

It may be noted that the cost of Technical consultancy, training and travel for mechanical kilns would be in excess of ten times the corresponding costs for brink laid kilns.

## Operating Cost

**Cost of Raw Material**

For producing one ton of charcoal - four tons of bamboo would be needed. Based on the processing capacity of 300 tons in a year the annual raw material consumption would be 1200 Ton of bamboo. The cost for the same will be Nu.1200 x 3000 = Nu 3,600,000 i.e. 3.6 million – taking an average cost of Rs. 3,000 per ton for the raw material.

The price has been considered keeping in mind prevalent prices in Thimphu.

**Table A8: Raw Materials Requirement**

| S. No. | Particulars | Qty. (Ton) | Rate Per Ton (Nu) | Total Value (Nu in Millions) |
|---|---|---|---|---|
| 1 | Bamboo | 1200 | 3,000 | 3.6 |
| | | | Total | 3.6 |

**Land Lease Charge**

Required land is 1,000 sq. meter (10764 sq. ft.), which has been considered on lease @ Nu.4.00 per sq. ft. per annum for first three years and @ Nu 6.00 per sq feet for the fourth year and subsequently @ 3% increase every year.

**Table A9: Land Lease Charges**

| S. No. | Year | Lease Rate Per Sq. Ft Per Year (Nu.) | Lease Charges Per Annum (Nu. In Millions) |
|---|---|---|---|
| 1 | 1st Year | 4.00 | 0.04 |
| 2 | 2nd Year | 4.00 | 0.04 |

| | | | |
|---|---|---|---|
| 3 | 3rd Year | 4.00 | 0.04 |
| 4 | 4th Year | 6.00 | 0.06 |
| 5 | 5th Year | 6.20 | 0.07 |
| 6 | 6th Year | 6.40 | 0.07 |
| 7 | 7th Year | 6.60 | 0.07 |
| 8 | 8th Year | 6.80 | 0.07 |
| 9 | 9th Year | 7.00 | 0.08 |
| 10 | 10th Year | 7.20 | 0.08 |

**Sales Realization**

It is assumed that 60% capacity utilization will be achieved during first year of operation, 70% in the second year and 80% from the third year onwards. The selling price is considered on the basis of the retail prices of these produce in the similar period.

**Table A10.A: Sales Realization at 100% Capacity Utilization**

| S. No. | Particulars | Production Per Annum (MT) | Rate Per Ton | Total Amount Per Annum (Nu. In Millions) |
|---|---|---|---|---|
| 1 | Bamboo charcoal | 300 | 56,700 | 17.01 |
| | | | **Total** | **17.01** |

**Table A10.B: Sales Realization at reduced Capacity Utilization**

| | **Nu. in Millions** |
|---|---|
| Total sales realization at 100% | 17.01 |
| First year 60% | 10.21 |
| Second Year 70 % | 11.91 |
| Third Year 80% | 13.61 |

**Salary and Wages**

Salaries & wages (including benefits) for different categories of employees have been considered based on present day expenses being incurred by other industries in the vicinity. Adequate adjustments have been considered for expatriates. The breakdown of manpower and incidence of salaries & wages are detailed in Table 30(Salary & wages) are increased @ 5% every year.

**Table A11: Salary and Wages**

| S. No. | Description | Requirement | Salary Per Annum (Nu in Millions) |
|---|---|---|---|
| A | Administration | | |
| 1 | General Manager | 1 | 0.47 |
| 2 | Marketing Executive | 1 | 0.26 |

| | | | |
|---|---|---|---|
| 3 | Production Executive | 1 | 0.26 |
| 4 | Finance / Admin Executive | 1 | 0.26 |
| 5 | Marketing Officer | 2 | 0.26 |
| 6 | Finance Executive | 1 | 0.13 |
| | | | 1.64 |
| B | Production | | |
| 1 | Labor | 8 | 0.576 |
| | | | 0.576 |
| | | | 2.22 |

**Electrical and Water Consumption Charges**

Power & water charges are increased @ 5% every year.

The electricity and water charges would be primarily on account of usage for office &personal purposes. A notional amount of Nu 100,000 per annum is assumed.

**Table A12: Term Loan Requirement**

| S. No. | Particulars | Amount (Nu. in Millions) | Promoters Contribution (Nu. in Millions) | Bank Loan (Nu. in Millions) |
|---|---|---|---|---|
| 1 | Land 1000 sq. meters | | | |
| 2 | Building and Civil Construction | 5.2 | | |
| 3 | Plant and machinery | 1.2 | | |
| 4 | Other Misc. & Fixed Assets | 1.75 | | |
| 5 | Preliminary Expenses | 0.1 | | |
| 6 | Pre-operative Expenses | 1.62 | | |
| 7 | Margin Money for Working Capital | 0.13 | | |
| 8 | Contingencies | 0.73 | | |
| | **Total** | **10.82** | **4.33** | **6.49** |

A debt equity ratio of 60:40 has been considered for the above calculation

**Working Capital Requirement**

Working capital requirements have been worked out in the following table:

**Table A13: Working Capital Requirement**

| S. No. | Particulars | Period | Margin | Amount (Nu. In Millions) | Promoters Contribution (Nu. In Millions) | Bank Loan (Nu. In Millions) |
|---|---|---|---|---|---|---|
| 1 | Raw Material | 15 days | 25% | 0.09 | 0.02 | 0.07 |
| 2 | Receivables | 15 days | 25% | 0.43 | 0.11 | 0.32 |
| **Total** | | | | **0.76** | **0.19** | **0.57** |

**Estimated Cost of Production & Profitability**

The profitability projections have been worked out for 10 years; at 60% capacity utilization during first year of operation, 70% in second year and 80% from third year onwards and following assumptions and basis as relevant and applicable to Bhutan have been considered while preparing the profitability.

- Repairs & maintenance have been taken as @4% p.a. on fixed assets.
- Bank interest rate has been calculated @13% p.a. on term loan & working capital loan.
- Insurance charges @0.25% on all assets in first year, then @5% decrease every year.
- Power charges are increased @5% every year.
- Administrative expenses have been increased @5% every year.
- Debt equity ratio has been taken to be 60:40 for term loan.
- Margin money on bank loan has been considered @25% on working capital
- Bank loan has been considered for repayment in 8 years with one year moratorium
- Preliminary exp. will be written off @10% every year in next 10 years.
- Pre operative exp. will be written off from II year @10% every year in next 10 years.
- Straight Line Depreciation has been charged taking useful life for buildings to be 30 years with a residual value of 10%; 7 years on other fixed assets and 6 years on machinery with no residual value.
- Insurance, lease rent & interest has been taken as fixed cost for calculating B.E.P.
- Income tax has been charged @30% every year as per Bhutan's tax rates.

## B. Financial Analysis

**Profitability**

**Table B1: Profitability**

| Heads | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RM | 2.16 | 2.52 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 |
| Utilities | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 |
| Salary | 2.22 | 2.33 | 2.45 | 2.57 | 2.70 | 2.83 | 2.98 | 3.12 | 3.28 | 3.44 |
| Fringe benefits | 0.33 | 0.35 | 0.37 | 0.39 | 0.40 | 0.43 | 0.45 | 0.47 | 0.49 | 0.52 |
| Insurance | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Repair & maintenance | 0.33 | 0.34 | 0.36 | 0.38 | 0.40 | 0.42 | 0.44 | 0.46 | 0.48 | 0.51 |
| Land Lease Rate | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| Other Admin expenses | 0.09 | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.14 |
| Production Cost | 5.22 | 5.73 | 6.24 | 6.43 | 6.60 | 6.79 | 6.98 | 7.18 | 7.39 | 7.62 |
| Sales | 10.21 | 11.91 | 13.61 | 13.61 | 13.61 | 13.61 | 13.61 | 13.61 | 13.61 | 13.61 |
| S&D Cost | 1.53 | 1.79 | 2.04 | 2.04 | 2.04 | 2.04 | 2.04 | 2.04 | 2.04 | 2.04 |
| Cost of Sales | 6.75 | 7.51 | 8.28 | 8.47 | 8.64 | 8.83 | 9.02 | 9.22 | 9.43 | 9.66 |
| PBIDT | 3.46 | 4.39 | 5.32 | 5.14 | 4.96 | 4.78 | 4.59 | 4.39 | 4.17 | 3.95 |
| Interest on TL | 0.84 | 0.79 | 0.69 | 0.58 | 0.47 | 0.37 | 0.26 | 0.16 | 0.05 | 0 |
| Interest on Loan for WC | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Interest | 0.89 | 0.84 | 0.74 | 0.63 | 0.53 | 0.42 | 0.31 | 0.21 | 0.10 | 0.05 |
| PBDT | 2.56 | 3.55 | 4.59 | 4.51 | 4.44 | 4.36 | 4.27 | 4.18 | 4.07 | 3.90 |
| Depreciation | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| PAD | 2.51 | 3.50 | 4.54 | 4.46 | 4.39 | 4.31 | 4.22 | 4.13 | 4.02 | 3.85 |
| Write off POE | 0 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 |
| Write off PE | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| PBT | 2.41 | 2.68 | 3.72 | 3.64 | 3.57 | 3.49 | 3.40 | 3.31 | 3.20 | 3.03 |
| Tax @ 30% | 0.72 | 0.80 | 1.12 | 1.09 | 1.07 | 1.05 | 1.02 | 0.99 | 0.96 | 0.91 |
| PAT | 1.69 | 1.88 | 2.60 | 2.55 | 2.50 | 2.44 | 2.38 | 2.32 | 2.24 | 2.12 |
| Accumulated Profit | 1.69 | 3.57 | 6.17 | 8.72 | 11.21 | 13.66 | 16.04 | 18.36 | 20.60 | 22.72 |

**Calculation of Interest on Term Loan**

**Table B2: Interest on Term Loan**

| Year | Opening Balance (Nu. in Millions) | Repayment ( Nu. in Millions) | Closing Balance (Nu. in Millions) | Interest (Nu. in Millions) |
|---|---|---|---|---|
| 1 | 6.49 | 0.00 | 6.49 | 0.84 |
| 2 | 6.49 | 0.81 | 5.68 | 0.79 |
| 3 | 5.68 | 0.81 | 4.87 | 0.69 |
| 4 | 4.87 | 0.81 | 4.06 | 0.58 |
| 5 | 4.06 | 0.81 | 3.25 | 0.47 |
| 6 | 3.25 | 0.81 | 2.43 | 0.37 |
| 7 | 2.43 | 0.81 | 1.62 | 0.26 |
| 8 | 1.62 | 0.81 | 0.81 | 0.16 |
| 9 | 0.81 | 0.81 | 0.00 | 0.05 |

**DSCR Calculation**

**Computation of Net Operating Income**

**Table B3: Net Operating Income**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| PAT | 1.69 | 1.88 | 2.60 | 2.55 | 2.50 | 2.44 | 2.38 | 2.32 | 2.24 | 2.12 |
| Dep | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Int | 0.89 | 0.84 | 0.74 | 0.63 | 0.53 | 0.42 | 0.31 | 0.21 | 0.10 | 0.05 |
| NOI | 2.63 | 2.77 | 3.39 | 3.23 | 3.07 | 2.91 | 2.75 | 2.58 | 2.40 | 2.22 |

**Computation of Debt Services**

**Table B4: Debt Services**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Repayment | 0.00 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | |
| Lease | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| Interest | 0.89 | 0.84 | 0.74 | 0.63 | 0.53 | 0.42 | 0.31 | 0.21 | 0.10 | 0.05 |
| DS | 0.93 | 1.69 | 1.59 | 1.50 | 1.40 | 1.29 | 1.19 | 1.09 | 17.76 | 13.23 |

**Computation of DSCR (Net Operating Income/Debt Services)**

**Table B5: DSCR**

| | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|
| DSCR | 2.82 | 1.64 | 2.14 | 2.15 | 2.20 | 2.25 | 2.31 | 2.37 | 0.13 | 0.17 |

**Break Even Point**

**Table B6: Break Even Point**

| Calculation of B.E.P | 1st Year | 2nd Year | 3rd Year |
|---|---|---|---|
| Sales | 10.21 | 11.91 | 13.61 |
| Variable Cost | 6.69 | 7.45 | 8.23 |
| Fixed Cost | 0.95 | 0.90 | 0.79 |
| Break Even Point (B.E.P) | 16.29% | 14.16% | 11.81% |
| Average B.E.P | 14.09% | | |

**Note on unit Costing & Pricing**

**Table B7: Unit Costing and Pricing**

| Heads | Average % |
|---|---|
| Raw Material Costs | 21.16 |
| Sales & Distribution Costs | 15.00 |
| Overheads | 40.67 |
| Margin | 23.17 |
| Total | 100.00 |

**NPR and ROI**

**Table B8: NPR and RI**

| Ratio | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year |
|---|---|---|---|---|---|---|---|---|---|---|
| Net Profit Ratio | 16.54 | 15.77 | 19.12 | 18.72 | 18.36 | 17.96 | 17.51 | 17.02 | 16.47 | 15.59 |
| Return on Investment | 1.05 | 1.25 | 1.73 | 1.69 | 1.66 | 1.62 | 1.58 | 1.54 | 1.49 | 1.41 |

**Cash Flow Statement (Nu. In Millions)**

**Table B9: Cash Flow Statement**

| S. No. | Years | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Inflows | | | | | | | | | | | |
| 1.1 | Net Profit After Tax | 0.00 | 1.69 | 1.88 | 2.60 | 2.55 | 2.50 | 2.44 | 2.38 | 2.32 | 2.24 | 2.12 |
| 1.2 | Depreciation | 0 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.3 | Preliminary Expenses Write Off | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 1.4 | Pre Operative Expenses Write off | 0 | 0 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| 1.5 | Total Cash Inflows | 0 | 1.84 | 2.39 | 3.11 | 3.05 | 3.01 | 2.95 | 2.89 | 2.82 | 2.75 | 2.63 |
| 2 | Outflows | | | | | | | | | | | |
| 2.1 | Investment in Fixed Assets | 8.15 | | | | | | | | | | |
| 2.2 | Investment in Working Capital | 0.05 | | | | | | | | | | |
| 2.3 | Interest on Term Loan and WC | | 0.89 | 0.84 | 0.74 | 0.63 | 0.53 | 0.42 | 0.31 | 0.21 | 0.10 | 0.05 |
| 2.4 | Total Outflows | 8.20 | 0.89 | 0.84 | 0.74 | 0.63 | 0.53 | 0.42 | 0.31 | 0.21 | 0.10 | 0.05 |
| 3 | NET CASH-FLOW | -8.20 | 0.94 | 1.54 | 2.37 | 2.42 | 2.48 | 2.53 | 2.58 | 2.61 | 2.64 | 2.58 |
| 4 | Net Present Value | -8.20 | 0.84 | 1.21 | 1.64 | 1.49 | 1.35 | 1.22 | 1.10 | 0.98 | 0.88 | 0.76 |

Net Present Value (NPV) at 13% is Nu.3.26 million

IRR: 20.93%

**Project Viability: -** For mechanical kiln based operations, the IRR is 20.937% and the NPV is Nu 3.26 million . We can safely conclude that the project continues to be viable with mechanical kilns.