Project Report on

"Cultivation of Bamboo and its bioenergy production"

Submitted to:-

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1. INTRODUCTION

There are 1500 bamboo species in the world and more than 20 million hactor of bamboo forests and plantation. China is the country with the richest bamboo resource. More than 500 bamboo species grow in 20 provinces of China and cover 4.2 million ha land. Bamboo has been recognized as the fastest growing plant species in the world with very favorable characteristics for gasification and the synthesis of gasoline and diesel. Bamboo has a number of desirable fuel characteristics such as low ash content and alkali index. Its heating value is higher than most agricultural residues, grasses and straw. Besides bamboo has high biomass productivity, self-regeneration, sustainable basis and environmental friendly functions with over 5000 applications, this should be considered as the best amongst other known biomass resources. But, it is still not used extensively. This is world's largest grass and already known to us for its thematic uses like in construction work, furniture, utensils, fiber & paper. It has got huge potential to bring revolution as a bio-energy resource. Time has come to explore its usage as a renewable energy resource. But, it is not something newly explored; it is already tested but needs huge awareness buildup among the common people considering its importance as a biomass energy resource, environment protector and poverty alleviator. This is Bamboo. Although a non-wood plant it is called as tree.

The world market for bamboo is valued at US $ 10 billion of which China's share alone is to the tune of 50%. Market for bamboo is expected to reach about US $ 20 billion by 2015.

The size of the India bamboo industry is estimated to be about Rs. 6505 crores, which may grow to Rs. 26,000 crores by 2015.

National Mission on Bamboo Applications (NMBA) has been specially created by TIFAC to address the issue of value addition of these residues. One such application conceived by NMBA is distributed power generation through bamboo gasification and further value addition of the residues. Several project were made for gasifier applications in the North Eastern region of the country where large scale bamboo flowering are to occur.

The technology has been developed, tested and stabilised and is now available for large scale induction, suitable for application in the 25Kw to 1 Mw range.

2 .**BOTANY AND APPLICATION**

Botanically, bamboo is classified as under

KINGDOM: Plantae

PHYLUM (DIVISION): Magnoliophyta

CLASS: Liliopsida

SUBCLASS: Commelinidae

ORDER: Cyperales

FAMILY: Gramineae (Poaceae)

SUBFAMILY: Bambusoideae

TRIBE: Bambuseae

SUBTRIBE: bambusinae

Bamboo is the plant of family Gramineae (grass family), chiefly of warm or tropical and subtropical regions, where it is sometimes an extremely important component of the vegetation. It is most abundant in the monsoon area of East Asia. Bamboo can reach 30 m high and 30 cm diameter. The culms are round (rarely square), jointed, sometimes thorny, and hollow or solid with evergreen or deciduous leaves. Some types die after flowering and some do not flower in several decades. In many places bamboo is used as wood for construction work, furniture, utensils, fabric, paper, fuel, and innumerable small articles. Bamboo shoots are delicious vegetable, and some grains of some species are also utilized for food. The bamboo has long been used for decorative purposes, both in gardens and in art.

Bamboo can easily compete with the most effective wood species in terms of carbon sequestration capacities. It can play a significant role in linking climate change mitigation to sustainable economic development in the developing world. So, the Clean Development Mechanism (CDM) projects as per the Kyoto Protocol can be thought of in order to combat global warming.

It does not depend on quality, species, and maturity of bamboo. Bamboo is a renewable, flexible and versatile material. It grows in natural forests, and is cultivated in homesteads, groves and on private plantations (source: TIFAC)

A substantial number of villages in our country are still neither electrified nor these are energy secured. Still now, we have mostly used the conventional fossil fuels like coal, oil, etc but its limited storage and pollution friendly nature have forced us to look for alternatives. The situation is deteriorating in most of the developing countries. Bamboo has got potential to tide over this problem and ensure energy security.

The availability of sufficient quantity of biomass resource on sustainable basis has been the concern in most of the areas. The chosen biomass resource should not only be available but also be affordable as the project sustainability is concened. The uncultivable wasteland is not the problem in most cases; so, right type of tree should be selected for this. Short rotation forestry should be the choice. Some of the varieties of bamboo grow so fast that their cultivation can be considered as short rotation forestry. It can be processed for thematic uses and the unused part can be used for power generation along with other energy purposes. It can be harvested in 3-5 years versus 10-20 years for most softwood. Bamboo tolerates extremes of precipitation, from 30-250 inches of annual rainfall

Carbon credits may help in creation of jobs and wealth generation. Again, it can be start up fund for various bamboo related developmental projects. Unlike tree crop plantations which are facing criticism regarding an unclear pro-poor focus, bamboo is highly suitable for cultivation specifically for pro-poor development.

The annual biomass and carbon sink per hectare of many bamboo species are comparative to wood tree crops, such as eucalyptus or teak. It can sequestrate CO2 in the form of 12 T per hectare of plantation

3.Bamboo in Andrapradesh

Bamboo is estimated to occur over an area of 9,883 sq.kms. It is distributed extensively in the districts of Adilabad, Khammam, Mahabubnagar, East Godavari, West Godavari, Visakhapatnam and Kurnool. Small patches of bamboo forests are also found in Srikakulam, Warangal, Prakasham and Chittor districts.
The dominant species are Dendrocalamus strictus, Bambusa bambos and Dendrocalamus hamiltonii.

Bamboo areas in Andhra Pradesh (Coverage in square kilometers)
Source: Facts & Figures, 2001: AP Forest Department

	Bambusa spp.	Dendrocalamus strictus	Total	% of total bamboo area
Adilabad	-	2080.81	2080.81	21.1
East Godavari	457.00	3775.00	4232.00	42.8
Mahbubnagara	-	285.20	285.20	2.9
Nallamallaiu	190.00	1093.75	1283.75	13.0
Warangal	-	120.43	120.43	1.2
Kothagudem	68.07	497.33	565.40	5.7
Sheshachalam	41.12	136.21	177.33	1.8
Other areas	-	1137.65	1137.65	11.5
Total	**756.19**	**9126.38**	**9882.57**	**100.00**

Under a World Bank aided forestry project 70,536 hectares were treated for improving bamboo stocking. This included soil moisture conservation works, mounding at the base of clumps and enrichment planting. An important feature was the involvement of people through Vana Samrakshna Samithies (VSS); 110 VSSs were involved in bamboo stock improvement activities. The Forest Department has since initiated steps for extraction over an area of 6030 hectares, the benefits from which will be shared by Vana Samrakshna Samithies.

The growing stock of bamboo in the State is 3.8 million tonnes. About 2 lakh metric tonnes are removed annually of which around 1 lakh tonnes are supplied to the three paper mills in the State. 1 lakh tonnes are made available to domestic sectors and Burood societies.

Burood societies comprising of medharas (professional bamboo workers) are consumers of bamboo for making baskets, mats and other articles. As a welfare measure bamboo is

supplied to local artisans (through Burood societies) at concessional rates fixed by the Government each year. There are around 300 burood societies, with a membership of about 12,000 medharas.

4. CULTIVATION METHODOLOGY

- **SOIL AND MULCHING**

Most bamboos are happiest in a moderately acidic loamy soil. Under very heavy soil the organic material can be added. It can be dug into the soil where the bamboo is to be planted, but the easiest thing is to mulch very heavily and let the earthworms do the work. Spread 2 or more inches of mulch in the area around the bamboo, and where you want the bamboo to grow.

Bamboo is a forest plant and does best if a mulch is kept over the roots and rhizomes. It is best not to rake or sweep up the bamboo leaves from under the plant, as they keep the soil soft, and moist, and recycle silica and other natural chemicals necessary for the bamboo growth and development

- **Propagation**

There are various methods of propagating bamboo through seed and vegetative methods. The vegetative method is mainly through rhizome. Although, for early realization of income generation, rhizome as planting material is desirable, due to non availability of rhizome in large quantity for developing as high as 1000 hectare is a constraint. Therefore, seedlings are being used for commercial crop production.

However, the tissue culture saplings are best suited for large scale biomass production for bio energy purpose.

- **Variety**

Out of all bamboo species, *Bamboosa balcooa* found to be the best one for high energy production and variety by name Beema,an selection of the same could be recognized best performer under indian agro climatic condition. Beema, not only produces the high yield high (about 40tonnes an acre / year), its energy value at 4,000 Kcal is also high, at 80 per cent of coal energy value.

Beema along with excellent carbon sink, under well managed condition with drip and fertigation, the crop could be harvested in two years, unlike the normal crop which could be harvested only after 6-7 years.

- **Planting techniques**

Usually, the planting will be taken up with the on set of monsoon. Pits of 60 cm X 60 cm will be dug and the seedlings will be planted at a spacing of 5m x 4 m. The number of plants per acre is 200. A provision was made for casualty replacement in the second year to the extent of 20%.

However, for economic viability of the commercial project to obtained the maximum biomass, it is advisable to have the planting density of 1000 plants per acre by following the distance of 2m* 2m or 2.5m *1.5m.

- **Nutrition Management**

The application of fertilizer is most important during transplantation from nursery to main field. Bamboo is a heavy feeder and therefore, even a rich soil might become depleted after a few years if no fertilizer is added. The fertilizers although may be applied at any time in a year, it is preferred to apply after harvest and before irrigations. It should be noted that rhizomes continue to be active (growing) except in the coldest part of the year. It is therefore advisable to apply small quantities of fertilizers round the year than one/two large doses. Bamboo responds well to nitrogen and potassium which are found in compost, green manure, wood ash and chemical fertilizers. Lime is often applied to neutralize soil acidity.

- **Irrigation management**

Bamboo considered to grows under rain fed conditions. For successful commercial plantation it could be beneficial if irrigation is provided alteast twice or thrice in a month after monsoon.

- **Plant protection**

Bamboo is generally free from pest and diseases however, diseases such as rhizome rot, bamboo blister, shoot and clump borer, are observed sporadically. Timely application of systemic fungicides and pesticides will control the problems. The spray and drenching of carbendazim found to be better in controlling rhizome rot.

- **Weeding management**

Bamboo plantations receive more sun because of the relatively wide separation of the culms. Sunlight encourages the growth of weeds which consume nutrients intended for bamboo and shade the ground, lower the soil temperature and thus retard shoot emergence. Regular weeding during the 1st three years is necessary for vigorous growth of bamboo.

- **Pruning:**

Bamboo grows vigorously and many branches develop on the culms along with thorns. It is therefore necessary to prune undesirable branches to maintain healthy growth of the harvestable culms.

- **Intercropping pattern**

The gestation period in bamboo plantation is five years. During the first two to three years, it is possible to take up intercrops such as turmeric, ginger, chilli, ground nut, garlic etc.

- **Harvesting and Output**

The annual yield of a bamboo clump depends on the number of new culms produced each year. This in turn is related to the production of young leaves. Culms become mature after two to three years. To maximize shoot output some shoots must be left each year to develop into leafy young culms. It is reported that a bamboo clump on an average produces 10 culms in a year under good growing conditions. Considering a 30 year life cycle one clump may produce 300 culms on the whole.

Generally, harvesting performed from the fifth year onwards, however, for commercial production, harvesting will start from the sixth year. In the first year of harvest i.e**.,** sixth year, 6 culms per clump will be harvested followed by 7 culms in seventh year, 8 in eighth year and 9 culms per clump from ninth year onwards. The culms which are one or two years old are generally left for regeneration. Considering the average weight of culms as 10 kg, the yield in the first year of harvest would be 12 ton per acre which will stabilizes at 20 ton by ninth year with 200 plants population per acre. However, up to 30-40 ton biomass could be obtained under intensive cultivation by managing 1000 plants per acre

Given the large amounts of biomass that bamboo can produce it provides a very interesting source of bioenergy in the tropics. When grown as a commercial crop the biomass produced by bamboo can be considered as a renewable source of energy.

Under gasification in which a solid fuel is burnt at very high temperatures between 700 and 900°C in the presence of a gasification agent such as air. The energy present in the biomass is converted into a gaseous combustible, or chemical energy. Gas products are easier to handle, they can be used in combustion engines or gas turbines and combustion is clean and less polluting. The produced gas has a calorific value of 25-30% of natural gas and is a valuable source of bioenergy for a variety of purposes.

Bamboo Biomass and Gasification

Biomass gasification.

Gasification processes convert biomass into combustible gases that ideally contain all the energy originally present in the biomass. In practice, conversion efficiencies ranging from 60 percent to 90 percent are achieved. Gasification processes can be either direct (using air or oxygen to generate heat through exothermic reactions) or indirect (transferring heat to the reactor from the outside). The gas can be burned to produce industrial or residential heat, to run engines for mechanical or electrical power, or to make synthetic fuels.

Large scale applications of gasifiers include comprehensive versions of the small scale updraft and downdraft technologies, and fluidized bed technologies. The superior heat and mass transfer of fluidized beds leads to relatively uniform temperatures throughout the bed, better fuel moisture utilization, and faster rate of reaction, resulting in higher throughput capabilities.

Biomass criteria for gasification:

- Dried bamboo of any variety to maintain the moisture content of less than 20%.
- The bamboo of 2-3 inch length and 1-2 inch diameter. The sizing can be done either manually or by machine.
- The chopped bamboo is then used for gasification purpose

The requirements for the gasification units are a small proportion of the total availability. A 100 Kw gasifier would require only about 1000 ton per annum, the equivalent of a truckload every three days on the average.

An added advantage of gasification of bamboo is that 15% of the biomass would also be available as a by-product in the form of high grade charcoal. In the case of a 100 Kw gasifier, around 135 ton of charcoal would be available each year to meet local needs of fuel. It is clean, cheap & renewable source of energy.

One of the most important reasons why there is limited income earning opportunities in rural areas is lack of electricity or availability of quality electricity. Biomass gasification technology can not only generate power but also create employment in rural areas. This distributed power generation can cut down the limitations of centralized power generation. Biomass based distributed power generation has got huge potential to electrify the non-electrified villages.

Benefits of Bamboo biomass energy

A biomass fuel based power plant converts an existing waste stream to useful electrical energy.

- A biomass fuel based power plant uses a completely renewable fuel. Craven's energy output displaces generation from non-renewable fossil fuels that have limited reserves and are being rapidly depleted.
- A biomass fuel based power plant provides a completely domestic energy supply, reducing our dependence on foreign oil. Craven's annual production of 350,000 MWH is the equivalent of approximately one half million barrels of foreign oil.
- A biomass fuel based power plant utilizes a local fuel source, resulting in a boost to the local economy. Fossil fuels are not indigenous to North Carolina and result in a drain on the state's economy.
- A biomass fuel based power plant is completely dispatch able, i.e. output can be varied and matched with customer demand. Unlike other sources of renewable energy that are instantaneously dependent on natural forces.
- A biomass fuel based power plant diverts material from landfills, prolonging the life of these landfills.
- A biomass fuel based power plant has extremely low air emissions.
    - Sulfur dioxide emissions are insignificant since there is virtually no sulfur in wood. Due to the moisture content, biomass combust at a cooler temperature than fossil fuels, resulting in inherently lower nitrous oxide emissions. Although all combustion processes release carbon dioxide, biomass combustion has a neutral "carbon balance," since trees convert carbon dioxide to oxygen. In addition, decomposing wood emits carbon dioxide, as well as methane – a greenhouse gas 22 times worse than carbon dioxide.
- A biomass fuel based power plant can recycle the fly ash produced. At CCWE, it is recycled as an agricultural liming agent, providing

Another smart bioenergy concept has been developed by Ankur Scientific Energy Technologies Pvt. Ltd. (ASCENT), ASCENT is helping more than 100 villages build small-scale power plants to areas that lack electricity and is creating jobs with the launch of micro-enterprises.

The ASCENT plants use biomass gasification to provide power that costs up to 20 times less than realistic alternatives like solar power. None of the poor villagers could ever afford solar energy, but the bio-electricity is within their reach. To electrify the villages, ASCENT's biomass gasification plants use the abundant agricultural waste streams generated by the farmers themselves. Waste products from the conversion are returned to the soil.

The tests and analysis conducted by MITCON have shown that 1.2 kg of bamboo biomass can generate 1 kWh of electricity. Selection of bamboo as the biomass to generate power is ideal, as bamboo produces the maximum biomass per unit area and unit.

Economics of Bamboo cultivation for Biomass

Cost of the cultivation Per Acres (1000 Plants)

Sr.No.	Particulars	Amount (INR)

		Ist yr	IInd yr	IIIrd yr	IVth yr	Vth yr	VIth yr
1.	Land making and Pits Digging (1000No.) @ 5/- each	5000/-					
2.	TC Saplings @20/-	20000/-					
3.	Fertilizers and nutrition Rs6/- per plant yr	6000/-	5000/-	4000/-	3000/-	3000/-	3000/-
4.	Plant Protection	1000/-					
5.	Labour charges or soil Working ,pruning	1500/-	1000/-	1000/-	1000/-	1000/-	1000/-
6.	Drip installation charges	15000/-					
7.	Consultancy charges	3000/-	2500/-	2500/-	2500/-	2500/-	2500/-
8.	Miscellaneous	500/-	500/-	500/-	500/-	500/-	500/-
	Total expenditure	**52,000/-**	**9,000/-**	**8000/-**	**4500/-**	**4500/-**	**4500/-**

Returns per Acre

s.no.	Particulars	IIIrdyr	IVth yr	Vth yr	VIth yr	VII yr	VIII yr	IX yr
1.	No. of culms per clump	7	7	8	8	8	8	8
2.	Av.No. of culms Per acre	7000	8000	8000	8000	8000	8000	8000
3.	Av. weight per culms	5.00	7.00	7.00	8.00	8.00	8.00	8.00
4.	Av. biomass yield per acre (t)	35.00	43.00	56.00	64.00	64.00	64.00	64.00
5.	Av.sale price of Biomass Rs-2000/- Per ton	2000/-	2000/-	2000/-	2000/-	2000/-	2000/-	2000/-
6.	Gross returns	70000	86000	112000	128000	128000	128000	128000
7.	**Net Returns**	**18000**	**77000**	**107000**	**123000**	**123000**	**123000**	**123000**

AV.RETURNS FROM BAMBOO BIOMASS POWER PROJECT

1. Charcoal yield 1500t@2000/- 30.00lacs
2. Total carbon sequester value@Rs. 400/- CER 40.00lacs
3. Electricity/power generation4000000kwh@ 3.50/- 140.00lacs

Conclusion

In India, energy demand is expected to grow in line with industrial growth, but may not be the energy production, leaving a gap which provides opportunity for energy projects. With the electricity supply being erratic, captive power production shall be the answer for the industries requires uninterrupted power supply. Among the several options available for captive power production, biomass based power plants are the most environmental friendly.

Biomass is an important source of energy in tropical countries. Properly managed biomass energy plantations can be sustainable, environmentally advantageous, economically sound and generates substantial local employment. Biomass resources are potentially the world's largest renewable source.

Current trend indicates that biomass will continue to be an important source of energy and Govt. policies have been modified to support the production of biomass and utilization of biomass for energy.

Tropical countries enjoy favorable condition for growing biomass, however lack of information and implementation of technology in biomass production by energy plantation has restricted its growth. Use of conventional energy like oil, coal and electricity has introduced the problem of global warming. Biomass energy includes fuel, wood, charcoal and agriculture residues are renewable in nature and does not contribute to the problem of Global warming.

At present, managed bamboo plantations are not available due to lack of information and technology adoption in the field level. The common bamboo available is thorny and making it difficult to cultivate and harvest. The newer high yielding clones of bamboo developed are thorn less, fast growing, thick walled, non-flowering and responsive to field management practice. Due to lack of availability of such superior clones of bamboo and assured buy back arrangement and lack of awareness of the yield potential and economics, bamboo cultivation is not popular among farmers. Considering the future trend in agriculture, increase in labour cost and availability, plantations of bamboo would come up as alternative for many field crops.

In this framework bamboo provides a lot of opportunities. It is a hardy plant which a range of ecological advantages and as a material can be supplied in a sustainable way to different industries. The use of bamboo as raw material for industry or bioenergy is a completely different approach compared to high end uses such as handicrafts, utensils and bamboo parquet. But when introduced into Europe, it may or will have a serious socio-economic impact in agriculture.

- 1 MW Biomass based Gasification power project at Tiruvadanai Taluka of Ramanathapuram Dist. for Merit Biozone Limited, Chennai.
- 1 MW Biomass based based gasification power Project at Sattur Taluka of Viruthunagar Dist. for Jai Sakthi Biopower, Chennai.
- A renewable energy company focused on electricity, Renewable Natural Gas and liquids
- One of the most experienced development and management team in the renewable industry:
    - over 90 years in the energy and related industries
    - including over 4000 MW installed and/or managed and farming operations on 3 continents
    - developed & operated one of the largest biomass advanced gasification facilities in the world