

# Napier Grass Feasibility as a Feedstock for Producing CBG in India - A Case Study

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**Abstract:** *Napier grass, also known as Elephant Grass, has been an integral part of India's agricultural landscape for decades. This tropical grass species, scientifically known as *Pennisetum purpureum*, has a rich history in India, dating back to the early 20th century. Napier grass was first introduced in India by the British colonial authorities in the early 20th century. The grass was brought from Africa, where it was widely cultivated as a fodder crop for livestock. Initially, Napier grass was grown in small pockets in southern India, particularly in the states of Tamil Nadu and Kerala. To promote renewable energy and reduce dependence on fossil fuels, the Government of India has launched an initiative to produce biogas from Napier grass on a large scale. This move is expected to not only provide a sustainable source of energy but also create employment opportunities and promote rural development. The Government of India's initiative to promote large-scale production of biogas from Napier grass is a step in the right direction towards promoting renewable energy and reducing dependence on fossil fuels. While there are challenges that need to be addressed, the benefits of this initiative are expected to far outweigh the costs. Biogas production from Napier grass is a promising renewable energy technology that can help reduce greenhouse gas emissions and dependence on fossil fuels.*

**Keywords:** Napier grass, Compressed Bio Gas (CBG), Methane, India, Renewable Energy source, Digester, Anaerobic Digestion

## 1. Introduction

Napier grass (*Pennisetum purpureum*) is a tropical grass species that has been identified as a potential feedstock for biogas production. This study investigates the feasibility of using Napier grass as a feedstock for biogas production, with a focus on its biomass yield, biogas production potential, and economic viability. This grass grows up to 4-6 meters tall, with broad, flat leaf blades that are typically 30-60 cm long and 2-5 cm wide. The leaves are dark green in color and have a waxy texture.

One of the key characteristics of Napier grass is its high yield potential. Some varieties of Napier grass can produce up to 50-60 tons of mass per hectare per year, making it an attractive crop for farmers and livestock producers. Additionally, Napier grass is drought-tolerant and can thrive in areas with limited rainfall, making it an ideal crop for regions with water scarcity. It is also highly adaptable to different soil types, including acidic, alkaline, and saline soils.

The background of bio-gas production has been shaped by the evolution of renewable and sustainable energy sources in response to environmental concerns and the quest for cleaner fuel alternatives. The need for renewable energy sources has been emphasized by the detrimental environmental impact of traditional fossil fuels, particularly in terms of greenhouse gas emissions.

### Characteristics Of Napier Grass

Napier grass is a perennial grass species characterized by its robust and erect stem, growing up to 2-4 meters tall. Its leaves are long, flat, and linear, measuring 30-100 cm in length and 1-3 cm in width. The inflorescence is a panicle, 20-40 cm long, with numerous spikelets. Napier grass has a fast growth rate

and high biomass production, making it an ideal crop for energy production.

Physiologically, Napier grass has an extensive root system with a deep taproot and numerous lateral roots. It requires adequate moisture, with an annual rainfall of 1,000-2,000 mm, and can tolerate a wide range of temperatures, from 10°C to 40°C. In terms of chemical composition, Napier grass contains 6-12% crude protein, 25-35% crude fiber, 5-10% lignin, and 30-40% cellulose on a dry matter basis.



**Figure 1:** Napier Grass

Assuming a harvest interval of 60-90 days, Napier grass can be harvested around 4-6 times a year. This translates to a harvest cycle of:

- Every 60 days: 6 harvests per year
- Every 75 days: 4.8 harvests per year
- Every 90 days: 4 harvests per year

### Cultivation characteristic of Napier Grass

Napier grass has a fast growth rate, with some varieties growing up to 3-4 meters tall in just 6-8 weeks. This rapid growth rate makes it an ideal crop for livestock producers who require a consistent supply of high-quality fodder. Napier grass is also a nutritious feed for livestock, with high levels of protein, fiber, and other essential nutrients. It requires minimal inputs, such as fertilizers and pesticides, making it a low-cost crop to cultivate.

Napier grass is a perennial crop that can be harvested multiple times a year, depending on factors such as climate, soil quality, and farming practices.

- 1) In tropical regions with high rainfall and temperatures, Napier grass can be harvested 4-6 times a year, with a harvest interval of 60-90 days.
- 2) In subtropical regions with moderate rainfall and temperatures, Napier grass can be harvested 3-4 times a year, with a harvest interval of 90-120 days.
- 3) In temperate regions with low rainfall and temperatures, Napier grass can be harvested 2-3 times a year, with a harvest interval of 120-180 days.

### The cultivation of Napier grass

Can be done through two methods: the conventional method and the Thumbkiza method.

- 1) The conventional method involves planting Napier grass slips or seedlings in well-prepared soil. This method requires more labor and resources, but it provides better establishment and growth of the Napier grass. The process begins with soil preparation, where the soil is plowed and harrowed to create a smooth surface. Then, Napier grass slips or seedlings are established in a nursery, and once they reach a suitable size, they are transplanted into the field. The soil is then irrigated and mulched to retain moisture and suppress weeds.
- 2) Thumbkiza method is a more cost-effective and efficient way of cultivating Napier grass. This method involves planting Napier grass seeds directly in the field, eliminating the need for a nursery. The process begins with soil preparation, where the soil is plowed and harrowed to create a smooth surface. Then, Napier grass seeds are sown directly in the field, usually in rows 30-60 cm apart. The seeds are covered with a thin layer of soil to retain moisture and protect them from pests and diseases. Finally, the soil is irrigated and mulched to retain moisture and suppress weeds.

The Thumbkiza method has several advantages over the conventional method. It is more cost-effective, as it eliminates the need for a nursery, and it is faster and more efficient, as it eliminates the need for transplanting. Additionally, the Thumbkiza method promotes soil health by minimizing soil disturbance and preserving soil organic matter. However, the success of the Thumbkiza method depends on the quality of the Napier grass seeds used, and it requires proper soil preparation to ensure good germination and establishment of the Napier grass.

### About Napier Grass general trend:-

- 1) "single harvest" refers to the yield of biomass obtained from a single cutting or harvesting of the crop.
- 2) Harvesting can be done multiple times in a year.

- 3) Harvesting is done one the height of grass is around 1-2 meters.
- 4) Single harvest, therefore,
  - a) Low-yielding varieties: 60-90 tons per hectare
  - b) Medium-yielding varieties: 90-135 tons per hectare
  - c) High-yielding varieties: 135-180 tons per hectare

In terms of days, this means that Napier grass can be harvested every 60-90 days, which is equivalent to:

- 365 days / 6 harvests = 60.8 days per harvest
- 365 days / 4.8 harvests = 76 days per harvest
- 365 days / 4 harvests = 91.3 days per harvest

### Biogas Yield

- Studies have reported biogas yields ranging from 200-400 L/kg of Napier grass biomass (Kumar et al., 2018; Singh et al., 2020).
- The average biogas yield of 300 L/kg is a reasonable estimate based on these studies.



Figure 2: Cultivation of Grass

### Methane Content

- The methane content of biogas produced from Napier grass has been reported to be around 50-60% (Kumar et al., 2018; Singh et al., 2020).
- This range is consistent with the methane content of biogas produced from other biomass feedstocks.

### Biogas Production Rate

- The biogas production rate of 0.2-0.4 m<sup>3</sup>/t of Napier grass biomass per day is based on studies that have reported biogas production rates ranging from 0.1-0.5 m<sup>3</sup>/t of biomass per day (Kumar et al., 2018; Singh et al., 2020).
- The average biogas production rate of 0.3 m<sup>3</sup>/t of biomass per day is a reasonable estimate based on these studies.

### Biomass Yield

- The biomass yield of Napier grass can vary depending on factors such as climate, soil type, and irrigation.
- However, studies have reported average biomass yields ranging from 15-25 tons per hectare per year (Kumar et al., 2018; Singh et al., 2020).
- The assumed biomass yield of 20 tons per hectare per year is a reasonable estimate based on these studies.

### Total Biogas Production Capacity

- Based on the assumed biogas yield, methane content, biogas production rate, and biomass yield, the total biogas production capacity of Napier grass can be estimated.

- The estimated total biogas production capacity of 6,000-12,000 m<sup>3</sup> per hectare per year is based on these assumptions.

**Table 1:** Physical and chemical characteristics of feedstocks:

Variety	Super Napier Grass
Height of Grass	10 to 12 Feet
Yield/Acre/Year	200 ton
cellulose	35-39 %
xylene	19-23 %
lignin	15-19 %
Whether Condition	All
Retained on Field	Up to 8 years

### Cultivation Feasibility in India

The cultivation of Napier grass in India is a highly suitable and beneficial endeavor. The tropical climate and diverse soil types found in India provide an ideal environment for Napier grass to thrive. This grass species can grow well in a wide range of soils, including acidic, alkaline, and saline soils, which are common in India. Napier grass requires adequate rainfall, and India's diverse regions receive varying amounts of rainfall, making it suitable for cultivation in many areas. Irrigation facilities are also well-developed in India, ensuring a steady water supply for Napier grass cultivation.

**Figure 3:** Bio gas Plant Running on Napier Grass

The demand for Napier grass in India is also significant, driven primarily by the livestock sector. As a popular forage crop, Napier grass is in high demand among dairy farmers and livestock rearers. Furthermore, the Indian government is actively promoting the use of biofuels and biogas, and Napier grass can be used as a feedstock for these industries. This presents a lucrative opportunity for farmers to cultivate Napier grass for biofuel and biogas production. The government also provides subsidies and incentives to farmers to encourage the cultivation of non-food crops like Napier grass.

### Grass as Fodder and Bio Gas Production

The use of Napier grass for biogas production can have both positive and negative effects on its use as fodder. On the positive side, utilizing Napier grass for biogas production can increase its availability as a fodder crop. By generating additional income from biogas production, farmers can maintain a stable livestock population, ensuring year-round availability of fodder. Moreover, the biogas production process can improve the quality of Napier grass as fodder by reducing its lignin content, making it more palatable and nutritious for livestock.

However, diverting Napier grass for biogas production can also reduce its quantity available for fodder, potentially impacting livestock nutrition and productivity. The anaerobic digestion process used in biogas production can alter the nutritional content of Napier grass, affecting its value as fodder. Furthermore, the cost of Napier grass may increase if it is diverted for biogas production, making it less competitive as a fodder crop.

**Figure 4:** Biogas Plant**Table 2:** Energy Production Method

Biogas Production from Napier Grass Juice	Biomass Energy from Dried Napier Grass
1. Juice Extraction: Napier grass is harvested and the juice is extracted through a pressing or crushing process.	1. Drying: The solid residue left after juice extraction is dried to a moisture content of around 10-20%.
2. Pre-treatment: The extracted juice may undergo pre-treatment processes such as filtration, pasteurization, or acidification to improve its quality and suitability for biogas production.	2. Pelletization or Briquetting: The dried biomass can be compressed into pellets or briquettes to increase its energy density and facilitate handling and transportation.
3. Anaerobic Digestion: The pre-treated juice is fed into an anaerobic digester, where microorganisms break down the organic matter into biogas (primarily methane and carbon dioxide).	3. Combustion: The dried and pelletized/briquetted biomass is burned in a combustion chamber to produce heat or electricity.
4. Biogas Collection and Purification: The biogas is collected and purified to remove impurities such as hydrogen sulfide, water vapor, and carbon dioxide.	4. Energy Generation: The heat or electricity generated from the combustion of Napier grass biomass can be used for various applications such as power generation, industrial processes, or heating.
5. Energy Generation: The purified biogas can be used as a renewable energy source for power generation, cooking, or transportation.	

### Production of Bio Gas from Napier Grass

The production of biogas from Napier grass involves a multi-step process that begins with the collection and preparation of the grass. Napier grass is typically harvested when it reaches maturity, usually after 60-90 days of growth.

- The harvested grass is then chopped into smaller pieces to increase its surface area, making it easier for microorganisms to break down the complex organic matter.
- The chopped Napier grass is then mixed with water to create a slurry, which helps to facilitate the anaerobic digestion process.
- The Napier grass slurry is then loaded into a digester tank, where it undergoes anaerobic digestion. In the absence of oxygen, microorganisms such as bacteria and archaea break down the complex organic matter in the Napier grass



into simpler compounds like volatile fatty acids, carbon dioxide, and hydrogen. Methanogenic microorganisms then convert these compounds into methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>), which form a biogas mixture. This biogas mixture is primarily composed of methane (50-60%) and carbon dioxide (30-40%).

- d) As the biogas is produced, it is collected from the digester tank and stored in a gas holder or storage tank.
- e) The biogas may then be purified to remove impurities like hydrogen sulfide, moisture, and carbon dioxide.
- f) The purified biogas can be used as a renewable energy source for various applications, including cooking, lighting, heating, and generating electricity.

The entire process, from harvesting Napier grass to biogas production, can take around 30-60 days, depending on factors like temperature, pH, and microbial activity.

#### Comparison of the cultivation of Napier grass in various states of India

Climate and Soil Suitability	Water Availability	Market Demand	Government Support
<u>Tamil Nadu:</u> Suitable for Napier grass cultivation due to its tropical climate and well-drained soils.	<u>Punjab:</u> Has a well-developed irrigation system, making it suitable for Napier grass cultivation.	<u>Andhra Pradesh:</u> Has a high demand for Napier grass as a forage crop for dairy farming.	<u>Madhya Pradesh:</u> Provides subsidies and incentives for farmers to cultivate Napier grass.
<u>Maharashtra:</u> Has a diverse climate, with some regions suitable for Napier grass cultivation, while others may require irrigation.	<u>Haryana:</u> Also has a well-developed irrigation system, making it suitable for Napier grass cultivation.	<u>Telangana:</u> Also has a high demand for Napier grass as a forage crop for dairy farming.	<u>Chhattisgarh:</u> Also provides subsidies and incentives for farmers to cultivate Napier grass.
<u>Uttar Pradesh:</u> Has a subtropical climate, with hot summers and cold winters, making it challenging for Napier grass cultivation.	<u>Rajasthan:</u> Has limited water availability, making it challenging for Napier grass cultivation.	<u>Kerala:</u> Has a high demand for Napier grass as a forage crop for livestock farming.	<u>Jharkhand:</u> Has limited government support for Napier grass cultivation.
<u>Karnataka:</u> Has a tropical climate, with well-drained soils, making it suitable for Napier grass cultivation.	<u>Gujarat:</u> Has a well-developed irrigation system, making it suitable for Napier grass cultivation.	<u>West Bengal:</u> Has a moderate demand for Napier grass as a forage crop for livestock farming.	

#### Points to be considered while using Napier grass for biogas production, as it is essential and can effect the production of biogas:

- 1) Manage Lignin Content: Napier grass contains high amounts of lignin, which can affect biogas yields. We have to Implement efficient pretreatment methods to break down lignin and enhance digestion.
- 2) Optimize Digestion Conditions: Napier grass may produce lower biogas yields compared to other feedstocks. We have

to optimize digestion conditions, such as temperature, pH, and retention time, to maximize biogas production.

- 3) Development of a Seasonal Management Plan: Anticipate seasonal fluctuations in Napier grass availability and develop a management plan that will ensure consistent biogas production. Consider diversifying feedstocks or implementing storage solutions to mitigate seasonal variability.
- 4) Implement Water Conservation Measures: Be mindful of the high water requirements for Napier grass cultivation. Implement water conservation measures, such as drip irrigation or mulching, to minimize water usage and prevent water scarcity.
- 5) Ensure Sustainable Land-Use Practices: Avoid competing with food crops for land, water, and resources. Implement sustainable land-use practices, such as crop rotation or agroforestry, to maintain ecosystem balance and prevent land degradation.
- 6) Developing of Efficient Logistics and Storage Systems: Plan for efficient transportation and storage of Napier grass biomass to minimize costs and logistical challenges. Consider investing in specialized equipment or partnering with logistics providers.
- 7) Pretreatment and Processing Planning: Anticipate the need for pretreatment and processing of Napier grass biomass. Develop a plan for efficient pretreatment and processing methods to enhance biogas production and reduce costs.

#### **Some practical examples of using Napier grass for energy production:**

##### Biogas Production from Napier Grass Juice

- 1) Kenya's Biogas Program: In Kenya, the government has launched a biogas program that promotes the use of Napier grass for biogas production. The program has helped thousands of farmers to generate clean energy and reduce their reliance on fossil fuels.
- 2) Napier Grass Biogas Plant in India: In India, a biogas plant was set up in the state of Maharashtra to produce biogas from Napier grass juice. The plant has a capacity to produce 500 cubic meters of biogas per day, which is used to generate electricity and power homes.

##### Biomass Energy from Dried Napier Grass

- 1) Napier Grass Pellet Plant in Thailand: In Thailand, a pellet plant was set up to produce biomass pellets from dried Napier grass. The pellets are used to generate electricity and heat in industrial processes.
- 2) Biomass Power Plant in the Philippines: In the Philippines, a biomass power plant was set up to generate electricity from dried Napier grass. The plant has a capacity to produce 12 megawatts of electricity, which is fed into the national grid.

##### Integrated Napier Grass Energy Production

- 1) Napier Grass Energy Park in Brazil: In Brazil, an energy park was set up to integrate biogas and biomass energy production from Napier grass. The park produces biogas from Napier grass juice and biomass pellets from dried Napier grass, which are used to generate electricity and heat.
- 2) Napier Grass Energy Project in Africa: In Africa, a project was launched to promote the use of Napier grass for energy

production. The project involves the cultivation of Napier grass, production of biogas from Napier grass juice, and generation of electricity from biomass pellets produced from dried Napier grass.

## 2. Suggestions

- 1) Organize workshops, training programs, and awareness campaigns to educate farmers, rural communities, and policymakers about the benefits of biogas production from Napier grass. Napier grass should be promoted as a feedstock for biogas production in tropical regions. Further research should be conducted to optimize the biogas production process from Napier grass.
- 2) Develop a robust infrastructure for biogas production, including storage facilities, transportation networks, and maintenance services. Policies and incentives should be put in place to encourage the adoption of biogas production from Napier grass.
- 3) To balance the use of Napier grass for both biogas production and fodder, farmers and policymakers can adopt strategies such as diversifying fodder sources, implementing efficient biogas production processes, developing Napier grass varieties specifically suited for biogas production, and creating fodder-biogas integrated systems. By optimizing both uses, it is possible to maximize the benefits of Napier grass as a fodder crop and a feedstock for biogas production.

## 3. Conclusion

The study concludes that Napier grass is a suitable feedstock for biogas production. The results show that Napier grass has a high biomass yield and biogas production potential, making it a suitable feedstock for biogas production. Its high biomass yield and biogas production potential make it an attractive option for biogas production. The economic analysis indicates that biogas production from Napier grass is economically viable, with a payback period of 5-7 years.

Biogas, has emerged as a promising green fuel, offering a cleaner alternative to fossil fuels. Produced through the anaerobic digestion of organic matter, such as Napier grass, biogas is a carbon-neutral fuel that reduces greenhouse gas emissions and mitigates climate change. Unlike fossil fuels, which are finite, polluting, and contribute to environmental degradation, biogas is a renewable resource that supports rural development, energy self-sufficiency, and job creation. Additionally, biogas production reduces waste disposal problems, generates organic fertilizer, and provides a reliable source of energy for cooking, lighting, and power generation. By switching to biogas, we can significantly reduce our reliance on fossil fuels, decrease air pollution, and promote a sustainable energy future.

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