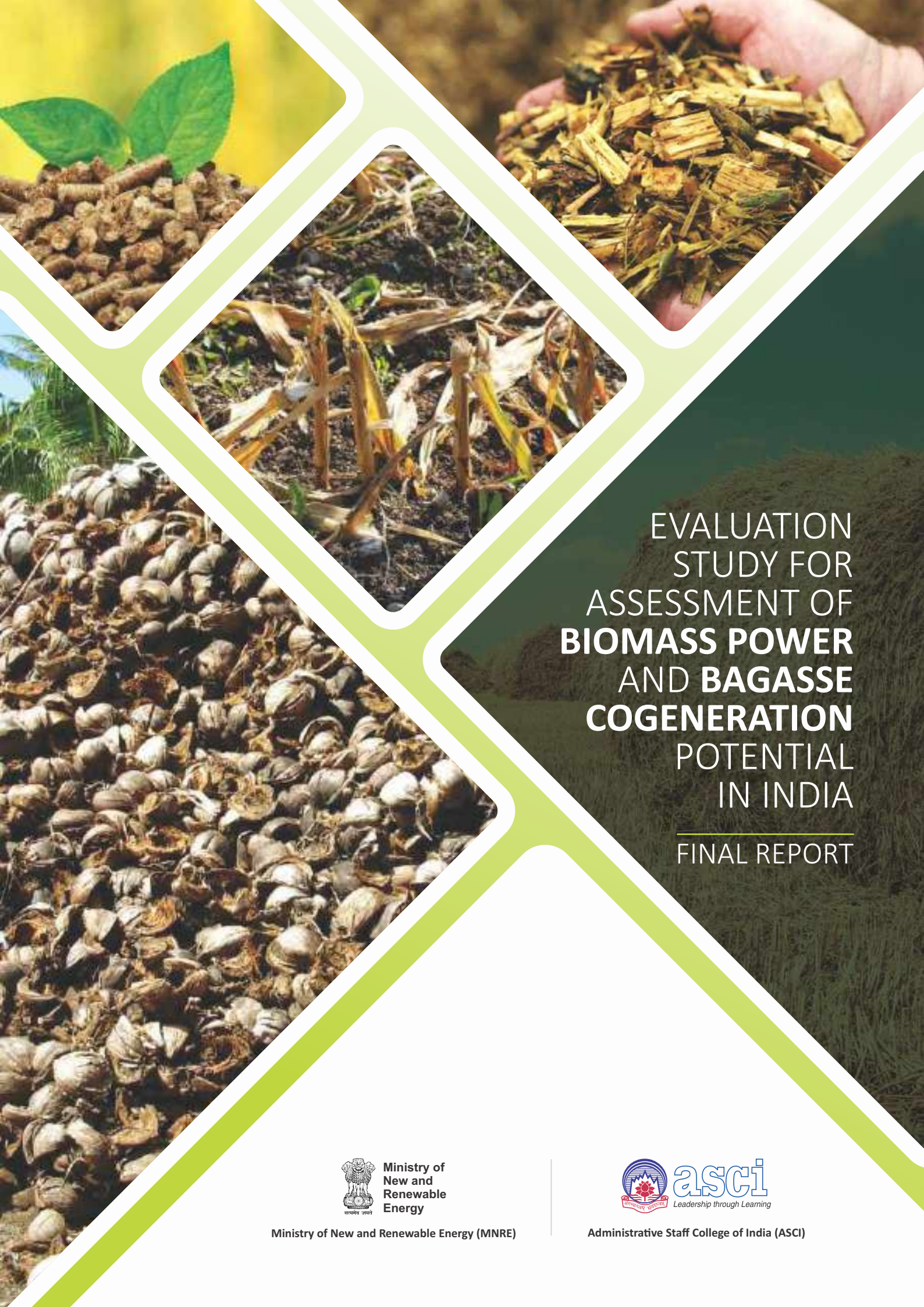

EVALUATION STUDY FOR ASSESSMENT OF **BIOMASS POWER** AND **BAGASSE COGENERATION** POTENTIAL IN INDIA

FINAL REPORT

Ministry of New and Renewable Energy

Ministry of New and Renewable Energy (MNRE)

asci Leadership through Learning

Administrative Staff College of India (ASCI)

FINAL REPORT
ON

EVALUATION STUDY FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Submitted to
Ministry of New and Renewable Energy (MNRE), New Delhi
www.mnre.gov.in

March 2021

Submitted by
Centre for Energy Studies (CES)
Administrative Staff College of India (ASCI), Hyderabad

asci
Leadership through Learning

Ministry of New and Renewable Energy

BIOMASS

STORAGE

PROCESSING

TRANSPORTATION OF BIOMASS & SUPPLY CHAIN

BIOMASS GENERATION

RE GRID

CLEAN USAGE

CARBON NEUTRALITY AND POLLUTION REDUCTION

ACKNOWLEDGEMENT

We thank the Ministry of New and Renewable Energy (MNRE), India, for awarding "Evaluation Study for the Assessment of Biomass Power and Bagasse Co-generation Plants in the Country" to the Administrative Staff College of India (ASCI).

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About the Ministry of New and Renewable Energy (MNRE)

In 1982, the Department of Non- Conventional Energy Sources (DNES) was created in the Ministry of Energy to look after all aspects of new and renewable energy. The Department was upgraded into a separate Ministry of Non-Conventional Energy Sources (MNES) in 1992 and was re-christened as Ministry of New and Renewable Energy (MNRE) in October 2006.

The Ministry of New and Renewable Energy (MNRE) is a ministry under the Government of India responsible for research & development, intellectual property protection, international cooperation, promotion and coordination in renewable energy sources such as wind power, small hydro, biogas, and solar power.

The ministry's broad aim is to develop and deploy new and renewable energy for supplementing India's energy requirements.

The Mission of the Ministry is to ensure

1. Energy Security: Lesser dependence on oil imports through development and deployment of alternative fuels (hydrogen, biofuels and synthetic fuels) and their applications to contribute towards bridging the gap between domestic oil supply and demand;
2. Increase in the share of clean power: Renewable (bio, wind, hydro, solar, geothermal & tidal) electricity to supplement fossil fuel-based electricity generation;
3. Energy Availability and Access: Supplement energy needs of cooking, heating, motive power and captive generation in rural, urban, industrial and commercial sectors;
4. Energy Affordability: Cost-competitive, convenient, safe, and reliable new and renewable energy supply options; and
5. Energy Equity: Per-capita energy consumption at par with the global average level by 2050, through a sustainable and diverse fuel- mix.

About Administrative Staff College of India (ASCI)

The Administrative Staff College of India (ASCI) is an institution of national importance established in Hyderabad in the Year 1956, at the Government of India and Indian industry. ASCI has pioneered post-experience management training in India. With its synergistic blend of Management Development, Consultancy and Research, ASCI made a significant contribution towards professionalizing Indian management.

Over the years, ASCI has carved a niche for itself on the strength of its domain expertise for management development, policy advice to governments and technical assistance to government organizations, institutions and industry.

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ABBREVIATIONS

ASCI	Administrative Staff College of India
CEA	Central Electricity Authority
CES	Centre for Energy Studies
CRR	Crop Residue Ratio
EJ	Exa Joule
FAO	Food and Agriculture Organization
FCI	Food Corporation of India
FGD	Focus Group Discussions
FY	Financial Year
GW	Giga Watt
GCV	Gross Calorific Value
GDP	Gross Domestic Product
IEA	The International Energy Agency
IIMR	Indian Institute of Millet Research
IISc	Indian Institute of Sciences
KG	Kilo Grams
Kcal	Kilo Calories
LUS	Land Use Statistics
MNRE	Ministry of New and Renewable Energy
MOAFW	Ministry of Agriculture and Farmers Welfare
MMTs	Million Metric Tonnes
MTs	Million Tonnes
MJ	Mega Joules
MW	Mega Watt
MUs	Million Units
NFSM	National Food Security Mission
NIBE	National Institute of Bio Energy
NSBI	National Spices Board of India
NSSO	National Sample Survey Office
PLF	Plant Load Factor
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
TE	Triennium
toe	Tonnes of Equivalent
TIFAC	Technology Information Forecasting and Assessment Council
TFC	Total Final Consumption
TPES	Total Primary Energy Supply

EXECUTIVE SUMMARY

India is an agriculture-based country with about 197 million hectares of gross sown area with a large diversity in the type and productivity of crops[1]. A large number of crop residues are generated from different types of crops in the process of production. The crop residue is generated at the farmer level, the mills level and the processing level. The residues are mainly used for animal feeding, compost fertilizer, thatching, domestic fuel (cooking & heating) and other industrial uses. In addition to crop residue's specific use, a large portion remains in farms as straw and stubble. About one-third of crop residue as biomass remains unutilized for any gainful economic purpose[2].

The study quantified the surplus biomass of different crops in three crop growing seasons (Kharif, Rabi and Summer) in 254 districts spread across 28 states and 08 Union Territories of India. The sample districts were selected based on 90% of crop acreage and production of crop therein. A total of 54 crops were considered for collecting the crop samples based on crop production as high, medium and low.

Three different survey instruments were developed to capture the information at the farmer level, Biomass plant level, and Bagasse co-generation level. The farmer level questionnaire captures the cropping pattern, family size, cattle size and crop residue utilization for different crops in different seasons, and the difficulties/issues in handling crop residue. Biomass plant level questionnaire captures plant installed capacity, biomass required to run at full load, running hours, generation, captive consumption, price of biomass and type of different biomass used in the plant. Bagasse co-generation plant level questionnaire captures similar information with bagasse as fuel. Based on primary data collected through administered survey instruments and secondary data sources, an assessment of total potential against Biomass and Bagasse was carried out separately.

The biomass power potential assessment was done by adopting a model developed by ASCI and approved by MNRE. The construction of the model was based on the following steps:

1. Calculation of gross residue potential – Gross residue potential was calculated based on the area covered by the crop, yield of the crop, and crop residue ratio

2. Calculation of surplus residue potential – Surplus residue potential was calculated based on surplus factor applied on calculated gross residue potential. The surplus factor was derived from the primary survey.

3. Estimation of Biomass power potential – Biomass power potential was estimated based on surplus residue potential and GCV of that particular crop residue. The GCV of the crop is estimated based on accredited lab tested values of collected crop samples during the primary survey.

1. Agricultural Statistics at a glance 2019, Ministry of Agriculture and Farmers welfare, Department of Agriculture Cooperation and Farmers welfare, Directorate of Economics and Statistics
2. Estimation of surplus crop residues in India for biofuel production – A joint report of TIFAC and IARI, Oct 2018

The Assessment of Bagasse co-generation power potential at sugar mills was done by adopting a model developed by ASCI and approved by MNRE. The construction of the model was based on the following steps:

1. Calculation of gross residue potential (Gross Bagasse Availability) - Gross residue potential in sugar mills was calculated based on the area under sugarcane cultivation, yield of the Sugarcane, sugarcane production, sugar production, sugar recovery rate, cane crushed in sugar mills and crop residue ratio

2. Calculation of surplus residue potential – surplus residue potential (Surplus Bagasse Availability) was calculated based on the consumption of bagasse towards heating purpose in sugar mills and consumption of bagasse towards cogeneration in the sugar mills with the co-generation facility.

3. Estimating Bagasse power potential – Bagasse power potential was estimated based on surplus residue potential (Surplus Bagasse Availability) and GCV of bagasse. The GCV of bagasse is estimated based on accredited lab tested values of collected crop samples during the primary survey.

State-wise and Crop-wise Biomass power potential is estimated for the entire country by processing the data using the above statistical models. Similarly, all India Bagasse cogeneration power potential, state-wise Bagasse cogeneration power potential were estimated. The report also provides information on state-wise cattle holding pattern, residue utilisation pattern at farmer level in different seasons and state-wise shredding cost for selected crops.

At all India level, the total gross cropped area (selected crops list of 54) (TE-2015-2018) brought under selected crops in India was around 198.11 million hectares. Total crop production against selected 54 crops at all India level for the selected period was around 774.38 million tonnes.

The calculated total available biomass potential at all India level was derived as 754.50 million tonnes. Around 2/3rd portion of total biomass produced, i.e., 525.98 million tonnes, is utilized for domestic purpose and other purposes like cattle feeding, compost fertilizer, etc. The remaining 1/3rd portion, 228.52 million tonnes has resulted in surplus biomass.

The estimated gross biomass power potential for 2015-18 from the selected crops is around 28445.52 MWe at all India level.

The estimated gross biomass power potential for 2019-20 from the selected crops is around 30319.00 MWe at all India level.

The estimated gross bagasse co-generation power potential in sugar mills for 2019-20 is 13929.55 MWe at all India level.

To the total biomass power potential for 2015-18, Punjab contributing to 3022.11 MWe (10.6%), Uttar Pradesh 2800.31 MWe (9.8%) followed by Gujarat 2637.84 MWe (9.3%), Maharashtra 2637.84 MWe (9.2%), Madhya Pradesh 2516.42 MWe (8.8%), Andhra Pradesh 1999.49 MWe (7.0%), Karnataka 1793.88 MWe (6.3%), West Bengal 1741.88 MWe (6.1%), Telangana 1678.36 MWe (5.9%), Tamil Nadu 1560.08 MWe (5.5%) and Haryana 1353.35 MWe (4.8%) contributing to 83.4% of all India Biomass Power Potential.

For the year 2019-20, the lions share is contributed by Madhya Pradesh 3301.1 MWe (10.9%), followed by Punjab 3100.7 MWe (10.2%), Maharashtra 3074.0 MWe (10.1%), Gujarat 3042.5 MWe (10%), Uttar Pradesh 2636.2 MWe (8.7%), Andhra Pradesh 2302.3 MWe (7.6%), Karnataka 2104.2 MWe (6.9%), Rajasthan 1817.2 MWe (6%), West Bengal 1590.6 MWe (5.2%), Telangana 1342.8 MWe (4.4%), Haryana 1322.2 MWe (4.4%), contributing to 84.4% of all India Biomass Power Potential.

For 2015-18, the highest biomass power generating potential crops are Rice 5682.46 MWe (19.98%) followed by Cotton 5590.08 MWe (19.65%), Wheat 4505.30 MWe (15.84%), Maize 1776.35 MWe (6.24%), Potato 1617.08 (5.68%), Coconut 1168.80 MWe (4.11%), Banana 963.71 MWe (3.39%), Sugarcane 867.92 MWe (3.05%), Other Oilseeds 679.65 MWe (2.39%), Arhar/Tur 591.76 MWe (2.08%) and Castor 534.16 MWe (1.88%) contributing to 84.29% of all India Biomass Power Potential.

For the year 2019-20, the highest biomass power generating potential crops are Cotton 6165.49 MWe (20.34%), followed by Rice 5791.51 MWe (19.10%), Wheat 4846.56 MWe (15.99%), Maize 1856.77 MWe (6.12%), Potato 1500.02 MWe (4.95%), Coconut (4.44%), Banana (3.94%), Sugarcane (3.15%), Arhar/Tur (2.73%), Castor (2.18%) and Bajra (2.15%) contributing to 85.09% of all India Biomass Power Potential.

In the bagasse power potential for the year 2019-20, the lion's share contributed by Uttar Pradesh (2996.2 MWe), followed by Maharashtra (1566.0 MWe), Gujarat (533.9 MWe), Haryana (260.1 MWe) and Punjab (253.4 MWe).

BACKGROUND OF THE PROJECT

Agriculture and its allied sectors are the backbone of the Indian Economy as well as the largest source of livelihood. As per the Food and Agriculture Organization (FAO), India is the largest producer of pulses in the world and the second-largest producer of rice, wheat, sugarcane, cotton, groundnut etc[3]. The high crop production results in enormous crop residue generation. The residue generated has a wide range of application, viz. cattle feeding, domestic fuel, brick kilns, industrial fuel etc. The leftover agro-residue available with the farmer and in mills are termed as "Surplus Residue". This surplus residue can be utilized for power generation without jeopardizing the livelihood of rural families.

In the past, the Indian Institute of Sciences (IISc) Bangalore has conducted biomass resource assessment in two phases, 1998-99 and 2002-04, for the estimation of biomass generation, availability of surplus biomass and its associated power potential. The study estimated that the country's biomass availability was at about 500 Million Metric Tonnes (MMT), and the availability of surplus biomass was about 120-150 MMT with the estimated potential of 18,000 MW, including both agriculture and forest residue.

Technology Information, Forecasting and Assessment Council (TIFAC) carried out a study for the "Estimation of Surplus Crop Residues in India for Bio-fuel Production" in 2018. The study was restricted to eleven major producing crops of India: Rice, Wheat, Maize, Sugarcane, Cotton, Gram, Tur, Groundnut, Mustard, Soyabean, and Castor. These eleven crops have generated 683 Million Metric Tonnes (MMT) of dry biomass during all three seasons, i.e. Kharif, Rabi and summer seasons. As per the study, the estimated surplus crop biomass was 178 MMT, which was 26% of the total dry biomass generated. The report also mentioned that 72% of the agriculture area was covered by Rice, Wheat, Soyabean and Cotton.

The socio-economic condition of the farmers has changed over the years. The usage pattern of the residue and the cropping pattern has also seen changes based on market demand. Therefore, it is essential to periodically re-assess the biomass and surplus biomass potential to plan for its utilization. The Govt. of India has planned to achieve 175 GW of grid-connected renewable energy generation, including 10 GW of power from biomass by March 2022, to meet Sustainable Development Goals (SDGs). Estimating existing Biomass and Bagasse power potential across the country is of paramount importance in this context.

Given the above, the Ministry of New and Renewable Energy (MNRE) has awarded the country's biomass potential assessment assignment to the Administrative Staff College of India (ASCI) based on MNRE's Call for Proposals for the "Evaluation Study for the Assessment of Biomass Power and Bagasse Cogeneration Potential in the Country".

3. FAO-in-India/India-at-a-glance (www.fao.org)

01
CHAPTER

Introduction

INTRODUCTION

India bestowed with favourable climatic conditions for agriculture; immense biomass is produced from agriculture. Biomass is an essential RE (Renewable Energy) source because it is widely available, carbon-neutral, capable of providing firm energy and generating significant employment in rural areas. About 32 per cent of the total primary energy used in the country is still derived from biomass, and more than 70 per cent of the country's population depends upon it for its energy needs[4]. Biomass is the most commonly used energy source for several small-scale industries and is also fuel for independent power plants. Biomass materials used for power generation include sugarcane Bagasse and other non-bagasse materials like rice husk, straw, cotton stalk, coconut shells, soyabean husk, de-oiled cakes, coffee waste, jute waste, groundnut shells, sawdust etc.[5]

Overview of Biomass in India

With a population of 1.3 billion, India is the second-most populous country globally, the seventh-largest country in the world with an area of 3.288 million Sq.kms and the third-largest economy by purchasing power parity (PPP). When it comes to land area, around 45% of India's land area is under agricultural, and over 24% is under forest and 30% non-cultivable area. Two-thirds of the population in India still live-in rural areas. However, the cities are growing fast, and the urbanization rate is around 2.4% per year.[6]

Agriculture, with its allied sectors, is the largest source of livelihoods in India. Seventy percent of its rural households still depend primarily on agriculture for their livelihood, with 82 per cent of farmers being small and marginal. India is the largest producer (25% of global production), the consumer (27% of world consumption) and the importer (14%) of pulses in the world. It is the second-largest producer of rice, wheat, sugarcane, cotton and groundnuts, and the second-largest fruit and vegetable producer, accounting for 10.9% and 8.6% of the world fruit and vegetable production, respectively.[7]

India has seen a robust economic performance in recent decades, with a significant decrease in poverty levels, greater energy access for its citizens and growing penetration of cleaner energy across the economy. India has set a target growth rate of 9%, which would place it on a trajectory towards becoming a USD 5 trillion economy by 2024-25, making it the fastest-growing large economy in the world. To sustain its rapid economic growth, India is placing an enormous demand for energy resources, energy systems and infrastructure.[8]

Energy Scenario

Over the past decades, energy demand has steadily increased across all sectors, including agriculture, industry, commercial and residential, and is expected to grow linearly. Nonetheless, India's per capita energy consumption stands at 30% of the world's average (0.44 tonnes of oil equivalent (toe) per capita versus the global average of 1.29 (toe) and the International Energy Agency (IEA) average of 2.9). India's energy system is primarily based on coal for power generation, oil for transport and industry, and biomass for residential heating and cooking. Bio-energy and coal are produced in the country, while oil and natural gas are mainly imported. In 2017, India's Total Primary Energy Supply (TPES) was 882 million tonnes of oil equivalent, with nearly two-thirds being covered by domestic production, i.e. 554 million tonnes of oil equivalent. Industry accounted for the largest share of India's total final consumption (TFC), followed by the residential sector, transport and the service sector, including agriculture.[9]

India has been able to meet the gap between demand for and domestic supply of energy while addressing energy use environmental externalities. Despite high growth rates experienced in energy-intensive sectors, energy consumption and carbon dioxide (CO2) emissions have not grown as rapidly as Gross Domestic Product (GDP). Electricity supply is growing in line with economic growth, while its carbon intensity is declining due to an increase in the share of renewable energy and a decline in utilisation of coal power plants. India has reduced around 13% in the emissions intensity during the past decade, while total final energy consumption and electricity generation continue to rise.[10]

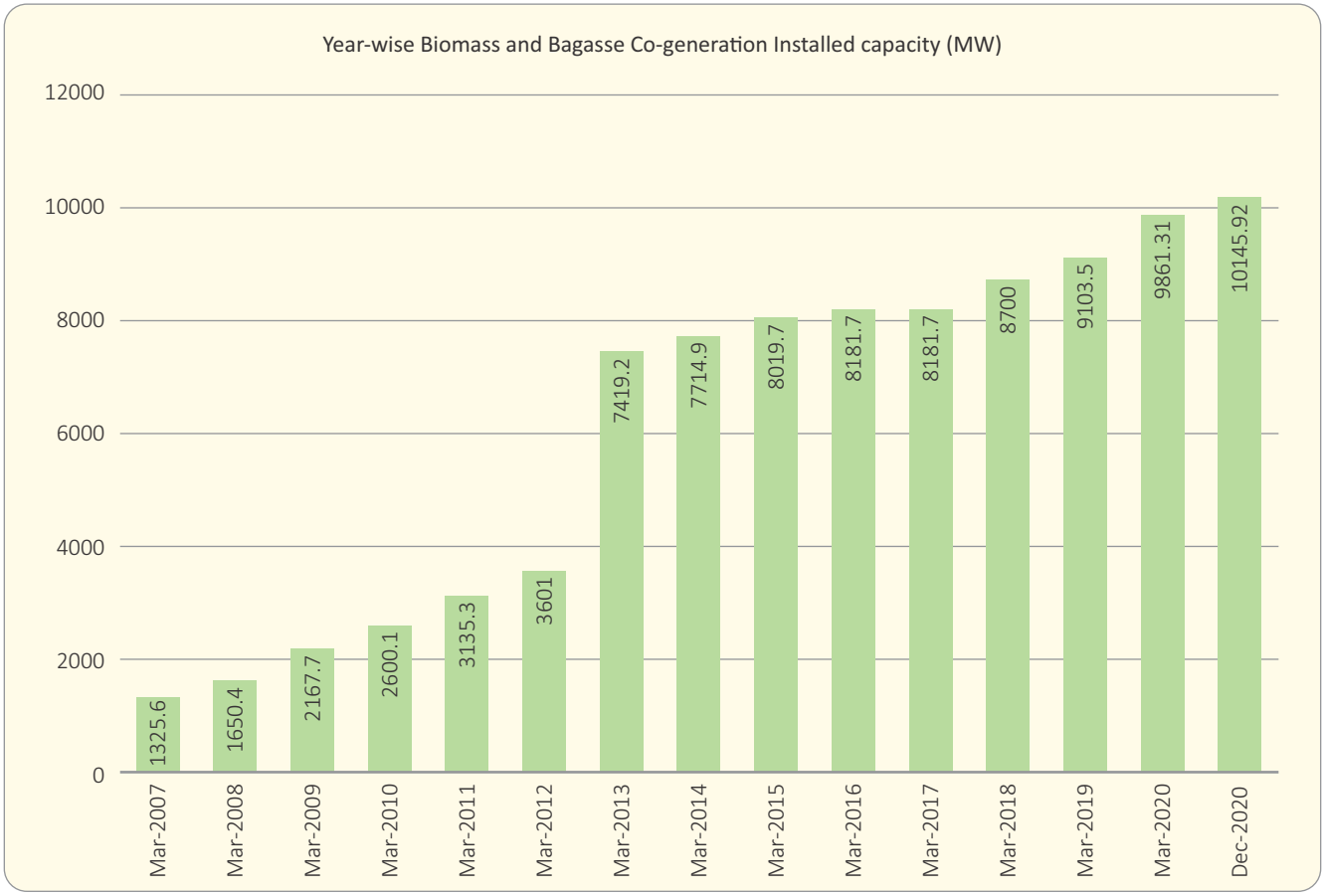
India is implementing various programs to curb CO2 emissions, and one of the programmes is Biomass Power and Bagasse Co-generation. Since plants use carbon dioxide for their growth, more significant stress on biomass production may reduce the emissions levels. Biomass energy is thus, an environmentally adequate resource. The broader use of biomass power for development offers minimal ecological imbalance and provide means to recycle nutrients and CO2 from the atmosphere. Furthermore, biomass constituents a significant, clean and renewable energy source and is a very desirable option. Therefore, terrestrial and aquatic biomass merits a great deal of consideration in any energy development programme, particularly in India.

4. Report of the Comptroller and Auditor General of India on Renewable Energy Sector in India, Govt of India, 2015
5. Union Civil Performance Renewable Energy Report (https://cag.gov.in/sites/default/files/audit_report_files/Union_Civil_Performance_Renewable_Energy_Report_34_2015_chap_6.pdf)
6. Niti Ayog, In-depth Energy Policy, 2020-21 (https://niti.gov.in/sites/default/files/2020-01/IEA-India%202020-In-depth-EnergyPolicy_0.pdf)
7. Food and Agriculture Organisation of United Nation, FAO Report on India, 2017-18
8. ibid
9. India 2020, Energy Policy Review, IEA
10. Food and Agriculture Organization of United Nations (http://www.fao.org/india/fao-in-india/india-at-a-glance/en/)

Biomass and Bagasse Co-generation Power Scenario

Biomass Power and Bagasse Co-generation Programme in India is to recover the energy from various agricultural crop residues for use in power generation. As per the MNRE Annual report (2018-19), the potential for power generation from agricultural and agro-industrial residue is estimated to be **18,000 MW**, and for bagasse cogeneration in sugar mills, it is **8,000 MW**. Thus, the total estimated biomass power in the country is **26,000 MW**.[11]

As of December 2020, the total installed capacity of Biomass Power / Bagasse Cogeneration is **10145.92 MW**. RE generation for the month of November 2020 from Biomass is **303.51 MU**, and from Bagasse, it is **1437.83 MU** of electricity.[12]

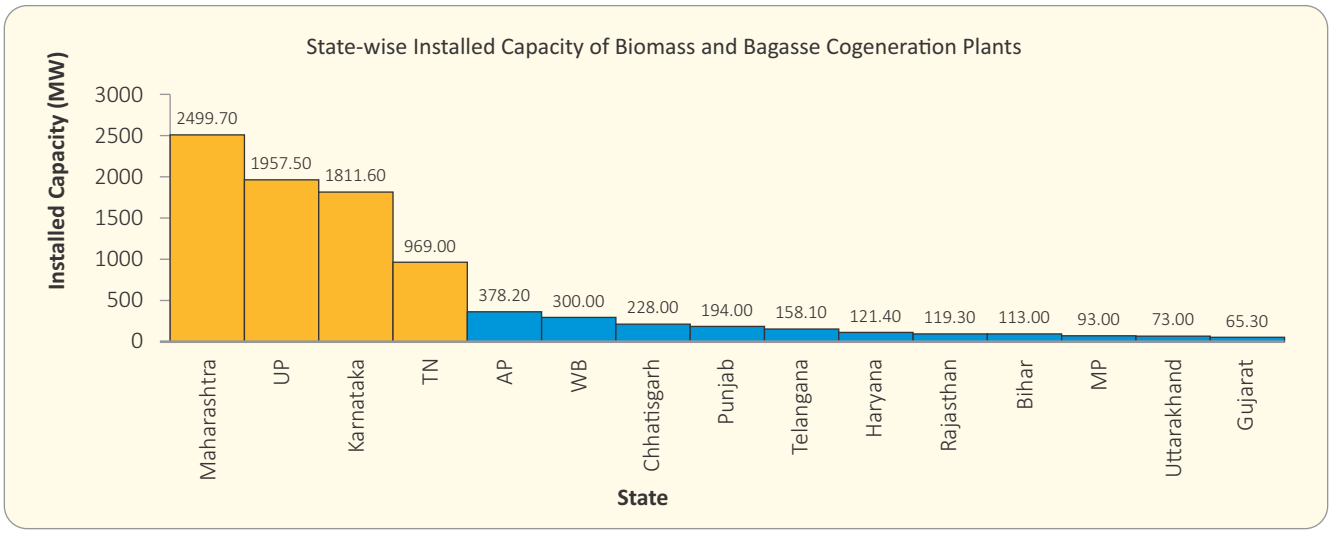


Source: Central Electricity Authority (CEA)

Figure 1: Year-wise Biomass and Bagasse Co-generation installed capacity (MW) for the last 14 years

The above graph represents the growth in installed capacity of biomass power plants in India from the financial year 2006-07 to 2019-20. There is a linear growth in installed capacity over the years. However, there was an upsurge in the FY 2012-13 compared with FY 2011-12 with an addition of 3818.2 MW. A substantial increase in the number of Biomass/ Bagasse Co-generation plants observed during this period was due to the government's special incentive. Central Financial Assistance (CFA) of Rs. 20 lakhs per MW with a cap of Rs. 1.5 Cr. per project was offered to biomass power projects and Rs. 15 lakhs per MW with the maximum assistance of Rs. 1.5 Cr per project was offered to Bagasse cogeneration power projects[13].

11. MNRE, Annual Report, 2018-19, Chapter-04, Page no.47 and 48
12. CEA, Monthly report, Renewable Energy Project Monitoring Division, RE Generation data for the month of December, 2020, Page no. 03 (http://www.cea.nic.in/reports/monthly/renewable/2020/renewable-12.pdf)
13. Biomasspower.gov.in (URL: https://biomasspower.gov.in/policy-grid-connected.php)



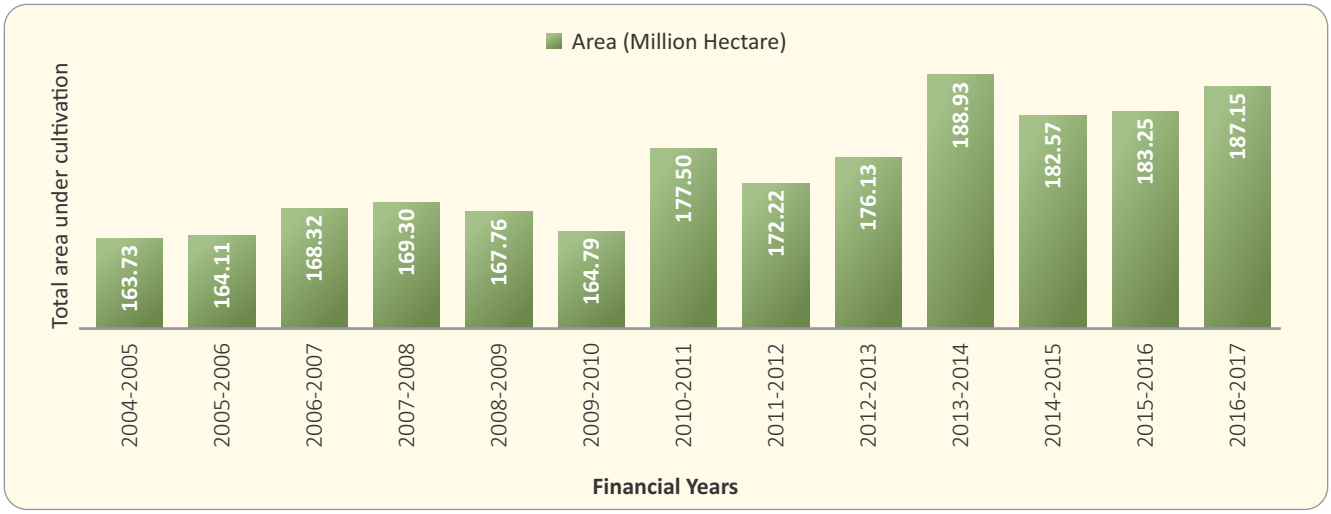
Source: Ministry of New and Renewable Energy (MNRE)

Figure 2: State-wise installed capacity of biomass and bagasse co-generation plants in India

The above graph represents the state-wise installed capacity (MW) of Biomass and Bagasse Cogeneration Plants. So far, only 16 states have installed Biomass and Bagasse Cogeneration Plants in the country. The four (04) states with maximum installed capacity are Maharashtra, Uttar Pradesh, Karnataka, and Tamil Nadu.

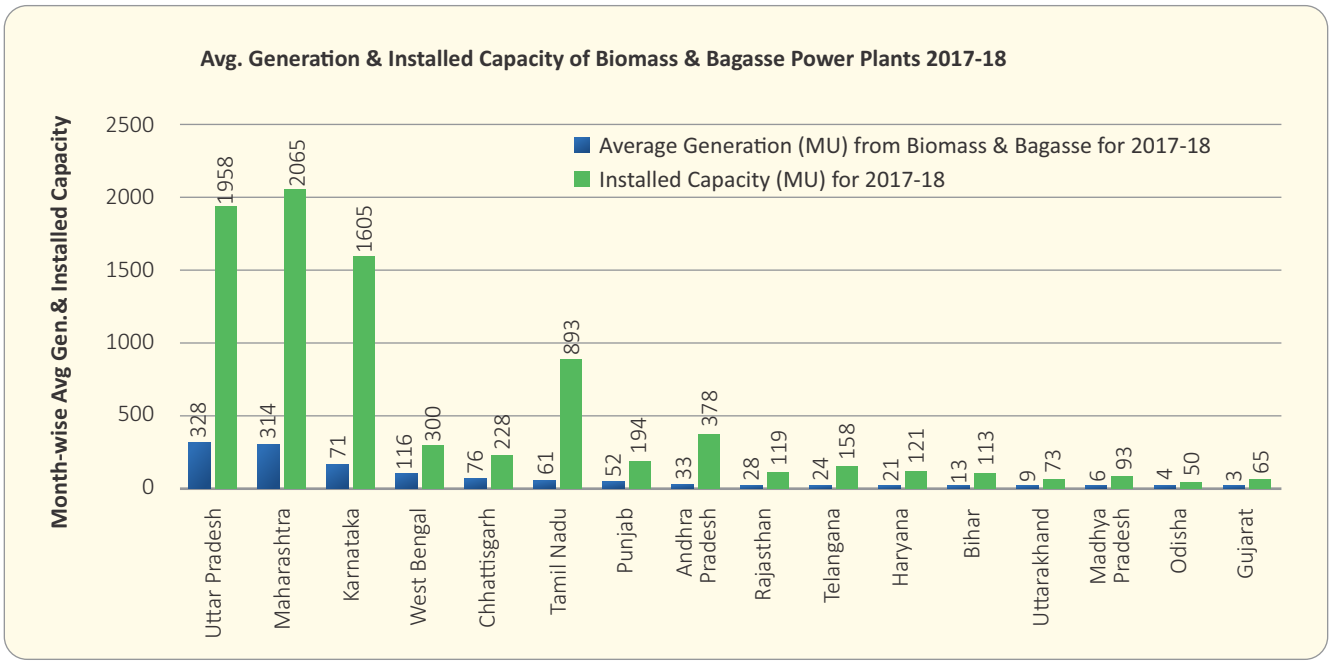
These states are well equipped with the agro-processing industry and hence more agro-residue. Based on the region's specific agro-climatic conditions, every state offers promising potential to utilize the residue from some crops or the other. The following graph represents the year-wise total area under crop cultivation in India.

Year-wise total area under crop cultivation



Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare

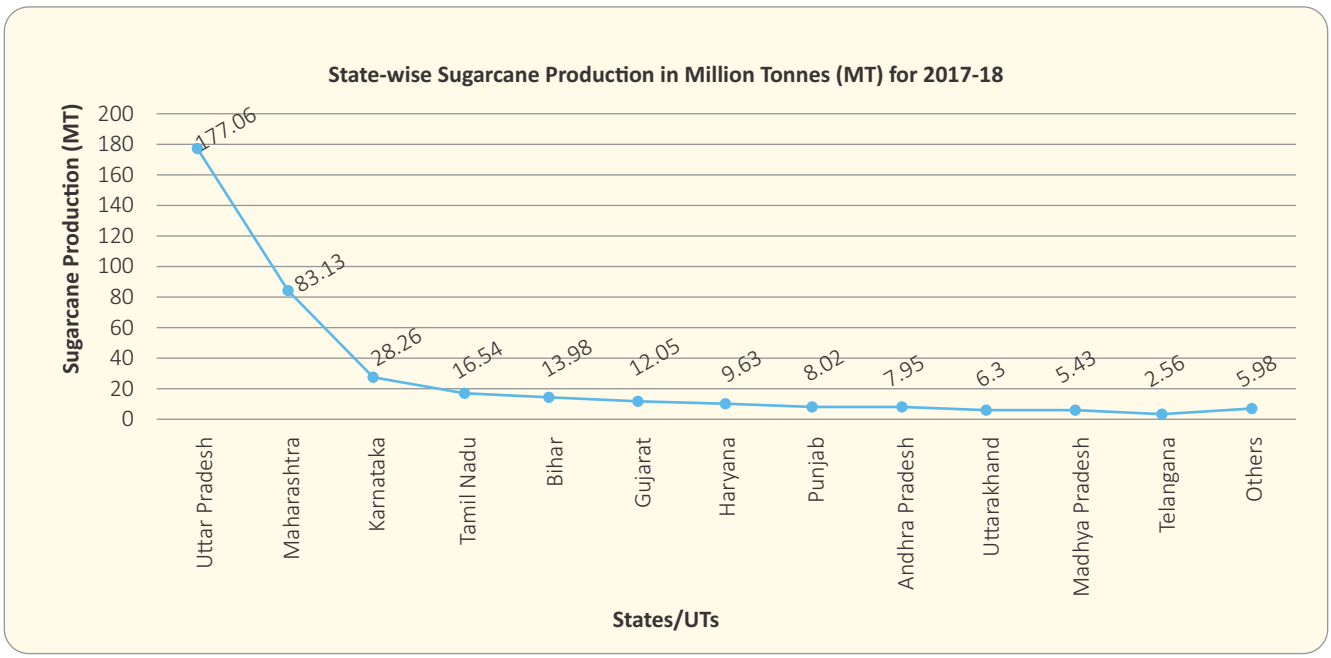
Figure 3: Year-wise agriculture area under cultivation



Source: MNRE Annual Report/Chapter 4: Power from other Renewable/Installed Capacity of Grid Connected Biomass/Bagasse Power Plants, Central Electricity Authority/Report/Monthly/Executive Summary

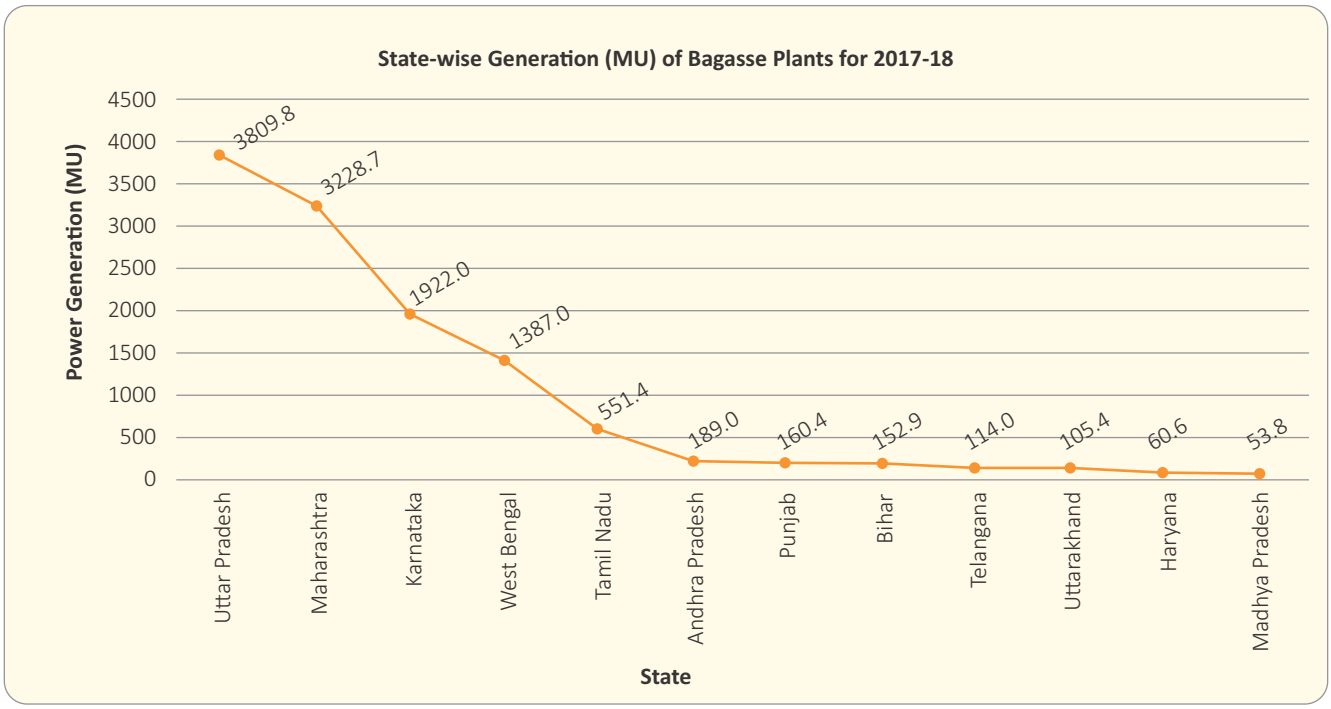
Figure 4: Avg. Gen. & Installed Capacity of Biomass/Bagasse Power Plants (2017-18)

The above graph (Figure 04) represents the state-wise generation and installed Biomass and Bagasse Plants' capacity for the year 2017-18. From the graph, it can be inferred that Maharashtra has the highest generation capacity, followed by Uttar Pradesh, Karnataka and Tamil Nadu. However, on the generation front, Uttar Pradesh generates maximum electricity from Biomass/ Bagasse, followed by Maharashtra, Karnataka, West Bengal and Chhattisgarh. States like West Bengal and Chhattisgarh have generated more electricity than Tamil Nadu, though they have less installed capacity compared to Tamil Nadu owing to the higher utilisation factor of plants. On analyzing generation, it is found that West Bengal and Chhattisgarh generated 0.387 MU/MW and 0.334MU/MW, respectively, which is relatively high as compared to states with high installed capacity, like Uttar Pradesh 0.167 MU/MW, Maharashtra 0.152 MU/MW, Karnataka 0.107 MU/MW and Tamil Nadu 0.106 MU/MW.



Source: Agriculture Statistics at glance 2018

Figure 5: State-wise Sugarcane Production in India for 2017-18



Source: Agriculture Statistics at glance 2018

Figure 6: State-wise Generation (MU) from Bagasse Plants for the FY 2017-18

Further, when we look at State-wise generation from Bagasse Plants and State-wise Sugarcane Production, it is found that the state of West Bengal, being the minimal producer of Sugarcane compared to other states, generates substantial power from Bagasse. It can be inferred that the state makes the optimal use of Bagasse for power generation compared to other states.

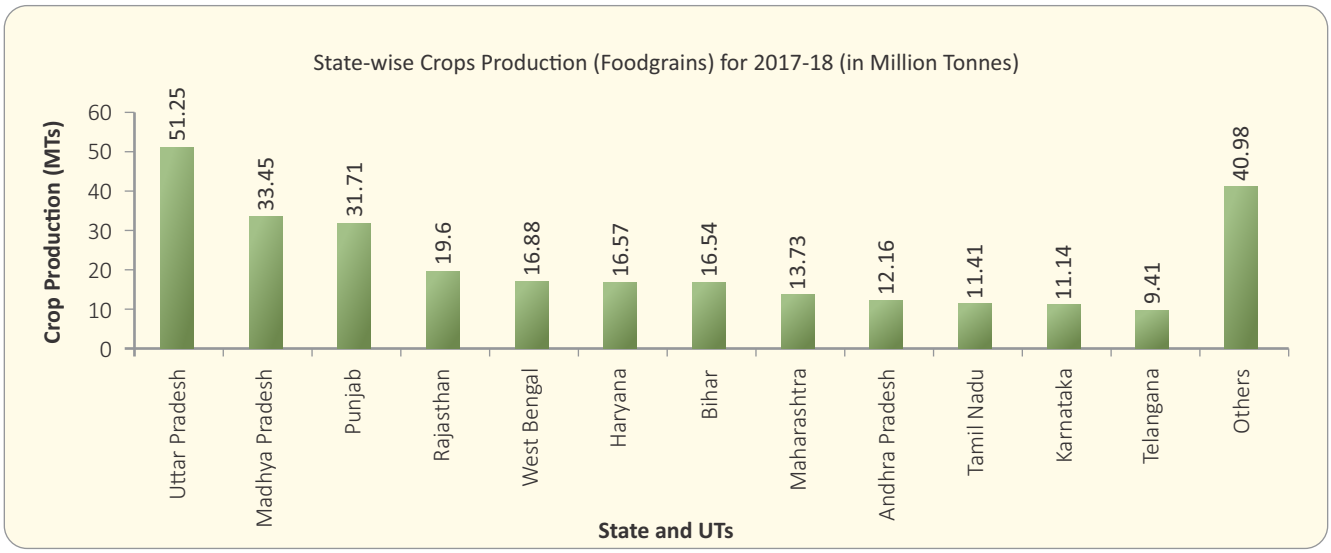
Table 1: State-wise and Month-wise Generation (MU) of Bagasse Plants for the Year 2017-18

States/Months	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Chandigarh	0	0	0	0	0	0	0	0	0	0	0	0
Delhi	0	0	0	0	0	0	0	0	0	0	0	0
Haryana	9	3	0	0	0	0	0	0	10	14	9	15
HP	0	0	0	0	0	0	0	0	0	0	0	0
J & K	0	0	0	0	0	0	0	0	0	0	0	0
Punjab	13	9	8	0	0	0	0	2	2	45	45	35
Rajasthan	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	386	138	76	12	12	35	75	479	657	669	604	666
Uttarakhand	19	6	0	0	0	0	0	0	0	28	25	28
Total Northern Region	**427**	**157**	**83**	**12**	**13**	**35**	**75**	**480**	**669**	**756**	**683**	**744**
Chhattisgarh	0	0	0	0	0	0	0	0	0	0	0	0
Gujarat	0	0	0	0	0	0	0	0	0	0	0	0
Madhya Pradesh	0	0	0	0	0	0	0	0	3	8	21	22
Maharashtra	29	48	28	15	22	13	28	486	653	697	622	587
Dadra and Nagar Haveli	0	0	0	0	0	0	0	0	0	0	0	0
Daman & Diu	0	0	0	0	0	0	0	0	0	0	0	0
Total Western Region	**29**	**48**	**28**	**15**	**23**	**13**	**28**	**486**	**656**	**705**	**643**	**609**

States/Months	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Andhra Pradesh	5	6	2	4	4	2	2	13	29	47	40	35
Telangana	10	0	0	0	13	0	0	7	23	20	20	21
Karnataka	5	3	6	24	67	67	64	294	432	435	335	190
Kerala	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	52	40	45	53	42	33	48	64	55	32	52	36
Lakshadweep	0	0	0	0	0	0	0	0	0	0	0	0
Puducherry	0	0	0	0	0	0	0	0	0	0	0	0
Total Southern Region	**72**	**48**	**53**	**81**	**126**	**102**	**114**	**378**	**538**	**535**	**447**	**282**
Andaman Nicobar	0	0	0	0	0	0	0	0	0	0	0	0
Bihar	5	1	3	0	0	1	3	4	31	36	33	36
Jharkhand	0	0	0	0	0	0	0	0	0	0	0	0
Odisha	0	0	0	0	0	0	0	0	0	0	0	0
Sikkim	0	0	0	0	0	0	0	0	0	0	0	0
West Bengal	111	121	108	120	120	119	111	107	116	127	103	124
Total Eastern Region	**116**	**122**	**112**	**120**	**120**	**120**	**114**	**111**	**147**	**164**	**136**	**159**
Arunachal Pradesh	0	0	0	0	0	0	0	0	0	0	0	0
Assam	0	0	0	0	0	0	0	0	0	0	0	0
Manipur	0	0	0	0	0	0	0	0	0	0	0	0
Meghalaya	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	0	0	0	0	0	0	0	0	0	0	0	0
Nagaland	0	0	0	0	0	0	0	0	0	0	0	0
Tripura	0	0	0	0	0	0	0	0	0	0	0	0
Total North Eastern Region	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
All India Total	**644**	**374**	**276**	**228**	**282**	**270**	**332**	**1455**	**2010**	**2160**	**1908**	**1794**

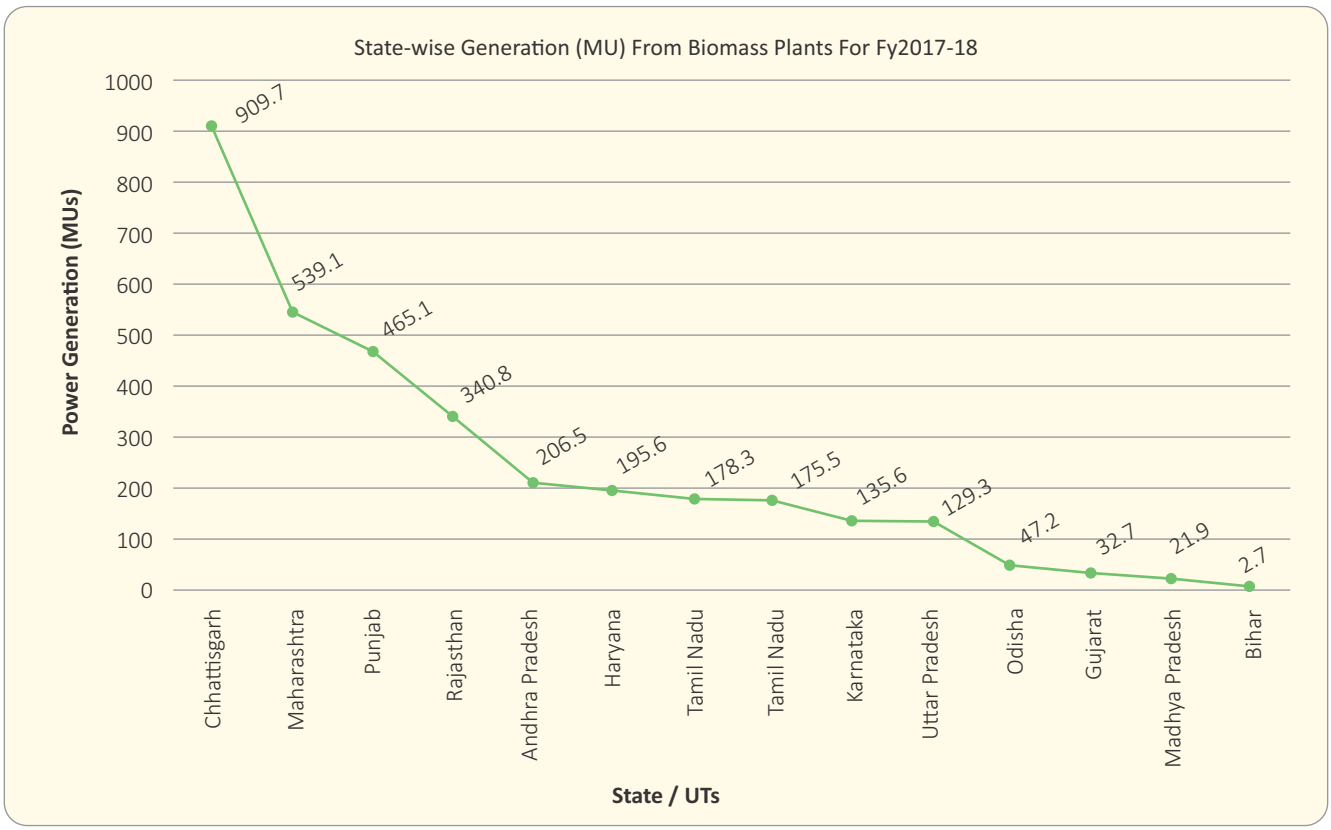
Source: Central Electricity Authority (CEA)

The above table represents month-wise and state-wise generation from Bagasse Cogeneration plants for the FY 2017-18. Generation from Bagasse plants is at its peak in the months ranging from November to March. The harvesting season of Sugarcane starts in October and continues till May. The availability of Bagasse is the reason behind the peak generation. Sugarcane crop is usually harvested after cane attains maturity. At some places, sugarcane production continues throughout the year. When we look at zone wise Bagasse plant generation, Northern Zone generates maximum followed by Western Zone, Southern Zone and Eastern Zone. Eastern Zone maintains consistency in the generation, especially in West Bengal, where the generation is almost the same throughout the year. While the Northern, Western and Southern Zone generate maximum during the months from November to March.



Source: Directorate of Economics and Statistics

Figure 7: State-wise Crop Production in (MT) for 2017-18



Source: Directorate of Economics and Statistics

Figure 8: State-wise Generation (MU) from Biomass Plants for FY 2017-18

The above graphs represent major crop-producing states and electricity generation from biomass plants. Being the largest crop-producing state, Uttar Pradesh and Madhya Pradesh generates less electricity with biomass vis-a-vis crop production. Whereas Chhattisgarh, which produces less crop as compared to Uttar Pradesh and other major crop-producing states as per graph, generates maximum electricity. Thus, it can be inferred that the state of Chhattisgarh makes optimal use of agriculture biomass for power generation.

Table 2: State-wise Generation (MU) of Biomass Plants for the Year 2017-18

States/Months	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Chandigarh	0	0	0	0	0	0	0	0	0	0	0	0
Delhi	0	0	0	0	0	0	0	0	0	0	0	0
Haryana	14	17	16	17	14	17	18	17	16	15	16	17
HP	0	0	0	0	0	0	0	0	0	0	0	0
J & K	0	0	0	0	0	0	0	0	0	0	0	0
Punjab	50	50	43	34	29	33	33	37	37	44	44	31
Rajasthan	32	31	30	24	26	24	28	29	31	30	28	28
Uttar Pradesh	16	15	12	5	10	8	7	8	12	12	11	12
Uttarakhand	0	0	0	0	0	0	0	0	0	0	0	0
Total Northern Region	**111**	**114**	**101**	**80**	**80**	**82**	**86**	**91**	**97**	**101**	**99**	**88**
Chhattisgarh	85	93	82	67	88	89	88	71	79	37	66	65
Gujarat	3	2	2	1	2	2	3	3	3	4	4	4
Madhya Pradesh	3	4	3	2	2	2	2	3	1	0	0	0
Maharashtra	49	43	48	46	39	41	36	45	49	51	46	46
Dadra and Nagar Haveli	0	0	0	0	0	0	0	0	0	0	0	0
Daman & Diu	0	0	0	0	0	0	0	0	0	0	0	0
Total Western Region	**139**	**141**	**135**	**115**	**131**	**135**	**129**	**122**	**132**	**92**	**116**	**116**
Andhra Pradesh	25	26	9	12	19	16	14	14	17	20	18	18
Telangana	15	17	14	14	10	14	10	15	17	19	16	17
Karnataka	13	13	11	11	9	12	10	11	11	13	10	12
Kerala	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	29	21	18	12	13	12	15	13	10	12	11	12
Lakshadweep	0	0	0	0	0	0	0	0	0	0	0	0
Puducherry	0	0	0	0	0	0	0	0	0	0	0	0
Total Southern Region	**82**	**76**	**51**	**49**	**50**	**54**	**48**	**52**	**55**	**63**	**56**	**59**
Andaman Nicobar	0	0	0	0	0	0	0	0	0	0	0	0
Bihar	0	1	0	0	0	0	0	0	0	0	0	0
Jharkhand	0	0	0	0	0	0	0	0	0	0	0	0
Odisha	0	0	5	2	3	2	4	4	8	5	7	7
Sikkim	0	0	0	0	0	0	0	0	0	0	0	0
West Bengal	0	0	0	0	0	0	0	0	0	0	0	0
Total Eastern Region	**0**	**1**	**6**	**3**	**3**	**2**	**4**	**4**	**9**	**5**	**7**	**7**

States/Months	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Arunachal Pradesh	0	0	0	0	0	0	0	0	0	0	0	0
Assam	0	0	0	0	0	0	0	0	0	0	0	0
Manipur	0	0	0	0	0	0	0	0	0	0	0	0
Meghalaya	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	0	0	0	0	0	0	0	0	0	0	0	0
Nagaland	0	0	0	0	0	0	0	0	0	0	0	0
Tripura	0	0	0	0	0	0	0	0	0	0	0	0
Total North Eastern Region	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
All India Total	**333**	**332**	**293**	**247**	**265**	**273**	**268**	**269**	**292**	**262**	**277**	**270**

When we look at the zone / state-wise and month-wise generation from biomass, it can be observed that the Western Region generates maximum electricity, followed by the Northern and Southern Region. In the Western Region, the state of Chhattisgarh and Maharashtra contribute towards maximum generation. In the Northern region, Punjab, Rajasthan, Uttar Pradesh and Haryana contribute towards maximum generation. While in the Southern Region, Tamil Nadu, Andhra Pradesh, Karnataka and Telangana contribute to maximum generation from Biomass.

02
CHAPTER

Scope of Work and Approach & Methodology

SCOPE OF WORK AND APPROACH & METHODOLOGY

In India, Biomass is available in various forms like wood, agricultural products, solid waste, landfill and biogas. In the last four to five decades, advanced technological interventions to harness high-grade heat or power gave momentum for biomass power generation and bagasse co-generation in India. As seen in chapter- 01, biomass growth and biomass utilization are evident in India. However, there are concerns in taking biomass as an energy source to make the desired impact in a more extensive energy mix. This may attribute to the complex nature of several factors associated with biomass utilization for biomass power, such as material variation, local, economic, environmental, fiscal and infrastructural factors. Accordingly, biomass availability varies from time to time. Besides, in practice, the agricultural commodities are processed at the family level, small processing units or modern mills. In the last decade, the lifestyle has changed in rural India, affecting these factors significantly.

The MNRE project to assess the surplus biomass potential executed by IISC and CGPL, and other Apex Institutions estimated the potential for biomass power as **18,000 MW** in **2002-04**. However, as mentioned above, the surplus may vary from time to time. Hence, it is necessary to update the biomass power potential in the country.

Thus, the MNRE called for proposals to assess the latest biomass power potential in India with the following scope of work:

Scope of Work

A. To assess the Biomass Power potential that can be generated through available surplus Biomass in the country

a. State-wise Crop Production;

b. State-wise Surplus Biomass Availability and Power Potential;

c. Resource Wise Power Potential;

d. Residue - Growth for all the crops depending on the crop yield and other parameters and, most importantly, the current usage trend in terms of nature and magnitude.

B. To assess the Bagasse Cogeneration power potential in sugar mills that can be generated through available surplus Bagasse

a. State-wise Sugar Production;

b. State-wise Availability of Bagasse and Power Potential.

Approach & Methodology

In response to the EOI, the Administrative Staff College of India suggested the approach and methodology for estimating the Biomass Power potential and Bagasse Co-generation potential in India. MNRE assigned the task to ASCI by accepting the suggested approach and methodology.

The study was designed to estimate the surplus biomass availability and its associated power potential in India. Further, it was also planned to look at the growth and usage patterns of crop residue over the years to understand the trend/ pattern utilization of Biomass and Bagasse.

Desk research work was carried out to assess the surplus biomass availability and surplus biomass power potential. The desk research includes secondary data collection of district wise crop statistics for the last 20 years like crop production, crop area, and crop yield. The crop statistics data was collected from the "Directorate of Economics and Statistics" under "Ministry of Agriculture and Farmers Welfare" and the State Agriculture Departments. The data is used to determine district wise and state-wise major and minor crops and to locate the sample districts for the primary survey.

Assumptions

The study is based on the following assumptions:

1. The proposed study estimated the biomass residue potential and surplus availability for power generation only from the agricultural produce. For this purpose, crops grown in India have been classified into six groups, and the associated yield and acreage data for the various crops have been collected. This approach allowed for trend analysis of growth of crop production and served as the basis for selecting locations for the primary survey.

Table 3: Category of Crops

S.no.	Category of Crops[14]	Crops
1	Cereals	Rice, Wheat, Maize, Bajra, Barley, Small Millet, Jowar and Ragi
2	Oil Seeds	Mustard & Rapeseed, Sesame, Linseed, Niger, Soyabean, Safflower, Sunflower, Ground Nut, Castor seed
3	Pulses	All types of gram viz., Black gram, Red gram, Green gram, Pigeon peas, Peas & beans and Lentil
4	Sugarcane	Bagasse and its top-end leaves
5	Horticulture	Coconut, Banana and Arecanut
6	Others	Including Cotton, Jute and Mesta

2. **Major Crop** of any state in India has been defined as that crop with maximum production, and minor crop of the state is defined as that crop with the second-highest production.

3. The **Residue to Product Ratio /Residue Factor** of each crop is calculated as the ratio of the weight of biomass generated by a particular crop to the weight of the main crop. This definition has been adopted from the methodology adopted by the Indian Institute of Science (IISc), Bangalore.[15]

4. For the primary survey, district and village selection was made through random stratified sampling based on crop acreage.

5. **Biomass Residue Potential** has been defined as the total/ maximum amount of agricultural biomass residue/ agricultural waste produced. It may be put to multiple uses such as fodder for cattle, thatched roofs, domestic fuel, brick-kiln industry, ice factories, etc.

6. **Surplus Biomass Residue Potential** of a crop has been defined as the excess amount of agricultural biomass residue/ agriculture waste which could be used for electricity generation after usage in other activities.

7. **Surplus Residue Factor** is the ratio of surplus biomass residue of a crop to that crop's total/gross biomass residue potential.[16] The **Surplus Residue Factor** is obtained through primary survey and secondary data sets.

The two critical parameters used in potential biomass generation and surplus biomass power potentials are Crop Residue Ratio (CRR) and Gross Calorific Value (GCV).

Crop Residue Ratio[17] **(CRR)**: The ratio of the weight of residue generated to the weight of the main crop (e.g. ratio of straw and grain in case of cereals).

Gross Calorific Value (GCV): Gross calorific value of residue is defined as the amount of heat released when the unit quantity of a residue is burnt. Its unit is MJ/kg or Kcal/kg.

With the above approach, a total of three variables are estimated in the study, viz "Gross Residue Potential", "Surplus Residue Potential", and "Biomass Power Potential". The secondary data on Area, Crop Production, Yield, Crop Residue Ratio, Biomass Generation, Biomass Utilization from Field Survey and other few parameters were collected from 2004 to 2018 to estimate "Gross Residue Potential", "Surplus Residue Potential", and "Biomass Power Potential". The detailed procedure adopted to arrive at the potential is described as below:

Model for Biomass Power Potential

1. Calculation of Gross residue potential[18]

Gross residue potential is the product of crop area, crop yield and the CRR value of that crop residue. District wise biomass potential of all crops is calculated similarly. Summation of biomass potential of all districts within a state will give biomass potential of that state. The gross residue potential of a particular crop depends upon three parameters are as below:

- Area covered by the crop;
- Yield of the crop; and
- CRR value of the crop residue.

Using the above parameters, the Gross Residue Potential will be estimated as

$$CRg(j)=\sum A(i,j)*Y(i,j)*CRR(i,j) \text{ ---------- i)}$$

Where,

CRg (j) is gross crop residue potential at j^{th} state from *n* number of crops, tonne;

A (i,j) is the area under i^{th} crop at j^{th} state, hectare;

Y (i,j) is the yield of i^{th} crop at jth state, tonne hectare-1 and

CRR (i,j) is the crop residue ratio of i^{th} crop at j^{th} state.

14. Bio-energy Potential from Crop Residue Biomass in India, Moonmoom Hiloidhari, Dhiman Das, DC Baruah, 2.1 Selection of Crops, Page no. 08 (URL:http://www.sciencedirect.com/science/article/pii/S1364032114000367)
15. Biomass Resource Atlas of India V2.0 – A Project of MNRE Executed by CGPL, IISc, Bangalore
16. Biomass Resource Atlas of India V2.0 – A Project of MNRE Executed by CGPL, IISc, Bangalore
17. Bio-energy and Food Security Rapid Appraisal/ Crop Residue and Livestock Residue User Manual/ Page no. 5
18. Bioenergy potential from crop residue biomass in India, Moonmoom Hiloidhari, Dhiman Das, DC Baruah

2. Calculation of Surplus Residue Potential

Surplus residue potential is the residue remaining with the farmer after it has been used for various purposes like domestic fuel, cattle feeding, thatching, organic manure (compost/green fertilizer) production and other industrial usages. This surplus residue is either dumped as waste on barren land or is set to open fire.

Crop residues have competing uses, and therefore, only a particular portion of gross residue is available for energy purpose. This portion is termed as surplus and is estimated as follows.

$$CRs(j)=\sum CRg(i,j)*SF(i,j) \quad \text{----------} \quad \text{ii)}$$

Where,

CRs (*j*) is the surplus residue potential at j^{th} state from *n* number of crops, tonne;

CRg (*i,j*) is the gross crop residue potential of i^{th} crop at j^{th} state, tonne and

SF (*i,j*) is the surplus residue fraction of i^{th} crop at j^{th} state.

3. Estimation of Biomass Power Potential

Product of surplus residue potential of a crop and its calorific value gives the Biomass power potential. In a similar manner, Biomass power potential for all the crops can be calculated.

The formula used for the calculation of Biomass power potential from surplus residue potential is as follows:

$$E(j)=\sum CRs(i,j)*HV(i,j) \quad \text{----------} \quad \text{iii)}$$

Where,

E (*j*) is biomass power potential of n crops at j^{th} state, MJ;

CRs (*i,j*) is surplus residue potential of i^{th} crop at j^{th} state, Tonne;

HV (*i, j*) is the heating value of i^{th} crop at j^{th} state, MJ tonne-1.

4. Time-series Analysis for predicting the crop-wise biomass power potential:

To the above-derived biomass power potential data, a time series analysis statistical technique was applied to predict/ forecast the future values of the biomass power potential of the selected crops across the selected states in India. In addition to that, trend analysis was performed to understand the trend pattern of the crop biomass power potential over a period of time. Timeseries analysis deals with times series data, i.e., the data is in a series of particular time periods/ interval. For the present study, we considered the data of crop-wise biomass power potential from the 2000-2018 period for all the selected crops across the states in India. Here, the dependent variable ŷi, i.e., biomass power potential, is regressed on the dependent variable time variable Xi.

The formula used for the analysis of time series analysis of biomass power potential is as follows:

$$\hat{y}i = mXi + C$$

Where,

ŷi = Predicted crop biomass power potential for the i^{th} period

Xi = Time variable for ith Period

M = Slope of the selected crop biomass power potential series

C = Intercept of the selected crop biomass power potential series

By applying the above formulae, biomass power potential values are predicted for the time period of 2019 to 2025 based on the trend component in the data series of the selected crop. Likewise, the values are forecasted for all the selected crops across the selected states. For each state, forecasted biomass power potential of all crops within state are compiled to derive the state level biomass power potential and scope for the selected period. Further, these values are aggregated across all the states to find the total potential and scope of the biomass power potential at all India level.

Sampling Methodology for Primary Survey

The main purpose of sampling methodology is to locate districts out of the total districts in India for conducting field survey in order to collect a maximum number of crop samples and filled in the questionnaire, i.e. responses from farmers to collect the data on parameters like crop residue utilization, seasonal cropping pattern, family size, cattle population, cost of shredding, cost of handling crop residue, willingness to sell the crop residue etc.

Sampling Objectives

The Objectives of the Sampling were as below:

- To select the representative respondents from identified samples out of the total population (districts);
- To represent complete Indian geography;
- To collect the primary data and crop samples for all the predominant crops from each state;
- To differentiate high, medium and low-density crop area so that crop residue utilization information from each crop density sub-group is collected.

Sampling Methodology

The agriculture land is spread across the country in various Zones/States and UTs. To identify biomass potential statistically, we have considered "Districts" as the population - 733 districts. The desired sample size is being calculated from the total population size through a statistical method which is as follows:

- The statistical sample size with **95%** confidence level, **50%** variability and **±5%** precision level is calculated to be **254** by using Cochrane's formula. Thus, **254 districts** from the whole of India would constitute a statistically valid sample for further analysis. (Stratified random sampling is applied);
- The selected 254 districts are spread in the states and UTs. Districts pertaining to the specific states are grouped for further analysis. Hence, states are different strata in stage 1 of multi-stage random sampling.

The study requires agricultural residue data covering more than 90% of the total cultivated land in that particular state. The districts with 90% and more coverage of individual crops in terms of cultivated land are selected as part of the sample as below:

- The districts are clubbed crop-wise. Then, they are further stratified as per crop density into three strata. The districts (Population) are clubbed crop-wise (which covers **90%** and above crop area), and cropping density wise further sub-grouped into three groups.
- The criteria for selection of the districts are based on the crop density in order to represent various types of respondent's behaviour with higher, medium and lower density of cropping, viz.
    a. **Higher Crop Density Strata**: High-Density Crop Districts are the ones that cover **50% - 100%** of agriculture land area for that crop in the descending order of their value.
    b. **Medium Crop Density Strata**: Medium Density Crop Districts are the ones that cover **20% - 50%** of agriculture land area for that crop in the descending order of their value.
    c. **Lower Crop Density Strata**: Low-Density Crop Districts are the ones that cover **0% - 20%** of agriculture land area for that crop in the descending order of their value.
- One district from each group is randomly selected (Random Sampling Without Replacement)
- Total districts selected from each state are in order to match the sample size of 254.

Two villages are randomly selected from each selected districts (Random Sampling WOR (Without Replacement)) (Stratification - strata (village))

- Here the villages are grouped district wise, and representative two villages are randomly selected from district wise group of villages. A minimum of 10 respondents from each village will be randomly selected for primary data collection for the proposed study.

Sample Selection Flow

The representative respondents are finally selected randomly from 254 districts out of the total 733 districts of India.

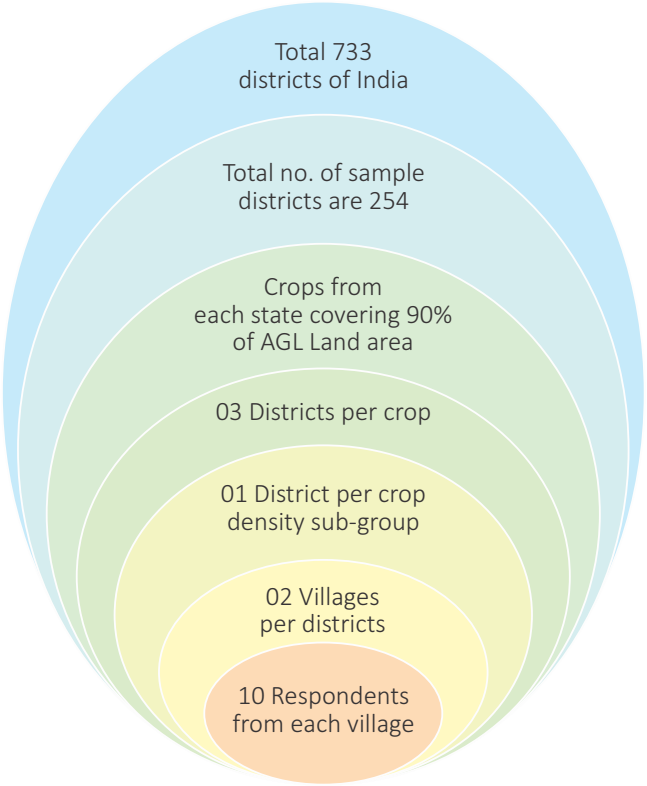


Figure 9: Sample Selection Flow

- The ten representative respondents (farmers) are randomly selected from each village;
- 02 villages are randomly selected from each district;
- 01 district is randomly selected from each crop density sub-groups;
- 03 districts from each crop group;
- The state-wise crops are selected, which covers 90% of the land;
- Total 254 districts are selected from all the states (from the total of 733 districts);

A detailed survey plan has been prepared for the field survey to cover the selected districts across pan India. The survey plans are prepared based on harvesting season to collect crop samples and required information from farmers as per the designed questionnaire. (Refer to Annexure- A)

The group of crops (number of crops) covering 90% of the cultivated land in that particular state were considered as a sample. The availability of those particular crops which comes under the 90% criteria in a particular month is tabulated against the total number of crops that comes under 90% of the criteria in that particular state for sample survey in Table 5.

Once the crops are mapped with the respective districts in a particular state, the survey plan based on the crop calendar was designed as below

Survey Plan based on Crop Calendar

The field survey was conducted to collect information about crop production, the area under cultivation, details about the year-round crops being cultivated, crop residue availability, crop residue usage and its management.

Apart from collecting the information about crop residue usage, the survey team also collected the crop samples from the agriculture fields. Planning of the field survey proved vital for the collection of the maximum number of crop samples during the field survey.

The harvesting season of crops is the most appropriate time for the collection of crop samples. The collected sample was a one-kilogram full-grown crop, except for sugarcane and coconut.

The month of September, October and November was considered as the appropriate time for conducting the field survey. The month of September marks the beginning of the harvesting season for Kharif crops in various States/ UTs across India and continues till November-December.

Amongst these three months, the month in which maximum crops are harvested in the state/ zone together with maximum agriculture land area covered by those crops were chosen for field survey and tabulated in table 5.

During the crop sample selection, preference was given to the crops that are produced extensively with agriculture land area coverage greater than or equal to 90% of the total agriculture land area in the state. Hence, the number of crops and crop species differ from state to state.

The state-wise, zone-wise harvesting season and percentage of land area covered by crops for that particular month is tabulated in Table no. 4. It is evident from the table that except for North Zone, all other zones (West, East, North-East and South) indicate that a significant percentage of the land area is covered by harvest crops in that particular state and zone.

One of the main reasons for the low percentage in North Zone is due to the dominance of crops like wheat, barley, etc., in those particular states. Wheat is extensively produced in the northern states like Uttar Pradesh, Punjab, Haryana, Rajasthan etc. It is a Rabi crop and is primarily harvested in the months of February – April, whereas the field survey was conducted in the months of September – November. However, the crop sample for wheat collected in the preliminary field survey was considered for GCV and further analysis.

Apart from the collection of crop samples, the emphasis was put on gathering information about crop residue usage and its management, which plays a crucial role in estimating state-wise and crop-wise surplus biomass and bagasse cogeneration power potential in the country.

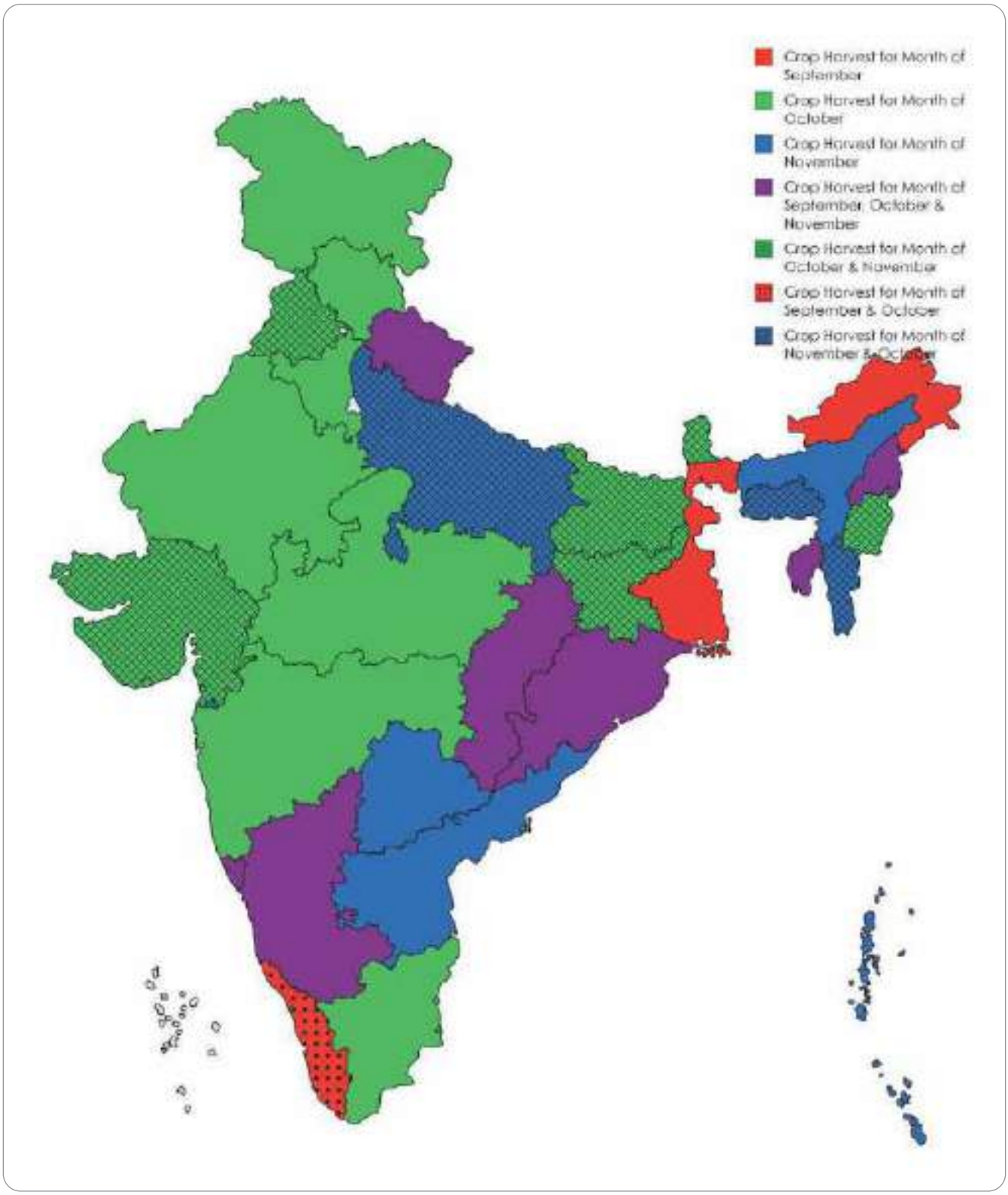


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Figure10: Map representing the month-wise field visits to respective states

All India map depicting the apt month for conducting the field survey was prepared as shown in the above figure. The different colour indicates the month. The map is self-explanatory, and it was helpful for our survey teams to plan field survey and team movements efficiently and effectively.

The following table represents the State-wise and Zone-wise percentage land area covered by predominant crops and harvesting season of crops.

Table 4: Zone-wise Crop Coverage (%)

Zones	States & Union Territories	Harvest Months	% of land area covered by harvest crops	Zone-wise Average (%)
West Zone	Maharashtra	October	57.5	74.2
	Goa	September	54.0	
	Gujarat	November	69.1	
	Madhya Pradesh	October	47.0	
	Chhattisgarh	October	91.6	
	Daman & Diu	October	100.0	
	Dadar and Nagar Haveli	November	100.0	
North Zone	Punjab	October	48.8	46.6
	Haryana	October	32.6	
	Rajasthan	October	47.8	
	Himachal Pradesh	October	49.1	
	Jammu &Kashmir	October	63.1	
	Uttarakhand	September	49.3	
	Uttar Pradesh	November	35.7	
	Chandigarh		0.0	
	Delhi		0.0	
East Zone	Bihar	October	66.3	83.3
	Jharkhand	October	86.5	
	West Bengal	September	80.5	
	Odisha	September	100.0	
North East Zone	Sikkim	October	94.3	83.7
	Assam	November	84.7	
	Arunachal Pradesh	September	70.8	
	Meghalaya	November	70.8	
	Tripura	November	93.3	
	Mizoram	November	100.0	
	Manipur	October	80.2	
	Nagaland	November	75.3	
South Zone	Andhra Pradesh	November	60.4	82.7
	Tamil Nadu	October	74.0	
	Kerala	September	87.8	
	Puducherry	October	100.0	
	Telangana	November	89.4	
	Karnataka	September	67.4	
	Andaman & Nicobar Islands	November	100.0	
	Lakshadweep		0.0	
All India Average %				**74.1**

The following table gives the approach to select the number of full-grown crops for the survey, based on their harvesting month, against the total crops required from that state. For Example, in Andhra Pradesh State, the total crop needs to be collected 12. However, due to the limitation of the harvesting period pertaining to some particular crops in the state, we could collect a maximum of 05 full-grown samples from AP. The rest of the samples were also collected in similar manner, matched with secondary data for CRR and sent the actual sample for GCV to a lab for testing. The GCV of that particular crop is only considered in the final calculation of biomass power potential.

Table 5: State-wise selection of the number of Crop samples based on Crop Coverage Percentage (%) for the Months of Sept, Oct, and Nov

States/ Uts	No. of harvesting crops & % of land area covered	Months			Total crops come under 90% criteria need to be collected	No. of Survey Districts
		September	October	November		
Andaman & Nicobar Islands	No. of harvesting crops available in that particular month	3	2	4	4	1
	% of land area covered by harvest crops	85.5	71.8	100		
Andhra Pradesh	No. of harvesting crops available in that particular month	3	3	5	12	7
	% of land area covered by harvest crops	14.1	26.7	60.4		
Arunachal Pradesh	No. of harvesting crops available in that particular month	2	1	1	4	6
	% of land area covered by harvest crops	70.8	51.2	18.8		
Assam	No. of harvesting crops available in that particular month	2	2	4	7	11
	% of land area covered by harvest crops	4.5	4.5	84.7		
Bihar	No. of harvesting crops available in that particular month	3	4	3	6	13
	% of land area covered by harvest crops	55.6	66.3	63.8		
Chandigarh	No. of harvesting crops available in that particular month	NA	NA	NA	NA	1
	% of land area covered by harvest crops	NA	NA	NA		
Chhattisgarh	No. of harvesting crops available in that particular month	2	3	2	5	10
	% of land area covered by harvest crops	89	91.6	89.5		
Dadar and Nagar Haveli	No. of harvesting crops available in that particular month	0	1	2	2	1
	% of land area covered by harvest crops	0	90.2	100		
Daman & Diu	No. of harvesting crops available in that particular month	1	2	1	2	1
	% of land area covered by harvest crops	19.6	100	80.4		
Delhi	No. of harvesting crops available in that particular month	NA	NA	NA	NA	4
	% of land area covered by harvest crops	NA	NA	NA		

States/ Uts	No. of harvesting crops & % of land area covered	Months			Total crops come under 90% criteria need to be collected	No. of Survey Districts
		September	October	November		
Goa	No. of harvesting crops available in that particular month	2	2	2	3	1
	% of land area covered by harvest crops	54	54	54		
Gujarat	No. of harvesting crops available in that particular month	3	7	7	14	14
	% of land area covered by harvest crops	29.7	70.1	69.1		
Haryana	No. of harvesting crops available in that particular month	2	2	1	6	7
	% of land area covered by harvest crops	28.3	32.6	11		
Himachal Pradesh	No. of harvesting crops available in that particular month	0	2	1	4	5
	% of land area covered by harvest crops	0	49.1	38.7		
Jammu &Kashmir	No. of harvesting crops available in that particular month	1	2	1	4	8
	% of land area covered by harvest crops	30.9	63.1	32.2		
Jharkhand	No. of harvesting crops available in that particular month	1	2	2	5	8
	% of land area covered by harvest crops	79.2	86.5	86.5		
Karnataka	No. of harvesting crops available in that particular month	12	11	10	19	11
	% of land area covered by harvest crops	67.4	64.9	61.9		
Kerala	No. of harvesting crops available in that particular month	4	3	3	6	5
	% of land area covered by harvest crops	87.8	80.1	74.2		
Lakshadweep	No. of harvesting crops available in that particular month	2	1	2	2	1
	% of land area covered by harvest crops	100		100		
Madhya Pradesh	No. of harvesting crops available in that particular month	3	4	4	10	17
	% of land area covered by harvest crops	37.5	47	20.1		
Maharashtra	No. of harvesting crops available in that particular month	4	7	5	11	12
	% of land area covered by harvest crops	42	57.5	42.6		
Manipur	No. of harvesting crops available in that particular month	2	2	2	5	4
	% of land area covered by harvest crops	14.4	80.2	80.2		

States/ Uts	No. of harvesting crops & % of land area covered	Months			Total crops come under 90% criteria need to be collected	No. of Survey Districts
		September	October	November		
Meghalaya	No. of harvesting crops available in that particular month	3	5	6	13	5
	% of land area covered by harvest crops	13.8	63.6	70.8		
Mizoram	No. of harvesting crops available in that particular month	2	3	5	5	3
	% of land area covered by harvest crops	15.8	94.8	100		
Nagaland	No. of harvesting crops available in that particular month	4	5	6	11	4
	% of land area covered by harvest crops	70.1	72.8	75.3		
Odisha	No. of harvesting crops available in that particular month	2	1	1	2	6
	% of land area covered by harvest crops	100	92.4	92.4		
Puducherry	No. of harvesting crops available in that particular month	4	5	3	5	2
	% of land area covered by harvest crops	24	100	92.9		
Punjab	No. of harvesting crops available in that particular month	0	2	2	4	7
	% of land area covered by harvest crops	0	48.8	48.8		
Rajasthan	No. of harvesting crops available in that particular month	2	6	4	13	12
	% of land area covered by harvest crops	23.1	47.8	24.2		
Sikkim	No. of harvesting crops available in that particular month	3	5	4	6	2
	% of land area covered by harvest crops	71.6	94.3	89.9		
Tamil Nadu	No. of harvesting crops available in that particular month	5	7	3	13	13
	% of land area covered by harvest crops	62.5	74	5.7		
Telangana	No. of harvesting crops available in that particular month	4	2	5	8	11
	% of land area covered by harvest crops	27.1	18.8	89.4		
Tripura	No. of harvesting crops available in that particular month	2	2	1	4	3
	% of land area covered by harvest crops	96.3	96.3	93.3		
Uttar Pradesh	No. of harvesting crops available in that particular month	2	7	8	21	25
	% of land area covered by harvest crops	4.1	34	35.7		

States/ Uts	No. of harvesting crops & % of land area covered	Months			Total crops come under 90% criteria need to be collected	No. of Survey Districts
		September	October	November		
Uttarakhand	No. of harvesting crops available in that particular month	4	4	3	8	5
	% of land area covered by harvest crops	49.3	49.3	46.9		
West Bengal	No. of harvesting crops available in that particular month	2	1	1	6	8
	% of land area covered by harvest crops	80.5	73.4	73.4		
Total Survey Districts						**254**

** NA – Information Not Available*

Note:

1. The details about Chandigarh, Delhi and Lakshadweep are not represented in the above table. In the case of Chandigarh, Wheat is the only crop that is predominantly produced and is not harvested in the months considered above. So, the details are not mentioned.
2. In the case of Delhi and Lakshadweep, the required data is not available.

Note: As of now, Ladakh is a separate UT. However, at the time of designing the methodology, it was covered in J&K. Similarly, Daman & Diu and Dadar & Nagar Haveli, which were considered separately in the methodology, have been merged into a single UT.

Based on the above, the final selected list of districts for the survey is as below:

Table 6: State-wise list of districts for a field survey

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
1	**Andaman and Nicobar Islands**	South Andaman	1
2	**Andhra Pradesh**	Kurnool	7
		Anantapur	
		East Godavari	
		Visakhapatnam	
		Vizianagaram	
		West Godavari	
		Guntur	
3	**Arunachal Pradesh**	Lower Dibang Valley	6
		East Kameng	
		Anjaw	
		Changlang	
		West Siang	
		Lohit	
4	**Assam**	Sonitpur	11
		Udalguri	
		Kokrajhar	
		Darrang	
		Goalpara	
		Karbi Anglong	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
		Dima Hasao	
		Barpeta	
		Nagaon	
		Nalbari	
		Dhubri	
5	Bihar	Purbi Champaran	13
		Muzaffarpur	
		Vaishali	
		Katihar	
		Purnia	
		Madhepuri	
		Gopalgunj	
		Patna	
		Gaya	
		Paschim Champaran	
		Darbhanga	
		Rohtas	
		Aurangabad	
6	Chandigarh	Chandigarh	1
7	Chhattisgarh	Kondagaon	10
		Raigarh	
		Kanker	
		Mungeli	
		Durg	
		Dantewada	
		Bemetara	
		Rajnandgaon	
		Mahasamund	
		Kabirdham	
8	Dadra and Nagar Haveli	Dadra and Nagar Haveli	1
9	Daman and Diu	Daman	1
10	Goa	North Goa	1
11	Gujarat	Bharuch	14
		Ahmedabad	
		Kachchh	
		Dohad	
		Surendranagar	
		Banas Kantha	
		Kheda	
		Surat	
		Rajkot	
		Patan	
		Vadodara	
		Jamnagar	
		SabarKantha	
		Mahisagar	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
		Dima Hasao	
		Barpeta	
		Nagaon	
		Nalbari	
		Dhubri	
5	Bihar	Purbi Champaran	13
		Muzaffarpur	
		Vaishali	
		Katihar	
		Purnia	
		Madhepuri	
		Gopalgunj	
		Patna	
		Gaya	
		Paschim Champaran	
		Darbhanga	
		Rohtas	
		Aurangabad	
6	Chandigarh	Chandigarh	1
7	Chhattisgarh	Kondagaon	10
		Raigarh	
		Kanker	
		Mungeli	
		Durg	
		Dantewada	
		Bemetara	
		Rajnandgaon	
		Mahasamund	
		Kabirdham	
8	Dadra and Nagar Haveli	Dadra and Nagar Haveli	1
9	Daman and Diu	Daman	1
10	Goa	North Goa	1
11	Gujarat	Bharuch	14
		Ahmedabad	
		Kachchh	
		Dohad	
		Surendranagar	
		Banas Kantha	
		Kheda	
		Surat	
		Rajkot	
		Patan	
		Vadodara	
		Jamnagar	
		SabarKantha	
		Mahisagar	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
12	Haryana	Sirsa	7
		Hisar	
		Bhiwani	
		Jind	
		Karnal	
		Jhajjar	
		Panipat	
13	Himachal Pradesh	Chamba	5
		Kullu	
		Sirmaur	
		Kangra	
		Solan	
14	Jammu & Kashmir	Jammu	8
		Rajauri	
		Udhampur	
		Ladakh	
		Poonch	
		Reasi	
		Kulgam	
		Anantnag	
15	Jharkhand	Palamau	8
		Gumla	
		Garhwa	
		Hazaribagh	
		Chatra	
		Lohardaga	
		Simdega	
		Ranchi	
16	Karnataka	Belgaum	11
		Bijapur	
		Gulbarga	
		Koppal	
		Bellary	
		Haveri	
		Shimoga	
		Tumkur	
		Hasan	
		Chitradurg	
		Bidar	
17	Kerala	Kozhikode	5
		Palakkad	
		Thrissur	
		Wayanad	
		Kollam	
18	Lakshadweep	Lakshadweep	1

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
19	Madhya Pradesh	Vidisha	17
		Ujjain	
		Dhar	
		Chhindwara	
		Bhopal	
		Satna	
		Panna	
		Khargone	
		Gwalior	
		Morena	
		Guna	
		Chhatarpur	
		Sagar	
		Seoni	
		Mandsaur	
		Harda	
		Rewa	
20	Maharashtra	Yavatmal	12
		Osmanabad	
		Latur	
		Amravati	
		Solapur	
		Beed	
		Bhandara	
		Nagpur	
		Jalgaon	
		Nashik	
		Kolhapur	
		Sangli	
21	Manipur	Thoubal	4
		Churachandpur	
		Imphal West	
		Senapati	
22	Meghalaya	East Khasi Hills	5
		West Garo Hills	
		East Garo Hills	
		North Garo Hills	
		South West Khasi Hills	
23	Mizoram	Lunglei	3
		Serchhip	
		Kolasib	
24	Nagaland	Dimapur	4
		Kohima	
		Tuensang	
		Mon	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
25	NCT Delhi	EL-Dstt 05 South-West	4
		EL-Dstt 01 North-West	
		EL-Dstt 03 South	
		EL-Dstt 08 North	
26	Odisha	Mayurbhanj	6
		Kendujhar	
		Nuapada	
		Ganjam	
		Balangiri	
		Boudh	
27	Puducherry	Pondicherry	2
		Karaikal	
28	Punjab	Sangrur	7
		Bathinda	
		Mansa	
		Faridkot	
		Tarn Taran	
		Fazilka	
		Amritsar	
29	Rajasthan	Hanumangarh	12
		Jodhpur	
		Bhilwara	
		Tonk	
		Ajmer	
		Bikaner	
		Churu	
		Jaipur	
		Bundi	
		Jhalawar	
		Kota	
		Sikar	
30	Sikkim	East Sikkim	2
		South Sikkim	
31	Tamil Nadu	Erode	13
		Coimbatore	
		Thiruvarur	
		Tiruvannamalai	
		Ariyalur	
		Villupuram	
		Namakkal	
		Theni	
		Karur	
		Dharmapuri	
		Salem	
		Krishnagiri	
		Dindigul	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
32	Telangana	Sangareddy	11
		Vikarabad	
		Nalgonda	
		Mahabubnagar	
		Janagaon	
		Nizamabad	
		Jayashankar Bhupalapally	
		Mahbubabad	
		Nagarkurnool	
		Kamareddy	
		Wanaparthy	
33	Tripura	Sephahijala	3
		Dhalai	
		West Tripura	
34	Uttar Pradesh	Hardoi	25
		Lucknow	
		Bijnor	
		Azamgarh	
		Agra	
		Mirzapur	
		Allahabad	
		Kannauj	
		Firozabad	
		Lalitpur	
		Bareilly	
		Pratapgarh	
		Hamirpur	
		Kaushambi	
		Baharaich	
		Jhansi	
		Varanasi	
		Fatehpur	
		Banda	
		Ghazipur	
		Mahoba	
		Gorakhpur	
		Etah	
		Gonda	
		Kheri	
35	Uttarakhand	Dehradun	5
		Pauri Garhwal	
		Tehri Garhwal	
		Haridwar	
		Udham Singh Nagar	

Sr. No	States/ Uts	Districts for a field survey	No. of Districts for a field survey
36	West Bengal	Medinipur West	8
		Bankura	
		Murshidabad	
		Maldah	
		Hooghly	
		Nadia	
		Paraganas North	
		Jalpaiguri	
Total Survey Districts			254

Questionnaire Design

Questionnaire for Field Survey

A set of Questions have been designed focusing on agricultural farmers to collect relevant information about:

- Crop Area, Production and Yield;
- Crop Residue generation and Utilization (for a domestic and commercial purpose);
- Surplus biomass availability;
- Cost of selling residue for commercial purposes (Vendors, Biomass plants etc.);
- State-wise cropping pattern followed as per season;
- Management of surplus biomass;
- Residue transportation cost etc.

The questions were designed in such a way that they would collect both qualitative and quantitative data as per the scope of work. Refer to Annexure – A for Primary Field Survey Questionnaire

Questionnaire for Biomass and Bagasse Cogeneration Plants

The questionnaire was designed by focusing on the Biomass Plant and Bagasse Co-generation Plants/ Sugar mills to extract useful technical, economic and operational information about the plants like

- Plant Installed Capacity (MW);
- Biomass Power Generation (MU) for the last 03 years;
- Availability of Biomass and Type of Fuel;
- Procurement of residue, its storage and mode of transportation;
- Type of Boilers and its fuel usage;
- Plant Operating Condition (Full Load /Half Load);
- Life of the Plant, Years of Operations;
- Financial incentives.

Based on the questionnaires, efforts were put to coordinate and collect maximum responses from the Biomass and Bagasse Co-generation Plants via e-mail. Selected Biomass/Bagasse co-generation plants were visited for conducting Focus Group Discussions (FGDs)/ Interviews with key executives to understand issues and challenges faced by plants, considering both technical and commercial aspects.

Refer to Annexure – A for Survey Questionnaire for Biomass Power and Bagasse Co-generation Power Plants (Sugar Mills)

Field Survey

The field survey included the collection of crop samples and gathering of information about crop production, crop residue generation, crop residue utilization, and the crops being produced by the farmers across the year.

Based on the crop calendar, harvesting months, September, October and November months were chosen to collect crop samples and to interact with farmers (Large, Medium and Small) with approved questionnaires.

The state-wise districts determined through the sampling methodology, as mentioned above, were surveyed. Two villages from each sample district were randomly selected for the survey. The villages that are located a minimum of five (05) km from the main road were preferred for the survey . In villages, respondents, i.e. farmers, were randomly selected. Interaction with a minimum of ten (10) farmers was taken in each village. While collecting the crop samples, the emphasis was put on the crops that cover agriculture land area greater than or equal to 90% of the total agriculture land area in the state.

Collection of Crop Sample:

Collection of crop samples during the harvesting season by using a quadrat frame of a known size is the most straightforward approach to collect crop samples. Quadrat frame is used to restrict large agriculture field to a limited area for collecting crop samples. Considering the crop density per unit area same across the field, the crop encapsulated by the quadrat frame is collected as the crop sample. The frame of appropriate size like 1'x1' for sample collection was used for all crops except crops like sugarcane, banana, coconut etc. However; adjustable frames were used as per requirement;

The crop sample was clipped from the field and was weighed with the help of a digital weighing machine. Care was taken while weighing by removing unwanted debris and grass that gets attached to the crop samples.

Weighed crop samples were stored in the sealed plastic bags. The crop samples collected across India were received at ASCI Hyderabad. The received crop samples were segregated and the parts mentioned in column 3, column 4, and column 5 are processed for assessment such as CRR and GCV calculation.

Table 7: Crop Residues for selected/identified crops as part of the assessment

Sr. No	Total Crops	Field Residue (Level 1: At Farmer Level)	Mills (Level 2: At mills)	After Processing (Level 3: Others)	Final output (Crop/ Grains)	Remarks
1	2	3	4	5	6	7
1	Arecanut (Betal nut)	Leaves, Husk, Fronds	Husk	-	Nut	After separation of nut
2	Arhar (Tur)	Stalk, Leaves	Husk	-	Arhar Dal	Dal Mills- husk after preparation of Arhar Dal
3	Bajra	Stalk, Husk, Cobs	-	-	Bajra grains	-
4	Banana	Tree, Stalk, Leaves	The outer cover of the banana & some attachments	-	Banana	For making Banana chips outer cover and connecting attachments will be separated from the banana
5	Barley	Stalk, Husk	-	-	Barely grains	-
6	Black pepper	Leaves, Husk	-	-	Black pepper	-
7	Cashew nut	Pericarp, the outer layer of the cashew seed	-	-	Cashew seed	-
8	Castor seed	Pods, Stalk	Pods	Castor cake	Castor seed and castor oil	After extraction of oil caster cake will be the final output which is generally used for animal food
9	Coconut	Fronds, Husk &Pith, Shell	Outer cover of coconut	Coconut cake	Coconut & its various product like coconut oil, coconut milk etc	The outer shell of the coconut after making various products from coconut
10	Coffee	Husk, pruning waste	Husk, pruning waste	-	Seeds	-
11	Coriander	Stalk	Stalk- coriander seed	-	Seed, coriander powder & wet plant.	No residue- dried coriander is used for coriander power, & Seeds are also used for power

Sr. No	Total Crops	Field Residue (Level 1: At Farmer Level)	Mills (Level 2: At mills)	After Processing (Level 3: Others)	Final output (Crop/ Grains)	Remarks
1	2	3	4	5	6	7
12	Cotton	Ball shell, Husk, Stalks	Cotton seed	Cotton seed cake	Cotton, Cotton seed oil	Cotton seed in ginning, Cotton seed cake after extraction of oil in oil mill
13	Cowpea	Stalk, Husk	Husk	-	Pea, Dal	-
14	Cumin seed	Stalk	Husk	-	Cumin Seed & Spices Powder	-
15	Dry chillies	Stalk, Husk	End attachment & Seed	-	Chillies, Chillies Power	-
16	Garlic	Sheath (middle stem of garlic), husk (only dry part of the spring garlic)	Husk & Cobs of garlic	-	Garlic Powder & various spices	-
17	Ginger	husk (only dry part of the spring garlic)	Husk	-	Ginger Powder & various spices	-
18	Gram	Stalk, Husk	Husk	-	Whole Gram & Dal	Husk- processing into dal mill
19	Groundnut	stalk, husk shell	Shell	Groundnut cake	Groundnut & Ground nut oil	The shell of groundnut, groundnut cake- after processing into oil mills
20	Guar seed	Stalk, Husk	Husk	-	Gaur seed	Husk- processing into dal mill
21	Horse-gram	Stalk, Husk	Husk	-	Gram	Husk- processing into dal mill
22	Jute	Leaves, Husk	Leaves, Husk	-	-	Less or no residue
23	Linseed (Flex seed)	Stalk	Stalk	Cake	-	Extraction of oil in oil mill
24	Maize	Cobs, Husk, Stalk, Maize seed- if deshelling is done on the farm for seeding purpose	Husk, Cobs	-	Maize seed	-
25	Masoor	Husk, Stalk	Husk	-	-	Husk- processing into dal mill
26	Mesta	Leaves, husk, Stalk	Stalk	-	-	-
27	Moong	Stalk, Husk	Husk	-	Moong grains	Husk- processing into dal mill
28	Moth	Stalk, husk	Husk	-	Moth Beans	Nil
29	Mustard	Stalks	Husk	Mustered cake	Mustard Seeds	cake after extraction of oils

Sr. No	Total Crops	Field Residue (Level 1: At Farmer Level)	Mills (Level 2: At mills)	After Processing (Level 3: Others)	Final output (Crop/ Grains)	Remarks
1	2	3	4	5	6	7
30	Niger Seed	Stalks	Husk	Niger seed cake	Niger Seed	cake after extraction of oils
31	Oats	stalk, husk	Husk	-	Oats	Husk- processing into dal mill
32	Onion	Stalks	Husk	-	-	-
33	Other Cereals	Stalks	Husk	-	Grains to market	-
34	Other Kharif pulses	Stalks	Husk	-	Grains to market	-
35	Other Oilseeds	Stalks	Husk	Cake	Grains and Oil	cake after extraction of oils
36	Other Rabi pulses	Stalks	Husk	-	Grains to market	-
37	Paddy (Rice)	Husk, Stalks, Straw	Husk	Bran cake	Paddy	Husk- processing into the mill Bran cake after extraction of oil
38	Peas & beans	Stalks	Stalks	-	Peas and Seeds	-
39	Potato	Leaves, Stalks	Outer covering	-	Potato & other products	-
40	Ragi	stalk, husk, Straw	Husk	-	Ragi Grains	-
41	Rapeseed & Mustard	Stalks	Husk	Cake	Mustard seeds Rapeseed & Mustard oil	extraction of oil in oil mill
42	Rubber	Primary wood, Secondary wood	-	-	-	-
43	Rye	Stalk, Husk	Stalk, Husk	-	Ray	husk- processing into dal mill
44	Safflower	Leaves, Stalk	-	Cake	-	Cake after extraction of oils
45	Sesame (Til)	Stalks	Stalks	Cake	Seasame seed & Seasame oil	Cake after extraction of oils
46	Small Millets	Stalk, Husk	Husk	-	Millets	Husk- processing into dal mill
47	Sorghum (Jowar)	Stalk, Husk, Cobs	Husk	-	Jowar grains	
48	Soyabean	Stalk, Husk	Husk	cake	Soyabean, Soyabean dal & Soyabean oil	Husk- processing into dal mill Cake- after extraction of oils
49	Sugarcane	Bagasse, Top& Leaves	Bagasse	-	Sugar & Allied products	-
50	Sunflower	Stalks, Husk, Leaves	Husk	-	Seeds	Cake after extraction of oils

Sr. No	Total Crops	Field Residue (Level 1: At Farmer Level)	Mills (Level 2: At mills)	After Processing (Level 3: Others)	Final output (Crop/ Grains)	Remarks
1	2	3	4	5	6	7
51	Sweet Potato	Stalks	Stalks	-	Tuber	-
52	Tapioca	Stalks	Stalks	-	-	-
53	Tea	Stalks	Stalks	-	-	-
54	Tobacco	Stalk	-	-	-	Leaves used for Beedi preparation
55	Turmeric	Stalks	-	-	Dried &Cooked Turmeric send to the market	Nil
56	Urad	Stalk, Husk	Stalk, Husk	-	Urad	Husk- processing into dal mill
57	Wheat	Stalk, Husk Pods	Stalk, Husk, Pods	-	Wheat	-

Apart from field Crop Sample Collection/ Survey Questionnaire; Focus Group Discussions (FGDs) were conducted with Biomass and Bagasse plants to collect relevant information on biomass usage and its availability, issues and challenges, annual consumption pattern and fuel availability.

Survey in Cotton Fields and collecting the crop sample of cotton and measuring the plant-to-plant distance, Asni (M), Yavathmal (Dist.), Maharashtra

Data Variables

Based on the above methodology, the selected/ identified data variables are tabulated as below for data model preparation and further analysis

Table 8: Data Variables considered for data model preparation and analysis

Sr. No	Data Variables	Units	Nature of Variables	Type of Data	Source for Secondary Data
1	Area	Hectare	Independent	Secondary Data	Directorate of Economics and Statistics
2	Yield	Tonnes/ Hectare	Dependent	Secondary Data	Directorate of Economics and Statistics
3	Crop Residue Ratio	Constant	Dependent	Primary & Secondary Data	IISC Biomass Atlas & Relevant Research Papers
4	Biomass Generation	Tonnes	Dependent	Calculation	-
5	Biomass Utilization	Tonnes	Dependent	Primary Data	Will be Estimated based on Statistical Model
5(a)	Farmers Family Size	No.	Independent	Primary & Secondary Data	Agriculture Senses
5(b)	Cattle Population	No.	Independent	Primary & Secondary Data	Department Animal Husbandry and Dairying
5(c)	Biomass Plant/Sugar mills Installed Capacity	MW	Independent	Primary & Secondary Data	through SNAs and MNRE
5(d)	Paper mills	No.	Independent	Secondary Data	Research Papers and Secondary Data
5(e)	Brick Kilns	No.	Independent	Primary & Secondary Data	
5(f)	Ice Factories	No.	Independent	Primary & Secondary Data	
5(g)	Thermal Power Plants	No.	Independent	Primary & Secondary Data	
5(h)	Briquette Plants	No.	Independent	Primary & Secondary Data	
5(i)	Mushroom Cultivation	No.	Independent	Primary & Secondary Data	
5(j)	Other Biomass Usages	%	Independent	Primary & Secondary Data	Research Paper and Primary Field Survey
5(k)	Rice mills Utilization	Percentage	Independent	Secondary Data	Research Papers, Rice mills Association
5(l)	Oil mills Utilization	Percentage	Independent	Secondary Data	Research Papers, Oil mills Association
5(m)	Other Bagasse Utilization	Percentage	Independent	Secondary Data	Research Papers, Bagasse Co-generation Association
6	Surplus Biomass	Tonnes	-	Calculation	-
7	Gross Calorific Value	MJ/ Kg or Kcal/ kg	-	Primary & Secondary Data	Through Lab Analysis
8	Biomass Potential	MJ or Mwe	-	Calculation	-

03
CHAPTER

Data Collection and Data Analysis

DATA COLLECTION AND DATA ANALYSIS

As per the approach and methodology, the primary field survey was carried out from August to November 2020.

The present study was primarily undertaken through a field survey using a pre-structured schedule in 254 districts based on the concentration of the crops in the location as described in the chapter - 02.

In order to assess the surplus biomass availability and surplus biomass power potential, extensive desk research work was carried out on the data sets of 2004 – 2018 on various parameters/variables (Refer to Table 08). The desk research includes secondary data collection of district wise crop statistics for the last 14 years like crop production, crop area, and crop yield for about 54 crops. The crops covering 90% of the area are selected in each state. The crop statistics data was collected from the "Directorate of Economics and Statistics" under "Ministry of Agriculture and Farmers Welfare" and also from the State Agriculture Departments. The joint report by TIFAC and IARI on "Estimation of Surplus Crop Residue in India for Biofuel Production" as of October 2018. The data is used to determine district wise and state-wise major and minor crops and to locate the sample districts for a primary survey.

In the case of Primary data, they are collected with the help of a well-structured schedule from the respondents in the sampled districts in respective states. In the primary survey, information collected from the respondents includes farm holding size, family size, cattle count, crop-wise-season wise area, and crop-wise-season wise production & productivity, utilization pattern of the biomass, shredding cost and opinions of the respondents (farmers) with reference to the biomass procurement by the biomass processing plants and their willingness towards the processing of biomass for biomass power generation etc., across the 32 states including UT's in India.

Data compilation procedure and analytical tools used in the study

The collected primary information from the field was scrutinized to validate the data; quantitative techniques were employed for the analysis of the primary data. In order to maximize the accuracy, consistency checks were performed to validate the data. The collected data were statistically analyzed by using descriptive statistics (Mean, Growth rates, Summation), pivot tables. The data analyzed so are presented in tabulation and graphic form for better interpretation. The data was analyzed by keeping in view four critical parameters in tune with the objectives of the study. These include **"Total Biomass Potential", "Utilization Pattern", "Surplus Biomass Potential", and "Biomass Power Potential"**. The study was carried out by comparing the biomass power potential across the crops and across the states in India during the selected study period.

The analysis is carried out by the adoption of the formulas using both primary and secondary data collected from different sources by the method described in chapter 02.

As the farmers are harvesting one to three crops in an individual year, the crop-wise biomass and the biomass produced from various crops in a current year is calculated and aggregated to derive the total biomass produced at the individual farmer level. The biomass production and utilization pattern vary from farmer to farmer and crop to crop. By considering these variations, each crop-wise utilization pattern is calculated and summed up to derive the single value for the total utilization of the produced biomass at the farmer level. Based on this, the surplus biomass is derived by subtracting the utilized biomass from the total produced biomass at the farmer level. From this aggregated dataset, state-level average values are calculated for the cultivated area, production from the crop, biomass produced, biomass utilized and surplus biomass potential at individual farm level for better and comparative understanding across the states.

Synthesis of the Report

Based on the objectives of the study, with the statistical analysis, tabular forms, and graphs support, an interpretation was made to develop the project report on **"Evaluation study of Assessment of Biomass Power and Bagasse Co-generation Power Potential in the Country".**

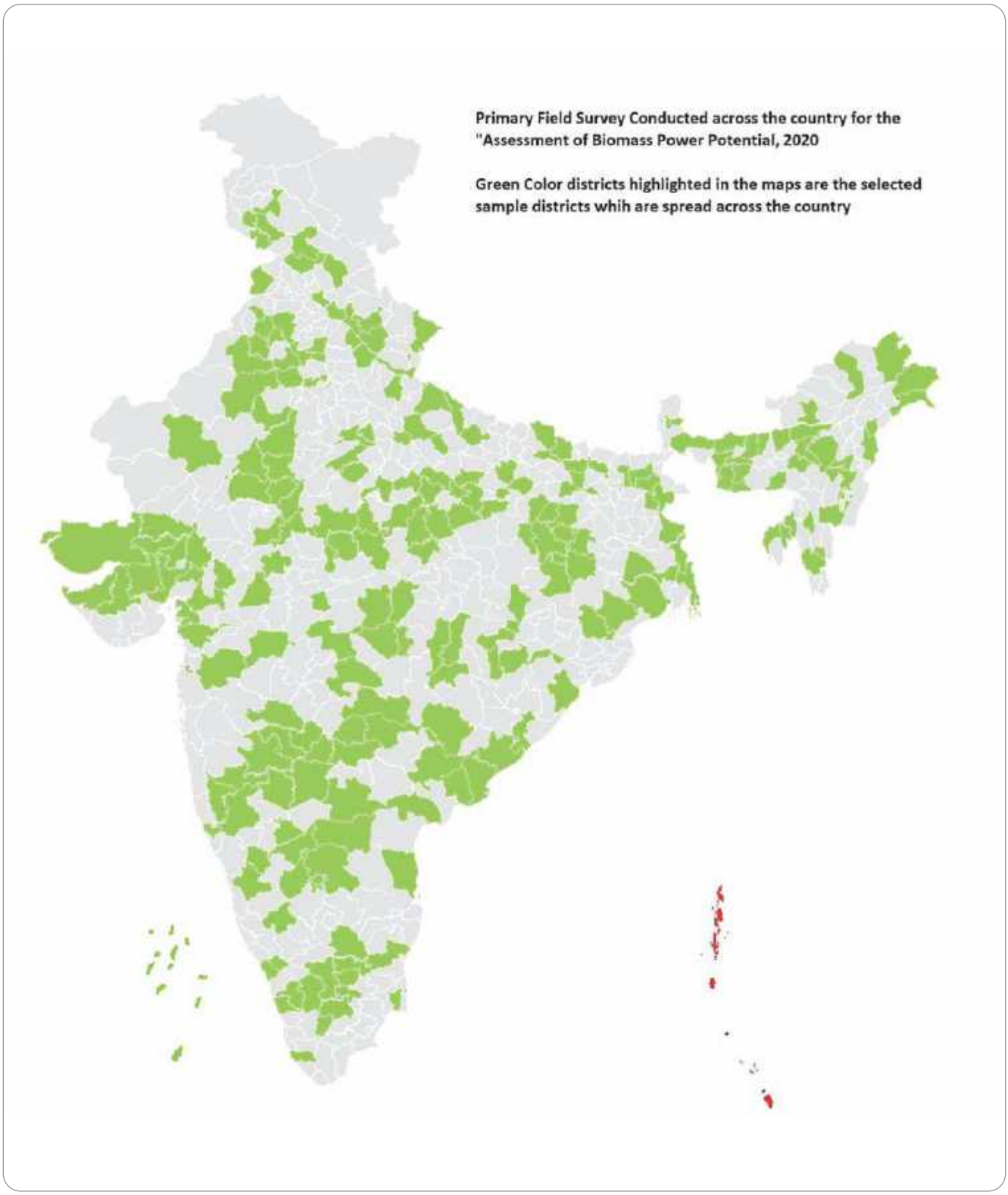


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Figure 11: India map represents the coverage of sample districts in various States/UTs for Field Survey

The survey was conducted in the entire country, and the completion of the survey is tabulated below.

Table 9: State-wise no. of districts completed and planned

S.no	Completed States / UTs	No. of Districts Completed compared to the No of districts planned
01	Chhattisgarh	10/10
02	Gujarat	14/14
03	Kerala	05/05
04	Madhya Pradesh	17/17
05	Uttar Pradesh	25/25
06	Uttarakhand	05/05
07	Karnataka	11/11
08	Telangana	11/11
09	Himachal Pradesh	05/05
10	Haryana	07/07
11	Punjab	07/07
12	West Bengal	07/07
13	Maharashtra	12/12
14	Assam	11/11
15	Sikkim	02/02
16	Arunachal Pradesh	06/06
17	Meghalaya	05/05
18	Tripura	03/03
19	Rajasthan	12/12
20	Bihar	13/13
21	Jharkhand	08/08
22	Andhra Pradesh	07/07
23	Tamil Nadu	13/13
24	Delhi	04/04
25	Odisha	06/06
26	Chandigarh	01/01
27	Daman Diu	01/01
28	Dadra N. Haveli	01/01
29	J & K	05/07
30	Manipur	05/05
31	Nagaland	04/04
32	Goa	01/01

Note: Field Survey could not be done in Andaman & Nicobar (2), Leh (1), Puducherry (1) due to COVID restrictions, non-availability of transport. Secondary data was used for Andaman and Nicobar, Leh, and Puducherry

The analysis was carried out on selected crops to understand the available residue during the crop processing cycle. The collected crop sample after drying and processing was sent for GCV analysis to an accredited lab in M/s Lucid Labs Pvt. Ltd. The GCV from lab testing results and CRR (from the secondary data source) is mapped for further analysis and tabulated as below:

Table 10: Crop-wise CRR (Crop Residue Ratio) and GCV

Sr. No	Crop Name	Crop Residue Types	Crop Residue Ratio (Secondary & Primary)	GCV (Primary & Secondary)
1	Arecanut	Fronds	3 (Tons/hectare)	4323
2	Arecanut	Husk (Coir)	0.8	4520
3	Arecanut	Shell		4950
4	Arhar / Tur	Stalks	2.5	4110
5	Arhar	Leaves		3940
6	Avare	Fronds / Stalk	1.1	
7	Bajra	Stalks	2	4180
8	Bajra	Cobs	0.33	3720
9	Bajra	Husk	0.3	4175
10	Bajra	Leaves		4410
11	Banana	Leaves, Steam, Fruit branch and Pith (Peel)	3	4156
12	Barley	Stalks	1.3	3936
13	Barley	Husk		4190
14	Black Pepper	Husk / Leaves		4160
15	Black Pepper	Stalks		
16	Black Gram	Stalks	0.24	3030
17	Black Gram	Leaves	0.61	3430
18	Black Gram	Shell	0.15	4050
19	Cardamom	Stalks	0.64 (Tons/hectare)	5130
20	Cardamom	Leaves	0.14	5370
21	Cashewnut	Shell		5580
22	Castor seed	Shell	0.03	4040
23	Castor seed	Stalks	724.63	4260
24	Castor seed	Leaves	246.37	3720
25	Coconut	Fronds	4 (Tons/hectare)	2389
26	Coconut	Husk & Pith	0.53	4600
27	Coconut	Shells	0.22	5100
28	Casurina	Fronds / Stalks	10 (Tons/hectare)	NA
29	Coriander	Stalks	1.15	4300
30	Cotton	Boll Shell	1.1	3900
31	Cotton	Husk / Leaves	1.1	3610
32	Cotton	Stalks	3.8 (Tons/hectare)	4340
33	Cotton	Grains / Seed		4560
34	Cow Pea	Fronds / Stalk	1.1	NA
35	Cumin seed	Fronds / Stalk	1.55	NA
36	Dry chillies	Stalks	1.5	4400
37	Dry Ginger	Stalks	0.05	4310
38	Eucalyptus	Fronds / Stalk	10 (Tons/hectare)	NA
39	Garlic	Fronds / Stalk	0.05	NA
40	Garlic	Others	0.25	NA
41	Ginger	Stalks		4310
42	Gram	Stalks	1.1	4340
43	Gram	Stalks	2	3439
44	Gram	Shell (Grain Shell)	0.3	4750
45	Gram	Stalks	2	4310
46	Gram	Straw		3726

Sr. No	Crop Name	Crop Residue Types	Crop Residue Ratio (Secondary & Primary)	GCV (Primary & Secondary)
47	Groundnut	Shells	0.3	4290
48	Groundnut	Stalks	2	4110
49	Groundnut	leaves		2910
50	Guar Seed	Stalks	2	4190
51	Horse gram	Stalks	1.3	4330
52	Horse gram	Leaves	0.42	3820
53	Jowar	Stalks	1.7	4300
54	Jowar	Cobs	0.5	4154
55	Jowar	Husk / Leaves	0.2	3620
56	Jute	Stalks	2	4538
57	Linseed	Stalks	1.48	3427
58	Lentils	Stalks	1.8	3499
59	Maize	Stalks	2	3910
60	Maize	Cobs	0.3	4310
61	Maize	leaves	0.12	3680
62	Moong (Green Gram)	Stalks	1.1	4420
63	Moong (Green Gram)	Husk / Leaves	0.15	3680
64	Moong (Green Gram)	Bean Shell	0.18	4230
65	Moth Beans	Stalks	1.8	3950
66	Moth Beans	Leaves	0.5	2830
67	Mustard	Stalks	1.8	4460
68	Mustard	Husk	0.16	4070
69	Niger Seed	Stalks	1	4250
70	Niger Seed	Leaves	1.28	3720
71	Niger Seed	Flower	0.08	4060
72	Oil Seeds	Stalks	2	3200
73	Oil Seeds	Palm Shells		5114
74	Ragi	Straw	1	4230
75	Ragi	Husk / Leaves	0.3	4150
76	Rice (Paddy)	Straw	1.5	NA
77	Rice (Paddy)	Stalks		4080
78	Rice (Paddy)	Husk	0.2	3870
79	Rapeseed & Mustard	Stalks	1.8	4060
80	Rapeseed & Mustard	Husk		3840
81	Rubber	Fronds / Stalk	3 (Tons/hectare)	NA
82	Rubber	Others	2 (Tons/hectare)	NA
83	Safflower	Stalks	3	3198
84	Soyabean	Stalks	1.7	4250
85	Soyabean	leaves	0.22	4080
86	Sesamum	Stalks	1.5	4300
87	Sesamum	Leaves	1.3	4000
88	Sesamum	Shell		3800
89	Small Millets	Stalks	1.2	4290
90	Small Millets	Leaves		3660
91	Sugarcane	Tops and Leaves	0.05	4620
92	Sugarcane	Bagasse	0.33	4350
93	Sugarcane	Bagasse (Husk)		4220

Sr. No	Crop Name	Crop Residue Types	Crop Residue Ratio (Secondary & Primary)	GCV (Primary & Secondary)
94	Sun Flower	Stalks	2	3820
95	Sun Flower	Cobs / Leaves	1	3550
96	Sweet Potato	Stalks	0.1	3070
97	Sweet Potato	Leaves		4490
98	Tapioca	Stalks	0.75	3670
99	Tapioca	Leaves		4720
100	Wheat	Stalks	1.5	4380
101	Wheat	Straw		4010
102	Wheat	Pod / Husk	0.3	5600
103	Wheat	Husk (from mills)		3980
104	Briquettes	Mix of 2-3 crops	1	3620

*NA – Not Available

Based on the above mapping, the weighted average GCV was calculated considering different types of crop residue against each crop. In addition, it was necessary to convert surplus biomass in tonnage in terms of power (Mwe). The factor for this conversion is derived against each crop by considering plant efficiency, surplus biomass, gross calorific value (GCV), Plant availability and plant running hours.

Table 10.1 Crop-wise Weighted Avg. GCV and Conversion Factor

Sr. No.	Crop Name	Weighted Average GCV	Factor for Conversion
1	Arecanut	4520	0.13
2	Tur / Arhar	4091	0.12
3	Bajra	4124	0.12
4	Banana	4500	0.13
5	Barley	3936	0.12
6	Black Pepper	4160	0.12
7	Black Gram	3091	0.09
8	Cardamom	5130	0.15
9	Cashewnut	5517	0.16
10	Castor Seed	4246	0.13
11	Coconut	4656	0.14
12	Coriander	4300	0.13
13	Cotton	4101	0.12
14	Cow Pea	4545	0.13
15	Dry Chillies	4400	0.13
16	Garlic	4600	0.14
17	Ginger	4310	0.13
18	Gram	4427	0.13
19	Groundnut	4133	0.12
20	Guar Seed	4190	0.12
21	Horse Gram	4330	0.13
22	Jowar	4212	0.12
23	Jute	4538	0.13
24	Linseed	3427	0.10

Sr. No.	Crop Name	Weighted Average GCV	Factor for Conversion
25	Lentils (Masoor)	3499	0.10
26	Maize	3962	0.12
27	Moong (Green Gram)	4331	0.13
28	Moth Beans	3950	0.12
29	Niger Seed	4059	0.12
30	Oil Seeds	3209	0.09
31	Potato	3157	0.09
32	Ragi	4211	0.12
33	Rice (Paddy)	4620	0.14
34	Rapeseed & Mustard	4460	0.13
35	Safflower	3685	0.11
36	Soyabean	4230	0.12
37	Sesamum	4160	0.12
38	Small Millets	4290	0.13
39	Sugarcane	4620	0.14
40	Sunflower	3730	0.11
41	Sweet Potato	3070	0.09
42	Tobacco	4500	0.13
43	Tapioca	3670	0.11
44	Wheat	4583	0.14
45	Other Cereals	4000	0.12
46	Khesari	4200	0.12
47	Other Kharif Pulses	4100	0.12
48	Other Rabi Pulses	4100	0.12
49	Other Summer Pulses	4100	0.12
50	Peas and Beans (Pulses)	4200	0.12
51	Sunhemp	4200	0.12
52	Turmeric	4500	0.13
53	Onion	4600	0.14
54	Mesta	4538	0.13

04
CHAPTER

Data Analysis for Biomass Power Potential

DATA ANALYSIS FOR BIOMASS POWER POTENTIAL

Primary Data

For a better understanding of biomass production, its utilization pattern and surplus production potential at the farm level, information on these aspects were collected from 4,716 samples respondents and was analyzed. The details of the sampling distribution were illustrated in the below table. The respondents are selected from 247 Districts, 323 Mandals / Taluks and 494 Villages in total.

Table 11: Sample design of the selected study in India

States / UTs	Sample Size (No.)	Districts (No.)	Mandal's / Taluks (No.)	Villages (No.)
Andhra Pradesh	139	7	10	14
Arunachal Pradesh	119	7	8	12
Assam	160	11	7	14
Bihar	259	14	15	26
Chandigarh	5	1	1	1
Chhattisgarh	200	10	12	20
Dadra & Nagar Haveli	20	1	1	2
Daman & Diu	20	2	1	2
Goa	20	1	2	2
Gujarat	281	14	16	29
Haryana	140	7	8	14
Himachal Pradesh	100	5	6	10
Jammu and Kashmir	100	5	7	10
Jharkhand	160	8	13	18
Karnataka	210	12	14	21
Kerala	100	5	9	10
Madhya Pradesh	340	17	30	46
Maharashtra	241	12	17	24
Manipur	100	5	6	10
Meghalaya	100	5	6	10
Mizoram	60	3	3	6
Nagaland	79	4	5	8
Odisha	120	6	9	12
Punjab	140	7	12	14
Rajasthan	240	12	15	24
Sikkim	40	2	3	4
Tamil Nadu	260	13	25	27
Telangana	179	11	11	18
Tripura	60	3	3	6
Uttar Pradesh	499	25	31	50
Uttarakhand	83	5	6	10
West Bengal	142	7	11	14
Grand Total	4716	247	323	488

Zone wise sampling distribution is also derived from understanding the coverage of the area for the sample respondent's selection. Primary sample respondents were selected from the North zone (1307), Followed by West Zone (1122), South zone (888) and Northeast zone (718) and East Zone (681) respondents.

Table 12: Zone wise sample size distribution in the study area

S.no.	Zones	Sample size
1	East Zone	681
2	North East Zone	718
3	North Zone	1307
4	South Zone	888
5	West Zone	1122
Grand Total		**4716**

The distribution of respondents according to the type of land and landholding was done for every state and presented as below.

Table 13: District wise details of farm holding of the selected respondents in selected states in India

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Andhra Pradesh	Anantapur	2.772	9	13	1	6	13	0
	East Godavari	0.951	13	5	13	6	1	0
	Guntur	1.700	13	7	5	9	6	0
	Kurnool	1.507	11	9	7	10	3	0
	Visakhapatnam	1.184	12	8	11	6	3	0
	Vizianagaram	0.840	6	14	15	3	2	0
	West Godavari	1.470	16	3	5	9	5	0
	Total	**1.489**	**80**	**59**	**57**	**49**	**33**	**0**
Arunachal Pradesh	Chanulang	1.072	18	2	11	8	1	0
	East Siang	0.880	10	10	15	4	1	0
	Lohit	1.133	20	0	9	10	1	0
	Lower Dibang Valley	1.093	19	0	13	6	1	0
	Namsai	1.747	19	1	0	11	8	0
	West Siang	0.708	10	10	18	2	0	0
	Total	**1.100**	**96**	**23**	**66**	**41**	**12**	**0**
Assam	Barpeta	0.492	20	0	20	0	0	0
	Darrang	0.546	20	0	20	0	0	0
	Dhubri	0.337	8	12	20	0	0	0
	Goalpara	0.597		20	19	0	1	0
	Kokrajhar	0.337	20	0	20	0	0	0
	Nalbar	0.533	20	0	18	2	0	0
	Sonitpur	0.438	7	13	20	0	0	0
	Udalguri	0.567	20	0	20	0	0	0
	Total	**0.481**	**115**	**45**	**157**	**2**	1	**0**

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Bihar	Aurangabad	1.129		20	14	4	2	0
	Darbhanga	0.629	10	0	10	0	0	0
	Dharbhanga	0.582	10	0	10	0	0	0
	East Champaran	0.709	11	9	17	3	0	0
	Gaya	0.785	3	17	18	2	0	0
	Gopalganj	0.444	13	7	19	1	0	0
	Kathiar	0.740	19	1	15	4	1	0
	Madhepura	0.762	18	2	16	3	1	0
	Muzaffarpur	0.590	19	1	19	1	0	0
	Patna	0.714	9	11	16	4	0	0
	Purniya	1.137	18	1	11	5	3	0
	Rohtas	0.910	1	19	14	5	1	0
	Vaishali	0.385	18	2	20	0	0	0
	West Champaran	0.352	20	0	20	0	0	0
	Total	**0.711**	**169**	**90**	**219**	**32**	**8**	**0**
Chandigarh	Chandigarh	1.835	5	0	0	3	2	0
	Total	**1.835**	**5**	**0**	**0**	**3**	**2**	**0**
Chhattisgarh	Bemetara	4.249	18	2	1	4	13	2
	Dantewada	2.469	1	19	3	3	14	0
	Durg	2.954	19	1	0	6	14	0
	Kabirdham	2.064	10	10	4	6	10	0
	Kanker	1.659	4	16	9	3	8	0
	Kondagaon	1.862	12	8	2	7	11	0
	Mahasamund	3.804	16	4	1	3	15	1
	Mungeli	5.079	9	11	3	1	14	2
	Raigarh	3.804	18	2	2	2	16	0
	Rajnandgaon	2.833	8	12	0	6	14	0
	Total	**3.078**	**115**	**85**	**25**	**41**	**129**	**5**
Dadra & Nagar Haveli	Dadra & Nagar Haveli	1.481	10	10	8	9	3	0
	Total	**1.481**	**10**	**10**	**8**	**9**	**3**	**0**
Daman & Diu	Daman	1.505	2	8	3	5	2	0
	Daman & Diu	1.068	1	9	7	2	1	0
	Total	**1.287**	**3**	**17**	**10**	**7**	**3**	**0**
Goa	North Goa	0.865		20	13	5	2	0
	Total	**0.865**		**20**	**13**	**5**	**2**	**0**
Gujarat	Ahmedabad	6.325	15	1	2	2	14	2
	Banaskantha	2.837	7	13	1	5	14	0
	Bharuch	1.724	15	9	4	8	8	0
	Dahod	3.233	10	10	2	4	14	0
	Jamnagar	3.118	13	7	3	3	14	0

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Gujarat	Kachchh	1.756	13	2	2	13	5	0
	Kheda	2.578	15	5	1	6	13	0
	Mahisagar	2.056	14	6	3	8	9	0
	Patan	1.846	13	8	1	16	4	0
	Rajkot	2.141	14	9	2	7	11	0
	Sabarkantha	2.351	6	14	1	7	12	0
	Surat	1.809	16	4	0	11	9	0
	Surendranagar	2.007	16	4	1	15	4	0
	Vadodara	2.635	15	7	1	9	10	0
	Total	**2.598**	**182**	**99**	**24**	**114**	**141**	**2**
Haryana	Bhiwani	1.507	20	0	7	10	3	0
	Hisar	2.003	20	0	3	9	8	0
	Jhajjar	1.194	20	0	10	8	2	0
	Jind	2.671	20	0	0	5	15	0
	Karnal	1.922	20	0	3	7	10	0
	Panipat	2.954	20	0	2	2	16	0
	Sirsa	2.590	20	0	1	4	15	0
	Total	**2.120**	**140**	**0**	**26**	**45**	**69**	**0**
Himachal Pradesh	Chamba	0.166		20	20	0	0	0
	Kangra	1.695	20	0	5	7	8	0
	Kullu	0.488		20	18	2	0	0
	Sirmaur	0.933	20	0	14	4	2	0
	Solan	0.510		20	18	2	0	0
	Total	**0.758**	**40**	**60**	**75**	**15**	**10**	**0**
Jammu and Kashmir	Jammu	0.524	20	0	19	0	1	0
	Poonch	0.216	20	0	20	0	0	0
	Rajowri	0.187	20	0	20	0	0	0
	Reasi	0.223	20	0	20	0	0	0
	Udhampur	0.233	20	0	20	0	0	0
	Total	**0.276**	**100**	**0**	**99**	**0**	**1**	**0**
Jharkhand	Chatra	0.986	20	1	11	9	0	0
	Garhwa	0.789	20		14	6	0	0
	Gumla	1.145	20		9	8	3	0
	Hazaribagh	0.865	20		16	2	2	0
	Lohardaga	0.789	19		15	5	0	0
	Palamu	0.870	20		15	3	2	0
	Ranchi	0.956	20		14	5	1	0
	Simdega	1.062	20		7	13	0	0
	Total	**0.933**	**159**	**1**	**101**	**51**	**8**	**0**

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Karnataka	Belgaum	1.963	6	9	6	8	6	0
	Bellary	1.841	11	9	6	7	7	0
	Bidar	1.244		20	7	12	1	0
	Bijapur	2.428	10	20	1	6	13	0
	Chitradurg	2.044	7	14	3	8	9	0
	Gulbarga	2.654	6	10	1	14	4	1
	Hassan	1.902	10	0	2	2	6	0
	Hassan	1.214	9	6	4	5	1	0
	Haveri	8.539	10	10	0	0	7	3
	Koppal	1.295	14	12	8	9	3	0
	Shivamogga	1.963	9	0	8	3	9	0
	Tumkur	1.720	6	2	8	6	6	0
	Total	**2.189**	**98**	**112**	**54**	**80**	**72**	**4**
Kerala	Kollam	1.639	20	0	5	8	7	0
	Kozhikode	1.022	16	4	13	6	1	0
	Pallakad	1.639	8	12	3	10	7	0
	Thrissur	21.610	19	1	0	0	3	17
	Wayanad	1.467	19	1	7	6	7	0
	Total	**5.475**	**82**	**18**	**28**	**30**	**25**	**17**
Madhya Pradesh	Bhopal	5.888	19	1	1	8	7	4
	Chhatarpur	1.558	9	11	3	11	6	0
	Chindwara	5.726	19	1	0	6	10	4
	Dhar	2.529	20	0	2	3	15	0
	Guna	2.023	14	6	1	7	12	0
	Gwalior	1.140	20	0	7	12	1	0
	Harda	3.379	10	10	1	2	17	0
	Khargone	2.388	15	5	0	6	14	0
	Mandsaur	1.611	18	2	7	5	8	0
	Morena	1.425	20	0	8	8	4	0
	Panna	1.679	10	10	3	9	8	0
	Rewa	2.145	12	8	3	8	9	0
	Sagar	2.914	16	4	1	7	12	0
	Satna	2.388	12	8	7	7	5	1
	Seoni	2.995	16	4	3	6	10	1
	Ujjain	1.288	20	0	10	6	4	0
	Vidisha	2.051	19	1	4	7	9	0
	Total	**2.537**	**269**	**71**	**61**	**118**	**151**	**10**
Maharashtra	Amravati	2.003	18	2	1	9	10	0
	Beed	2.398	13	7	6	6	7	1
	Bhandara	2.023	4	16	2	9	9	0

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Maharashtra	Jalgaon	1.767	14	8	3	10	8	0
	Kolhapur	1.831	15	0	2	8	10	0
	Latur	2.125	9	11	2	9	9	0
	Nagpur	2.974	14	12	1	6	13	0
	Nashik	1.507	8	12	4	11	5	0
	Osmanabad	1.497	11	9	5	11	4	0
	Sangli	2.317	15	3	0	8	12	0
	Solapur	1.513	12	8	3	9	8	0
	Yavatmal	2.742	17	3	0	7	13	0
	Total	**2.057**	**150**	**91**	**29**	**103**	**108**	**1**
Manipur	Churachandpur	1.040	4	16	9	9	2	0
	Imphal East	0.552		20	18	2	0	0
	Imphal West	0.676	4	16	16	4	0	0
	Senapati	0.457		20	19	1	0	0
	Thoubal	0.448	5	15	20	0	0	0
	Total	**0.634**	**13**	**87**	**82**	**16**	**2**	**0**
Meghalaya	East Garo Hills	2.798	4	16	0	6	14	0
	East Khasi Hills	0.718	13	7	15	5	0	0
	North Garo Hills	0.661	18	2	19	1	0	0
	South West Khasi Hills	0.789	13	7	12	8	0	0
	West Garo Hills	2.825	12	8	0	2	18	0
	Total	**1.558**	**60**	**40**	**46**	**22**	**32**	**0**
Mizoram	Aizawl	0.506	15	5	20	0	0	0
	Kolasib	0.447	1	19	20	0	0	0
	Serchhip	0.634	3	17	16	4	0	0
	Total	**0.529**	**19**	**41**	**56**	**4**	**0**	**0**
Nagaland	Dimapur	0.077	18	2	20	0	0	0
	Kohima	0.339	19	0	19	0	0	0
	Peren	0.449	9	11	20	0	0	0
	Wokha	0.523	18	2	19	1	0	0
	Total	**0.347**	**64**	**15**	**78**	**1**	**0**	**0**
Odisha	Balangir	0.809		20	15	5	0	0
	Boudh	1.862	16	4	3	11	6	0
	GANJAM	0.921	20	0	13	7	0	0
	Kendujhar	0.866		20	13	6	1	0
	Mayurbhanja	0.712		20	15	5	0	0
	Naupada	0.921		20	11	9	0	0
	Total	**1.015**	**36**	**84**	**70**	**43**	**7**	**0**
Punjab	Amritsar	9.166	20	0	0	0	11	9
	Bathinda	2.630	20	0	2	6	12	0

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Punjab	Faridkot	3.905	20	0	1	6	12	1
	Fazilka	2.347	20	0	7	6	6	1
	Mansa	1.133	20	0	9	7	4	0
	Sangrur	2.307	20	0	5	5	10	0
	Tarn Taran	2.711	20	0	1	4	15	0
	Total	**3.457**	**140**	**0**	**25**	**34**	**70**	**11**
Rajasthan	Ajmer	2.302		20	3	6	11	0
	Bhilwara	2.074	14	7	4	7	9	0
	Bikaner	1.808	9	11	2	11	7	0
	Bundi	2.567	19	1	3	5	12	0
	Churu	2.251	19	1	1	8	11	0
	Hanumangarh	1.922	16	4	1	13	6	0
	Jaipur	2.947	3	19	3	5	11	1
	Jhalawar	2.011	3	17	3	8	9	0
	Jodhpur	1.910	11	6	2	11	7	0
	Kota	2.466	9	11	2	6	12	0
	Sikar	2.011	13	7	0	10	10	0
	Tonk	2.782		20	2	5	13	0
	Total	**2.254**	**116**	**124**	**26**	**95**	**118**	**1**
Sikkim	East Sikkim	0.749	10	10	16	4	0	0
	North Sikkim	0.546	10	0	10	0	0	0
	Sikkim North	0.769	10	0	7	3	0	0
	Total	**0.703**	**30**	**10**	**33**	**7**	**0**	**0**
Tamil Nadu	Ariyalur	2.023	20	0	1	6	13	0
	Coimbatore	2.914	20	0	0	2	18	0
	Dharmapuri	1.963	20	0	2	7	11	0
	Dindigul	2.003	20	0	2	7	11	0
	Erode	2.772	20	0	0	1	19	0
	Karur	2.286	20	0	0	4	16	0
	Krishnagiri	1.821	20	0	0	15	5	0
	Namakkal	2.317	20	0	1	5	14	0
	Salem	2.185	20	0	1	5	14	0
	Theni	2.651	20	0	0	1	19	0
	Thiruvannamalai	2.084	20	0	1	8	11	0
	Thiruvarur	2.003	20	0	0	7	13	0
	Villupuram	2.206	20	0	0	5	15	0
	Total	**2.248**	**260**	**0**	**8**	**73**	**179**	**0**
Telangana	Jangaon	1.538	8	8	5	8	7	0
	Jayashankar Bhupalapally	1.093	11	9	12	6	2	0
	Kamareddy	2.420	11	8	8	6	5	1

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Telangana	Mahbubabad	2.792	10	16	0	0	20	0
	Mahbubnagar	1.963	10	10	0	14	6	0
	Nagarkurnool	1.661	7	12	5	9	5	0
	Nalgonda	2.489	11	11	6	3	11	0
	Nizamabad	1.740	10	6	2	12	6	0
	Wanaparthy	1.882	11	10	4	7	9	0
	Total	**1.955**	**89**	**90**	**42**	**65**	**71**	**1**
Tripura	Dhalai	0.321	17	3	20	0	0	0
	Sepahijala	0.353	20	0	19	1	0	0
	West Tripura	0.329	4	16	20	0	0	0
	Total	**0.335**	**41**	**19**	**59**	**1**	**0**	**0**
Uttar Pradesh	Agra	0.897	5	15	14	5	1	0
	Azamgarh	0.395	19	1	17	3	0	0
	Baharaich	2.833	20	0	7	4	7	2
	Banda	1.679	7	13	6	6	8	0
	Bareilly	0.823	18	2	14	6	0	0
	Bijnor	1.828	18	2	7	7	6	0
	Etah	1.194	7	13	11	6	3	0
	Fatehpur	1.234	7	13	6	12	2	0
	Firozabad	1.450	18	2	9	5	6	0
	Ghazipur	0.465	18	2	20	0	0	0
	Gonda	1.497	20	0	10	3	7	0
	Gorakhpur	0.807	20	0	12	7	1	0
	Hamirpur	2.131	8	12	3	13	4	0
	Hardoi	1.049	18	2	8	11	1	0
	Jhansi	1.639	2	18	9	5	6	0
	Kannauj	1.862	20	0	2	7	11	0
	Kaushambi	0.432	19	1	20	0	0	0
	Kheri	0.682	19	0	15	4	0	0
	Lalitpur	1.002	19	1	15	3	2	0
	Lucknow	0.659	19	1	15	5	0	0
	Mahoba	1.207	6	14	7	11	2	0
	Mirzapur	0.371	17	3	20	0	0	0
	Pratapgarh	0.324	16	4	20	0	0	0
	Prayagraj	0.580	20	0	17	3	0	0
	Varanasi	0.270	18	2	19	1	0	0
	Total	**1.093**	**378**	**121**	**303**	**127**	**67**	**2**
Uttarakhand	Dehradun	0.275	20	0	20	0	0	0
	Haridwar	0.262	20	0	20	0	0	0
	Pauri Garhwal	0.661	10	0	8	1	1	0

State	District	Avg. Total Agri. Land (in ha)	Land type (No. of Respondents)		Farmer type (No. of Respondents)			
			Wet land	Dry land	Marginal (<1 ha)	Small (1-2 ha)	Medium (2-10 ha)	Large (>10 ha)
Uttarakhand	Tehri Garhwal	0.148		13	13	0	0	0
	Udham Singh Nagar	1.416	20	0	14	1	5	0
	Total	**0.574**	**70**	**13**	**75**	**2**	**6**	**0**
West Bengal	Bankura	0.935	22	0	15	6	1	0
	Hoogly	0.814	20	0	16	1	3	0
	Jalpaiguri	0.445	14	6	20	0	0	0
	Mednipur	0.486	20	0	18	2	0	0
	Murshidabad	0.391	20	0	19	1	0	0
	Nadia	0.388	20	0	20	0	0	0
	Parganas North	0.479	14	6	20	0	0	0
	Total	**0.568**	**130**	**12**	**128**	**10**	**4**	**0**
Grand Total		**2.701**	**3259**	**1457**	**2083**	**1245**	**1334**	**54**

Source: Area in ha, Production in tones and Yield in t/ha

The above table explains the average farm holding of the selected respondents, farm holding type in the study area. On average, the selected respondents are holding 2.7101 Ha. The range of average farm holding across the major states is between 0.16 Ha to 9.1 Ha. The majority of the sample farm respondents belong to wetland (3259), whereas 1457 respondents have dry land for cultivations to. From the selected total sampled respondents, a significant chunk of the respondent's belongs to the marginal category (2083), followed by medium category (1334), small (1245) and a small proportion is from large category (54) respondents.

Further, the sample data was collected and mapped for livestock holding per family and district wise representation is as below:

Briquette Making Factory, Amaravati, Maharashtra

Table 14: District wise details of family size and livestock holding capacity of the selected respondents in selected states in India

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Andhra Pradesh	Anantpur	7.85	3.00	10.00	18.00	2.00	7.00	3.78	12.78
	East Godavari	6.30	0.00	7.00	16.00	2.00	0.00	3.19	5.19
	Guntur	7.15	0.00	18.00	20.00	2.11	0.00	3.80	5.91
	Kurnool	7.35	2.00	11.00	18.00	2.00	10.00	3.61	15.61
	Visakhapatnam	6.20	1.00	15.00	16.00	2.13	2.00	3.50	7.63
	Vizianagaram	4.90	0.00	9.00	17.00	2.22	0.00	2.88	5.10
	West Godavari	6.42	0.00	11.00	18.00	2.18	0.00	3.89	6.07
	Total	**6.60**	**6.00**	**81.00**	**123.00**	**2.10**	**7.17**	**3.54**	**12.80**
Arunachal Pradesh	Chanulang	7.30	0.00	1.00	19.00	0.0	0.00	6.58	6.58
	East Siang	5.90	15.00	1.00	2.00	3.00	2.40	8.00	13.40
	Lohit	8.65	0.00	0.00	20.00	0.00	0.00	7.35	7.35
	Lower Dibang Valley	7.15	0.00	0.00	20.00	0.00	0.00	5.65	5.65
	Namsai	7.16	0.00	0.00	17.00	0.00	0.00	6.88	6.88
	West Siang	6.25	1.00	8.00	8.00	2.75	3.00	5.88	11.63
	Total	**7.07**	**16.00**	**10.00**	**86.00**	**2.78**	**2.44**	**6.57**	**11.79**
Assam	Barpeta	5.25	0.00	1.00	20.00	1.00	0.00	1.25	2.25
	Darrang	5.30	0.00	0.00	18.00	0.00	0.00	1.89	1.89
	Dhubri	4.85	0.00	0.00	20.00	0.00	0.00	3.80	3.80
	Goalpara	6.00	0.00	0.00	18.00	0.00	0.00	4.44	4.44
	Kokrajhar	4.55	0.00	0.00	20.00	0.00	0.00	3.50	3.50
	Nalbar	5.35	0.00	0.00	17.00	0.00	0.00	1.00	1.00
	Sonitpur	5.60	0.00	0.00	20.00	0.00	0.00	3.35	3.35
	Udalguri	4.70	0.00	0.00	19.00	0.00	0.00	2.00	2.00
	Total	**5.20**	**0.00**	**1.00**	**152.00**	**1.00**	**0.00**	**2.68**	**3.68**
Bihar	Aurangabad	8.20	0.00	0.00	20.00	0.00	0.00	3.10	3.10
	Darbhanga	7.30	0.00	0.00	10.00	0.00	0.00	2.70	2.70
	Dharbhanga	6.70	0.00	0.00	10.00	0.00	0.00	2.80	2.80
	East Champaran	8.40	0.00	0.00	19.00	0.00	0.00	1.58	1.58
	Gaya	7.40	0.00	0.00	17.00	0.00	0.00	1.82	1.82
	Gopalganj	9.10	0.00	0.00	20.00	0.00	0.00	1.80	1.80
	Kathiar	7.85	0.00	0.00	19.00	0.00	0.00	2.79	2.79
	Madhepura	7.40	0.00	0.00	20.00	0.00	0.00	1.90	1.90
	Muzaffarpur	6.25	0.00	0.00	20.00	0.00	0.00	1.90	1.90
	Patna	6.70	0.00	0.00	17.00	0.00	0.00	2.29	2.29
	Purniya	7.42	0.00	0.00	18.00	0.00	0.00	2.33	2.33
	Rohtas	7.00	0.00	0.00	19.00	0.00	0.00	2.21	2.21
	Vaishali	5.45	0.00	0.00	20.00	0.00	0.00	1.75	1.75
	West Champaran	7.20	0.00	0.00	20.00	0.00	0.00	1.35	1.35
	Total	**7.34**	**0.00**	**0.00**	**249.00**	**0.00**	**0.00**	**2.12**	**2.12**

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Chandigarh	Chandigarh	7.20	0.00	0.00	5.00	0.00	0.00	4.80	4.80
	Total	**7.20**	**0.00**	**0.00**	**5.00**	**0.00**	**0.00**	**4.80**	**4.80**
Chhattisgarh	Bemetara	5.45	15.00	17.00	10.00	1.94	2.07	4.10	8.11
	Dantewada	5.30	7.00	15.00	10.00	2.20	1.71	4.70	8.61
	Durg	6.30	6.00	15.00	16.00	1.93	1.83	4.63	8.39
	Kabirdham	5.45	7.00	15.00	12.00	2.00	1.43	4.08	7.51
	Kanker	4.45	6.00	5.00	13.00	2.00	1.33	1.46	4.79
	Kondagaon	4.55	3.00	9.00	11.00	2.00	1.67	2.73	6.39
	Mahasamund	5.45	2.00	14.00	13.00	2.00	2.00	1.77	5.77
	Mungeli	5.35	8.00	14.00	19.00	1.93	1.50	4.05	7.48
	Raigarh	5.40	7.00	12.00	15.00	2.00	1.86	2.33	6.19
	Rajnandgaon	5.65	6.00	11.00	15.00	2.00	1.67	5.00	8.67
	Total	**5.34**	**67.00**	**127.00**	**134.00**	**2.00**	**1.73**	**3.51**	**7.24**
Dadra & Nagar Haveli	Dadra & Nagar Haveli	9.95	6.00	11.00	17.00	3.55	6.50	2.24	12.28
	Total	**9.95**	**6.00**	**11.00**	**17.00**	**3.55**	**6.50**	**2.24**	**12.28**
Daman & Diu	Daman	6.90	1.00	3.00	9.00	1.67	9.00	1.56	12.22
	Daman & Diu	7.00	0.00	2.00	10.00	2.00	0.00	2.10	4.10
	Total	**6.95**	**1.00**	**5.00**	**19.00**	**1.80**	**9.00**	**1.84**	**12.64**
Goa	North Goa	5.00	5.00	17.00	0.00	1.76	1.80	0.00	3.56
	Total	**5.00**	**5.00**	**17.00**	**0.00**	**1.76**	**1.80**	**0.00**	**3.56**
Gujarat	Ahmedabad	6.60	1.00	11.00	17.00	3.27	10.00	2.47	15.74
	Banaskantha	6.95	0.00	9.00	18.00	1.89	0.00	2.94	4.83
	Bharuch	6.00	3.00	1.00	14.00	2.00	5.00	2.50	9.50
	Dahod	9.00	0.00	5.00	16.00	2.20	0.00	3.13	5.33
	Jamnagar	6.05	0.00	4.00	18.00	2.00	0.00	1.72	3.72
	Kachchh	6.20	0.00	15.00	19.00	1.93	0.00	1.58	3.51
	Kheda	5.55	2.00	8.00	18.00	2.38	3.00	2.67	8.04
	Mahisagar	7.35	0.00	2.00	19.00	2.00	0.00	2.89	4.89
	Patan	6.67	0.00	0.00	16.00	0.00	0.00	3.69	3.69
	Rajkot	5.70	1.00	2.00	16.00	1.50	3.00	2.31	6.81
	Sabarkantha	6.15	0.00	4.00	19.00	1.75	0.00	1.84	3.59
	Surat	5.45	1.00	0.00	10.00	0.00	3.00	3.30	6.30
	Surendranagar	6.30	2.00	5.00	16.00	1.60	8.50	2.00	12.10
	Vadodara	5.30	1.00	0.00	15.00	0.00	22.00	3.67	25.67
	Total	**6.38**	**11.00**	**66.00**	**231.00**	**2.18**	**6.91**	**2.58**	**11.67**
Haryana	Bhiwani	5.50	0.00	0.00	20.00	0.00	0.00	4.15	4.15
	Hisar	4.55	0.00	0.00	20.00	0.00	0.00	3.80	3.80
	Jhajjar	5.30	0.00	0.00	20.00	0.00	0.00	3.80	3.80
	Jind	5.90	0.00	0.00	20.00	0.00	0.00	5.20	5.20
	Karnal	5.80	0.00	0.00	20.00	0.00	0.00	3.80	3.80

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Haryana	Panipat	6.90	0.00	0.00	20.00	0.00	0.00	5.40	5.40
	Sirsa	4.35	0.00	0.00	20.00	0.00	0.00	2.75	2.75
	Total	**5.47**	**0.00**	**0.00**	**140.00**	**0.00**	**0.00**	**4.13**	**4.13**
Himachal pradesh	Chamba	4.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kangra	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kullu	4.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sirmaur	5.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Solan	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**5.08**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Jammu and Kashmir	Jammu	6.10	0.00	0.00	20.00	0.00	0.00	2.95	2.95
	Poonch	3.65	0.00	0.00	20.00	0.00	0.00	2.30	2.30
	Rajowri	4.55	0.00	0.00	20.00	0.00	0.00	2.90	2.90
	Reasi	4.55	0.00	0.00	20.00	0.00	0.00	2.70	2.70
	Udhampur	4.65	0.00	0.00	20.00	0.00	0.00	2.40	2.40
	Total	**4.70**	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**	**2.65**	**2.65**
Jharkhand	Chatra	6.90	0.00	0.00	20.00	0.00	0.00	3.15	3.15
	Garhwa	6.35	0.00	0.00	20.00	0.00	0.00	2.30	2.30
	Gumla	8.05	0.00	0.00	18.00	0.00	0.00	1.72	1.72
	Hazaribagh	7.15	0.00	0.00	19.00	0.00	0.00	2.00	2.00
	Lohardaga	7.75	0.00	0.00	20.00	0.00	0.00	0.85	0.85
	Palamu	6.80	0.00	0.00	20.00	0.00	0.00	2.80	2.80
	Ranchi	7.60	0.00	0.00	20.00	0.00	0.00	0.75	0.75
	Simdega	7.20	0.00	0.00	20.00	0.00	0.00	2.40	2.40
	Total	**7.23**	**0.00**	**0.00**	**157.00**	**0.00**	**0.00**	**2.00**	**2.00**
Karnataka	Belgaum	5.50	11.00	12.00	13.00	2.17	4.18	2.38	8.73
	Bellary	7.80	4.00	18.00	19.00	2.00	9.75	3.16	14.91
	Bidar	6.85	0.00	14.00	20.00	1.93	0.00	2.70	4.63
	Bijapur	5.90	19.00	19.00	19.00	0.11	0.00	3.84	3.95
	Chitradurg	6.60	12.00	19.00	20.00	0.95	2.50	3.20	6.65
	Gulbarga	6.65	6.00	17.00	18.00	2.24	12.50	2.94	17.68
	Hassan	8.10	1.00	9.00	10.00	2.00	10.00	3.10	15.10
	Hassan	5.40	9.00	9.00	9.00	0.00	0.00	2.00	2.00
	Haveri	7.00	9.00	9.00	9.00	0.00	0.00	5.00	5.00
	Koppal	6.50	13.00	18.00	18.00	1.44	2.31	2.17	5.92
	Shivamogga	7.35	0.00	4.00	20.00	2.00	0.00	3.10	5.10
	Tumkur	6.40	0.00	10.00	13.00	2.00	0.00	2.62	4.62
	Total	**6.65**	**84.00**	**158.00**	**188.00**	**1.39**	**2.74**	**3.00**	**7.12**
Kerala	Kollam	8.70	0.00	0.00	17.00	0.00	0.00	5.59	5.59
	Kozhikode	6.10	0.00	0.00	9.00	0.00	0.00	1.89	1.89
	Pallakad	8.55	0.00	0.00	19.00	0.00	0.00	4.37	4.37

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Kerala	Thrissur	7.85	0.00	0.00	18.00	0.00	0.00	4.22	4.22
	Wayanad	5.45	0.00	0.00	11.00	0.00	0.00	2.18	2.18
	Total	**7.33**	**0.00**	**0.00**	**74.00**	**0.00**	**0.00**	**3.99**	**3.99**
Madhya Pradesh	Bhopal	4.60	0.00	0.00	20.00	0.00	0.00	3.70	3.70
	Chhatarpur	4.50	4.00	7.00	15.00	2.00	1.50	2.27	5.77
	Chindwara	4.95	0.00	9.00	20.00	2.22	0.00	5.60	7.82
	Dhar	4.50	0.00	0.00	18.00	0.00	0.00	3.78	3.78
	Guna	5.00	2.00	14.00	16.00	1.86	1.00	3.81	6.67
	Gwalior	5.45	0.00	0.00	19.00	0.00	0.00	2.16	2.16
	Harda	5.35	0.00	0.00	20.00	0.00	0.00	4.95	4.95
	Khargone	5.00	0.00	5.00	19.00	2.00	0.00	3.95	5.95
	Mandsaur	4.35	0.00	8.00	13.00	2.00	0.00	2.54	4.54
	Morena	6.10	0.00	0.00	19.00	0.00	0.00	2.95	2.95
	Panna	4.25	0.00	6.00	16.00	1.67	0.00	2.69	4.35
	Rewa	5.10	0.00	8.00	17.00	1.63	0.00	2.29	3.92
	Sagar	4.95	0.00	2.00	18.00	3.00	0.00	3.28	6.28
	Satna	4.25	0.00	1.00	20.00	2.00	0.00	3.25	5.25
	Seoni	5.20	6.00	10.00	15.00	2.20	1.50	2.80	6.50
	Ujjain	6.05	0.00	1.00	18.00	2.00	0.00	4.00	6.00
	Vidisha	5.30	0.00	0.00	19.00	0.00	0.00	4.00	4.00
	Total	**4.99**	**12.00**	**71.00**	**302.00**	**1.99**	**1.42**	**3.47**	**6.88**
Maharashtra	Amravati	5.55	9.00	16.00	4.00	1.88	1.89	2.75	6.51
	Beed	5.90	5.00	17.00	2.00	1.82	2.20	2.50	6.52
	Bhandara	4.70	8.00	16.00	8.00	2.25	1.88	4.75	8.88
	Jalgaon	4.57	10.00	10.00	10.00	1.90	2.70	3.50	8.10
	Kolhapur	5.80	1.00	4.00	17.00	1.75	3.00	1.94	6.69
	Latur	5.45	1.00	11.00	9.00	2.09	2.00	2.11	6.20
	Nagpur	8.60	0.00	0.00	17.00	0.00	0.00	3.53	3.53
	Nashik	5.85	1.00	8.00	16.00	2.00	3.00	1.88	6.88
	Osmanabad	4.90	19.00	12.00	0.00	1.75	2.95	0.00	4.70
	Sangli	5.25	8.00	17.00	5.00	1.82	2.38	3.80	8.00
	Solapur	5.00	12.00	13.00	0.00	1.77	2.67	0.00	4.44
	Yavatmal	4.25	13.00	10.00	2.00	2.00	2.15	2.00	6.15
	Total	**5.48**	**87.00**	**134.00**	**90.00**	**1.92**	**2.45**	**2.82**	**7.19**
Manipur	Churachandpur	5.80	0.00	0.00	7.00	0.00	0.00	2.57	2.57
	Imphal East	5.75	0.00	0.00	2.00	0.00	0.00	1.50	1.50
	Imphal West	4.95	0.00	0.00	7.00	0.00	0.00	2.71	2.71
	Senapati	6.00	0.00	0.00	2.00	0.00	0.00	2.50	2.50
	Thoubal	4.70	0.00	0.00	3.00	0.00	0.00	2.00	2.00
	Total	**5.44**	**0.00**	**0.00**	**21.00**	**0.00**	**0.00**	**2.45**	**2.45**

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Meghalaya	East Garo Hills	6.95	0.00	0.00	20.00	0.00	0.00	4.70	4.70
	East Khasi Hills	4.45	1.00	12.00	14.00	1.42	1.00	1.43	3.85
	North Garo Hills	5.70	0.00	0.00	20.00	0.00	0.00	4.70	4.70
	South West Khasi Hills	4.40	0.00	7.00	11.00	1.29	0.00	1.55	2.83
	West Garo Hills	6.65	0.00	0.00	20.00	0.00	0.00	4.65	4.65
	Total	**5.63**	**1.00**	**19.00**	**85.00**	**1.37**	**1.00**	**3.74**	**6.11**
Mizoram	Aizawl	4.70	1.00	5.00	9.00	1.40	2.00	1.67	5.07
	Kolasib	5.80	0.00	0.00	1.00	0.00	0.00	1.00	1.00
	Serchhip	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**5.30**	**1.00**	**5.00**	**10.00**	**1.40**	**2.00**	**1.60**	**5.00**
Nagaland	Dimapur	3.35	0.00	0.00	2.00	0.00	0.00	1.50	1.50
	Kohima	4.05	8.00	19.00	19.00	0.00	0.00	2.53	2.53
	Peren	8.65	14.00	8.00	1.00	2.13	3.29	2.00	7.41
	Wokha	3.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**4.91**	**22.00**	**27.00**	**22.00**	**0.63**	**2.09**	**2.41**	**5.13**
Odisha	Balangir	4.10	6.00	4.00	2.00	2.25	3.33	1.50	7.08
	Boudh	4.45	0.00	7.00	11.00	2.86	0.00	4.09	6.95
	GANJAM	6.30	0.00	0.00	15.00	0.00	0.00	2.07	2.07
	Kendujhar	5.45	3.00	0.00	17.00	0.00	4.00	3.59	7.59
	Mayurbhanja	4.65	2.00	0.00	15.00	0.00	7.00	2.80	9.80
	Naupada	4.90	3.00	0.00	15.00	0.00	5.67	2.20	7.87
	Total	**4.98**	**14.00**	**11.00**	**75.00**	**2.64**	**4.50**	**2.87**	**10.00**
Punjab	Amritsar	5.20	0.00	0.00	20.00	0.00	0.00	6.65	6.65
	Bathinda	4.90	0.00	0.00	20.00	0.00	0.00	2.30	2.30
	Faridkot	4.90	0.00	0.00	20.00	0.00	0.00	3.60	3.60
	Fazilka	4.60	0.00	0.00	20.00	0.00	0.00	4.70	4.70
	Mansa	4.80	0.00	0.00	20.00	0.00	0.00	2.05	2.05
	Sangrur	4.80	0.00	0.00	20.00	0.00	0.00	2.15	2.15
	Tarn Taran	4.40	0.00	0.00	20.00	0.00	0.00	4.40	4.40
	Total	**4.80**	**0.00**	**0.00**	**140.00**	**0.00**	**0.00**	**3.69**	**3.69**
Rajasthan	Ajmer	10.35	8.00	9.00	16.00	3.67	4.25	2.38	10.29
	Bhilwara	9.00	4.00	15.00	14.00	2.00	4.50	2.71	9.21
	Bikaner	4.30	11.00	4.00	14.00	2.25	1.73	2.21	6.19
	Bundi	9.60	8.00	11.00	18.00	4.00	13.38	1.83	19.21
	Churu	4.85	12.00	9.00	14.00	1.89	2.67	3.00	7.56
	Hanumangarh	4.05	14.00	2.00	15.00	2.50	1.71	2.13	6.35
	Jaipur	10.65	11.00	15.00	13.00	4.80	3.27	2.31	10.38
	Jhalawar	7.00	1.00	9.00	16.00	1.89	9.00	1.75	12.64
	Jodhpur	4.90	12.00	6.00	12.00	2.33	2.17	3.08	7.58
	Kota	8.10	2.00	11.00	16.00	1.64	5.50	1.50	8.64

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Rajasthan	Sikar	4.25	16.00	3.00	14.00	2.00	2.00	2.07	6.07
	Tonk	8.90	9.00	14.00	11.00	2.07	3.33	2.00	7.40
	Total	**7.16**	**108.00**	**108.00**	**173.00**	**2.72**	**3.50**	**2.22**	**8.44**
Sikkim	East Sikkim	4.95	3.00	3.00	15.00	2.67	6.00	2.00	10.67
	North Sikkim	4.70	0.00	1.00	4.00	2.00	0.00	1.25	3.25
	Sikkim North	6.00	1.00	1.00	7.00	1.00	1.00	1.43	3.43
	Total	**5.15**	**4.00**	**5.00**	**26.00**	**2.20**	**4.75**	**1.73**	**8.68**
Tamil Nadu	Ariyalur	4.80	0.00	3.00	20.00	2.00	0.00	4.00	6.00
	Coimbatore	4.75	0.00	0.00	20.00	0.00	0.00	3.05	3.05
	Dharmapuri	5.25	0.00	0.00	20.00	0.00	0.00	4.90	4.90
	Dindigul	4.35	1.00	4.00	20.00	2.00	4.00	3.35	9.35
	Erode	5.10	0.00	1.00	19.00	2.00	0.00	3.05	5.05
	Karur	6.15	8.00	6.00	11.00	2.33	2.38	5.18	9.89
	Krishnagiri	5.65	0.00	9.00	13.00	2.11	0.00	4.38	6.50
	Namakkal	5.55	0.00	0.00	19.00	0.00	0.00	4.37	4.37
	Salem	5.35	0.00	0.00	19.00	0.00	0.00	3.84	3.84
	Theni	4.85	0.00	3.00	20.00	2.67	0.00	3.95	6.62
	Thiruvannamalai	6.25	1.00	0.00	19.00	0.00	2.00	4.89	6.89
	Thiruvarur	5.25	1.00	6.00	19.00	2.00	2.00	4.37	8.37
	Villupuram	5.05	0.00	4.00	20.00	2.00	0.00	4.25	6.25
	Total	**5.26**	**11.00**	**36.00**	**239.00**	**2.14**	**2.45**	**4.08**	**8.67**
Telangana	Jangaon	6.20	0.00	0.00	20.00	0.00	0.00	4.60	4.60
	Jayashankar Bhupalapally	5.95	1.00	18.00	19.00	2.00	1.00	3.37	6.37
	Kamareddy	7.70	5.00	10.00	19.00	2.00	4.60	4.63	11.23
	Mahbubabad	6.10	0.00	0.00	20.00	0.00	0.00	4.15	4.15
	Mahbubnagar	7.75	1.00	7.00	20.00	2.29	10.00	4.90	17.19
	Nagarkurnool	8.11	1.00	8.00	19.00	2.25	10.00	5.16	17.41
	Nalgonda	7.40	1.00	7.00	20.00	2.29	20.00	5.25	27.54
	Nizamabad	6.45	15.00	8.00	6.00	3.25	2.27	3.50	9.02
	Wanaparthy	7.80	2.00	11.00	19.00	2.18	4.00	3.68	9.87
	Total	**7.04**	**26.00**	**69.00**	**162.00**	**2.26**	**4.08**	**4.44**	**10.78**
Tripura	Dhalai	4.25	0.00	1.00	19.00	1.00	0.00	1.37	2.37
	Sepahijala	4.45	0.00	0.00	19.00	0.00	0.00	1.37	1.37
	West Tripura	4.30	1.00	1.00	16.00	1.00	2.00	1.25	4.25
	Total	**4.33**	**1.00**	**2.00**	**54.00**	**1.00**	**2.00**	**1.33**	**4.33**
Uttar Pradesh	Agra	5.75	2.00	6.00	15.00	1.67	1.50	3.20	6.37
	Azamgarh	4.65	7.00	5.00	13.00	2.00	1.86	1.92	5.78
	Baharaich	6.20	7.00	6.00	13.00	2.00	2.14	3.38	7.53
	Banda	5.30	0.00	3.00	15.00	2.67	0.00	3.93	6.60
	Bareilly	5.20	6.00	6.00	13.00	2.00	1.83	2.62	6.45

State	Districts	Avg. Family Size	Total Count of Holding Cattle Population per sample in that particular district			Avg. Count of Cattle population			
			Others	Oxen	Cows, Buffaloes	Cows, Buffaloes	Oxen	Others	Total
Uttar Pradesh	Bijnor	5.75	0.00	0.00	20.00	0.00	0.00	2.95	2.95
	Etah	5.95	4.00	6.00	15.00	2.33	1.75	2.93	7.02
	Fatehpur	6.55	0.00	2.00	20.00	2.00	0.00	4.45	6.45
	Firozabad	7.05	0.00	0.00	20.00	0.00	0.00	3.70	3.70
	Ghazipur	5.35	0.00	0.00	20.00	0.00	0.00	2.50	2.50
	Gonda	5.95	7.00	3.00	15.00	2.00	1.86	2.60	6.46
	Gorakhpur	5.60	7.00	5.00	14.00	2.00	1.29	2.43	5.71
	Hamirpur	6.60	0.00	1.00	20.00	2.00	0.00	4.75	6.75
	Hardoi	5.70	0.00	0.00	20.00	0.00	0.00	3.45	3.45
	Jhansi	5.50	7.00	2.00	16.00	1.50	2.86	2.31	6.67
	Kannauj	6.20	0.00	1.00	20.00	2.00	0.00	3.45	5.45
	Kaushambi	6.90	0.00	8.00	20.00	2.13	0.00	4.10	6.23
	Kheri	5.58	7.00	2.00	14.00	2.00	2.00	2.64	6.64
	Lalitpur	6.50	7.00	3.00	16.00	2.00	2.29	3.31	7.60
	Lucknow	5.35	0.00	2.00	20.00	2.00	0.00	3.50	5.50
	Mahoba	5.80	0.00	3.00	20.00	2.00	0.00	3.90	5.90
	Mirzapur	5.00	0.00	0.00	20.00	0.00	0.00	2.45	2.45
	Pratapgarh	5.25	0.00	0.00	20.00	0.00	0.00	3.25	3.25
	Prayagraj	5.40	5.00	4.00	15.00	2.00	1.40	3.07	6.47
	Varanasi	4.90	0.00	0.00	20.00	0.00	0.00	3.05	3.05
	Total	**5.76**	**66.00**	**68.00**	**434.00**	**2.03**	**1.94**	**3.25**	**7.22**
Uttarakhand	Dehradun	5.30	0.00	0.00	18.00	0.00	0.00	2.28	2.28
	Haridwar	5.30	3.00	3.00	19.00	1.33	1.33	2.37	5.04
	Pauri Garhwal	7.10	0.00	0.00	10.00	0.00	0.00	2.40	2.40
	Tehri Garhwal	4.54	1.00	0.00	12.00	0.00	2.00	1.67	3.67
	Udham Singh Nagar	5.75	0.00	0.00	20.00	0.00	0.00	2.70	2.70
	Total	**5.51**	**4.00**	**3.00**	**79.00**	**1.33**	**1.50**	**2.33**	**5.16**
West Bengal	Bankura	5.00	0.00	0.00	22.00	0.00	0.00	3.23	3.23
	Hoogly	4.60	2.00	1.00	4.00	4.00	1.00	1.50	6.50
	Jalpaiguri	5.50	0.00	8.00	16.00	2.88	0.00	2.00	4.88
	Mednipur	5.00	1.00	0.00	15.00	0.00	0.00	1.67	1.67
	Murshidabad	4.30	5.00	2.00	17.00	2.50	5.60	2.35	10.45
	Nadia	3.75	3.00	0.00	18.00	0.00	2.00	1.61	3.61
	Parganas North	4.65	7.00	0.00	5.00	0.00	11.00	2.20	13.20
	Total	**4.69**	**18.00**	**11.00**	**97.00**	**2.91**	**6.65**	**2.21**	**11.76**
Grand Total		**5.89**	**571.00**	**1045.0**	**3684.00**	**1.99**	**2.95**	**3.15**	**8.09**

The average family size of the selected respondents is 5.89 at all India level. The family size is ranging from 4 to 11 persons in each family across the states. The state-wise and district wise average family size, cattle holding capacity by the respondents were presented in detail in the above table. The average cattle holding by each respondent is about 8 number which includes cows, buffaloes and oxen and etc., Family size and cattle population is used as a proxy variable in analysis for biomass utilization at an individual level. These two variables - family size and cattle count, with the respondents are holding a direct positive relationship with the biomass utilization,

which indicates that as the cattle population is increased, the biomass utilization also increases.

The collected data was analyzed with the crop residue ratio (as mentioned in table no. 10) to calculate gross crop residue potential (mentioned in column 3 of the table no. 15). Further, the data was processed to calculate surplus residue fraction (as mentioned in Model for Calculation of Biomass Power Potential" in chapter-2). After arriving at surplus factor, it was put into the model to arrive at surplus biomass potential and tabulated as below:

Table 15: State-wise average biomass utilization and surplus biomass potential at the farm level in the study area

States / Uts	Avg. Area Cultivated (Ha)	Avg. Crop Production (Tonnes)	Avg. Biomass Production (Tonnes)	Avg. Surplus Biomass (Tonnes)	Avg. Biomass Utilization (Tonnes)	% share of Utilization of biomass out of total biomass	% Share of Surplus Biomass out of total biomass	Surplus Biomass (Tonnes/ Ha)
	1	2	3	4	5	6	7	8
Andhra Pradesh	2.23	16.72	23.69	12.30	11.39	48.08	51.92	5.51
Arunachal Pradesh	2.20	4.81	6.97	0.48	6.49	93.07	6.93	0.22
Assam	0.90	3.73	5.92	1.68	4.24	71.64	28.36	1.87
Bihar	1.46	9.68	10.69	2.62	8.07	75.52	24.48	1.79
Chandigarh	3.67	14.34	25.09	9.79	15.30	60.98	39.02	2.67
Chhattisgarh	5.65	13.02	20.58	3.85	16.73	81.28	18.72	0.68
Dadra & Nagar Haveli	2.96	10.85	22.19	4.15	18.04	81.31	18.69	1.40
Daman & Diu	2.55	6.90	12.84	1.37	11.47	89.31	10.69	0.54
Goa	0.86	1.92	6.16	0.00	6.16	100.00	0.00	0.00
Gujarat	4.50	17.87	27.96	11.17	16.78	60.04	39.96	2.48
Haryana	4.24	15.04	32.58	4.15	28.42	87.25	12.75	0.98
Himachal Pradesh	1.41	4.21	7.55	0.00	7.55	100.00	0.00	0.00
Jammu & Kashmir	0.55	3.17	5.93	0.02	5.92	99.69	0.31	0.03
Jharkhand	1.16	2.69	4.67	0.85	3.81	81.71	18.29	0.74
Karnataka	2.37	48.72	54.70	48.42	6.29	11.49	88.51	20.41
Kerala	5.04	29.79	93.65	4.66	88.99	95.03	4.97	0.92
Madhya Pradesh	4.90	8.76	14.82	4.41	10.41	70.25	29.75	0.90
Maharashtra	3.21	18.17	17.09	5.75	11.34	66.34	33.66	1.79
Manipur	0.69	3.22	5.43	2.15	3.28	60.44	39.56	3.12
Meghalaya	1.97	5.99	14.92	9.74	5.18	34.73	65.27	4.95
Mizoram	0.55	1.45	2.72	0.32	2.40	88.32	11.68	0.58
Nagaland	1.55	3.00	5.25	0.65	4.60	87.55	12.45	0.42
Odisha	1.50	3.35	5.47	1.17	4.29	78.56	21.44	0.78
Punjab	6.91	48.94	98.06	34.84	63.22	64.47	35.53	5.04
Rajasthan	4.25	6.87	13.44	2.82	10.62	79.02	20.98	0.66
Sikkim	0.80	0.84	1.20	0.12	1.08	90.18	9.82	0.15
Tamil Nadu	2.24	32.84	26.17	2.45	23.72	90.66	9.34	1.09
Telangana	2.32	7.58	17.12	6.72	10.39	60.72	39.28	2.89
Tripura	0.52	3.22	4.00	0.00	4.00	100.00	0.00	0.00
Uttar Pradesh	1.64	10.53	10.48	0.45	10.03	95.74	4.26	0.27
Uttarakhand	1.12	3.76	5.03	0.81	4.22	83.86	16.14	0.73
West Bengal	1.45	6.34	10.32	2.81	7.51	72.79	27.21	1.93
Grand Total	2.72	13.71	20.13	6.47	13.66	67.86	32.14	2.38

Note: Results are based on the primary survey conducted during 2020 – 21

From the primary data analysis of the area, production, yield of the crops, total biomass production, utilization pattern of the biomass produced and surplus biomass at individual farmer level, it is clearly evident that the average farm holding size is minimal at 2.72 ha with a minimum of 0.52 ha in Tripura state and a maximum of 6.91 ha in Punjab state. Sample respondents in Chhattisgarh, Kerala and Madhya Pradesh states are holding on an average area of about 5-5.65 ha. Average biomass production is significantly varied from state to state as the cropping pattern is different across the selected states. Highest average biomass production at individual farm level is seen in Punjab and Kerala state around 93-98 tons, followed by Karnataka 54.7 tons and Haryana with 32 tons. The remaining states have less than 10-20 tonnes average biomass production at individual farm level.

Average biomass production state level is highest in Karnataka (20.41 t/ha) followed by Andhra Pradesh (5.51 t/ha) and Punjab (5.04 t/ha). Andhra Pradesh, Karnataka and Meghalaya states are utilizing more than half of the produced biomass for domestic purposes, whereas in other states such as Chandigarh, Gujarat, Maharashtra, Manipur, Punjab and Telangana state the utilization rate is about 30-40% range in total biomass production. The remaining states showed a level of 20% and below the utilization rate.

At all India level, the calculation infers that an average area of 2.72 ha results in avg. production of 13.71 tons and 20.13 tons of biomass. From this, 13.66 tonnes is utilized, i.e., 67% is utilized for domestic uses, and the remaining 6.47 tons is surplus biomass at the individual farmer level in India.

The state-wise average biomass production and biomass utilization pattern is represented as below:

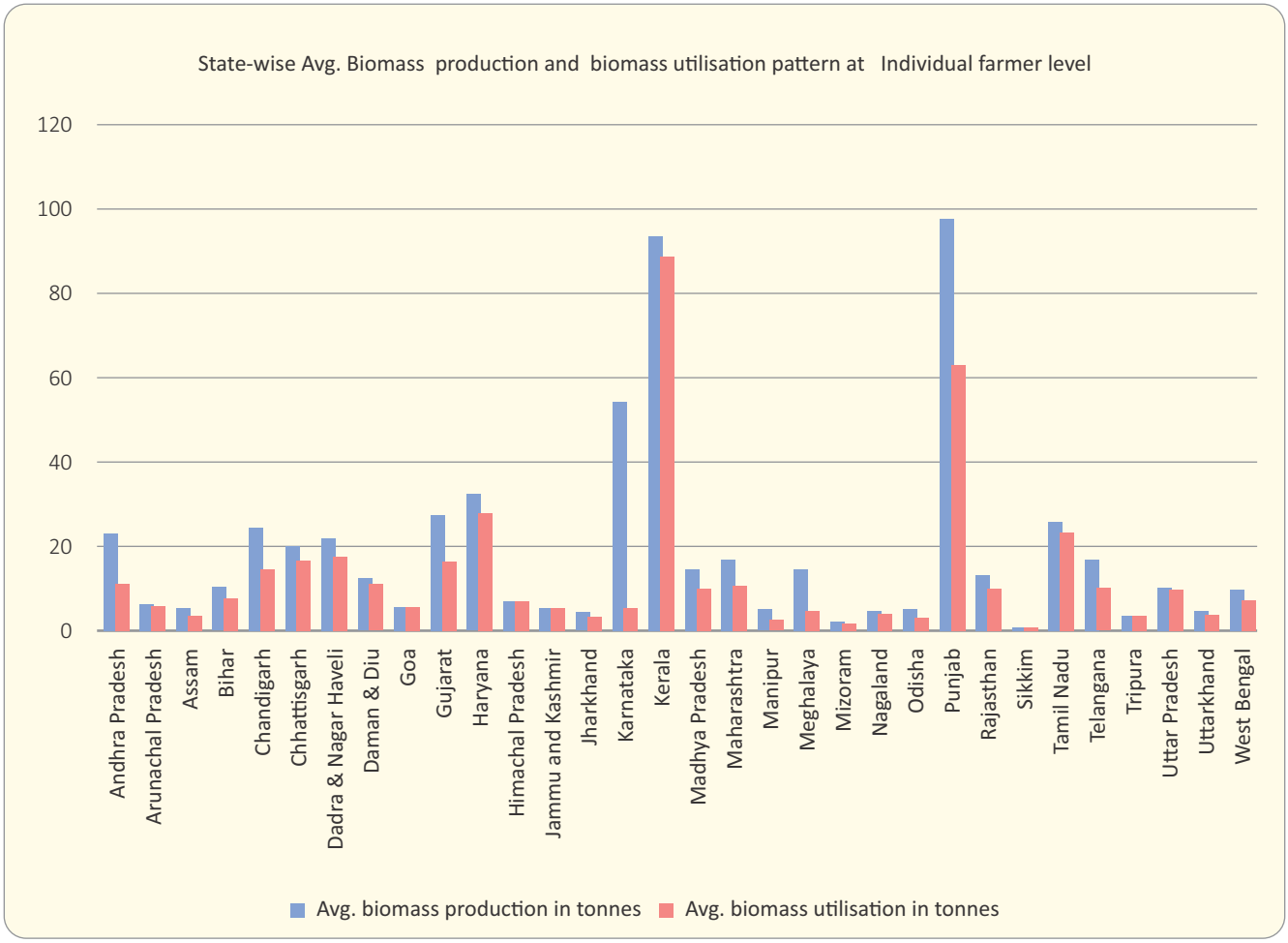


Figure 12: State-wise Average Biomass Production and its Utilization Pattern at Individual Farmer level

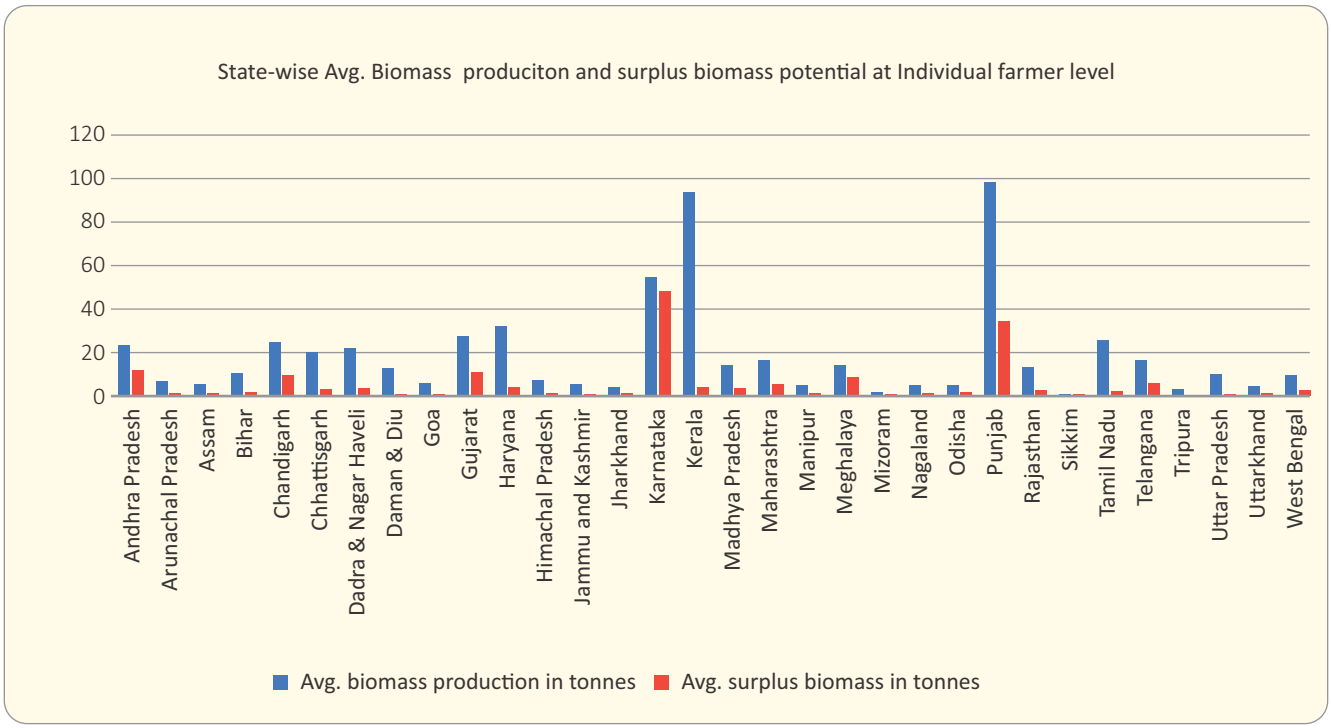


Figure 13: State-wise Average Biomass Production and surplus biomass potential at individual farmer level

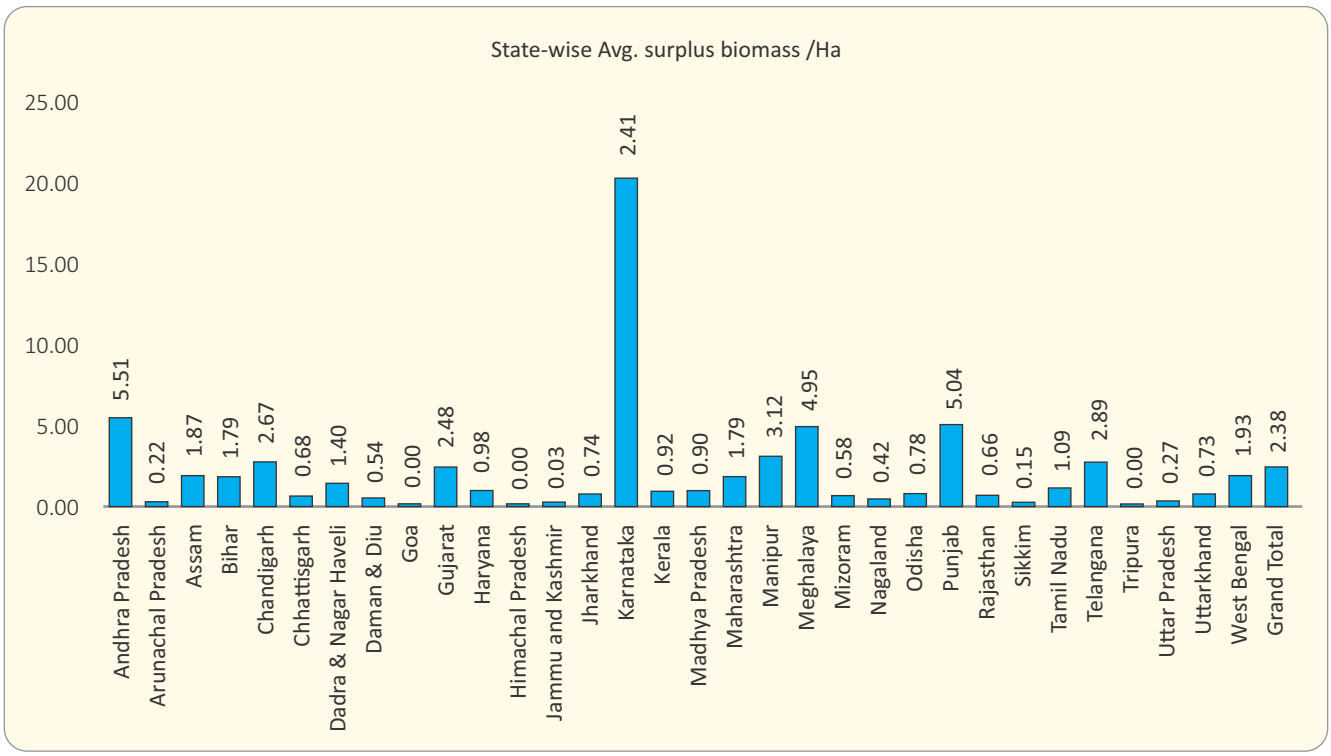


Figure 14: State-wise Average Surplus biomass per Ha.

Utilization pattern of the biomass residues of the different crops across the state level

The utilization of the crop residues is one of the essential components to understand the extent of use of the biomass residue at the Individual farmer level. To understand the utilization pattern of the biomass residue, information is collected from the primary sources for the selected crops across the states for both the seasons Kharif and Rabi.

The compiled and analyzed data infers that Cashewnut, Garlic, cotton, Dry chillies, sugarcane crops are having low utilization of biomass across the states is ranging between 10 – 20%. In contrast, cereals are having a high utilization rate of biomass residue, which is in the range of 50 – 90% with varying degree across the states and crops. Maize, jowar, bajra and rice have higher utilization in particular. For pulses, the utilization is medium-level, i.e., 30 – 60%. In major producing states, soyabean residue is used completely. Sesamum is also another crop residue that is used completely in some states like Uttarakhand and Uttar Pradesh. In oilseeds, the utilization percentage varied from 60 – 90% as per farmer-to-farmer respondent. The biomass residue is majorly used as cattle feed, domestic fuel and fertilization composition. Irrespective of the season, the utilization pattern of the crop residue is more or less similar in both the seasons and the observations for Kharif crops and Rabi crops are tabulated in table no. 16 and 17.

Table 16: Statewise, Cropwise Residual Utilisation Pattern from Kharif Crops in the selected study area

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
Andhra Pradesh		0.48	0.00	0.00	0.48	0.52
	Cashewnut	0.00	0.00	0.00	0.00	1.00
	Cotton	0.18	0.00	0.00	0.18	0.82
	Dry Chillies	0.20	0.00	0.00	0.20	0.80
	Groundnut	0.81	0.00	0.00	0.81	0.20
	Jowar	0.90	0.00	0.00	0.90	0.10
	Maize	0.44	0.00	0.00	0.44	0.56
	Oil Seeds	0.00	0.00	0.00	0.00	1.00
	Rice	0.82	0.00	0.00	0.82	0.18
	Sugarcane	0.00	0.00	0.00	0.00	1.00
	Tur	0.53	0.00	0.00	0.53	0.47
Arunachal Pradesh		0.79	0.01	0.15	0.95	0.05
	Maize	0.77	0.10	0.02	0.89	0.11
	Rice	0.79	0.00	0.16	0.96	0.04
Assam		0.55	0.35	0.01	0.92	0.08
	Rice	0.55	0.35	0.01	0.92	0.08
Bihar		0.71	0.01	0.02	0.75	0.25
	Maize	0.62	0.06	0.07	0.74	0.26
	Rice	0.90	0.00	0.00	0.90	0.10
	Sugarcane	0.10	0.02	0.00	0.12	0.88
	Turmeric	0.04	0.00	0.36	0.40	0.60
Chandigarh		0.00	0.00	0.20	0.20	0.80
	Rice	0.00	0.00	0.20	0.20	0.80
Chhattisgarh		0.69	0.03	0.10	0.81	0.19
	Maize	0.62	0.03	0.21	0.86	0.15
	Rice	0.69	0.03	0.08	0.80	0.20
	Soyabean	0.70	0.01	0.12	0.83	0.17

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
Dadra & Nagar Haveli		1.00	0.00	0.00	1.00	0.00
	Bajra	1.00	0.00	0.00	1.00	0.00
	Guarseed	1.00	0.00	0.00	1.00	0.00
	Maize	1.00	0.00	0.00	1.00	0.00
	Moong	1.00	0.00	0.00	1.00	0.00
Daman & Diu		0.97	0.00	0.00	0.97	0.03
	Garlic	0.00	0.00	0.00	0.00	1.00
	Groundnut	1.00	0.00	0.00	1.00	0.00
	Maize	1.00	0.00	0.00	1.00	0.00
	Soyabean	1.00	0.00	0.00	1.00	0.00
	Goa	0.71	0.00	0.29	1.00	0.00
	Rice	0.77	0.00	0.23	1.00	0.00
	Vegetable	0.50	0.00	0.50	1.00	0.00
Gujarat		0.57	0.00	0.13	0.71	0.29
	Bajra	0.56	0.00	0.25	0.81	0.19
	Beat	0.93	0.00	0.04	0.97	0.03
	Castor Seed	0.00	0.00	0.32	0.32	0.68
	Cotton	0.05	0.01	0.09	0.15	0.85
	Ginger	1.00	0.00	0.00	1.00	0.00
	Green Gram	0.59	0.00	0.41	1.00	0.00
	Groundnut	0.76	0.00	0.20	0.95	0.05
	Jowar	0.42	0.00	0.37	0.78	0.22
	Maize	0.79	0.00	0.14	0.93	0.07
	Moong	0.41	0.00	0.58	0.99	0.01
	Okra	0.57	0.00	0.43	1.00	0.00
	Potato	0.73	0.00	0.08	0.81	0.19
	Rice	0.96	0.00	0.01	0.97	0.03
	Sugarcane	0.72	0.00	0.00	0.72	0.28
	Tomato	1.00	0.00	0.00	1.00	0.00
	Tur	0.21	0.00	0.07	0.29	0.71
	Wheat	0.94	0.00	0.00	0.94	0.06
Haryana		0.30	0.40	0.15	0.85	0.15
	Bajra	0.70	0.00	0.30	1.00	0.00
	Cotton	0.00	1.00	0.00	1.00	0.00
	Moong	0.80	0.00	0.20	1.00	0.00
	Rice	0.27	0.03	0.20	0.50	0.50
Himachal Pradesh		0.92	0.04	0.04	1.00	0.00
	Cotton	0.60	0.40	0.00	1.00	0.00
	Maize	0.94	0.06	0.00	1.00	0.00
	Rice	0.91	0.00	0.10	1.00	0.00
Jammu and Kashmir		0.85	0.15	0.00	1.00	0.00

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Maize	0.80	0.20	0.00	1.00	0.00
	Rice	1.00	0.00	0.00	1.00	0.00
Jharkhand		0.51	0.07	0.15	0.74	0.26
	Groundnut	0.20	0.00	0.30	0.50	0.50
	Maize	0.24	0.10	0.21	0.54	0.46
	Ragi	0.00	0.49	0.33	0.81	0.19
	Rice	0.76	0.03	0.11	0.90	0.10
	Sesamum	0.00	0.10	0.50	0.60	0.40
	Urad	0.06	0.16	0.12	0.34	0.66
Karnataka		0.60	0.03	0.00	0.63	0.37
	Arecanut	0.00	0.00	0.00	0.00	1.00
	Bajra	0.85	0.00	0.00	0.85	0.15
	Cotton	0.15	0.00	0.00	0.15	0.85
	Dry Chillies	0.00	0.00	0.00	0.00	1.00
	Green Gram	0.23	0.00	0.00	0.23	0.77
	Groundnut	0.90	0.00	0.00	0.90	0.10
	Jowar	0.89	0.00	0.00	0.89	0.11
	Maize	0.74	0.00	0.00	0.74	0.26
	Moong	0.24	0.16	0.00	0.40	0.60
	Ragi	0.77	0.00	0.00	0.77	0.23
	Rice	0.85	0.00	0.00	0.85	0.15
	Soyabean	0.86	0.06	0.00	0.92	0.08
	Sugarcane	0.07	0.00	0.00	0.07	0.94
	Tur	0.37	0.33	0.00	0.70	0.30
	Kerala	0.46	0.03	0.35	0.84	0.16
	Banana	0.83	0.00	0.13	0.95	0.05
	Black Pepper	0.00	0.00	0.89	0.89	0.11
	Rice	0.71	0.06	0.00	0.76	0.24
	Tapioca	0.05	0.00	0.86	0.91	0.09
Madhya Pradesh		0.69	0.01	0.02	0.72	0.28
	Bajra	0.90	0.10	0.00	1.00	0.00
	Jowar	0.83	0.14	0.03	0.99	0.01
	Maize	0.54	0.01	0.05	0.60	0.40
	Rice	0.60	0.00	0.02	0.62	0.38
	Soyabean	0.82	0.01	0.01	0.84	0.16
	Urad	0.35	0.00	0.01	0.37	0.63
Maharashtra		0.57	0.01	0.11	0.69	0.31
	Bajra	0.96	0.00	0.04	1.00	0.00
	Chia seeds	0.00	0.00	1.00	1.00	0.00
	Cotton	0.05	0.02	0.02	0.09	0.91
	Dry Chillies	0.00	0.00	1.00	1.00	0.00

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Finger millet	0.80	0.00	0.00	0.80	0.20
	Ginger	0.20	0.00	0.80	1.00	0.00
	Groundnut	0.76	0.10	0.06	0.93	0.08
	Jowar	0.97	0.00	0.02	0.99	0.01
	Maize	0.93	0.00	0.06	0.99	0.01
	Moong	0.38	0.00	0.53	0.91	0.09
	Moth	0.71	0.00	0.29	1.00	0.00
	Onion	0.80	0.00	0.20	1.00	0.00
	Potato	0.00	0.00	1.00	1.00	0.00
	Rice	0.98	0.00	0.01	0.99	0.01
	Soyabean	0.80	0.00	0.06	0.86	0.14
	Tomato	0.80	0.20	0.00	1.00	0.00
	Tur	0.31	0.04	0.03	0.38	0.62
	Urad	0.13	0.00	0.58	0.70	0.30
Manipur		0.14	0.00	0.43	0.56	0.44
	Rice	0.14	0.00	0.43	0.56	0.44
Meghalaya		0.79	0.00	0.13	0.92	0.08
	Ginger	0.00	0.00	0.67	0.67	0.33
	Rice	0.90	0.00	0.04	0.94	0.06
	Sweet Potato	0.33	0.00	0.67	1.00	0.00
Mizoram		0.23	0.00	0.63	0.86	0.14
	Mustard	0.00	0.00	0.63	0.63	0.38
	Rice	0.24	0.00	0.64	0.88	0.12
Nagaland		0.59	0.00	0.12	0.70	0.30
	Maize	0.00	0.00	0.80	0.80	0.20
	Rice	0.59	0.00	0.11	0.70	0.30
	Odisha	0.55	0.04	0.21	0.79	0.21
	Cotton	0.00	0.00	0.00	0.00	1.00
	Harad	0.21	0.01	0.26	0.49	0.51
	Moong	0.71	0.00	0.03	0.74	0.26
	Rice	0.56	0.04	0.22	0.82	0.18
Punjab		0.01	0.17	0.00	0.17	0.83
	Cotton	0.00	1.00	0.00	1.00	0.00
	Rice	0.01	0.00	0.00	0.01	0.99
Rajasthan		0.88	0.02	0.02	0.92	0.08
	Bajra	0.97	0.00	0.00	0.98	0.02
	Cotton	0.10	0.13	0.10	0.32	0.68
	Gram	1.00	0.00	0.00	1.00	0.00
	Groundnut	0.88	0.03	0.00	0.91	0.09
	Guarseed	0.86	0.03	0.02	0.91	0.09
	Jowar	0.96	0.00	0.00	0.96	0.04

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Maize	0.99	0.00	0.00	0.99	0.01
	Moong	0.33	0.14	0.18	0.65	0.35
	Mothbean	0.83	0.00	0.05	0.88	0.13
	Mustard	1.00	0.00	0.00	1.00	0.00
	Rice	1.00	0.00	0.00	1.00	0.00
	Soyabean	1.00	0.00	0.00	1.00	0.00
	Wheat	0.90	0.00	0.00	0.90	0.10
	White Gram	0.96	0.00	0.00	0.96	0.04
Sikkim		0.57	0.00	0.29	0.85	0.15
	Cardamom	0.00	0.00	0.50	0.50	0.50
	Ginger	0.00	0.00	0.83	0.83	0.17
	Maize	0.00	0.00	0.00	0.00	1.00
	Rice	0.99	0.00	0.00	0.99	0.01
Tamil Nadu		0.84	0.13	0.02	0.99	0.01
	Banana	0.88	0.00	0.12	1.00	0.00
	Cotton	0.00	0.97	0.00	0.97	0.03
	Groundnut	1.00	0.00	0.00	1.00	0.00
	Jowar	0.99	0.00	0.00	0.99	0.01
	Moong	0.98	0.00	0.00	0.98	0.02
	Ragi	0.99	0.00	0.00	0.99	0.01
	Rice	1.00	0.00	0.00	1.00	0.00
Telangana		0.67	0.00	0.00	0.67	0.33
	Cotton	0.15	0.00	0.00	0.15	0.85
	Dry Chillies	0.20	0.00	0.00	0.20	0.80
	Ginger	0.00	0.00	0.00	0.00	1.00
	Groundnut	0.90	0.00	0.00	0.90	0.10
	Jowar	0.90	0.00	0.00	0.90	0.10
	Maize	0.70	0.00	0.00	0.70	0.30
	Oil Seeds	0.10	0.00	0.00	0.10	0.90
	Peanut	0.90	0.00	0.00	0.90	0.10
	Rice	0.87	0.00	0.00	0.87	0.13
	Soyabean	0.93	0.00	0.00	0.93	0.07
	Tur	0.73	0.00	0.00	0.73	0.28
Tripura		1.00	0.00	0.00	1.00	0.00
	Rice	1.00	0.00	0.00	1.00	0.00
Uttar Pradesh		0.77	0.00	0.17	0.94	0.06
	Bajra	0.90	0.04	0.05	0.99	0.01
	Jowar	0.94	0.00	0.04	0.97	0.03
	Maize	0.87	0.01	0.12	1.00	0.00
	Moong	0.69	0.00	0.31	1.00	0.00
	Rice	0.89	0.00	0.10	0.99	0.01

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Sesamum	0.50	0.00	0.47	0.97	0.03
	Sugarcane	0.64	0.02	0.08	0.74	0.26
	Tur	0.11	0.00	0.02	0.14	0.86
	Urad	0.69	0.00	0.17	0.86	0.14
Uttarakhand		0.73	0.13	0.01	0.87	0.13
	Bajra	0.75	0.00	0.00	0.75	0.25
	Rice	0.81	0.01	0.02	0.84	0.16
	Sesamum	0.00	1.00	0.00	1.00	0.00
	Small Bajra	0.77	0.09	0.00	0.86	0.14
	Soyabean	1.00	0.00	0.00	1.00	0.00
West Bengal		0.67	0.24	0.04	0.95	0.05
	Jute	0.11	0.87	0.02	1.00	0.00
	Rice	0.71	0.20	0.04	0.95	0.05
	Grand Total	0.64	0.05	0.09	0.78	0.22

Table 17: State-wise, Crop-wise Residual Utilisation Pattern from Rabi crops in the selected study area

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
Andhra Pradesh		0.79	0.00	0.00	0.79	0.21
	Dry Chillies	0.20	0.00	0.00	0.20	0.80
	Rice	0.83	0.00	0.00	0.83	0.17
Arunachal Pradesh		0.19	0.00	0.00	0.19	0.81
	Cabbage	0.17	0.00	0.00	0.17	0.83
	Maize	0.05	0.00	0.00	0.05	0.95
	Mustard	0.08	0.00	0.00	0.08	0.92
	Potato	0.21	0.00	0.00	0.21	0.79
	Rice	0.55	0.00	0.00	0.55	0.45
	Urad	0.00	0.00	0.00	0.00	1.00
Assam		0.23	0.00	0.09	0.32	0.68
	Mustard	0.12	0.00	0.10	0.22	0.78
	Mustard	0.00	0.00	0.00	0.00	1.00
	Potato	0.15	0.00	0.21	0.36	0.64
	Urad	0.54	0.00	0.00	0.54	0.46
Bihar		0.59	0.00	0.01	0.60	0.40
	Gram	0.63	0.00	0.00	0.63	0.37
	Maize	0.36	0.00	0.02	0.38	0.62
	Masoor	0.09	0.00	0.00	0.10	0.90
	Potato	0.03	0.00	0.00	0.03	0.97
	Wheat	0.88	0.00	0.01	0.88	0.12
Chandigarh		1.00	0.00	0.00	1.00	0.00
	Wheat	1.00	0.00	0.00	1.00	0.00

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
Chhattisgarh	Chhattisgarh	0.78	0.00	0.03	0.81	0.19
	Gram	0.89	0.00	0.04	0.94	0.06
	Maize	0.61	0.00	0.03	0.64	0.36
	Rice	0.69	0.00	0.02	0.71	0.29
	Wheat	0.68	0.00	0.00	0.68	0.33
Dadra & Nagar Haveli		0.46	0.00	0.00	0.46	0.54
	Rapeseed	0.00	0.00	0.00	0.00	1.00
	Wheat	0.80	0.00	0.00	0.80	0.20
Daman & Diu		0.76	0.00	0.00	0.76	0.24
	Coriander	1.00	0.00	0.00	1.00	0.00
	Garlic	0.00	0.00	0.00	0.00	1.00
	Gram	1.00	0.00	0.00	1.00	0.00
	Groundnut	1.00	0.00	0.00	1.00	0.00
	Wheat	0.80	0.00	0.00	0.80	0.20
Gujarat		0.61	0.00	0.00	0.62	0.38
	Bajra	0.82	0.00	0.00	0.82	0.18
	Chick Pea	1.00	0.00	0.00	1.00	0.00
	Chickpeas	0.60	0.00	0.00	0.60	0.40
	Ginger	1.00	0.00	0.00	1.00	0.00
	Gram	1.00	0.00	0.00	1.00	0.00
	Jeera	0.00	0.00	0.00	0.00	1.00
	Jowar	1.00	0.00	0.00	1.00	0.00
	Mustard	0.70	0.00	0.00	0.70	0.30
	Rapeseed	0.48	0.00	0.00	0.48	0.53
	Rice	1.00	0.00	0.00	1.00	0.00
	Tomato	0.76	0.00	0.03	0.80	0.20
	Wheat	0.54	0.00	0.00	0.54	0.46
Haryana		0.94	0.00	0.00	0.94	0.06
	Mustard	0.80	0.00	0.00	0.80	0.20
	Wheat	1.00	0.00	0.00	1.00	0.00
Himachal Pradesh		1.00	0.00	0.00	1.00	0.00
	Wheat	1.00	0.00	0.00	1.00	0.00
Jammu and Kashmir		1.00	0.00	0.00	1.00	0.00
	Wheat	1.00	0.00	0.00	1.00	0.00
Jharkhand		0.33	0.00	0.07	0.40	0.60
	Cauliflower	0.50	0.00	0.00	0.50	0.50
	Gram	0.34	0.00	0.26	0.60	0.40
	Green Peas	0.45	0.00	0.00	0.45	0.55
	Lady Finger	0.00	0.00	0.00	0.00	1.00
	Masoor	0.33	0.00	0.20	0.53	0.48
	Mustard	0.08	0.00	0.14	0.22	0.78

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Mustard	0.08	0.00	0.14	0.22	0.78
	Potato	0.45	0.00	0.10	0.55	0.45
	Rapeseed	0.13	0.00	0.17	0.30	0.70
	Tobacco	0.00	0.00	0.00	0.00	1.00
	Tomato	0.50	0.00	0.15	0.65	0.35
	Urad	0.00	0.00	0.13	0.13	0.88
	Wheat	0.46	0.00	0.01	0.47	0.53
Karnataka		0.11	0.00	0.08	0.20	0.80
	Arecanut	0.00	0.00	0.10	0.10	0.90
	Betal Nut	0.00	0.00	0.10	0.10	0.90
	Coconut	0.00	0.00	0.10	0.10	0.90
	Dry Chillies	0.20	0.00	0.00	0.20	0.80
	Gram	0.90	0.00	0.00	0.90	0.10
	Sugarcane	0.00	0.00	0.10	0.10	0.90
	Wheat	0.90	0.00	0.00	0.90	0.10
Kerala		0.49	0.00	0.07	0.55	0.45
	Banana	0.76	0.00	0.01	0.78	0.23
	Black Pepper	0.00	0.00	0.00	0.00	1.00
	Rice	0.45	0.00	0.45	0.90	0.10
	Tapioca	0.15	0.00	0.00	0.15	0.85
Madhya Pradesh		0.74	0.00	0.01	0.75	0.25
	Gram	0.74	0.00	0.02	0.76	0.24
	Masur	0.00	0.00	0.00	0.00	1.00
	Mustard	0.00	0.00	0.50	0.50	0.50
	Wheat	0.74	0.00	0.01	0.75	0.25
Maharashtra		0.90	0.00	0.01	0.91	0.09
	Bajra	1.00	0.00	0.00	1.00	0.00
	Gram	0.97	0.00	0.00	0.98	0.02
	Groundnut	0.85	0.00	0.02	0.87	0.13
	Jowar	0.80	0.00	0.00	0.80	0.20
	Maize	0.93	0.00	0.00	0.93	0.07
	Masoor	0.50	0.00	0.10	0.60	0.40
	Moong	0.00	0.00	0.00	0.00	1.00
	Onion	0.76	0.00	0.02	0.78	0.22
	Peas	0.50	0.00	0.00	0.50	0.50
	Potato	0.00	0.00	0.00	0.00	1.00
	Rice	1.00	0.00	0.00	1.00	0.00
	Sugarcane	0.80	0.00	0.00	0.80	0.20
	Vegetables	1.00	0.00	0.00	1.00	0.00
	Wheat	0.87	0.00	0.01	0.88	0.12

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
Manipur		0.00	0.00	0.00	0.00	1.00
	Mustard	0.00	0.00	0.00	0.00	1.00
Meghalaya		0.12	0.00	0.00	0.12	0.88
	Maize	0.53	0.00	0.00	0.53	0.48
	Mesta	0.00	0.00	0.00	0.00	1.00
	Mustard	0.01	0.00	0.00	0.01	0.99
	Potato	0.00	0.00	0.00	0.00	1.00
Mizoram		0.01	0.00	0.00	0.01	0.99
	Maize	0.05	0.00	0.00	0.05	0.95
	Mustard	0.00	0.00	0.00	0.00	1.00
Nagaland		0.02	0.00	0.00	0.02	0.98
	Maize	0.00	0.00	0.00	0.00	1.00
	Mustard	0.02	0.00	0.00	0.02	0.98
	Sesamum	0.00	0.00	0.00	0.00	1.00
Odisha		0.43	0.00	0.07	0.50	0.50
	Moong	0.43	0.00	0.07	0.50	0.50
Punjab		1.00	0.00	0.00	1.00	0.00
	Wheat	1.00	0.00	0.00	1.00	0.00
Rajasthan		0.66	0.00	0.00	0.66	0.34
	Coriander	1.00	0.00	0.00	1.00	0.00
	Garlic	0.00	0.00	0.00	0.00	1.00
	Gram	1.00	0.00	0.00	1.00	0.00
	Ground Nut	1.00	0.00	0.00	1.00	0.00
	Mustard	0.92	0.00	0.01	0.93	0.07
	Rapeseed	0.05	0.00	0.00	0.05	0.95
	Tomato	0.90	0.00	0.00	0.90	0.10
	Wheat	0.83	0.00	0.00	0.83	0.17
Sikkim		0.33	0.00	0.00	0.33	0.68
	Cardamom	0.00	0.00	0.00	0.00	1.00
	Maize	0.25	0.00	0.00	0.25	0.75
	Urad	0.80	0.00	0.00	0.80	0.20
Tamil Nadu		0.91	0.00	0.03	0.95	0.05
	Coconut	0.00	0.00	0.90	0.90	0.10
	Groundnut	1.00	0.00	0.00	1.00	0.00
	Jowar	0.95	0.00	0.00	0.95	0.05
	Maize	0.80	0.00	0.15	0.95	0.05
	Ragi	0.97	0.00	0.00	0.97	0.03
	Rice	0.89	0.00	0.00	0.89	0.11
	Urad	0.87	0.00	0.01	0.88	0.12
Telangana		0.67	0.00	0.00	0.67	0.33
	Dry Chillies	0.19	0.00	0.00	0.19	0.81

States / Uts	Crops	Residue Utilisation (%)				Surplus Factor
		Cattle Feeding	Domestic Fuel	Compost Fertilizer	Total Consumption	
	Gram	0.79	0.00	0.00	0.79	0.21
	Rice	0.89	0.00	0.00	0.89	0.11
Tripura		0.50	0.00	0.02	0.52	0.48
	Potato	0.50	0.00	0.02	0.52	0.48
Uttar Pradesh		0.95	0.00	0.00	0.95	0.05
	Gram	0.92	0.00	0.00	0.92	0.08
	Mustard	0.77	0.00	0.02	0.79	0.21
	Peas	1.00	0.00	0.00	1.00	0.00
	Potato	0.88	0.00	0.00	0.88	0.12
	Urad	0.20	0.00	0.00	0.20	0.80
	Wheat	0.98	0.00	0.00	0.98	0.02
Uttarakhand		0.92	0.00	0.01	0.94	0.06
	Wheat	0.92	0.00	0.01	0.94	0.06
West Bengal		0.13	0.00	0.34	0.46	0.54
	Coriander	0.00	0.00	0.50	0.50	0.50
	Corn	0.00	0.00	1.00	1.00	0.00
	Groundnut	0.11	0.00	0.73	0.84	0.16
	Jute	0.15	0.00	0.81	0.96	0.04
	Lentils	0.32	0.00	0.36	0.68	0.32
	Mustard	0.04	0.00	0.47	0.51	0.49
	Potato	0.07	0.00	0.09	0.16	0.84
	Rice	0.50	0.00	0.14	0.64	0.36
	Wheat	0.28	0.00	0.00	0.28	0.72
Grand Total		**0.65**	**0.00**	**0.03**	**0.68**	**0.32**

Respondents' opinion on the supply of residue for Biomass Plants

During the primary field survey, respondents' opinion on the supply of residue for biomass power production and their willingness to supply the surplus biomass and its supply chain aspects collected in the study area. From table no. 18, it is evident that only 36.79 respondents are willing to supply residue for biomass power production and bagasse co-generation out of the total sample of 4716 respondents as the biomass producing plants are absent or not near to their field. Hardly 2.91% of the respondent's opined that they have a contractual obligation / Commitment with Energy producers or any other industries for selling crop residues in the selected study area. 54.90% of the total sample opined that they are not willing to sell crop biomass residue to agencies/ suppliers supplying biomass to energy producers. About half of the respondents, i.e. 41.37% of the sample respondents, are willing to go for contract obligation with energy producers for supplying the crop residues from their land/fields. 27.80% of the respondents confirmed that they are in favour of village-level co-operative body/ societies/ associations which can be formed by the government to regulate the supply and pricing of crop residues to energy producers, whereas a major chunk of them did not respond to this option. The responses are more or less the same across the respondents and states, as the standard intact supply chain model was not yet established and developed for the biomass generated from the crop residues at the district or state level. Farmers opined that they are not aware of these biomass power-producing plants and the supply chain of these process. In addition to that, they expressed a concern related to the occurrence of additional transportation cost in the transport of the biomass residue to the plant, in which they are not interested. Accordingly, the information on shredding cost is collected and tabulated as below:

Table 18: Respondents opinion on the supply of residue for Biomass Plants

States	Willingness Supply of residue for biomass plants				Having any contractual obligation/ Commitment with any Energy producers or any other industries for selling crop residues			willing to sell crop biomass residue to agencies/ suppliers supplying biomass to energy producers			willing to go for contractual obligation with energy producers for supplying the crop residues from the land/fields			Are you in favour of village-level co-operative body/ societies/ associations which can be formed by the government to regular the supply and pricing of crop residues to energy producers		
	Total sample size	Y	N	NR	Y	N	NR	Y	N	NR	Y	N	NR	Y	N	NR
Andhra Pradesh	139	55	83	1	0	139	0	6	133	0	52	85	2	109	0	30
Arunachal Pradesh	119	117	0	2	0	119	0	119	0	0	117	0	2	0	116	3
Assam	160	120	40	0	0	160	0	100	60	0	120	40	0	12	43	105
Bihar	259	1	258	0	0	258	1	3	255	1	3	254	2	86	0	173
Chandigarh	5	0	5	0	0	5	0	0	5	0	0	5	0	5	0	0
Chhattisgarh	200	121	78	1	0	200	0	127	73	0	5	195	0	32	0	168
Dadra & Nagar Haveli	20	0	20	0	0	20	0	20	0	0	20	0	0	0	0	20
Daman & Diu	20	2	9	9	0	20	0	20	0	0	20	0	0	0	0	20
Goa	20	3	17	0	0	20	0	1	19	0	0	20	0	0	0	20
Gujarat	281	170	109	2	0	280	1	186	95	0	235	46	0	2	0	279
Haryana	140	58	0	82	0	140	0	59	81	0	59	81	0	81	0	59
Himachal Pradesh	100	20	80	0	0	100	0	20	80	0	20	80	0	80	0	20
Jammu and Kashmir	100	0	100	0	0	100	0	0	100	0	0	100	0	100	0	0
Jharkhand	160	158	0	2	0	160	0	160	0	0	160	0	0	0	0	160
Karnataka	210	24	79	107	112	98	0	113	97	0	84	126	0	152	58	0
Kerala	100	4	96	0	6	89	5	1	93	6	2	92	6	91	2	7
Madhya Pradesh	340	133	207	0	0	340	0	184	156	0	24	316	0	29	0	311
Maharashtra	241	19	203	19	0	241	0	29	212	0	3	207	31	40	0	201
Manipur	100	0	100	0	0	100	0	0	100	0	0	100	0	0	0	100
Meghalaya	100	66	27	7	2	98	0	72	28	0	71	28	1	0	0	100
Mizoram	60	54	6	0	0	60	0	52	8	0	52	8	0	0	0	60
Nagaland	79	54	23	2	0	79	0	59	20	0	59	20	0	5	0	74

States	Willingness Supply of residue for biomass plants				Having any contractual obligation/ Commitment with any Energy producers or any other industries for selling crop residues			willing to sell crop biomass residue to agencies/ suppliers supplying biomass to energy producers			willing to go for contractual obligation with energy producers for supplying the crop residues from the land/fields			Are you in favour of village-level co-operative body/ societies/ associations which can be formed by the government to regular the supply and pricing of crop residues to energy producers		
	Total sample size	Y	N	NR	Y	N	NR	Y	N	NR	Y	N	NR	Y	N	NR
Odisha	120	14	101	5	0	119	1	7	112	1	27	93	0	52	0	68
Punjab	140	140	0	0	0	140	0	140	0	0	140	0	0	0	0	140
Rajasthan	240	40	199	1	0	240	0	161	79	0	140	100	0	11	0	229
Sikkim	40	23	16	1	0	40	0	22	18	0	22	18	0	2	0	38
Tamil Nadu	260	0	260	0	0	255	5	0	260	0	0	260	0	201	0	59
Telangana	179	65	109	5	0	176	3	28	149	2	73	105	1	82	20	77
Tripura	60	60	0	0	0	60	0	60	0	0	60	0	0	60	0	0
Uttar Pradesh	499	98	398	3	0	491	8	229	262	8	250	241	8	20	0	479
Uttarakhand	83	10	73	0	0	83	0	25	57	1	10	69	4	40	0	43
West Bengal	142	106	8	28	7	135	0	105	37	0	123	19	0	19	106	17
Grand Total	**4716**	**1735**	**2704**	**277**	**127**	**4565**	**24**	**2108**	**2589**	**19**	**1951**	**2708**	**57**	**1311**	**345**	**3060**
		36.79	**57.34**	**5.87**	**2.69**	**96.80**	**0.51**	**44.70**	**54.90**	**0.40**	**41.37**	**57.42**	**1.21**	**27.80**	**7.32**	**64.89**

Cost of Shredding for selected crops

In general, the recommended practice is to remove the stubbles from the field and use the same for biomass power generation or go for zero tillage by incorporating/ploughing the stubbles into the soil to increase the fertility of the soil. In contrary to this, open burning has been practised as the time gap between the two crop seasons is very limited, particularly in the Northern states of India. With reference to this, information on shredding cost from the respondents collected to analyse the average cost per acre incurred for shredding of the crop from one-acre land for various crops in the study area.

Table 19: Shredding cost of the selected crops in the study area

States	Arecanut	Bajra	Banana	Black Lentils	Black Pepper	Cardamom	Cashewnut	Castor	Coconut	Coriander	Cotton	Dry Chillies	Garlic	Ginger	Gram	Green Gram	Groundnut	Guarseed	Jeera	Jowar
Sikkim	0	0	0	0	0	2013	0	0	0	0	0	0	0	2000	0	0	0	0	0	0
Andhra Pradesh	0	0	0	0	0	0	1524	0	4500	0	1053	1333	0	0	0	0	1006	0	0	600
Arunachal Pradesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Assam	7024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7500	0	0	0
Bihar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4640	0	0	0	0	0
Chandigarh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chhattisgarh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Dadra & Nagar Haveli	0	3801	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4000	0	0
Daman & Diu	0	0	0	0	0	0	0	0	0	4031	0	0	3615	0	2000	0	3750	0	0	0
Goa	0	0	0	0	0	0	0	0	6339	0	0	0	0	0	0	0	0	0	0	0
Gujarat	0	2485	0	0	0	0	0	2737	0	0	3155	0	0	3083	2018	2412	2434	0	1875	2602
Haryana	0	0	0	0	0	0	0	0	0	0	1200	0	0	0	0	0	0	0	0	0
Himachal Pradesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jammu and Kashmir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jharkhand	0	0	0	1500	0	0	0	0	0	0	0	0	0	0	2585	0	0	0	0	0
Karnataka	26122	795	0	0	0	0	0	0	5950	0	962	950	0	0	738	900	1058	0	0	1019
Kerala	5000	0	3959	0	1000	0	0	0	4951	0	0	0	0	0	0	0	0	0	0	0
Madhya Pradesh	0	724	0	0	0	0	0	0	0	0	0	0	0	0	2006	0	0	0	0	2343

States	Arecanut	Bajra	Banana	Black Lentils	Black Pepper	Cardamom	Cashewnut	Castor	Coconut	Coriander	Cotton	Dry Chillies	Garlic	Ginger	Gram	Green Gram	Groundnut	Guarseed	Jeera	Jowar
Maharashtra	0	1792	0	0	0	0	0	0	0	0	1609	2000	0	2000	1085	0	1337	0	0	1274
Manipur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meghalaya	7107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mizoram	0	0	10023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nagaland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odisha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Punjab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rajasthan	0	1258	0	0	0	0	0	0	0	3250	983	0	2400	0	1125	0	1374	1472	0	2187
Tamil Nadu	0	0	8379	0	0	0	1583	0	5484	0	3005	0	0	0	0	0	4222	0	0	3497
Telangana	0	0	0	0	0	0	0	0	0	0	1192	985	0	0	1067	0	1000	0	0	1167
Tripura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	0	2414	0	0	0	0	0	0	0	0	0	0	0	0	3412	0	0	0	0	0
Uttarakhand	0	1625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Bengal	0	0	1500	0	0	0	0	0	0	3750	0	0	0	0	0	0	7151	0	0	0
Grand Total	**8884**	**1845**	**5835**	**1500**	**1000**	**2013**	**1548**	**2737**	**5449**	**3545**	**1777**	**1185**	**2774**	**2271**	**1371**	**2340**	**3581**	**1573**	**1875**	**2206**

Table 20: Shredding cost of the selected crops in the study area

States	Oil Seeds	Onion	Peas & Beans	Potato	Ragi	Rapeseed	Rice	Sesamum	Soyabean	Sugarcane	Sunflower	Sweet Potato	Tapioca	Tobacco	Tomato	Topioca	Tur	Turmeric	Urad	Wheat
Sikkim	0	0	0	0	0	0	2000	0	0	0	0	0	0	0	0	0	0	0	2000	0
Andhra Pradesh	870	0	0	0	0	0	1023	0	0	962	0	0	0	0	0	0	856	0	0	0
Arunachal Pradesh	0	0	0	2523	0	0	1567	0	0	4111	0	0	0	0	0	0	0	0	2222	0
Assam	0	0	0	5566	0	0	4527	0	0	0	0	0	0	0	0	0	0	0	5724	0
Bihar	0	0	0	4955	0	0	3111	0	0	9210	1867	0	0	0	0	0	0	4033	0	3379
Chandigarh	0	0	0	0	0	0	3112	0	0	0	0	0	0	0	0	0	0	0	0	3112
Chhattisgarh	0	0	0	0	0	0	1567	0	2	0	0	0	0	0	0	0	0	0	0	2
Dadra & Nagar Haveli	0	0	0	0	0	3883	0	0	0	0	0	0	0	0	0	0	0	0	0	3786
Daman & Diu	0	0	0	0	0	0	0	0	3618	0	0	0	0	0	0	0	0	0	0	3163
Goa	0	0	0	0	0	0	5500	0	0	0	0	0	0	0	0	0	0	0	0	0
Gujarat	0	0	0	3134	0	3559	2604	0	0	3417	0	0	0	0	3818	0	3344	0	0	2475
Haryana	0	0	0	0	0	0	1200	0	0	0	0	0	0	0	0	0	0	0	0	1000
Himachal Pradesh	0	0	0	0	0	0	3969	0	0	0	0	0	0	0	0	0	0	0	0	2761
Jammu and Kashmir	0	0	0	0	0	0	6012	0	0	0	0	0	0	0	0	0	0	0	0	5433
Jharkhand	0	0	1467	3360	0	2000	1500	2400	0	0	0	0	0	2000	1667	0	0	0	3192	2366
Karnataka	0	0	0	0	806	0	1720	0	1168	741	0	0	0	0	0	0	1150	0	0	1200
Kerala	0	0	0	0	0	0	1500	0	0	0	0	0	1617	0	0	0	0	0	0	0
Madhya Pradesh	0	0	0	0	0	0	2256	0	2470	0	0	0	0	0	0	0	0	0	1896	2584
Maharashtra	0	1200	1000	1067	0	0	1293	0	1700	4121	0	0	0	0	0	0	1044	667	1000	1457
Manipur	0	0	1613	968	0	0	1024	0	0	0	0	0	0	0	1640	0	0	0	0	0
Meghalaya	0	0	0	3167	0	0	4658	0	0	0	0	3750	0	0	0	0	0	0	0	0
Mizoram	0	0	0	0	0	0	7802	0	0	12121	0	0	0	0	0	0	0	0	0	0

States	Oil Seeds	Onion	Peas & Beans	Potato	Ragi	Rapeseed	Rice	Sesamum	Soyabean	Sugarcane	Sunflower	Sweet Potato	Tapioca	Tobacco	Tomato	Topioca	Tur	Turmeric	Urad	Wheat
Nagaland	0	0	0	0	0	0	7732	0	0	0	0	0	0	0	0	0	0	0	0	0
Odisha	0	0	0	0	0	0	1500	0	0	0	0	0	0	0	0	0	0	0	0	0
Punjab	0	0	0	0	0	0	1500	0	0	0	0	0	0	0	0	0	0	0	0	1500
Rajasthan	0	0	0	0	0	2549	2444	0	1976	0	0	0	0	0	2800	0	0	0	2400	2027
Tamil Nadu	0	0	0	0	3407	0	3836	0	0	4542	0	0	4463	0	4750	4729	0	0	2758	0
Telangana	0	0	0	0	0	0	1080	0	1115	0	0	0	0	0	0	0	857	0	0	0
Tripura	0	0	0	12109	0	0	16292	0	0	0	0	0	0	0	0	0	0	0	0	0
Uttar Pradesh	0	0	1500	2132	0	0	2441	2903	0	1947	0	0	0	0	0	0	0	0	3241	2823
Uttarakhand	0	0	0	0	0	0	1500	1600	1500	1500	0	0	0	0	0	0	0	0	0	1503
West Bengal	0	0	0	7306	0	0	7473	3662	0	0	0	0	0	0	0	0	0	0	0	5075
Grand Total	**870**	**1200**	**1439**	**5067**	**2010**	**2822**	**2981**	**2945**	**2058**	**4023**	**1867**	**3750**	**3124**	**2000**	**3518**	**4729**	**1116**	**2911**	**3944**	**2549**

Table 21: Average cost of Shredding per acre

States	Jute	Lentils	Maize	Masoor	Mesta	Moong	Moth	Mustard
Sikkim	0	0	2000	0	0	0	0	0
Andhra Pradesh	0	0	800	0	0	0	0	0
Arunachal Pradesh	0	0	2205	0	0	0	0	1608
Assam	12000	0	0	0	0	0	0	6571
Bihar	0	0	3359	3149	0	4461	0	0
Chandigarh	0	0	0	0	0	0	0	0
Chhattisgarh	0	0	2	0	0	0	0	0
Dadra & Nagar Haveli	0	0	4028	0	0	3722	0	0
Daman & Diu	0	0	3185	0	0	0	0	0
Goa	0	0	0	0	0	0	0	0
Gujarat	0	0	2355	0	0	3194	0	3438
Haryana	0	0	0	0	0	1000	0	1132
Himachal Pradesh	0	0	3129	0	0	0	0	0
Jammu & Kashmir	0	0	4081	0	0	0	0	0
Jharkhand	0	0	1500	3750	0	0	0	2505
Karnataka	0	0	800	0	0	1250	0	0
Kerala	0	0	0	0	0	0	0	0
Madhya Pradesh	0	0	2341	1667	0	0	0	21720
Maharashtra	0	0	1144	1500	0	1256	1000	0
Manipur	0	0	0	0	0	0	0	1518
Meghalaya	0	0	6487	0	4274	0	0	4014
Mizoram	0	0	5333	0	0	0	0	9397
Nagaland	0	0	3127	0	0	0	0	4519
Odisha	0	0	0	0	0	1545	0	0
Punjab	0	0	0	0	0	0	0	0
Rajasthan	0	0	2161	0	0	749	922	807
Tamil Nadu	0	0	3636	0	0	3187	0	0
Telangana	0	0	1073	0	0	0	0	0
Tripura	0	0	0	0	0	0	0	0
Uttar Pradesh	0	0	1600	0	0	1608	0	2824
Uttarakhand	0	0	0	0	0	0	0	0
West Bengal	7375	4500	4500	0	0	0	0	6151
Grand Total	**9225**	**4500**	**2603**	**3110**	**4274**	**2297**	**933**	**4269**

From the above analysis, it is evident that rice crop has shown high deviation in shredding cost from INR 2000 to 7000 per acre across the states, whereas other cereals, pulses and oilseeds shredding cost ranged between INR 2000-3500 per acre. The shredding cost for jute, sugar cane and Arecanut is slightly on the higher side at INR 7000 to 10000 per acre. The shredding cost of the crop residue is an additional cost to a farmer. Hence, willingness to go for shredding instead of open burning is found to be negligible, resulting in open burning practice, particularly in rice, wheat and sugar cane crops.

State-wise and Crop-wise Residue Surplus Availability (%)

The collected crop-wise data for each state was also analyzed with the crop residue ratio (as mentioned in table no. 10) to calculate gross crop residue potential (mentioned in column 4 of table no. 22). Further, the data was processed to calculate surplus residue factor (as mentioned in Model for Calculation of Biomass Power Potential in Chapter-2). After arriving at surplus factor, it was put into the model to finally arrive at surplus biomass potential for each state against considered crop and is tabulated as below:

Table 22: Crop-wise state-wise area covered for the survey, biomass potential and utilisation pattern based on Primary data

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
Andhra Pradesh	Cashewnut	11.13	16.70	38.41	0.00	38.41	0.00	100.00
	Cotton	83.37	138.40	830.40	148.29	682.11	17.86	82.14
	Dry Chillies	24.08	97.90	146.85	29.37	117.48	20.00	80.00
	Groundnut	18.62	38.90	89.47	72.02	17.45	80.50	19.50
	Jowar	0.81	2.00	4.80	4.32	0.48	90.00	10.00
	Maize	4.86	12.50	28.75	12.58	16.17	43.75	56.25
	Oil Seeds	3.64	8.60	17.29	0.00	17.29	0.00	100.00
	Rice	139.21	751.20	1277.04	1039.46	237.58	81.40	18.60
	Sugarcane	8.50	1160.00	440.80	0.00	440.80	0.00	100.00
	Tur	14.97	24.40	43.92	23.42	20.50	53.33	46.67
	Coconut	1.21	74.00	351.50	0.00	351.50	0.00	100.00
Arunachal Pradesh	Maize	17.00	40.90	94.07	39.19	54.88	41.66	58.34
	Rice	202.10	266.11	406.76	380.79	25.98	93.61	6.39
	Cabbage	1.82	9.30	23.25	3.88	19.38	16.67	83.33
	Mustard	5.67	7.40	13.32	1.04	12.28	7.78	92.22
	Potato	62.32	154.00	124.74	26.33	98.41	21.11	78.89
	Urad	4.86	7.70	10.01	0.00	10.01	0.00	100.00
	Sugarcane	5.67	10.90	4.14	0.00	4.14	0.00	100.00
Assam	Rice	71.56	329.20	559.64	513.28	46.36	91.72	8.28
	Mustard	28.87	42.85	77.13	16.66	60.47	21.60	78.40
	Jute	40.47	31.62	63.24	2.59	60.65	4.10	95.90
	Urad	6.74	10.20	13.26	7.12	6.14	53.67	46.33
	Arecanut	28.65	22.06	83.83	4.85	78.98	5.78	94.22
	Groundnut	17.40	13.90	31.97	28.37	3.60	88.75	11.25
	Potato	51.87	175.82	180.04	44.42	135.62	24.67	75.33
Bihar	Maize	43.65	111.62	256.73	127.66	129.07	49.73	50.27
	Rice	154.73	644.85	1096.25	991.40	104.84	90.44	9.56
	Sugarcane	15.13	994.50	377.91	44.42	333.49	11.75	88.25
	Turmeric	5.53	92.70	27.81	11.12	16.69	40.00	60.00
	Gram	1.11	0.76	0.84	0.53	0.31	63.00	37.00
	Masoor	19.48	15.90	28.46	2.79	25.67	9.81	90.19
	Potato	7.70	147.90	119.80	3.59	116.21	3.00	97.00
	wheat	113.12	428.16	770.69	680.70	89.99	88.32	11.68

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Moong	28.85	68.40	85.50	43.88	41.62	51.32	48.68
	sunflower	1.21	3.60	7.20	5.04	2.16	70.00	30.00
Chandigarh	Rice	9.17	36.00	61.20	12.24	48.96	20.00	80.00
	Wheat	9.17	35.70	64.26	64.26	0.00	100.00	0.00
Chhattisgarh	Maize	43.71	90.00	207.00	160.78	46.22	77.67	22.33
	Rice	796.02	1858.40	3159.28	2432.99	726.29	77.01	22.99
	Wheat	31.97	62.20	111.96	75.57	36.39	67.50	32.50
	Soyabean	48.56	93.30	158.61	131.57	27.04	82.95	17.05
	Gram	209.22	500.70	550.77	515.36	35.41	93.57	6.43
Dadra & Nagar Haveli	Bajra	14.89	57.70	151.75	151.75	0.00	100.00	0.00
	Gaurseed	3.24	7.90	15.80	15.80	0.00	100.00	0.00
	Maize	7.45	24.83	57.11	57.11	0.00	100.00	0.00
	Moong	4.05	12.06	15.08	15.08	0.00	100.00	0.00
	Rapeseed	10.93	28.95	52.11	0.00	52.11	0.00	100.00
	Wheat	18.70	85.60	154.08	123.26	30.82	80.00	20.00
Daman	Groundnut	3.88	7.20	16.56	16.56	0.00	100.00	0.00
	Maize	8.98	27.95	64.29	64.29	0.00	100.00	0.00
	Soyabean	12.87	35.30	60.01	60.01	0.00	100.00	0.00
	Corainader	1.29	1.45	1.67	1.67	0.00	100.00	0.00
	Garlic	3.24	1.30	0.39	0.00	0.39	0.00	100.00
	Gram	0.16	0.56	0.62	0.62	0.00	100.00	0.00
	Wheat	20.56	64.20	115.56	92.45	23.11	80.00	20.00
Goa	Rice	10.98	17.90	30.43	30.43	0.00	100.00	0.00
	Vegetables	1.82	0.90	2.25	2.25	0.00	100.00	0.00
	Coconut	4.50	19.50	92.63	92.63	0.00	100.00	0.00
Gujrat	Bajra	17.48	48.70	128.08	103.84	24.24	81.07	18.93
	Beat	8.50	2.40	3.60	3.49	0.11	97.00	3.00
	Castor	13.60	19.35	79.34	25.50	53.83	32.14	67.86
	Cotton	168.92	356.85	2141.10	317.60	1823.50	14.83	85.17
	Ginger	1.29	7.00	0.35	0.35	0.00	100.00	0.00
	Gram	4.37	4.90	5.39	5.39	0.00	100.00	0.00
	Green Gram	37.87	59.68	74.60	74.44	0.16	99.78	0.22
	Groundnut	86.72	223.70	514.51	491.21	23.30	95.47	4.53
	Jeera	1.29	0.70	1.05	0.00	1.05	0.00	100.00
	Jowar	30.59	64.60	155.09	151.14	3.95	97.45	2.55
	Maize	74.17	204.70	470.81	437.68	33.13	92.96	7.04
	Mustard	0.49	0.05	0.09	0.06	0.03	71.11	28.89
	Okra	3.88	28.70	4.30	4.30	0.00	100.00	0.00
	Potato	34.72	119.60	96.87	78.22	18.65	80.75	19.25
	Rapeseed	3.08	4.70	8.46	4.02	4.44	47.51	52.49

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Rice	203.11	555.35	944.09	906.68	37.41	96.04	3.96
	Sugarcane	46.86	1900.50	722.19	653.03	69.16	90.42	9.58
	Tomato	35.86	50.44	75.66	61.68	13.98	81.52	18.48
	Tur	17.24	15.14	19.68	5.62	14.06	28.54	71.46
	Wheat	466.56	1343.66	2418.58	1297.62	1120.96	53.65	46.35
Haryana	Bajra	36.02	43.19	113.59	113.59	0.00	100.00	0.00
	Cotton	137.79	194.20	1165.20	1165.20	0.00	100.00	0.00
	Moong	1.16	1.60	2.00	2.00	0.00	100.00	0.00
	Mustard	31.16	796.00	1353.20	1341.12	12.08	99.11	0.89
	Rice	121.40	33.56	60.41	-618.45	678.86	-1023.78	1123.78
	Wheat	265.68	1036.77	1866.19	1866.19	0.00	100.00	0.00
Himachal Pradesh	Apple	48.77	19.80	29.70	29.70	0.00	100.00	0.00
	Cotton	0.40	0.10	0.60	0.60	0.00	100.00	0.00
	Maize	28.25	35.40	81.42	81.42	0.00	100.00	0.00
	Rice	37.41	151.40	257.38	257.38	0.00	100.00	0.00
	Wheat	65.46	214.60	386.80	386.80	0.00	100.00	0.00
Jammu & Kashmir	Maize	16.26	64.30	147.89	147.89	0.00	100.00	0.00
	Rice	11.38	90.10	153.17	153.17	0.00	100.00	0.00
	Wheat	27.49	162.45	292.41	292.41	0.00	100.00	0.00
Jharkhand	Brinjal	0.01	0.10	0.15	0.15	0.00	100.00	0.00
	Cauliflower	0.81	1.66	2.49	1.25	1.25	50.00	50.00
	Gram	1.92	1.54	1.69	1.02	0.68	60.04	39.96
	Green Pea	0.36	1.40	0.70	0.32	0.39	45.00	55.00
	Groundnut	0.02	0.01	0.02	0.01	0.01	50.00	50.00
	Lady Finger	0.06	0.30	0.45	0.00	0.45	0.00	100.00
	Maize	19.95	24.31	55.39	29.63	25.76	53.50	46.50
	Masoor	0.51	0.37	0.66	0.35	0.31	52.57	47.43
	Mustard	9.81	6.09	12.04	2.62	9.42	21.79	78.21
	Potato	0.49	2.50	2.03	1.11	0.91	55.01	44.99
	Ragi	1.21	0.85	1.11	0.90	0.21	81.45	18.55
	Rapeseed	0.20	0.18	0.32	0.10	0.23	30.00	70.00
	Rice	91.14	291.05	494.79	446.39	48.40	90.22	9.78
	Seasame	0.10	0.04	0.10	0.06	0.04	60.00	40.00
	Tobacco	0.10	0.10	0.10	0.00	0.10	0.00	100.00
	Tomato	0.99	1.60	2.40	1.56	0.84	65.00	35.00
	Urad	3.46	3.51	4.56	1.35	3.21	29.63	70.37
	Wheat	53.39	93.75	168.75	80.12	88.63	47.48	52.52
Karnataka	Arecanut	24.28	490.00	1862.00	0.00	1862.00	0.00	100.00
	Bajra	367.10	4576.90	12037.25	10288.09	1749.16	85.47	14.53
	Betal nut	1.21	17.00	64.60	64.60	0.00	100.00	0.00

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Coconut	61.11	947.50	4500.63	0.00	4500.63	0.00	100.00
	Dry chillies	1.62	1.50	2.25	0.45	1.80	20.00	80.00
	Gram	6.88	16.00	17.60	15.84	1.76	90.00	10.00
	Sugarcane	24.88	2510.00	953.80	0.00	953.80	0.00	100.00
	Wheat	0.40	2.00	3.60	3.24	0.36	90.00	10.00
Kerala	Arecanut	80.33	99.25	377.15	342.21	34.94	90.74	9.26
	Banana	130.51	1855.00	5565.00	4968.20	596.80	89.28	10.72
	Black Pepper	18.82	1.31	0.66	0.51	0.14	78.32	21.68
	Coconut	159.04	621.75	2953.31	2909.33	43.99	98.51	1.49
	Rice	91.66	176.87	300.68	235.24	65.44	78.24	21.76
	Tapioca	23.27	225.00	168.75	144.00	24.75	85.33	14.67
Madhya Pradesh	Bajra	2.79	12.00	31.56	31.56	0.00	100.00	0.00
	Gram	166.69	249.90	274.89	208.13	66.76	75.71	24.29
	Jowar	21.24	80.30	192.72	192.72	0.00	100.00	0.00
	Maize	202.85	324.14	745.52	443.70	301.82	59.52	40.48
	Masur	1.21	1.50	2.69	0.00	2.69	0.00	100.00
	Mustard	3.35	11.00	19.80	9.90	9.90	50.00	50.00
	Rice	172.43	318.20	540.94	336.35	204.59	62.18	37.82
	Soyabean	422.24	722.70	1228.59	1026.90	201.69	83.58	16.42
	Urad	37.53	71.30	92.69	34.13	58.56	36.82	63.18
	Wheat	635.71	1187.60	2137.68	1602.93	534.75	74.98	25.02
Manipur	Cucumber	0.13	0.20	0.30	0.30	0.00	100.00	0.00
	Mustard	3.89	7.40	13.32	0.00	13.32	0.00	100.00
	Peas	0.13	1.50	0.75	0.75	0.00	100.00	0.00
	Potato	0.13	0.50	0.41	0.41	0.00	100.00	0.00
	Rice	63.44	297.92	506.46	284.63	221.83	56.20	43.80
	Tomato	1.13	14.50	21.75	21.75	0.00	100.00	0.00
Meghalaya	Arecanut	242.82	229.59	872.44	19.83	852.61	2.27	97.73
	Ginger	4.14	18.60	0.93	0.62	0.31	66.67	33.33
	Maize	10.44	70.70	162.61	91.37	71.24	56.19	43.81
	Mesta	4.41	10.40	21.32	0.00	21.32	0.00	100.00
	Mustard	24.36	22.10	39.78	0.57	39.21	1.43	98.57
	Potato	3.04	4.90	3.97	0.00	3.97	0.00	100.00
	Rice	64.41	229.20	389.64	367.67	21.97	94.36	5.64
	Sweet Potato	4.86	13.70	0.14	0.14	0.00	100.00	0.00
Mizoram	Banana	15.38	10.30	30.90	30.90	0.00	100.00	0.00
	Maize	1.82	3.30	7.59	0.38	7.21	5.01	94.99
	Mustard	6.06	9.10	16.38	1.58	14.81	9.62	90.38
	Rice	19.54	63.47	107.90	94.73	13.17	87.80	12.20
	Sugarcane	1.62	1.00	0.38	0.00	0.38	0.00	100.00

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
Nagaland	Maize	0.64	3.30	7.59	0.00	7.59	0.00	100.00
	Mustard	54.44	99.39	178.90	4.40	174.50	2.46	97.54
	Rice	67.15	133.75	227.38	159.74	67.64	70.25	29.75
	Seasame	0.17	0.34	0.85	0.00	0.85	0.00	100.00
Odisha	Cotton	0.61	1.00	6.00	0.00	6.00	0.00	100.00
	Haradi	1.62	1.95	2.93	1.42	1.50	48.58	51.42
	Moong	49.82	70.80	88.50	44.32	44.18	50.08	49.92
	Rice	127.76	328.47	558.39	457.51	100.88	81.93	18.07
Punjab	Cotton	30.96	400.70	2404.20	2404.20	0.00	100.00	0.00
	Rice	453.10	2870.30	4879.51	34.85	4844.66	0.71	99.29
	Wheat	484.00	3580.00	6444.00	6444.00	0.00	100.00	0.00
Rajasthan	Bajra	65.26	69.05	181.60	149.82	31.78	82.50	17.50
	Coriander	4.17	3.12	3.59	3.59	0.00	100.00	0.00
	Cotton	39.71	25.60	153.60	49.74	103.86	32.38	67.62
	Garlic	7.97	4.95	0.25	0.00	0.25	0.00	100.00
	Gram	53.62	36.56	40.22	40.22	0.00	100.00	0.00
	Groundnut	27.19	23.00	52.90	48.14	4.76	91.00	9.00
	Guar	13.71	5.85	11.70	10.55	1.15	90.17	9.83
	Guar Seed	45.02	45.34	90.68	76.72	13.96	84.60	15.40
	Jowar	13.15	30.30	72.72	58.18	14.54	80.00	20.00
	Maize	180.54	336.65	774.30	768.39	5.91	99.24	0.76
	Moong	39.71	21.90	27.38	17.85	9.52	65.22	34.78
	Moth	23.39	12.00	21.60	21.29	0.31	98.57	1.43
	Mustard	31.87	11.90	21.42	20.01	1.41	93.41	6.59
	Okra	2.43	0.80	1.20	0.00	1.20	0.00	100.00
	Palak	1.21	0.15	0.23	0.23	0.00	100.00	0.00
	Rapeseed	70.44	108.03	194.45	8.78	185.67	4.52	95.48
	Rice	14.16	23.30	39.61	39.61	0.00	100.00	0.00
	Soyabean	41.35	71.55	121.64	121.64	0.00	100.00	0.00
	Tomato	1.52	1.90	2.85	2.28	0.57	80.00	20.00
	Urad	2.02	3.10	4.03	4.03	0.00	100.00	0.00
	Wheat	312.75	749.40	1348.92	1115.25	233.67	82.68	17.32
	White Gram	34.65	64.15	70.57	65.86	4.70	93.33	6.67
Sikkim	Cardamom	16.91	7.55	4.83	1.98	2.85	41.02	58.98
	Ginger	1.42	3.80	0.19	0.13	0.06	66.84	33.16
	Maize	1.21	2.20	5.06	1.27	3.80	25.00	75.00
	Rice	6.39	13.10	22.27	22.09	0.18	99.19	0.81
	Urad	0.21	0.08	0.10	0.08	0.02	80.00	20.00
Tamil Nadu	Banana	15.78	40.00	120.00	120.00	0.00	100.00	0.00
	Cashewnut	11.33	3.90	8.92	7.27	1.64	81.56	18.44

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Coconut	122.42	575.00	2731.25	2485.90	245.35	91.02	8.98
	Cotton	21.04	46.00	216.00	209.52	6.48	97.00	3.00
	Groundnut	29.95	66.00	151.80	151.80	0.00	100.00	0.00
	Jowar	25.90	45.20	108.80	99.13	9.67	91.11	8.89
	Maize	12.95	29.00	66.70	60.38	6.33	90.52	9.48
	Moong	55.44	82.30	102.88	102.69	0.19	99.82	0.18
	Ragi	31.97	57.60	74.88	68.41	6.47	91.35	8.65
	Rice	49.37	150.30	255.51	237.27	18.24	92.86	7.14
	Sugarcane	133.95	7181.00	2728.78	2580.65	148.13	94.57	5.43
	Tapioca	41.48	216.57	162.43	155.85	6.57	95.95	4.05
	Tomato	4.45	14.00	21.00	16.80	4.20	80.00	20.00
	Urad	26.30	42.00	54.60	48.52	6.08	88.86	11.14
	Cotton	66.77	155.10	930.60	139.59	791.01	15.00	85.00
	Dry chillies	12.95	64.00	96.00	19.20	76.80	20.00	80.00
	Ginger	0.81	1.60	0.08	0.00	0.08	0.00	100.00
	Gram	6.27	17.00	18.70	14.93	3.77	79.83	20.17
	Groundnut	2.43	4.40	10.12	9.11	1.01	90.00	10.00
Telangana	Jowar	1.21	3.00	7.20	6.48	0.72	90.00	10.00
	Maize	41.08	132.50	304.75	213.33	91.43	70.00	30.00
	Oilseeds	4.05	6.00	12.06	1.21	10.85	10.00	90.00
	Rice	228.24	861.30	1464.10	1276.46	187.64	87.18	12.82
	Soyabean	39.30	84.60	143.82	133.40	10.42	92.75	7.25
	Tur	12.95	27.40	35.62	25.83	9.80	72.50	27.50
Tripura	Rice	14.71	91.60	155.72	140.15	15.57	90.00	10.00
	Potato	15.90	99.00	80.19	41.92	38.27	52.27	47.73
	Bajra	0.60	0.79	2.08	1.56	0.52	75.01	24.99
	Rice	38.73	113.30	192.61	161.42	31.19	83.81	16.19
	Seasame	0.66	3.50	8.75	8.75	0.00	100.00	0.00
Uttarakhand	Small Bajra	0.32	1.40	3.68	3.16	0.53	85.71	14.29
	Soyabean	5.47	14.45	24.57	24.57	0.00	100.00	0.00
	Sugarcane	14.97	95.50	36.29	36.29	0.00	100.00	0.00
	Wheat	44.64	83.45	150.21	132.23	17.98	88.03	11.97
	Bajra	12.68	30.56	80.37	72.34	8.03	90.01	9.99
	Gram	12.14	26.50	29.15	20.41	8.75	70.00	30.00
	Jowar	11.26	11.21	26.90	21.52	5.38	80.00	20.00
	Maize	53.15	99.07	227.86	225.58	2.28	99.00	1.00
Uttar Pradesh	Moong	12.29	17.10	21.38	21.38	0.00	100.00	0.00
	Mustard	29.54	27.05	48.69	38.44	10.25	78.95	21.05
	Peas	0.34	0.41	0.21	0.21	0.00	100.00	0.00
	Potato	5.53	31.20	25.27	22.27	3.00	88.13	11.87

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Rice	187.53	877.50	1491.75	1424.62	67.13	95.50	4.50
	Seasame	66.11	97.06	242.67	234.99	7.68	96.84	3.16
	Sugar Cane	221.72	2974.00	1130.12	981.78	148.34	86.87	13.13
	Toor	7.55	9.67	12.57	1.74	10.83	13.83	86.17
	Urad	16.45	15.56	20.22	17.44	2.78	86.26	13.74
	Wheat	318.89	1036.90	1866.42	1826.16	40.26	97.84	2.16
West Bengal	Banana	1.21	24.00	72.00	28.80	43.20	40.00	60.00
	Caoriander	0.47	0.52	0.60	0.30	0.30	50.00	50.00
	Ediable roat	0.40	0.30	0.45	0.45	0.00	100.00	0.00
	Ground Nut	51.30	67.62	155.53	155.53	0.00	100.00	0.00
	Guava	0.81	4.00	6.00	6.00	0.00	100.00	0.00
	Jute	45.94	43.90	87.80	83.22	4.58	94.78	5.22
	Lentils	1.27	2.80	5.04	3.43	1.61	68.06	31.94
	Maize	0.13	0.50	1.15	1.15	0.00	100.00	0.00
	Mustard	16.91	46.01	82.82	42.24	40.58	51.00	49.00
	Potato	38.71	182.80	148.07	23.38	124.69	15.79	84.21
	Rice	164.74	511.82	870.09	812.13	57.97	93.34	6.66
	Seasame	11.13	5.28	13.20	11.31	1.89	85.71	14.29
	Wheat	7.49	11.30	20.34	12.00	8.34	59.00	41.00
Maharashtra	Bajra	21.65	19.90	52.34	52.34	0.00	100.00	0.00
	Chia seed	0.81	0.50	0.75	0.75	0.00	100.00	0.00
	Chilli	3.84	3.49	5.24	5.24	0.00	100.00	0.00
	Cotton	115.25	194.60	1167.60	107.27	1060.33	9.19	90.81
	Finger Millet	0.02	0.10	0.24	0.19	0.05	80.00	20.00
	Ginger	1.01	4.60	0.23	0.23	0.00	100.00	0.00
	Gram	136.34	213.90	235.29	229.60	5.69	97.58	2.42
	Ground Nut	21.25	30.78	70.79	62.17	8.62	87.82	12.18
	Jowar	20.11	31.50	75.60	60.48	15.12	80.00	20.00
	Maize	36.06	62.22	143.11	139.49	3.62	97.47	2.53
	Masoor	1.42	0.70	1.25	0.75	0.50	60.00	40.00
	Moong	16.39	16.20	20.25	17.28	2.97	85.34	14.66
	Moth	5.26	2.60	4.68	4.68	0.00	100.00	0.00
	Onion	6.88	10.50	0.53	0.46	0.06	88.06	11.94
	Peas	0.61	0.50	0.25	0.13	0.13	50.00	50.00
	Potato	2.63	3.20	1.22	0.81	0.41	66.67	33.33
	Rice	53.82	148.40	252.28	250.07	2.21	99.12	0.88
	Shatawari	0.91	9.00	13.50	11.45	2.05	84.81	15.19
	Soyabean	138.61	262.20	445.74	381.13	64.61	85.51	14.49
	Sugar Cane	64.95	3135.00	1191.30	1036.19	155.12	86.98	13.02
	Tomato	0.40	2.00	3.00	3.00	0.00	100.00	0.00

States	Crops	Area (in ha)	Production (in tonnes)	Biomass (in tonnes)	Utilisation (in tonnes)	Surplus Biomass (in tonnes)	% share of residual used	% share of residual is surplus
	1	2	3	4	5	6	7	8
	Tur	32.82	54.99	71.49	27.49	44.00	38.45	61.55
	Turmeric	1.62	7.50	2.81	0.00	2.81	0.00	100.00
	Urad	2.63	1.20	1.56	1.09	0.47	70.00	30.00
	Vegetable	0.20	0.50	0.75	0.75	0.00	100.00	0.00
	Wheat	87.01	162.40	292.32	256.82	35.50	87.86	12.14

Biomass Power Potential

As mentioned in chapter-3, the number of crops considered for the study in various districts across the country has been tabulated as below. The secondary data from various sources on various parameters for selected 54 crops were collected and processed with the primary data to estimate biomass power potential in India.

Table 23: State-wise number of crops considered for estimation of Biomass power potential in India

Sl. No	States	Districts	Crops considered under study
1	Andhra Pradesh	13	47
2	Arunachal Pradesh	25	16
3	Assam	33	32
4	Bihar	38	41
5	Chhattisgarh	28	44
6	Goa	2	14
7	Gujarat	33	31
8	Haryana	22	38
9	Himachal Pradesh	12	35
10	Jammu Kashmir	22	35
11	Jharkhand	24	28
12	Karnataka	30	45
13	Kerala	14	34
14	Madhya Pradesh	51	44
15	Maharashtra	36	30
16	Manipur	16	28
17	Meghalaya	11	34
18	Mizoram	8	25
19	Nagaland	12	40
20	Odisha	30	38
21	Punjab	22	22
22	Rajasthan	33	42
23	Sikkim	4	14
24	Tamil Nadu	38	44
25	Telangana	33	41
26	Tripura	8	23
27	Uttar Pradesh	75	40
28	Uttarakhand	13	37
29	West Bengal	23	43
30	Andaman & Nicobar	3	24
31	Chandigarh	1	12
32	Dadra Nagar Havali	1	22
33	Daman & Diu	2	2
34	Puducherry	4	31
	India	**720**	**54**

Note: Excluding Delhi and Lakshadweep

All India – Crop Production, Surplus biomass availability and Biomass Power Potential for TE 2015-18

From the above table, it is evident that the total gross cropped area (TE-2015-2018) brought under selected crops in India was around 198.11 m.ha, which includes the Kharif, rabi and summer seasons acreage and annual crops. Total production produced from these selected crops at all India level for the selected period was around 774.38 million tonnes. From this total production, total biomass-derived by multiplying the crop-specific Crop Residue Ratio (CRR) with the total production of the respective crops. The calculated total available biomass potential at all India level was derived to around 754.50 million tonnes. Out of this total biomass production, a specific portion of the biomass is used for domestic uses such as domestic fuel, feed for cattle and manure etc.; the utilization rate of biomass varied from crop to crop and state to state.

From table no. 15, it is clear that 2/3rd portion of total biomass produced, i.e., 525.98 million tonnes, are utilized for domestic uses and for consumption, whereas the remaining 1/3rd portion has resulted in surplus biomass, i.e., 228.52 million tonnes. From this, biomass power potential is derived by multiplying the crop-specific power factor (derived from the Gross Heating Value) to the surplus biomass of the respective crop surplus biomass (refer to table no. 10.1). The estimated gross biomass power potential is around 28445.52 MWe at all India level.

The lions share of all India biomass power potential is contributed by Punjab (10.6%), Uttar Pradesh (9.8%), followed by Gujarat (9.3%), Maharashtra (9.2%), Madhya Pradesh (8.8%) and Andhra Pradesh (7%) states majorly.

Table 24: State-wise Total Cropped Area Production, Biomass Generation, Surplus Biomass Production and Biomass Power Potential in India (TE 2015-18)

States/UTs	Total Crop Area (Million Hectares)	Total Crop Production (Million Tonnes)	Total Biomass Generation (Million Tonnes)	Surplus Biomass Potential (Million Tonnes)	Biomass Utilization (Million Tonnes)	Biomass Power Potential (Mwe)	% Share in total Biomass Power Potential
Andhra Pradesh	7.36	28.62	40.01	17.09	22.92	1999.49	7.03
Arunachal Pradesh	0.33	0.58	0.75	0.17	0.58	18.46	0.06
Assam	3.40	8.93	12.57	2.54	10.03	321.89	1.13
Bihar	7.28	32.50	32.57	7.98	24.59	964.37	3.39
Chhattisgarh	5.47	8.71	12.99	2.65	10.34	353.68	1.24
Goa	0.14	0.24	0.45	0.23	0.22	32.97	0.12
Gujarat	9.67	32.27	50.24	21.74	28.50	2637.84	9.27
Haryana	6.60	27.17	36.24	10.91	25.33	1353.35	4.76
Himachal Pradesh	0.77	1.51	2.74	0.57	2.17	69.71	0.25
Jammu & Kashmir	0.96	1.77	3.24	0.65	2.59	82.82	0.29
Jharkhand	1.96	3.32	5.31	1.20	4.11	146.31	0.51
Karnataka	10.94	51.34	34.09	14.05	20.05	1793.88	6.31
Kerala	1.30	4.79	8.58	6.04	2.54	778.41	2.74
Madhya Pradesh	23.70	43.81	70.23	19.93	50.30	2516.42	8.85
Maharashtra	21.07	86.48	52.54	21.49	31.05	2629.55	9.24
Manipur	0.34	1.12	1.14	0.48	0.66	62.31	0.22
Meghalaya	0.25	0.91	1.37	0.56	0.81	68.54	0.24
Mizoram	0.05	0.13	0.13	0.02	0.11	2.90	0.01
Nagaland	0.44	1.37	1.37	0.44	0.94	53.90	0.19
Odisha	4.45	7.88	11.84	2.23	9.61	298.72	1.05
Punjab	7.17	37.88	53.00	22.25	30.75	3022.11	10.62
Rajasthan	31.93	32.11	59.50	10.21	49.29	1299.55	4.57
Sikkim	0.08	0.12	0.23	0.04	0.19	4.73	0.02

States/UTs	Total Crop Area (Million Hectares)	Total Crop Production (Million Tonnes)	Total Biomass Generation (Million Tonnes)	Surplus Biomass Potential (Million Tonnes)	Biomass Utilization (Million Tonnes)	Biomass Power Potential (Mwe)	% Share in total Biomass Power Potential
Tamil Nadu	8.96	47.92	52.14	12.22	39.92	1560.08	5.48
Telangana	9.38	18.57	33.62	13.76	19.86	1678.36	5.90
Tripura	0.35	0.97	1.41	0.25	1.16	34.35	0.12
Uttar Pradesh	24.19	246.66	124.69	21.60	103.09	2800.31	9.84
Uttarakhand	1.00	8.05	3.55	0.72	2.83	93.34	0.33
West Bengal	8.49	38.20	47.51	16.28	31.23	1741.74	6.12
Andaman & Nicobar	0.04	0.08	0.20	0.13	0.07	18.13	0.06
Chandigarh	0.00	0.00	0.00	0.00	0.00	0.15	0.00
Dadra & Nagar Haveli and Daman & Diu	0.02	0.10	0.07	0.02	0.06	2.16	0.01
Puducherry	0.02	0.27	0.12	0.04	0.08	5.00	0.02
Total	**198.11**	**774.37**	**754.50**	**228.53**	**525.98**	**28445.52**	**100**

(Note: District wise data compiled from Directorate of Economics and Statistics)

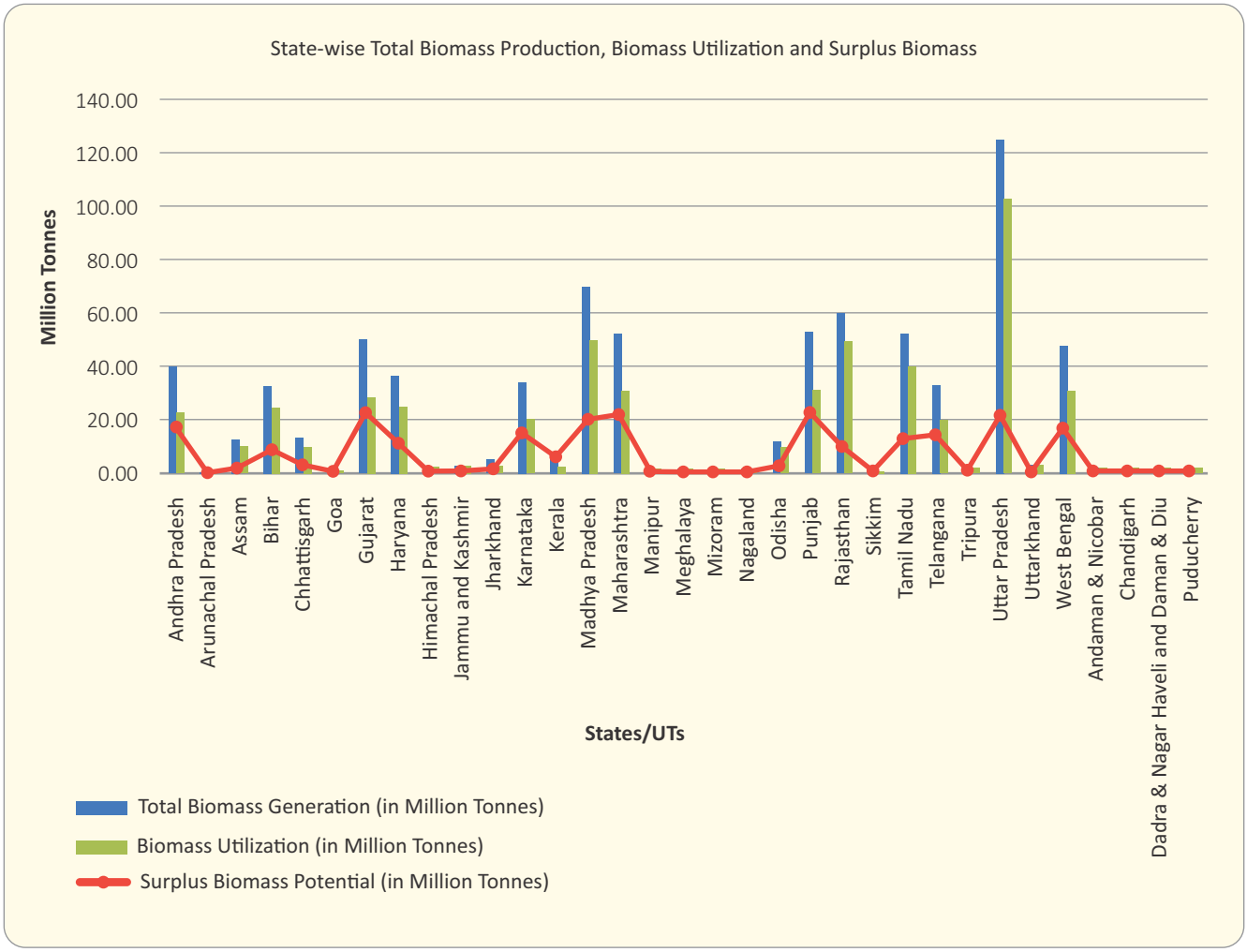


Figure 15: State-wise total biomass production, biomass utilization and surplus biomass

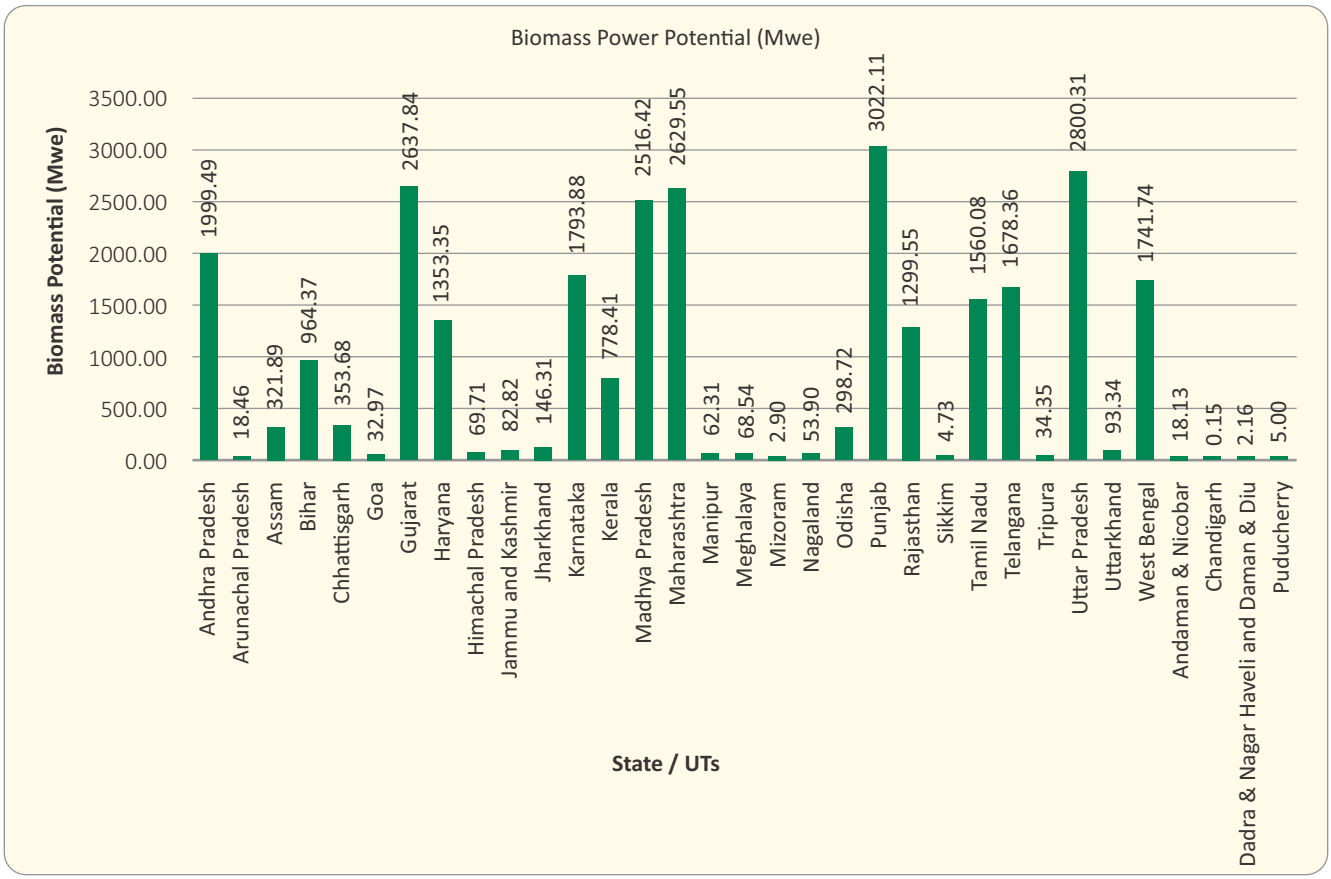


Figure16: State-wise Biomass Power Potential (in Mwe)

Further, analysis is done to estimate the biomass power potential against the selected 54 crops across India and tabulated as below:

Table 25: Resource/Crop-wise Total Cropped Area, Production, Biomass Production, Surplus Biomass Production and Biomass Power Potential in India (2018)

Sr. No	Crop	Total Crop Area (Million Hectare)	Total Crop Production (Million Tonnes)	Total Biomass Generation (Million Tonnes)	Total Biomass Utilisation (Million Tonnes)	Total Surplus Biomass (Million Tonnes)	Biomass Power Potential (Mwe)	Biomass Power Potential (Mwe)
1	Rice	46.15	123.03	184.55	142.83	41.72	5682.46	19.98
2	Wheat	34.00	106.85	192.34	158.97	33.37	4505.30	15.84
3	Barley	0.62	1.70	2.22	1.99	0.22	25.70	0.09
4	Jowar	6.58	5.23	12.55	10.63	1.92	238.14	0.84
5	Bajra	7.36	8.89	23.37	19.53	3.84	467.03	1.64
6	Maize	9.75	30.40	69.92	54.71	15.21	1776.35	6.24
7	Ragi	1.20	2.03	2.64	2.37	0.27	33.08	0.12
8	Small Millets	1.31	0.94	1.19	1.07	0.12	14.97	0.05
9	Other Cereals	0.10	0.09	0.12	0.11	0.01	1.40	0.00
10	Gram	10.57	8.09	8.90	7.03	1.88	244.91	0.86
11	Horse Gram	0.41	0.22	0.28	0.25	0.03	3.59	0.01
12	Arhar/Tur	3.06	2.59	7.24	2.33	4.91	591.76	2.08
13	Khesari	0.47	0.38	0.41	0.28	0.12	15.11	0.05
14	Masoor	1.52	1.36	2.44	0.74	1.70	175.88	0.62
15	Moong (Green Gram)	4.56	2.03	2.53	1.74	0.80	101.68	0.36

Sr. No	Crop	Total Crop Area (Million Hectare)	Total Crop Production (Million Tonnes)	Total Biomass Generation (Million Tonnes)	Total Biomass Utilisation (Million Tonnes)	Total Surplus Biomass (Million Tonnes)	Biomass Power Potential (Mwe)	Biomass Power Potential (Mwe)
16	Urad	4.24	2.48	3.23	1.93	1.30	118.49	0.42
17	Other Rabi Pulses	0.21	0.17	0.23	0.20	0.02	2.74	0.01
18	Other Kharif pulses	0.48	0.32	0.42	0.34	0.08	10.16	0.04
19	Other Summer Pulses	0.00	0.00	0.00	0.00	0.00	0.04	0.00
20	Peas & Beans	0.78	0.94	0.47	0.24	0.24	29.26	0.10
21	Cowpea	0.20	0.13	0.14	0.12	0.03	3.88	0.01
22	Moth	1.20	0.50	0.90	0.81	0.09	10.56	0.04
23	Castor Seed	0.90	1.56	6.39	2.12	4.27	534.16	1.88
24	Groundnut	5.30	7.70	17.71	16.20	1.51	184.18	0.65
25	Niger Seed	0.16	0.05	0.06	0.06	0.01	0.77	0.00
26	Rapeseed & Mustard	8.05	7.55	13.58	9.94	3.64	477.06	1.68
27	Safflower	0.12	0.06	0.19	0.15	0.04	4.21	0.01
28	Sunhamp	0.01	0.01	0.03	0.03	0.01	0.83	0.00
29	Linseed	0.22	0.13	0.19	0.16	0.04	3.93	0.01
30	Sesamum	1.56	0.77	1.92	1.21	0.70	86.67	0.30
31	Soyabean	12.65	11.34	19.27	16.85	2.42	302.58	1.06
32	Sunflower	0.37	0.23	0.46	0.04	0.42	45.74	0.16
33	Other oilseeds	1.81	3.59	7.18	0.00	7.18	679.65	2.39
34	Turmeric	0.16	0.73	0.24	0.10	0.14	19.16	0.07
35	Dry chillies	0.61	1.74	2.60	0.52	2.08	270.13	0.95
36	Garlic	0.24	1.13	0.34	0.00	0.34	45.90	0.16
37	Ginger	0.09	1.18	0.06	0.04	0.02	2.58	0.01
38	Coriander	0.38	0.33	0.38	0.19	0.19	24.24	0.09
39	Black Pepper	0.13	0.30	0.15	0.13	0.02	2.11	0.01
40	Arecanut	0.46	2.92	3.70	0.22	3.48	462.77	1.63
41	Cardamom	0.06	0.02	0.04	0.02	0.02	2.34	0.01
42	Banana	0.32	11.00	33.01	25.75	7.26	963.71	3.39
43	Onion	0.56	8.00	0.40	0.31	0.09	11.97	0.04
44	Potato	1.69	39.86	32.29	14.92	17.37	1617.08	5.68
45	Sugarcane	4.71	357.77	17.89	11.51	6.38	867.92	3.05
46	Sweet Potato	0.04	0.36	0.04	0.01	0.02	1.97	0.01
47	Tobacco	2.54	0.88	0.88	0.00	0.88	116.92	0.41
48	Cotton	12.46	4.67	57.61	11.37	46.24	5590.08	19.65
49	Guar Seed	4.59	2.10	4.19	3.55	0.65	79.76	0.28
50	Mesta	0.05	0.07	0.15	0.07	0.07	9.84	0.03
51	Jute	0.73	1.83	3.66	0.73	2.93	392.19	1.38
52	Coconut	1.86	2.71	9.46	0.95	8.51	1168.80	4.11
53	Cashewnut	0.38	0.17	0.40	0.00	0.40	64.83	0.23
54	Tapioca	0.10	5.21	3.91	0.59	3.32	358.99	1.26
	Total	**198.11**	**774.38**	**754.50**	**525.98**	**228.52**	**28445.52**	**100.0**

Note: District wise data compiled from the Directorate of Economics and Statistics

Table no. 25 illustrates the resource-wise / crop-wise total cultivated area, total production, biomass production, its utilization, surplus biomass potential and biomass power potential at all India level. The highest biomass power generating potential comes from Rice (19.97%), followed by Cotton (19.65%), Wheat (15.84%), Maize (6.24%), Potato (5.68%), Coconut (4.11%), Banana (3.39%), Sugarcane (3.05%), Other Oilseed and Arhar/Tur contributing about 2.39% and 2.08% respectively. Out of the total biomass power potential of 28445.52 MWe, the above-listed crops hold about 82.41% share during the selected study period. The remaining 17.59% is contributed by the Castor, Rapeseed & Mustard and other crops to the total estimated biomass power potential in India.

Resource wise Power Potential

Table 26: Major Crops contributing to the total biomass Power Potential at all India Level

S.no.	Crop	% Share in Total Biomass Power Generation
1	Rice	19.98
2	Wheat	15.84
3	Maize	6.24
4	Arhar/Tur	2.08
5	Castor seed	1.88
6	Oilseeds	2.39
7	Potato	5.68
8	Sugarcane	3.05
9	Banana	3.39
10	Arecanut	1.63
11	Cotton	19.65
12	Coconut	4.11
13	Others	14.08
	Total	**100.00**

The below graph represents the crop-wise biomass power potential at all India level (%) for 2018.

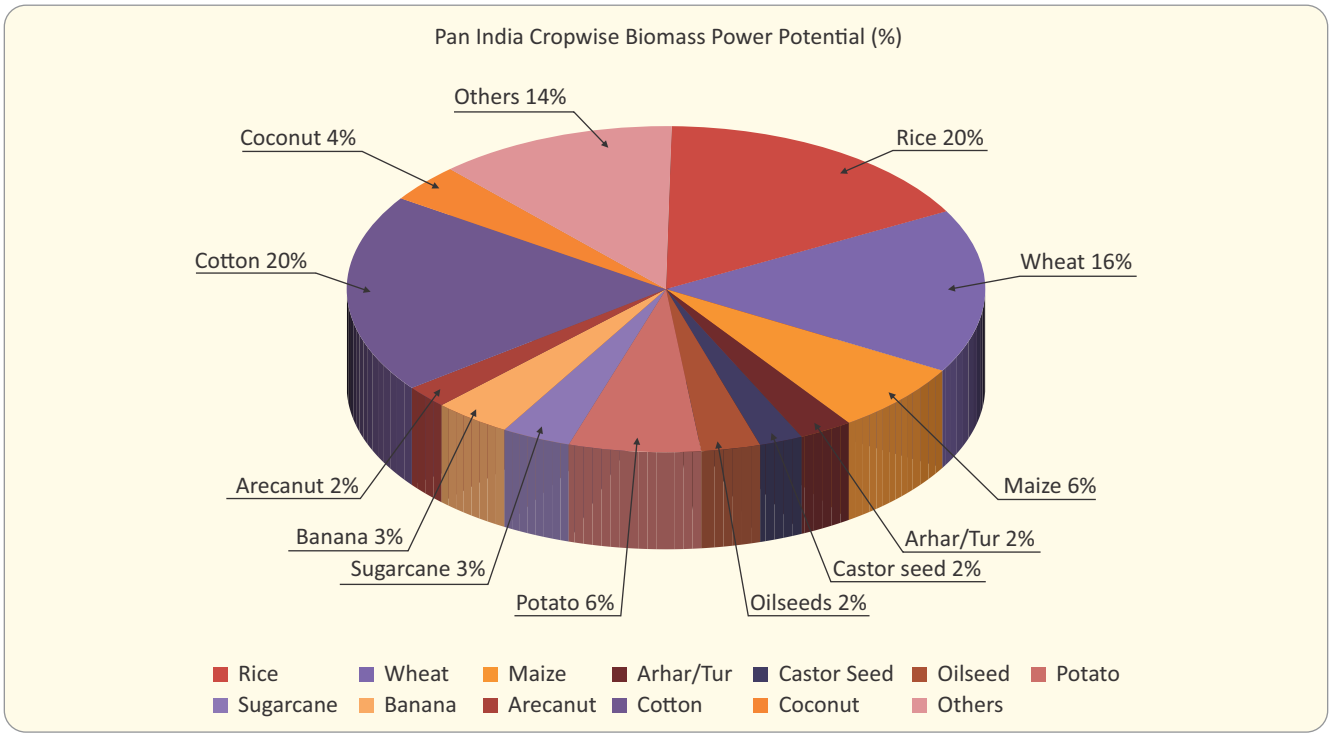
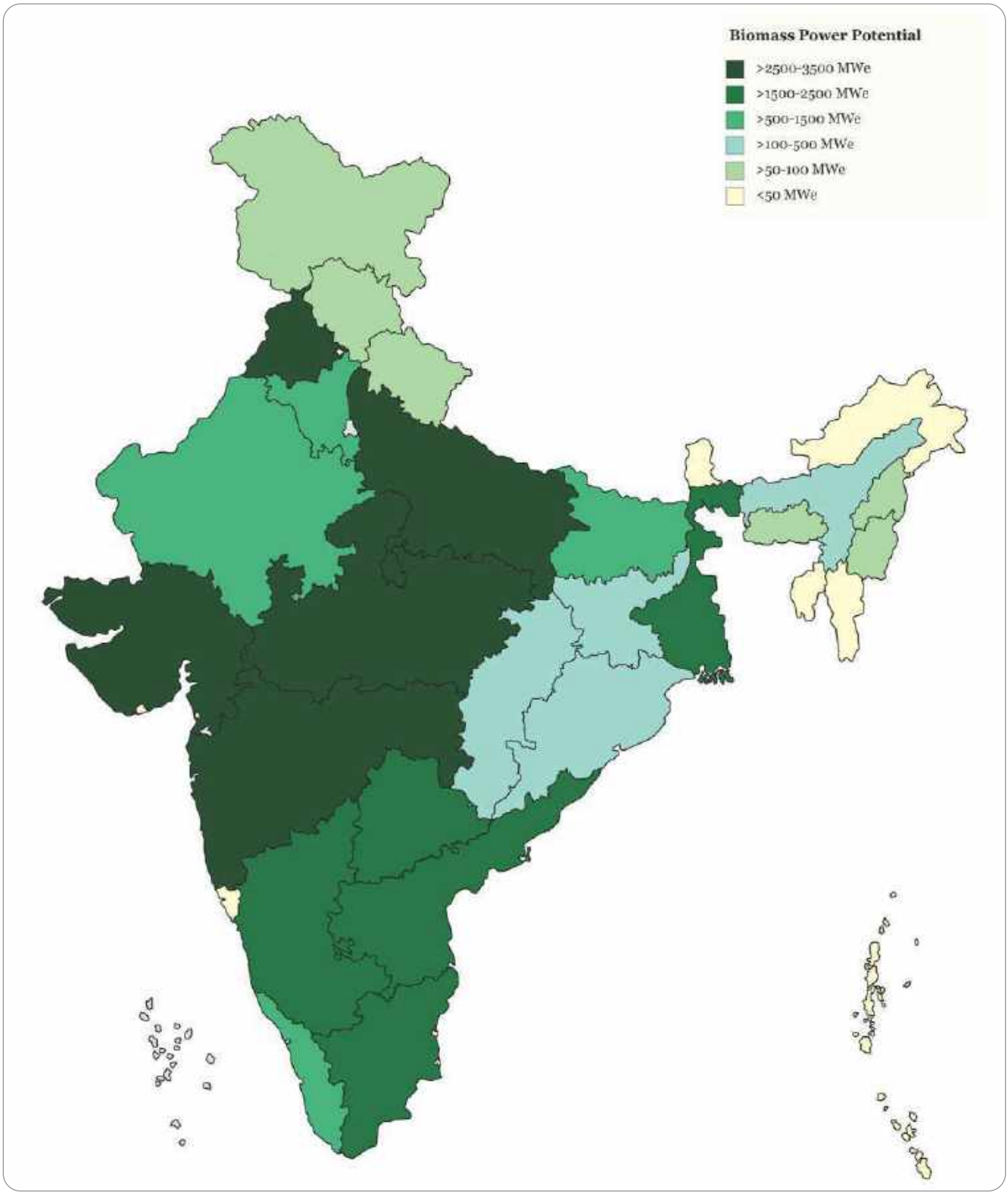


Figure 17: crop-wise biomass power potential at all India level (%)

The below tables illustrate the crop-wise and state-wise biomass power potential in India. The Rice /paddy crop contribution is around 20% of the total biomass power potential, i.e., 5682.46 MWe out of 28445.52 MWe in India during TE 2015-18. The high potential states in biomass power generation with reference to rice crop are Punjab, Tamil Nadu, Haryana, Andhra Pradesh, Chhattisgarh, Odisha, Madhya Pradesh, Telangana, West Bengal, Bihar and Uttar Pradesh, with 91.84% out of total Rice potential in the country. On average, the surplus factor for rice crop at all India level is around 0.21, i.e., 21% of the total biomass production is the surplus portion. The surplus factor for rice is ranging from 0.08 to 0.5 across the selected states in the study area. Out of the total biomass production of 184.55 million tones against rice, 41.72 million tones is surplus biomass, from which biomass power potential is about 5682.46 Mwe

All India Map depicting Biomass Power Potential for 2019-20 (in Mwe)



Note: Biomass Power potential is based on Agro-Residue and Forest Residue is not included.

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Estimated Biomass Power Potential (2019-20)

The estimation of biomass power potential is calculated on the basis of arrived power potential 2015-18, as seen in previous sections by observing trends.

Table 27: All India Biomass Power Potential (2019-20)

Sr. No	States/UTs	Area (Ha)	Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	% share of Biomass Power Potential	Biomass Utilization (Tonnes)
1	Andhra Pradesh	7222972	29328675	46433282	19169535	2302.3	7.6	27263746
2	Arunachal Pradesh	224264	478540	602981	105748	11.1	0.0	497232
3	Assam	3320948	9318633	13287650	2584580	330.1	1.1	10703069
4	Bihar	6938802	35567056	33126266	7519922	943.4	3.1	25606344
5	Chhattisgarh	5103123	9254235	14032055	2818010	377.1	1.2	11214045
6	Goa	96609	177087	367830	175426	25.3	0.1	192404
7	Gujarat	10162387	32649128	57345304	25003120	3042.5	10.0	32342184
8	Haryana	4129652	22191928	40905485	10196605	1322.2	4.4	30708880
9	Himachal Pradesh	741536	1451890	2691091	567485	69.2	0.2	2123605
10	Jammu &Kashmir	986701	1762790	3225825	656266	83.7	0.3	2569558
11	Jharkhand	1639797	3070174	4846500	1083499	133.0	0.4	3763001
12	Karnataka	10669416	58712962	38924600	16404500	2104.2	6.9	22520100
13	Kerala	1142000	5011243	8525032	5973386	769.2	2.5	2551646
14	Madhya Pradesh	25789607	55409223	93007714	26621857	3301.1	10.9	66385857
15	Maharashtra	21405216	111769727	59173935	25095269	3074.0	10.1	34078666
16	Manipur	395253	1523674	1661250	638823	81.9	0.3	1022427
17	Meghalaya	235563	887489	1380485	569876	69.9	0.2	810608
18	Mizoram	39859	90372	81882	13221	1.7	0.0	68660
19	Nagaland	386303	1124077	1420851	452119	56.7	0.2	968731
20	Odisha	5571987	9869008	14191170	2657671	355.7	1.2	11533499
21	Punjab	7221868	36274245	54435066	22877318	3100.7	10.2	31557748
22	Rajasthan	25289971	35223439	69576324	14463498	1817.2	6.0	55112826
23	Sikkim	58572	99875	208471	37842	4.5	0.0	170629
24	Tamil Nadu	4440515	44056880	36349654	9567789	1228.7	4.1	26781865
25	Telangana	5398487	14349885	26723384	10939380	1342.8	4.4	15784004
26	Tripura	319490	908460	1333002	246444	33.0	0.1	1086557
27	Uttar Pradesh	24355577	236287634	119389482	20372105	2636.2	8.7	99017377
28	Uttarakhand	770260	8288475	3246810	688668	89.2	0.3	2558142
29	West Bengal	8042688	36272640	44940491	14830932	1590.6	5.2	30109558
30	Andaman & Nicobar	35207	60824	188176	123594	16.8	0.1	64582
31	Chandigarh	513	2389	4285	906	0.1	0.0	3378
32	Dadra &Nagar Haveli and Daman & Diu	19271	84687	53259	12158	1.6	0.0	41101
33	Puducherry	16190	325268	102396	18028	3.8	0.0	84368
	Total	**182170618**	**801882624**	**791781999**	**242485592**	**30319**	**100**	**549296407**

India level aggregation of biomass power potential from all the selected states is illustrated in the above figures. The absolute biomass power potential from the selected crops increased from 17773 MWe in 2000 to 28446 MWe in 2018, an increase of 65.69%. The major contributing states to the biomass power potential are Punjab, Uttar Pradesh, Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka, West Bengal, Telangana, and Tamil Nadu, whereas the least potential states and Union Territories are Goa, Tripura, Arunachal Pradesh. The projected biomass power potential at all India level based on the time series analysis (trend component) is expected to increase to 30883.21 MWe, 32937.83 MWe, 35994.52 MWe by the Year 2020-21, 2025-26 and 2030-31, respectively. The increase in biomass power potential may be contributed by increased area and production under different crops or by a change in cropping pattern, utilization of the residual biomass at farm level.

All India Level - Crop-wise and State-wise Power Potential for 2019-20

The estimation of biomass power potential for each state for each selected crop is calculated on the basis of arrived power potential 2015-18, as seen in previous sections by observing trends and presented as below:

Table 28: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Rice Crop for 2015-18

Rice						
States/UTs	Crop Area (million ha)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Factor	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	2.18	9.61	14.41	0.18	2.57	350.24
Arunachal Pradesh	0.13	0.22	0.32	0.04	0.01	1.96
Assam	2.46	5.18	7.77	0.08	0.65	88.61
Bihar	3.29	7.71	11.57	0.10	1.11	150.73
Chhattisgarh	4.02	7.31	10.96	0.20	2.19	298.22
Goa	0.04	0.11	0.16	0.17	0.03	3.65
Gujarat	0.83	1.86	2.79	0.04	0.11	15.17
Haryana	1.24	3.99	5.99	0.50	3.00	408.97
Himachal Pradesh	0.07	0.11	0.17	0.17	0.03	3.86
Jammu & Kashmir	0.29	0.58	0.87	0.17	0.15	20.05
Jharkhand	1.41	2.32	3.48	0.10	0.34	46.35
Karnataka	1.05	2.94	4.41	0.17	0.75	102.18
Kerala	0.18	0.49	0.74	0.24	0.18	23.96
Madhya Pradesh	1.99	3.42	5.13	0.38	1.94	264.34
Maharashtra	1.50	2.97	4.46	0.01	0.04	5.87
Manipur	0.23	0.54	0.80	0.44	0.35	47.96
Meghalaya	0.11	0.30	0.46	0.06	0.03	3.49
Mizoram	0.04	0.06	0.09	0.12	0.01	1.54
Nagaland	0.20	0.46	0.68	0.30	0.20	27.72
Odisha	3.89	7.41	11.11	0.18	2.01	273.39
Punjab	3.03	12.61	18.92	0.99	18.79	2558.70
Rajasthan	0.19	0.42	0.64	0.17	0.11	14.74
Sikkim	0.01	0.02	0.03	0.01	0.00	0.03
Tamil Nadu	3.55	12.10	18.15	0.17	3.09	420.34
Telangana	2.13	7.22	10.84	0.13	1.37	186.42
Tripura	0.31	0.90	1.35	0.17	0.23	31.16
Uttar Pradesh	5.95	15.34	23.01	0.05	1.04	141.00
Uttarakhand	0.26	0.65	0.98	0.16	0.16	21.56
West Bengal	5.53	16.09	24.14	0.05	1.23	166.88
Andaman & Nicobar	0.01	0.01	0.02	0.17	0.00	0.46
Chandigarh	0.00	0.00	0.00	0.80	0.00	0.01
Dadra &Nagar Haveli and Daman & Diu	0.02	0.03	0.05	0.17	0.01	1.13
Puducherry	0.02	0.05	0.08	0.17	0.01	1.76
All India	**46.15**	**123.03**	**184.55**		**41.72**	**5682.46**

Table 29: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Rice Crop for 2019-20

Rice					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	2.42	8.95	13.42	2.42	328.99
Arunachal Pradesh	0.13	0.22	0.33	0.01	1.78
Assam	2.45	5.57	8.36	0.67	90.98
Bihar	3.12	7.79	11.68	1.17	158.83
Chhattisgarh	4.06	8.01	12.01	2.40	326.72
Goa	0.04	0.10	0.16	0.03	3.61
Gujarat	0.88	2.11	3.16	0.13	17.18
Haryana	1.40	4.59	6.88	3.44	467.68
Himachal Pradesh	0.07	0.11	0.16	0.03	3.80
Jammu &Kashmir	0.29	0.57	0.85	0.14	19.69
Jharkhand	1.18	2.13	3.20	0.32	43.50
Karnataka	1.18	3.59	5.39	0.92	124.56
Kerala	0.15	0.48	0.72	0.14	19.66
Madhya Pradesh	2.21	4.77	7.15	2.72	369.67
Maharashtra	1.52	3.22	4.84	0.05	6.58
Manipur	0.24	0.59	0.89	0.39	53.28
Meghalaya	0.11	0.31	0.46	0.03	3.74
Mizoram	0.03	0.04	0.06	0.01	1.01
Nagaland	0.21	0.53	0.80	0.24	32.66
Odisha	4.96	8.77	13.16	2.37	322.18
Punjab	3.08	12.92	19.37	19.18	2608.61
Rajasthan	0.18	0.44	0.66	0.11	15.22
Sikkim	0.01	0.02	0.03	0.00	0.04
Tamil Nadu	1.72	6.43	9.65	1.64	223.05
Telangana	1.93	6.67	10.00	1.30	176.86
Tripura	0.27	0.82	1.23	0.21	28.54
Uttar Pradesh	5.92	15.11	22.66	1.13	154.11
Uttarakhand	0.26	0.63	0.94	0.15	20.45
West Bengal	5.43	16.27	24.40	1.22	165.92
Andaman &Nicobar	0.00	0.01	0.01	0.00	0.28
Chandigarh	0.00	0.00	0.00	0.00	0.01
Dadra &Nagar Haveli, Daman Diu	0.02	0.03	0.04	0.01	0.95
Puducherry	0.01	0.04	0.06	0.00	1.37
All India	**45.48**	**121.82**	**182.74**	**42.57**	**5791.51**

All India Map depicting Biomass Power Potential for Rice (in Mwe)

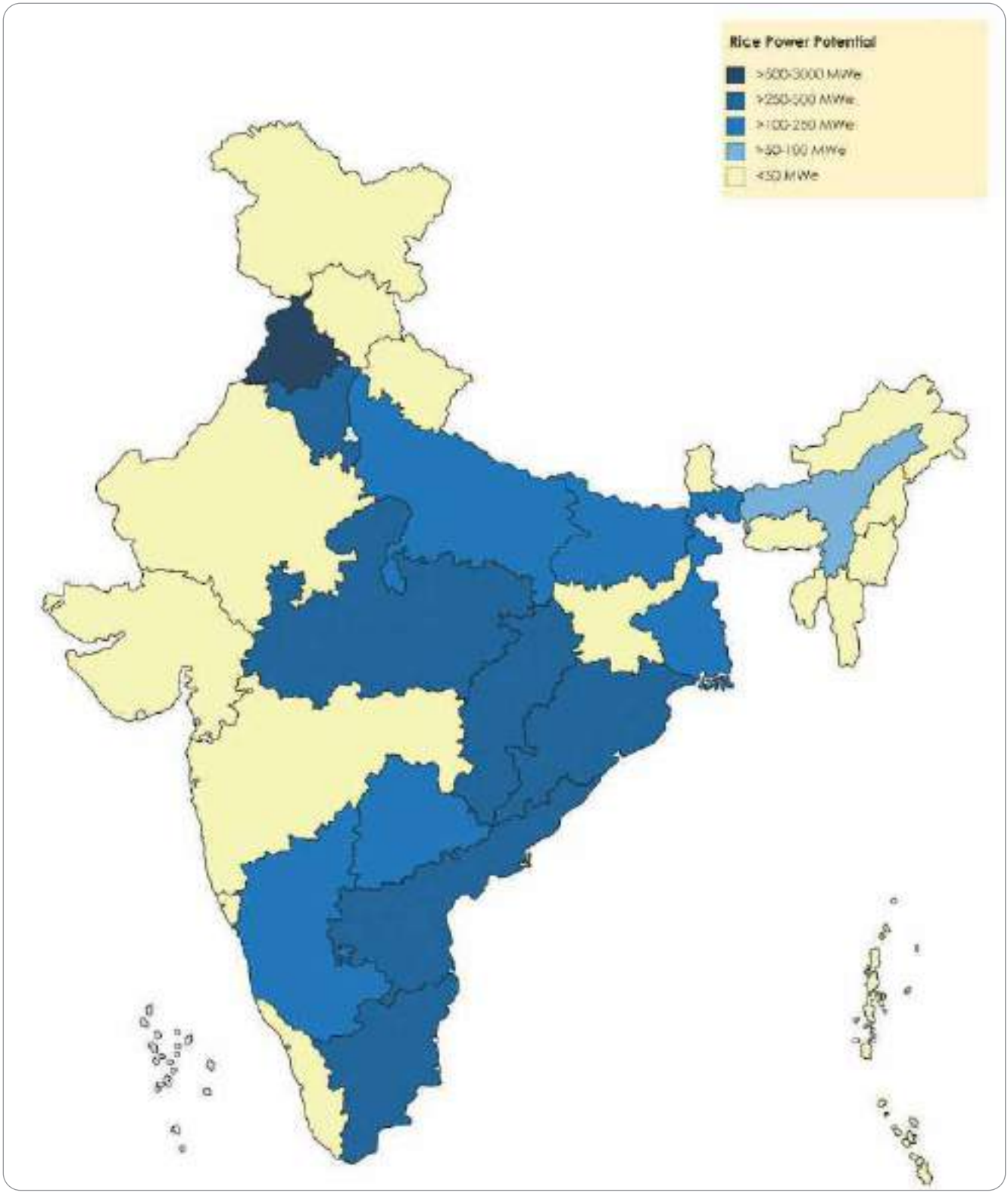


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 30: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Wheat Crop for 2015-18

Wheat						
States/UTs	Crop Area (million ha)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Factor	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.00	0.00	0.00	0.10	0.00	0.00
Arunachal Pradesh	0.00	0.01	0.01	0.20	0.00	0.38
Assam	0.02	0.02	0.04	0.20	0.01	1.18
Bihar	2.11	5.61	10.10	0.20	2.02	272.59
Chhattisgarh	0.10	0.15	0.27	0.20	0.05	7.24
Goa	0.00	0.00	0.00	0.20	0.00	0.00
Gujarat	0.97	2.72	4.90	0.20	0.98	132.43
Haryana	2.54	11.12	20.02	0.10	2.00	270.33
Himachal Pradesh	0.34	0.51	0.92	0.20	0.18	24.90
Jammu &Kashmir	0.29	0.58	1.04	0.20	0.21	28.08
Jharkhand	0.10	0.19	0.34	0.20	0.07	9.19
Karnataka	0.18	0.17	0.31	0.20	0.06	8.42
Kerala	0.00	0.00	0.00	0.20	0.00	0.00
Madhya Pradesh	6.01	17.53	31.56	0.20	6.31	852.00
Maharashtra	1.11	1.69	3.05	0.20	0.61	82.30
Manipur	0.00	0.01	0.01	0.20	0.00	0.27
Meghalaya	0.00	0.00	0.00	0.20	0.00	0.04
Mizoram	0.00	0.00	0.00	0.20	0.00	0.00
Nagaland	0.00	0.01	0.01	0.20	0.00	0.25
Odisha	0.00	0.00	0.00	0.20	0.00	0.01
Punjab	3.51	17.18	30.93	0.10	3.09	417.50
Rajasthan	6.28	11.45	20.61	0.20	4.12	556.45
Sikkim	0.00	0.00	0.00	0.20	0.00	0.02
Tamil Nadu	0.00	0.00	0.00	0.20	0.00	0.00
Telangana	0.01	0.01	0.02	0.20	0.00	0.65
Tripura	0.00	0.00	0.00	0.20	0.00	0.02
Uttar Pradesh	9.83	36.22	65.19	0.20	13.04	1760.24
Uttarakhand	0.33	0.91	1.64	0.20	0.33	44.26
West Bengal	0.27	0.75	1.35	0.20	0.27	36.41
Andaman & Nicobar	0.00	0.00	0.00	0.20	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.20	0.00	0.12
Dadra &Nagar Haveli and Daman & Diu	0.02	0.03	0.05	0.20	0.01	0.02
Puducherry	0.00	0.00	0.00	0.20	0.00	0.00
All India	**34.00**	**106.85**	**192.34**		**33.37**	**4505.30**

Table 31: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Wheat Crop for 2019-20

Wheat					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.00	0.00	0.00	0.00	0.00
Arunachal Pradesh	0.00	0.01	0.01	0.00	0.33
Assam	0.01	0.02	0.03	0.01	0.79
Bihar	2.15	6.14	11.06	2.21	298.81
Chhattisgarh	0.11	0.16	0.29	0.06	7.79
Goa	0.00	0.00	0.00	0.00	0.00
Gujarat	1.29	3.84	6.92	1.38	186.81
Haryana	2.68	13.59	24.46	2.45	330.26
Himachal Pradesh	0.34	0.53	0.96	0.19	25.93
Jammu & Kashmir	0.31	0.60	1.08	0.22	29.23
Jharkhand	0.09	0.17	0.31	0.06	8.41
Karnataka	0.18	0.20	0.37	0.07	9.93
Kerala	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	6.89	22.82	41.08	8.22	1088.66
Maharashtra	1.13	1.78	3.20	0.64	86.42
Manipur	0.00	0.01	0.02	0.00	0.42
Meghalaya	0.00	0.00	0.00	0.00	0.04
Mizoram	0.00	0.00	0.00	0.00	0.00
Nagaland	0.00	0.00	0.01	0.00	0.14
Odisha	0.00	0.00	0.00	0.00	0.01
Punjab	3.55	17.61	31.69	3.17	427.81
Rajasthan	3.50	12.78	23.00	4.60	620.93
Sikkim	0.00	0.00	0.00	0.00	0.01
Tamil Nadu	0.00	0.00	0.00	0.00	0.00
Telangana	0.00	0.01	0.02	0.00	0.44
Tripura	0.00	0.00	0.00	0.00	0.02
Uttar Pradesh	9.95	33.88	60.98	12.20	1647.55
Uttarakhand	0.31	0.93	1.67	0.33	45.08
West Bengal	0.21	0.63	1.13	0.23	30.60
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.11
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.00	0.00	0.01
Puducherry	0.00	0.00	0.00	0.00	0.00
All India	**32.69**	**115.71**	**208.28**	**36.04**	**4846.56**

All India Map depicting Biomass Power Potential for Wheat (in Mwe)

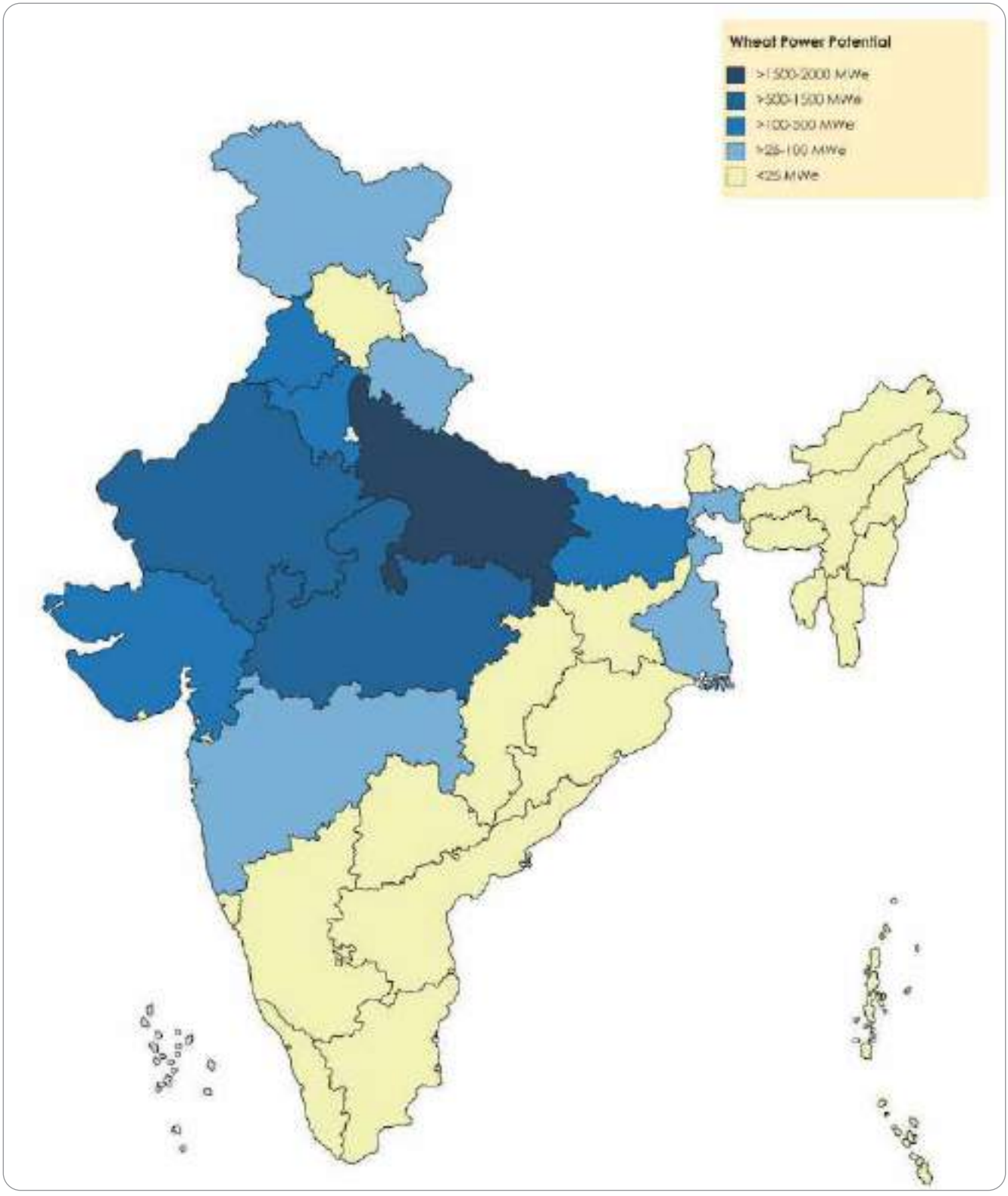


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 32: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Maize Crop for 2015-18

Maize						
States/UTs	Crop Area (million ha)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Factor	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.28	1.85	4.25	0.56	2.39	279.15
Arunachal Pradesh	0.05	0.08	0.18	0.11	0.02	2.36
Assam	0.03	0.09	0.21	0.20	0.04	4.96
Bihar	0.70	3.17	7.29	0.26	1.86	217.32
Chhattisgarh	0.12	0.26	0.60	0.15	0.09	10.15
Goa	0.00	0.00	0.00	0.20	0.00	0.00
Gujarat	0.41	0.72	1.66	0.07	0.12	13.64
Haryana	0.01	0.03	0.06	0.20	0.01	1.34
Himachal Pradesh	0.27	0.63	1.46	0.20	0.29	34.08
Jammu &Kashmir	0.30	0.53	1.22	0.20	0.24	28.53
Jharkhand	0.18	0.33	0.75	0.46	0.35	40.54
Karnataka	1.30	4.08	9.38	0.20	1.88	219.14
Kerala	0.00	0.00	0.00	0.20	0.00	0.00
Madhya Pradesh	1.03	2.31	5.32	0.40	2.15	251.39
Maharashtra	1.06	2.71	6.23	0.01	0.04	4.55
Manipur	0.03	0.06	0.14	0.20	0.03	3.17
Meghalaya	0.02	0.04	0.10	0.20	0.02	2.23
Mizoram	0.01	0.01	0.02	0.20	0.00	0.52
Nagaland	0.07	0.14	0.32	0.20	0.06	7.46
Odisha	0.06	0.14	0.33	0.20	0.07	7.77
Punjab	0.12	0.44	1.01	0.20	0.20	23.67
Rajasthan	0.90	1.44	3.32	0.01	0.03	2.96
Sikkim	0.04	0.07	0.16	0.20	0.03	3.67
Tamil Nadu	0.66	4.62	10.62	0.20	2.12	248.09
Telangana	1.02	3.41	7.83	0.30	2.35	274.53
Tripura	0.01	0.01	0.02	0.20	0.00	0.50
Uttar Pradesh	0.76	1.55	3.57	0.01	0.04	4.17
Uttarakhand	0.02	0.04	0.09	0.20	0.02	2.13
West Bengal	0.29	1.64	3.78	0.20	0.76	88.31
Andaman & Nicobar	0.00	0.00	0.00	0.20	0.00	0.02
Chandigarh	0.00	0.00	0.00	0.20	0.00	0.00
Dadra &Nagar Haveli and Daman & Diu	0.00	0.00	0.00	0.20	0.00	0.00
Puducherry	0.00	0.00	0.00	0.20	0.00	0.00
All India	**9.75**	**30.40**	**69.92**		**15.21**	**1776.35**

Table 33: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Maize Crop for 2019-20

Maize					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.40	2.65	6.10	3.42	399.28
Arunachal Pradesh	0.05	0.08	0.18	0.02	2.35
Assam	0.03	0.09	0.21	0.04	4.88
Bihar	0.72	3.35	7.71	2.00	234.16
Chhattisgarh	0.13	0.30	0.70	0.10	12.19
Goa	0.00	0.00	0.00	0.00	0.00
Gujarat	0.43	0.75	1.72	0.12	14.00
Haryana	0.01	0.01	0.03	0.01	0.79
Himachal Pradesh	0.28	0.62	1.43	0.29	33.43
Jammu & Kashmir	0.29	0.50	1.15	0.23	26.83
Jharkhand	0.16	0.30	0.69	0.32	36.99
Karnataka	1.56	4.79	11.02	2.20	257.62
Kerala	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	1.18	3.61	8.30	3.32	388.13
Maharashtra	1.19	3.07	7.05	0.07	8.25
Manipur	0.03	0.07	0.17	0.03	3.89
Meghalaya	0.02	0.04	0.10	0.02	2.31
Mizoram	0.01	0.01	0.02	0.00	0.36
Nagaland	0.08	0.15	0.35	0.07	8.28
Odisha	0.09	0.24	0.55	0.11	12.83
Punjab	0.11	0.48	1.10	0.22	25.80
Rajasthan	0.92	1.70	3.90	0.04	4.56
Sikkim	0.04	0.07	0.15	0.03	3.59
Tamil Nadu	0.39	2.60	5.97	1.19	139.55
Telangana	0.54	2.08	4.79	1.44	168.02
Tripura	0.01	0.02	0.04	0.01	0.91
Uttar Pradesh	0.70	1.44	3.31	0.03	3.87
Uttarakhand	0.02	0.04	0.09	0.02	2.17
West Bengal	0.22	1.15	2.64	0.53	61.72
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.00	0.00	0.00
Puducherry	0.00	0.00	0.00	0.00	0.00
All India	**9.61**	**30.20**	**69.47**	**15.89**	**1856.77**

All India Map depicting Biomass Power Potential for Maize (in Mwe)

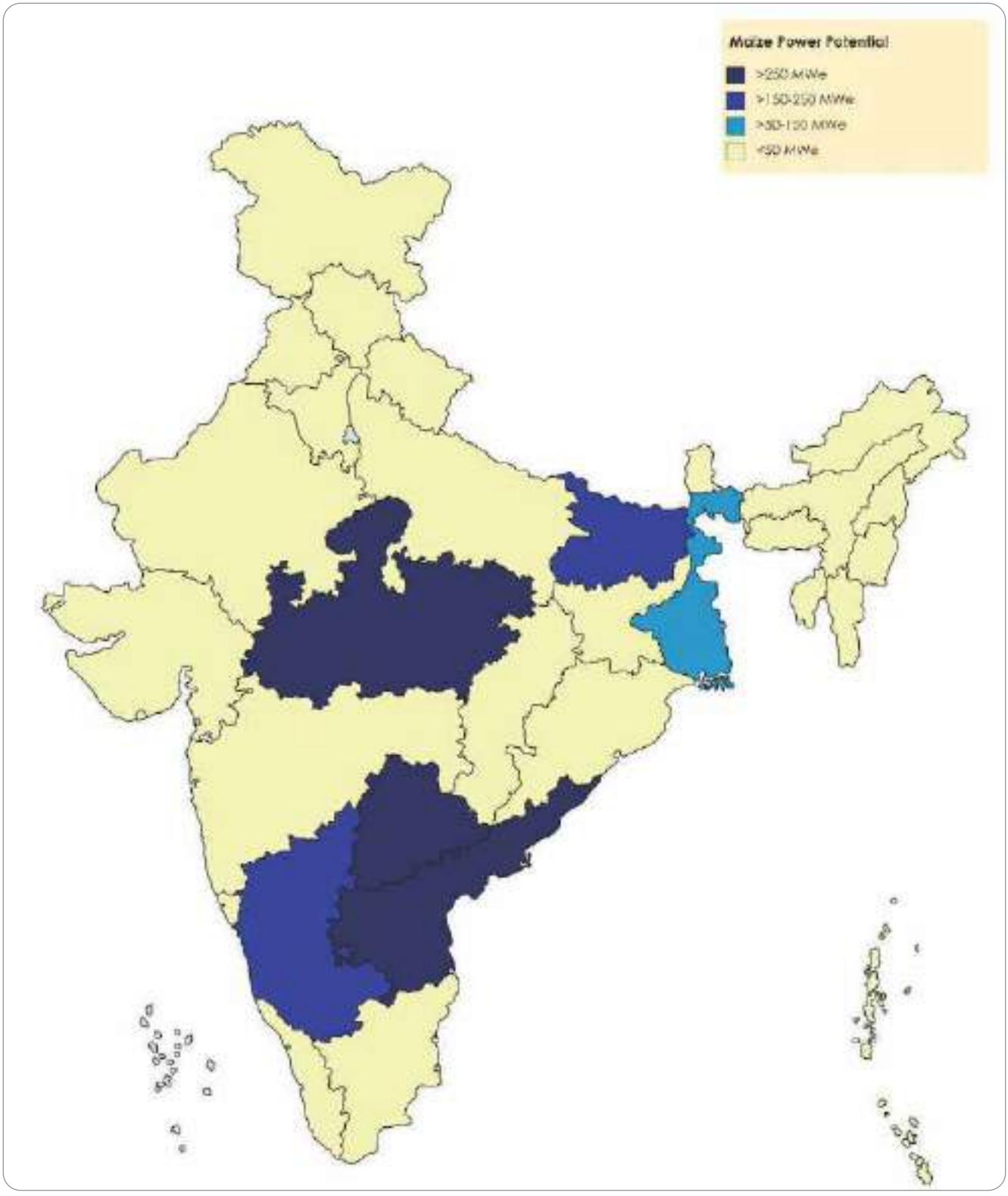


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 34: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Potato Crop for 2015-18

Potato						
States/UTs	Crop Area (million ha)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Factor	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.00	0.01	0.01	0.66	0.01	0.67
Arunachal Pradesh	0.01	0.04	0.04	0.79	0.03	2.64
Assam	0.10	0.73	0.59	0.64	0.38	35.38
Bihar	0.16	2.15	1.74	0.97	1.69	156.97
Chhattisgarh	0.01	0.07	0.06	0.66	0.04	3.61
Goa	0.00	0.00	0.00	0.66	0.00	0.00
Gujarat	0.12	3.32	2.69	0.66	1.78	165.44
Haryana	0.02	0.59	0.47	0.66	0.31	29.15
Himachal Pradesh	0.01	0.09	0.07	0.66	0.05	4.27
Jammu &Kashmir	0.00	0.03	0.03	0.66	0.02	1.55
Jharkhand	0.03	0.22	0.17	0.45	0.08	7.33
Karnataka	0.03	0.29	0.23	0.66	0.15	14.43
Kerala	0.00	0.01	0.01	0.66	0.00	0.38
Madhya Pradesh	0.08	1.05	0.85	0.66	0.56	52.11
Maharashtra	0.00	0.00	0.00	1.00	0.00	0.00
Manipur	0.01	0.13	0.10	0.66	0.07	6.30
Meghalaya	0.02	0.19	0.15	1.00	0.15	14.02
Mizoram	0.00	0.00	0.00	0.66	0.00	0.14
Nagaland	0.01	0.11	0.09	0.66	0.06	5.26
Odisha	0.01	0.06	0.05	0.66	0.03	3.01
Punjab	0.00	0.00	0.00	0.66	0.00	0.00
Rajasthan	0.01	0.19	0.15	0.66	0.10	9.42
Sikkim	0.00	0.00	0.00	0.66	0.00	0.00
Tamil Nadu	0.00	0.09	0.07	0.66	0.05	4.46
Telangana	0.00	0.06	0.04	0.66	0.03	2.76
Tripura	0.00	0.00	0.00	0.48	0.00	0.00
Uttar Pradesh	0.57	15.34	12.43	0.12	1.48	137.38
Uttarakhand	0.01	0.14	0.11	0.66	0.08	7.06
West Bengal	0.43	14.97	12.13	0.84	10.24	953.33
Andaman & Nicobar	0.00	0.00	0.00	0.66	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.66	0.00	0.01
Dadra Nagar Haveli and Daman & Diu	0.00	0.00	0.00	0.66	0.00	0.00
Puducherry	0.00	0.00	0.00	0.66	0.00	0.00
All India	**1.69**	**39.86**	**32.29**		**17.37**	**1617.08**

Table 35: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Potato Crop for 2019-20

Potato					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.00	0.03	0.02	0.02	1.42
Arunachal Pradesh	0.01	0.05	0.04	0.03	2.69
Assam	0.11	0.76	0.61	0.39	36.45
Bihar	0.05	0.80	0.65	0.63	58.74
Chhattisgarh	0.01	0.07	0.05	0.04	3.26
Goa	0.00	0.00	0.00	0.00	0.00
Gujarat	0.13	3.42	2.77	1.83	170.32
Haryana	0.01	0.30	0.24	0.16	14.70
Himachal Pradesh	0.01	0.09	0.07	0.05	4.47
Jammu &Kashmir	0.00	0.03	0.02	0.01	1.38
Jharkhand	0.04	0.25	0.21	0.09	8.65
Karnataka	0.03	0.28	0.22	0.15	13.70
Kerala	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	0.13	2.67	2.16	1.43	132.82
Maharashtra	0.00	0.00	0.00	0.00	0.00
Manipur	0.02	0.16	0.13	0.09	8.14
Meghalaya	0.02	0.19	0.15	0.15	14.35
Mizoram	0.00	0.00	0.00	0.00	0.09
Nagaland	0.00	0.08	0.06	0.04	3.97
Odisha	0.01	0.07	0.05	0.04	3.36
Punjab	0.00	0.00	0.00	0.00	0.00
Rajasthan	0.02	0.27	0.22	0.14	1.32
Sikkim	0.00	0.00	0.00	0.00	0.00
Tamil Nadu	0.00	0.09	0.07	0.05	4.48
Telangana	0.00	0.04	0.03	0.02	1.79
Tripura	0.00	0.00	0.00	0.00	0.00
Uttar Pradesh	0.63	15.72	12.74	1.53	142.29
Uttarakhand	0.01	0.13	0.10	0.07	6.43
West Bengal	0.46	13.66	11.06	9.29	865.21
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.00	0.00	0.00
Puducherry	0.00	0.00	0.00	0.00	0.00
All India	**1.70**	**39.14**	**31.70**	**16.24**	**1500.02**

All India Map depicting Biomass Power Potential for Potato (in Mwe)

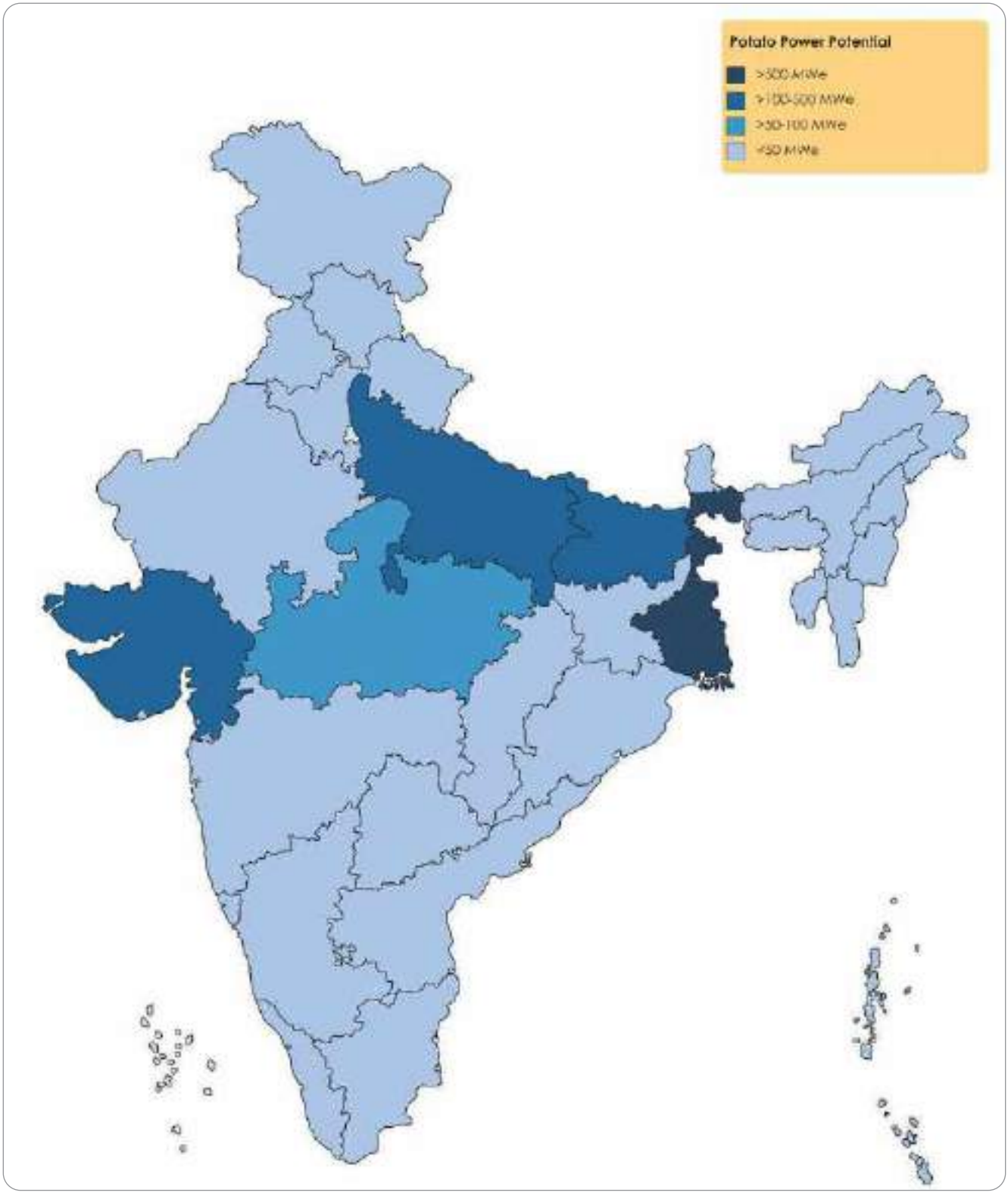


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 36: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Cotton Crop for 2015-18

Cotton						
States/UTs	Crop Area (million ha)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Factor	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.58	0.29	2.83	0.82	2.33	281.33
Arunachal Pradesh	0.00	0.00	0.00	0.80	0.00	0.00
Assam	0.00	0.00	0.00	0.80	0.00	0.33
Bihar	0.00	0.00	0.00	0.80	0.00	0.00
Chhattisgarh	0.00	0.00	0.00	0.80	0.00	0.03
Goa	0.00	0.00	0.00	0.80	0.00	0.00
Gujarat	2.58	1.29	12.65	0.85	10.77	1302.17
Haryana	0.60	0.36	3.08	0.80	2.46	298.01
Himachal Pradesh	0.00	0.00	0.00	0.80	0.00	0.01
Jammu & Kashmir	0.00	0.00	0.00	0.80	0.00	0.00
Jharkhand	0.00	0.00	0.00	0.80	0.00	0.00
Karnataka	0.57	0.23	2.66	0.60	1.59	192.72
Kerala	0.00	0.00	0.00	0.80	0.00	0.08
Madhya Pradesh	0.60	0.15	2.63	0.80	2.11	254.50
Maharashtra	4.26	1.18	18.76	0.91	17.04	2060.20
Manipur	0.00	0.00	0.00	0.80	0.00	0.00
Meghalaya	0.01	0.00	0.03	0.80	0.02	2.99
Mizoram	0.00	0.00	0.00	0.80	0.00	0.05
Nagaland	0.00	0.00	0.00	0.80	0.00	0.06
Odisha	0.00	0.00	0.00	1.00	0.00	0.00
Punjab	0.31	0.17	1.53	0.00	0.00	0.00
Rajasthan	0.50	0.16	2.25	0.68	1.52	183.92
Sikkim	0.00	0.00	0.00	0.80	0.00	0.00
Tamil Nadu	0.34	0.03	1.36	0.03	0.04	4.94
Telangana	2.11	0.81	9.79	0.85	8.32	1006.20
Tripura	0.00	0.00	0.00	0.80	0.00	0.39
Uttar Pradesh	0.01	0.00	0.02	0.80	0.02	1.98
Uttarakhand	0.00	0.00	0.00	0.80	0.00	0.00
West Bengal	0.00	0.00	0.00	0.80	0.00	0.09
Andaman & Nicobar	0.00	0.00	0.00	0.80	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.80	0.00	0.00
Dadra &Nagar Haveli and Daman & Diu	0.00	0.00	0.00	0.80	0.00	0.00
Puducherry	0.00	0.00	0.00	0.80	0.00	0.08
All India	**12.46**	**4.67**	**57.61**		**46.24**	**5590.08**

Table 37: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Cotton Crop for 2019-20

Cotton					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	0.98	0.48	4.78	3.92	474.25
Arunachal Pradesh	0.00	0.00	0.00	0.00	0.00
Assam	0.00	0.00	0.00	0.00	3.33
Bihar	0.00	0.00	0.00	0.00	0.00
Chhattisgarh	0.00	0.00	0.00	0.00	0.06
Goa	0.00	0.00	0.00	0.00	0.00
Gujarat	2.98	1.69	15.03	12.77	1545.53
Haryana	0.51	0.55	3.15	2.52	305.36
Himachal Pradesh	0.00	0.00	0.00	0.00	0.00
Jammu &Kashmir	0.00	0.00	0.00	0.00	0.00
Jharkhand	0.00	0.00	0.00	0.00	0.00
Karnataka	0.66	0.29	3.14	1.89	228.25
Kerala	0.00	0.00	0.00	0.00	0.03
Madhya Pradesh	0.59	0.18	2.64	2.11	255.80
Maharashtra	4.57	1.38	20.40	18.57	2246.56
Manipur	0.00	0.00	0.00	0.00	0.00
Meghalaya	0.01	0.00	0.03	0.02	2.94
Mizoram	0.00	0.00	0.00	0.00	0.02
Nagaland	0.00	0.00	0.00	0.00	0.05
Odisha	0.00	0.00	0.00	0.00	0.00
Punjab	0.35	0.23	1.83	0.18	22.17
Rajasthan	0.49	0.31	2.54	1.73	208.75
Sikkim	0.00	0.00	0.00	0.00	0.00
Tamil Nadu	0.15	0.05	0.70	0.02	2.53
Telangana	1.84	0.65	8.43	7.17	867.01
Tripura	0.00	0.00	0.01	0.00	0.57
Uttar Pradesh	0.01	0.00	0.02	0.02	2.09
Uttarakhand	0.00	0.00	0.00	0.00	0.00
West Bengal	0.00	0.00	0.00	0.00	0.15
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.00	0.00	0.00
Puducherry	0.00	0.00	0.00	0.00	0.06
All India	**13.13**	**5.83**	**62.71**	**50.93**	**6165.49**

All India Map depicting Biomass Power Potential for Cotton (in Mwe)

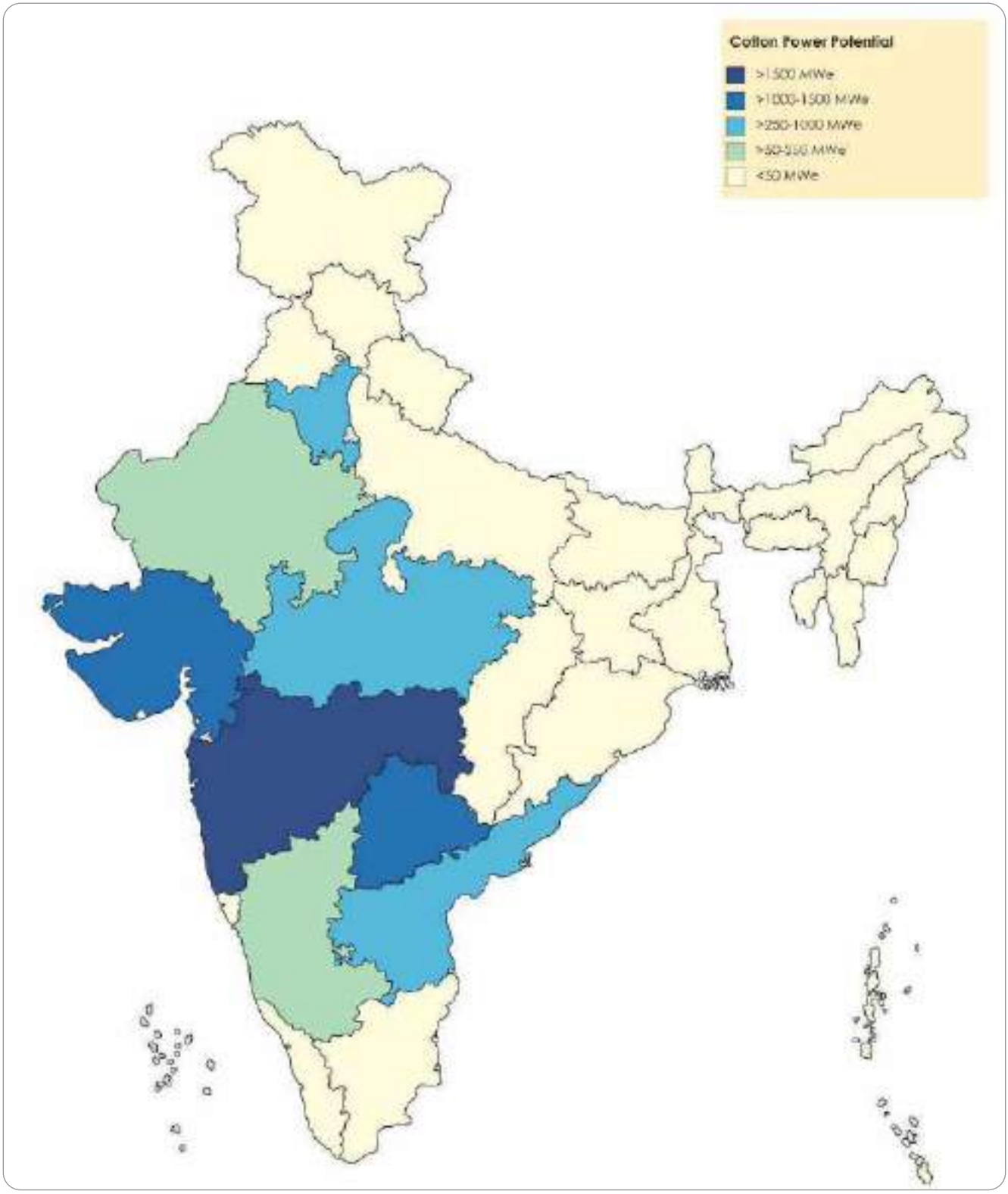


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 38: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Cereals Crop for 2015-18

Cereals					
States/UTs	Crop Area (million Ha)	Crop Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	2.68	11.82	19.50	5.06	641.63
Arunachal Pradesh	0.22	0.33	0.55	0.04	5.12
Assam	2.52	5.30	8.03	0.70	94.80
Bihar	6.13	16.52	29.00	4.99	641.36
Chhattisgarh	4.37	7.75	11.87	2.33	316.16
Goa	0.04	0.11	0.16	0.03	3.65
Gujarat	2.75	6.41	12.17	1.75	226.73
Haryana	4.30	16.08	28.35	5.43	731.35
Himachal Pradesh	0.71	1.29	2.59	0.51	63.36
Jammu &Kashmir	0.90	1.70	3.15	0.60	77.10
Jharkhand	1.71	2.86	4.60	0.76	96.68
Karnataka	4.51	9.51	18.51	3.39	416.70
Kerala	0.19	0.49	0.74	0.18	23.97
Madhya Pradesh	9.77	24.40	44.54	10.69	1402.26
Maharashtra	8.89	10.78	21.21	2.07	263.35
Manipur	0.26	0.60	0.95	0.38	51.39
Meghalaya	0.13	0.35	0.56	0.05	5.81
Mizoram	0.04	0.07	0.11	0.02	2.06
Nagaland	0.30	0.62	1.04	0.27	35.74
Odisha	3.99	7.58	11.48	2.08	281.67
Punjab	6.66	30.27	50.90	22.09	3000.37
Rajasthan	12.39	18.21	36.22	6.23	814.53
Sikkim	0.06	0.10	0.20	0.03	3.92
Tamil Nadu	5.23	18.35	32.10	5.46	698.87
Telangana	3.30	10.78	19.03	3.76	466.32
Tripura	0.31	0.91	1.37	0.23	31.68
Uttar Pradesh	17.77	55.52	97.48	14.73	1980.49
Uttarakhand	0.80	1.85	3.02	0.54	71.87
West Bengal	6.11	18.50	29.29	2.25	291.90
Andaman & Nicobar	0.01	0.01	0.02	0.00	0.48
Chandigarh	0.00	0.00	0.00	0.00	0.14
Dadra &Nagar Haveli and Daman & Diu	0.02	0.04	0.06	0.01	1.38
Puducherry	0.02	0.05	0.08	0.01	1.76
All India	**107.09**	**279.17**	**488.90**	**96.68**	**12744.43**

Table 39: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Cereals Crop for 2019-20

Cereals					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	2.87	11.89	20.22	5.91	738.40
Arunachal Pradesh	0.19	0.30	0.52	0.04	4.46
Assam	2.49	5.68	8.60	0.72	96.65
Bihar	6.00	17.30	30.48	5.39	692.44
Chhattisgarh	4.31	8.48	13.01	2.57	346.87
Goa	0.04	0.10	0.16	0.03	3.61
Gujarat	3.06	7.92	14.97	2.24	292.64
Haryana	4.91	20.03	35.94	6.74	901.25
Himachal Pradesh	0.71	1.30	2.60	0.51	63.67
Jammu & Kashmir	0.91	1.68	3.11	0.60	76.37
Jharkhand	1.44	2.62	4.21	0.70	89.27
Karnataka	4.67	10.91	21.35	3.94	484.41
Kerala	0.15	0.48	0.72	0.14	19.67
Madhya Pradesh	10.77	32.53	59.64	14.68	1897.18
Maharashtra	7.22	10.39	20.67	1.85	235.93
Manipur	0.28	0.67	1.07	0.43	57.59
Meghalaya	0.13	0.35	0.56	0.05	6.10
Mizoram	0.04	0.05	0.08	0.01	1.36
Nagaland	0.29	0.69	1.16	0.31	41.09
Odisha	5.09	9.05	13.75	2.48	335.57
Punjab	6.74	31.02	52.19	22.57	3062.53
Rajasthan	10.96	21.95	44.54	7.72	1000.82
Sikkim	0.05	0.08	0.18	0.03	3.64
Tamil Nadu	2.48	9.57	16.93	2.91	372.18
Telangana	2.54	8.83	14.98	2.76	347.57
Tripura	0.28	0.84	1.27	0.22	29.47
Uttar Pradesh	17.93	53.10	93.51	14.05	1889.45
Uttarakhand	0.61	1.62	2.74	0.51	68.11
West Bengal	5.85	18.05	28.18	1.98	258.28
Andaman &Nicobar	0.01	0.01	0.01	0.00	0.28
Chandigarh	0.00	0.00	0.00	0.00	0.12
Dadra &Nagar Haveli, Daman Diu	0.02	0.03	0.04	0.01	1.02
Puducherry	0.01	0.04	0.06	0.00	1.39
All India	**103.03**	**287.58**	**507.47**	**102.08**	**13419.38**

All India Map depicting Biomass Power Potential for Cereals (in Mwe)

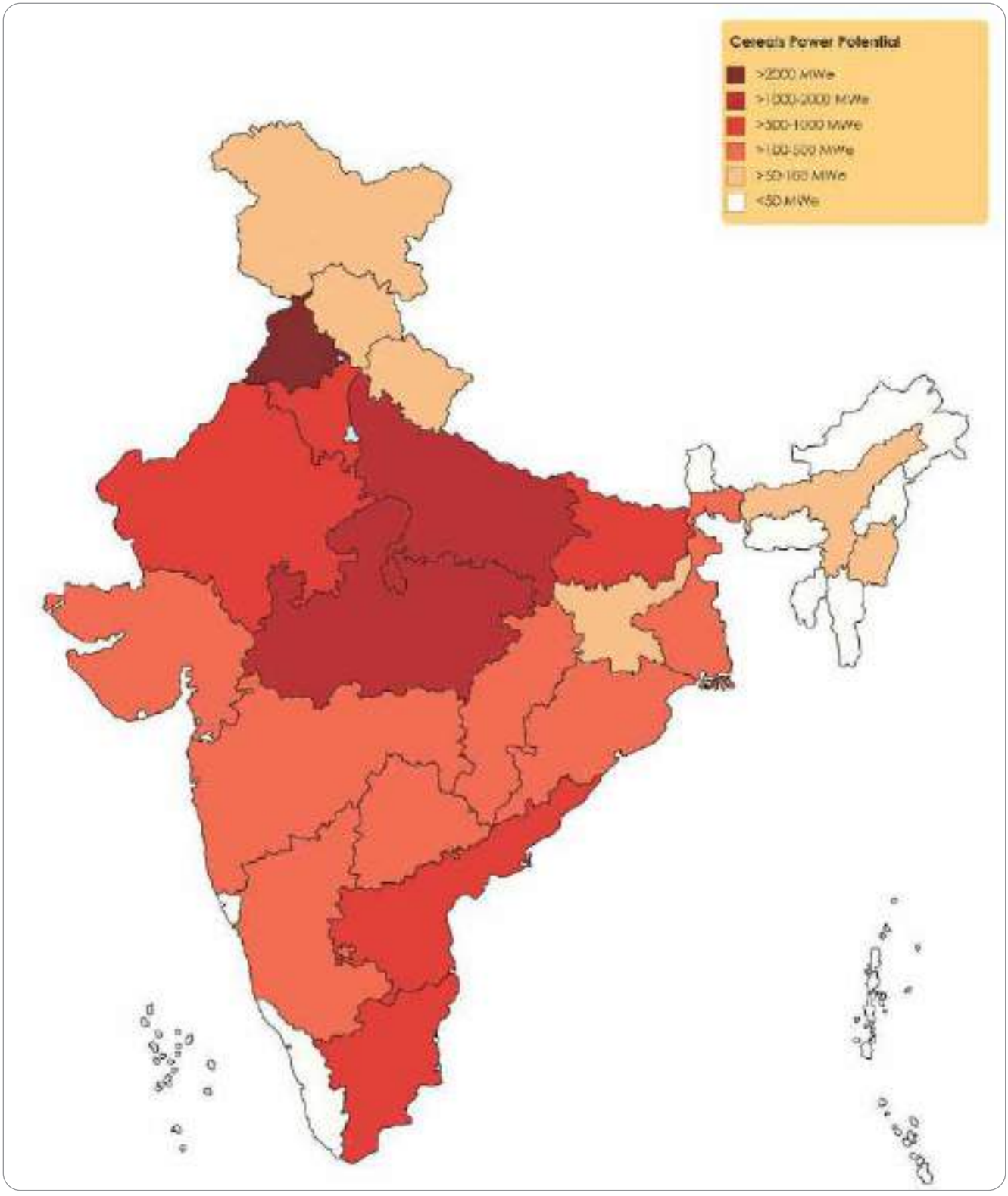


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 40: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Pulses Crop for 2019-20

Pulses					
States/UTs	Crop Area (million Ha)	Crop Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	1.36	0.96	1.31	0.54	59.86
Arunachal Pradesh	0.05	0.05	0.06	0.01	1.57
Assam	0.15	0.11	0.14	0.06	6.42
Bihar	0.49	0.45	0.66	0.40	44.33
Chhattisgarh	0.85	0.62	0.75	0.19	23.24
Goa	0.01	0.01	0.01	0.00	0.09
Gujarat	0.82	0.90	1.71	0.90	106.90
Haryana	0.09	0.07	0.10	0.04	4.36
Himachal Pradesh	0.03	0.06	0.07	0.01	1.31
Jammu &Kashmir	0.01	0.01	0.01	0.00	0.25
Jharkhand	0.17	0.21	0.47	0.31	36.04
Karnataka	2.94	1.77	3.29	1.67	201.89
Kerala	0.00	0.00	0.01	0.00	0.39
Madhya Pradesh	5.33	4.49	5.96	2.85	329.09
Maharashtra	2.82	1.97	2.24	0.46	57.44
Manipur	0.03	0.02	0.02	0.01	0.93
Meghalaya	0.01	0.01	0.01	0.01	0.75
Mizoram	0.00	0.01	0.01	0.00	0.20
Nagaland	0.04	0.05	0.06	0.02	2.43
Odisha	0.37	0.14	0.17	0.09	10.27
Punjab	0.04	0.03	0.04	0.02	2.30
Rajasthan	6.80	2.89	3.67	0.75	94.50
Sikkim	0.01	0.01	0.01	0.00	0.32
Tamil Nadu	1.63	1.03	1.50	0.38	43.33
Telangana	0.82	0.58	1.11	0.31	37.45
Tripura	0.02	0.01	0.02	0.01	1.08
Uttar Pradesh	2.36	2.34	3.23	1.92	216.15
Uttarakhand	0.05	0.05	0.07	0.02	2.60
West Bengal	0.38	0.35	0.47	0.20	21.46
Andaman & Nicobar	0.00	0.00	0.00	0.00	0.12
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli and Daman & Diu	0.00	0.01	0.01	0.01	0.83
Puducherry	0.00	0.00	0.00	0.00	0.13
All India	**27.71**	**19.23**	**27.20**	**11.20**	**1308.03**

Table 41: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Pulses Crop for 2019-20

Pulses					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	1.24	1.10	1.46	0.58	65.04
Arunachal Pradesh	0.00	0.00	0.00	0.00	0.00
Assam	0.15	0.11	0.13	0.07	6.86
Bihar	0.41	0.39	0.60	0.39	42.86
Chhattisgarh	0.53	0.43	0.53	0.12	13.49
Goa	0.01	0.01	0.01	0.00	0.11
Gujarat	0.73	0.78	1.45	0.80	96.31
Haryana	0.10	0.11	0.16	0.07	8.48
Himachal Pradesh	0.01	0.01	0.01	0.00	0.46
Jammu &Kashmir	0.01	0.01	0.01	0.00	0.40
Jharkhand	0.12	0.13	0.36	0.24	28.55
Karnataka	2.78	1.73	3.35	1.78	215.41
Kerala	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	6.70	6.79	8.88	4.19	474.48
Maharashtra	3.83	3.05	5.28	2.37	290.45
Manipur	0.03	0.03	0.02	0.01	1.10
Meghalaya	0.00	0.00	0.01	0.00	0.44
Mizoram	0.00	0.00	0.00	0.00	0.00
Nagaland	0.02	0.02	0.02	0.01	1.08
Odisha	0.39	0.15	0.19	0.09	11.15
Punjab	0.01	0.01	0.01	0.01	0.77
Rajasthan	3.95	2.74	3.23	0.78	98.37
Sikkim	0.00	0.00	0.00	0.00	0.06
Tamil Nadu	0.61	0.41	0.56	0.12	13.21
Telangana	0.50	0.43	0.82	0.23	27.18
Tripura	0.02	0.01	0.02	0.01	1.22
Uttar Pradesh	2.28	1.95	2.70	1.66	183.98
Uttarakhand	0.03	0.03	0.04	0.02	2.17
West Bengal	0.27	0.24	0.34	0.15	16.05
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.04
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.01	0.00	0.45
Puducherry	0.00	0.00	0.00	0.00	0.00
All India	**24.75**	**20.66**	**30.19**	**13.70**	**1600.16**

All India Map depicting Biomass Power Potential for Pulses (in Mwe)

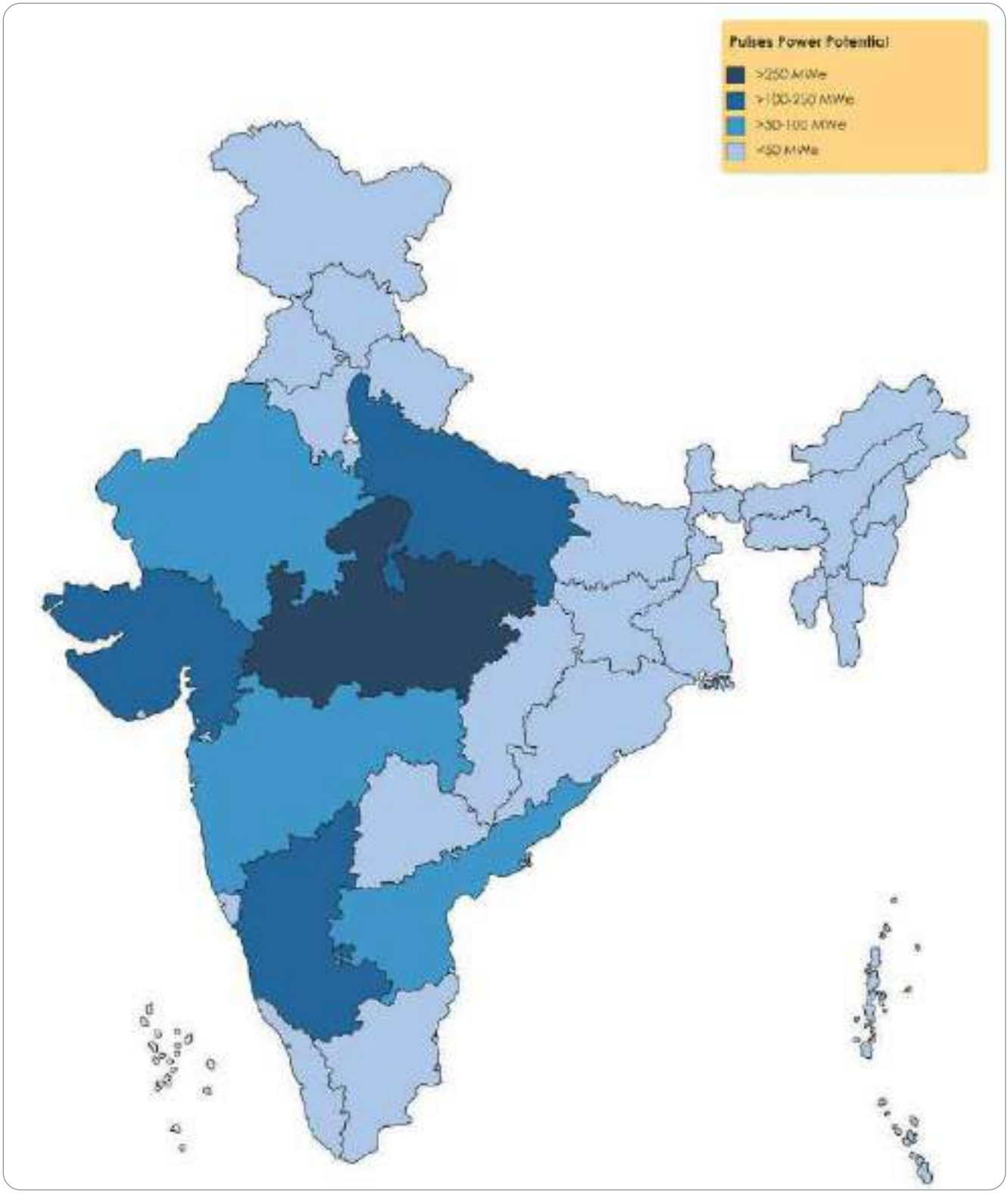


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 42: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Oilseeds Crop for 2015-18

Oilseeds					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	2.04	3.37	6.98	5.51	528.34
Arunachal Pradesh	0.04	0.04	0.08	0.08	7.45
Assam	0.31	0.21	0.38	0.18	23.75
Bihar	0.11	0.13	0.23	0.12	14.73
Chhattisgarh	0.19	0.10	0.20	0.05	6.48
Goa	0.00	0.00	0.01	0.00	0.48
Gujarat	2.70	4.85	13.36	4.47	560.66
Haryana	1.05	1.65	3.13	2.36	250.92
Himachal Pradesh	0.01	0.01	0.01	0.00	0.49
Jammu &Kashmir	0.05	0.03	0.06	0.03	3.92
Jharkhand	0.04	0.04	0.07	0.05	6.27
Karnataka	1.23	0.93	1.98	0.58	67.67
Kerala	0.00	0.00	0.00	0.00	0.04
Madhya Pradesh	7.42	6.26	11.02	2.32	291.14
Maharashtra	4.27	3.87	6.89	1.07	131.50
Manipur	0.04	0.03	0.06	0.02	3.09
Meghalaya	0.01	0.02	0.03	0.01	1.51
Mizoram	0.00	0.00	0.01	0.00	0.18
Nagaland	0.07	0.07	0.13	0.05	5.98
Odisha	0.07	0.06	0.13	0.03	3.63
Punjab	0.04	0.06	0.11	0.05	5.62
Rajasthan	7.91	7.05	13.49	0.83	98.74
Sikkim	0.01	0.01	0.01	0.00	0.49
Tamil Nadu	0.71	0.86	1.99	0.04	4.78
Telangana	0.72	1.03	2.15	0.47	52.65
Tripura	0.01	0.01	0.01	0.01	0.77
Uttar Pradesh	1.14	1.17	2.20	0.94	121.82
Uttarakhand	0.03	0.03	0.05	0.01	1.45
West Bengal	0.93	1.12	2.27	0.95	121.22
Andaman & Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli	0.00	0.00	0.00	0.00	0.00
Daman & Diu	0.00	0.00	0.00	0.00	0.00
Puducherry	0.00	0.00	0.00	0.00	0.06
All India	**31.16**	**32.99**	**67.01**	**20.24**	**2315.84**

Table 43: State-wise total cropped area, production, biomass production, surplus biomass production and biomass power potential in India in Oilseeds Crop for 2019-20

Oilseeds					
States/UTs	Area (million ha)	Production (million tonnes)	Biomass (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)
Andhra Pradesh	1.62	2.51	5.22	3.89	374.37
Arunachal Pradesh	0.02	0.02	0.04	0.04	3.75
Assam	0.29	0.20	0.37	0.18	23.72
Bihar	0.10	0.13	0.25	0.14	17.13
Chhattisgarh	0.22	0.17	0.32	0.08	9.64
Goa	0.00	0.01	0.01	0.00	0.34
Gujarat	2.66	5.36	14.88	5.21	652.87
Haryana	2.24	0.77	1.39	0.70	91.68
Himachal Pradesh	0.01	0.01	0.01	0.00	0.53
Jammu & Kashmir	0.06	0.05	0.09	0.04	5.55
Jharkhand	0.04	0.04	0.07	0.05	6.45
Karnataka	1.04	0.83	1.70	0.51	59.32
Kerala	0.00	0.00	0.00	0.00	0.02
Madhya Pradesh	7.47	8.37	14.72	3.12	394.65
Maharashtra	4.69	4.71	8.21	1.16	144.27
Manipur	0.05	0.04	0.08	0.03	4.42
Meghalaya	0.01	0.02	0.03	0.01	1.59
Mizoram	0.00	0.00	0.00	0.00	0.00
Nagaland	0.06	0.07	0.12	0.04	5.63
Odisha	0.07	0.07	0.17	0.04	4.60
Punjab	0.03	0.05	0.09	0.04	5.74
Rajasthan	5.14	7.04	14.04	1.61	199.55
Sikkim	0.01	0.01	0.01	0.00	0.42
Tamil Nadu	0.24	0.80	1.83	0.04	4.43
Telangana	0.31	0.58	1.23	0.16	19.38
Tripura	0.01	0.01	0.02	0.01	1.25
Uttar Pradesh	1.15	1.00	1.87	0.81	106.48
Uttarakhand	0.02	0.02	0.04	0.01	1.49
West Bengal	0.86	1.06	2.18	0.90	114.51
Andaman &Nicobar	0.00	0.00	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00
Dadra &Nagar Haveli, Daman Diu	0.00	0.00	0.00	0.00	0.00
Puducherry	0.00	0.00	0.00	0.00	0.03
All India	**28.45**	**33.94**	**68.99**	**18.82**	**2253.83**

All India Map depicting Biomass Power Potential for Oilseeds (in Mwe)

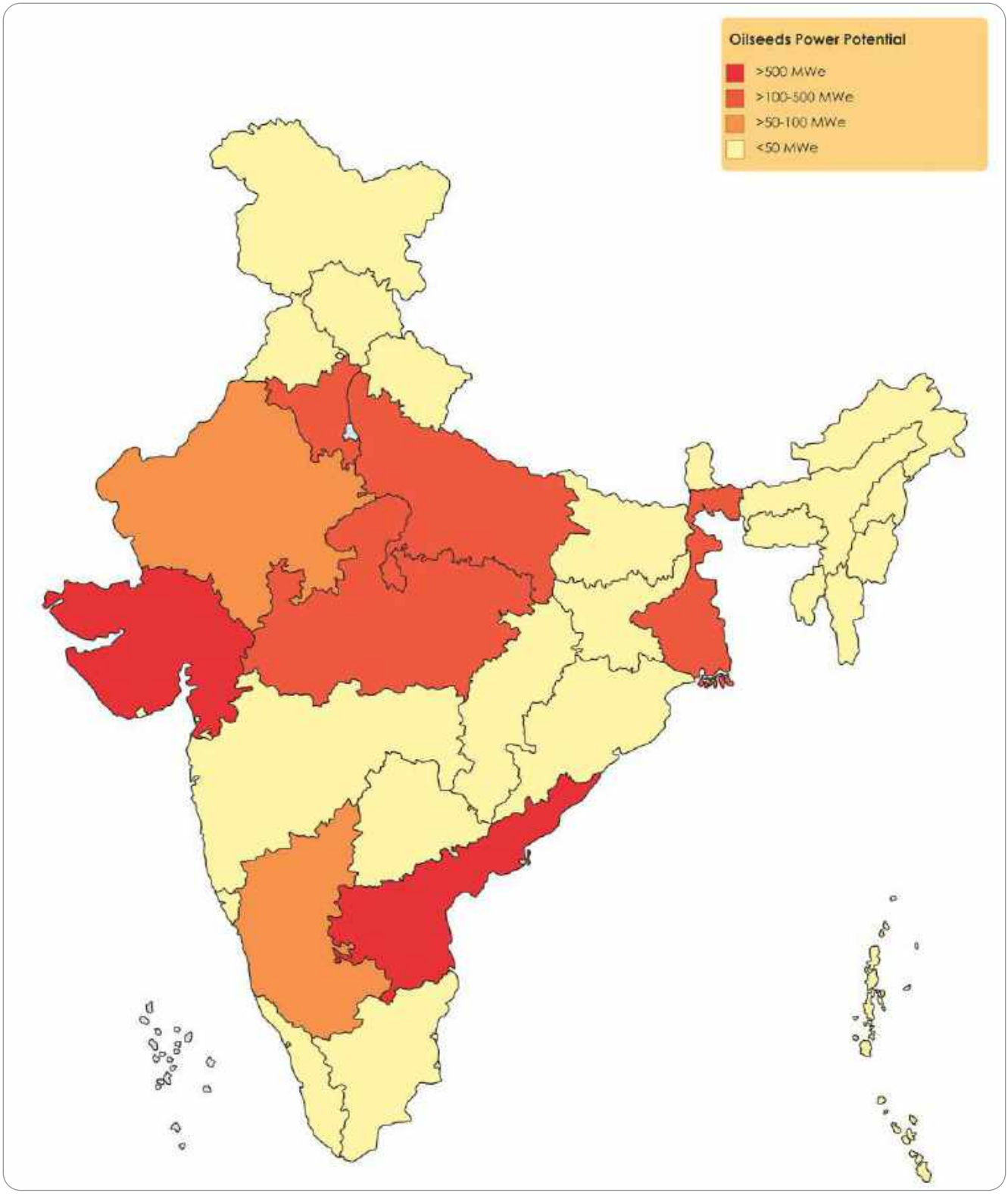


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

All India Trend 2000 to 2030

Biomass Power Potential trend at All India Level from the year 2000 to 2030

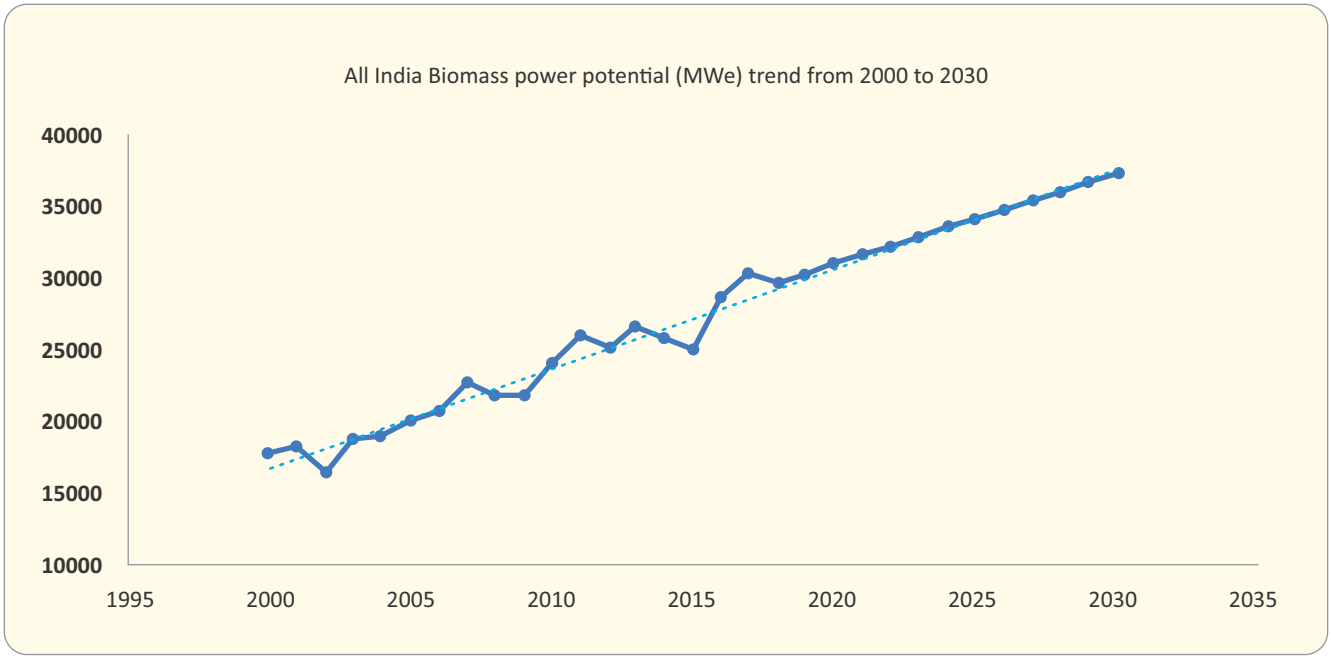


Figure 18: All India trend of Biomass Power Potential over the Years

05
CHAPTER

State wise Biomass Power Potential

State wise Data Analysis for All States and Uts ----

- **Introduction**
- **Utilisation of Crop residue at farmer level**
- **Cost of residue sold (Crop-wise)**
- **Crop wise Change in Area, Production, Biomass Potential and Growth Rate for 2006 to 2018**
- **Crop wise Area, Production, Biomass, Surplus Biomass, Biomass Power Potential in the year 2019-20**
- **Trend Analysis for Biomass Power potential (Crop wise)**

STATE-WISE BIOMASS POWER POTENTIAL

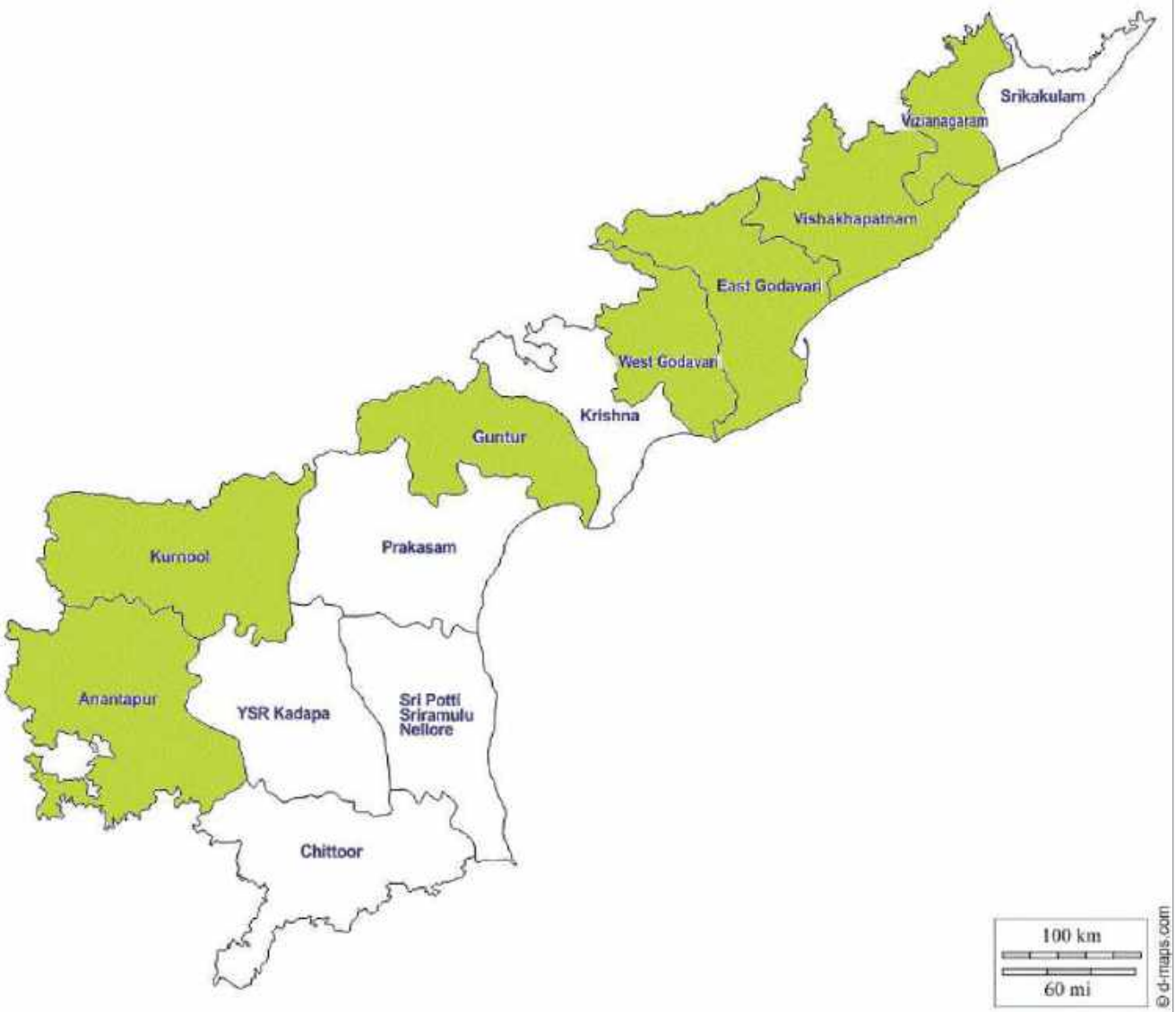
The socio-economic condition of the farmers has changed over the years. The usage pattern of the residue, as well as the cropping pattern, has also seen changes based on market demand. As learnt, Chapter 4 gives a compilation of data on various parameters to establish biomass power potential in India. Further, an effort was made to collate the state-wise information against each selected crop to establish state-wise biomass power potential. This chapter gives state-wise details of biomass power potential against each selected crop.

State-wise Biomass Power Potential

Sr. No	States/UTs	Total Crop Area (Million Hectare)	Total Crop Production (Million Tonnes)	Total Biomass Generation (Million Tonnes	Surplus Biomass Potential (Million Tonnes)	Biomass Power Potential (Mwe)
1	Andhra Pradesh	7.36	28.62	40.01	17.09	1999.49
2	Arunachal Pradesh	0.33	0.58	0.75	0.17	18.46
3	Assam	3.40	8.93	12.57	2.54	321.89
4	Bihar	7.28	32.50	32.57	7.98	964.37
5	Chhattisgarh	5.47	8.71	12.99	2.65	353.68
6	Goa	0.14	0.24	0.45	0.23	32.97
7	Gujarat	9.67	32.27	50.24	21.74	2637.84
8	Haryana	6.60	27.17	36.24	10.91	1353.35
9	Himachal Pradesh	0.77	1.51	2.74	0.57	69.71
10	Jammu &Kashmir	0.96	1.77	3.24	0.65	82.82
11	Jharkhand	1.96	3.32	5.31	1.20	146.31
12	Karnataka	10.94	51.34	34.09	14.05	1793.88
13	Kerala	1.30	4.79	8.58	6.04	778.41
14	Madhya Pradesh	23.70	43.81	70.23	19.93	2516.42
15	Maharashtra	21.07	86.48	52.54	21.49	2629.55
16	Manipur	0.34	1.12	1.14	0.48	62.31
17	Meghalaya	0.25	0.91	1.37	0.56	68.54
18	Mizoram	0.05	0.13	0.13	0.02	2.90
19	Nagaland	0.44	1.37	1.37	0.44	53.90
20	Odisha	4.45	7.88	11.84	2.23	298.72
21	Punjab	7.17	37.88	53.00	22.25	3022.11
22	Rajasthan	31.93	32.11	59.50	10.21	1299.55
23	Sikkim	0.08	0.12	0.23	0.04	4.73
24	Tamil Nadu	8.96	47.92	52.14	12.22	1560.08
25	Telangana	9.38	18.57	33.62	13.76	1678.36
26	Tripura	0.35	0.97	1.41	0.25	34.35
27	Uttar Pradesh	24.19	246.66	124.69	21.60	2800.31
28	Uttarakhand	1.00	8.05	3.55	0.72	93.34
29	West Bengal	8.49	38.20	47.51	16.28	1741.74
30	Andaman & Nicobar	0.04	0.08	0.20	0.13	18.13
31	Chandigarh	0.00	0.00	0.00	0.00	0.15
32	Dadra &Nagar Haveli and Daman & Diu	0.02	0.10	0.07	0.02	2.16
33	Puducherry	0.02	0.27	0.12	0.04	5.00
	Total	**198.11**	**774.37**	**754.50**	**228.53**	**28445.52**

State-wise Data Analysis

Andhra Pradesh



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter-02, based on secondary data, the survey teams in Andhra Pradesh collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Andhra Pradesh. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 1999.49 MWe and for 2019-20 is 2302.34 MWe.

Districts Selected for a primary field survey	07 (Anantapur, East Godavari, Guntur, Kurnool, Vishakhapatnam, Vizianagaram, West Godavari)
Average Rain fall	1,094 mm
Type of soil	Alluvial, Black cotton soil, Shallow soil, Red soil, Sandy loam
Major source of irrigation	Bore well, Canals, Tube well, open well, River
Major Rivers	Charavati, Godavari, Krishna, Nagarjuna Sagar, Penner, Sarada, Vagaru
Major Crops	Arhar (Tur), Bajra, Cashewnut, Cotton, Dry Chilly, Groundnut, Jowar, Maize, Mesta, Oilseed (Palm), Ragi, Rice, Sugarcane, Sunflower and Wheat

Utilization of Crop residue at farmer's level in Andhra Pradesh (AP):

1. **Essential Usage**: Residue of Arhar, Groundnut, Rice, Maize is extensively used as cattle feeding. The residue of Dry chilly, Groundnut and oilseed are mostly used for compost (Manure)
2. **Fuel Usage**: crop residue like Arhar, Cotton, sunflower and wheat are used for domestic cooking.
3. **Field preparation**: Stubbles of Arhar, cotton, Sunflower, Sugarcane and Rice are extensively used for open burning.
4. **Special Usage**: Some farmers follow mulching of stubbles (adding a layer of crop residue to suppress the weeds and to prevent water losses through evaporation) and zero budget natural farming (Without adding chemical fertilizers).
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue:

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
Existing cost of the crop residue being sold in the state	Arhar	2000
	Paddy	3000
Expected Cost against sale of crop residue in Future	Cotton	5000

Survey Images:

Narsapuram, Anantapur, Andhra Pradesh

Amarkathadu, Idhone, Kurnool, Andhra Pradesh

Konala, West Godavari, Andhra Pradesh

Table 44: Crop-wise change in Area, Production, Biomass Potential and Growth Rate in Andhra Pradesh for 2006 to 2018

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	2586869.33	8458992.67	12688489.00	2283928.02	310.61	2177169.67	9605162.33	14407743.50	2571508.65	350.24	12.76
Wheat	966.50	470.50	846.90	84.69	0.01	77.17	54.67	98.40	9.84	0.00	-86.72
Maize	189756.50	1354415.33	3115155.27	1744486.95	204.10	284347.33	1847321.33	4248839.07	2389971.98	279.15	36.77
Ragi	50373.17	54040.67	70252.87	7025.29	0.87	32889.33	40622.67	52809.47	5280.95	0.66	-24.61
Small Millets	32810.00	18215.33	21858.40	2185.84	0.28	21770.67	15291.67	18350.00	1835.00	0.23	-17.43
Bajra	43046.67	54713.33	143896.07	27340.25	3.34	37497.67	62683.33	164857.17	31205.11	3.79	13.61
Jowar	115821.33	200752.33	481805.60	48180.56	5.97	131016.50	253618.50	608684.40	60868.44	7.56	26.63
Moong (Green Gram)	161608.00	57396.67	71745.83	21523.75	2.76	131545.00	81054.67	101318.33	30395.50	3.88	40.63
Gram	500092.17	644956.83	709452.52	141890.50	18.59	465130.83	404275.67	444703.23	88940.65	11.61	-37.56
Arhar / Tur	180609.00	88245.83	247088.33	172961.83	20.93	292948.17	99571.67	278800.67	195160.47	23.54	12.45
Urad	369256.33	233897.67	304066.97	152033.48	13.84	406919.00	336884.00	437949.20	218974.60	19.95	44.14
Horse Gram	43254.83	20618.67	26804.27	2680.43	0.34	41792.83	16323.00	21219.90	2121.99	0.27	-20.74
Other Kharif Pulses	3842.17	1317.50	1712.75	342.55	0.04	10464.00	10643.00	13835.90	2767.18	0.33	737.07
Other Rabi Pulses	3679.00	3137.33	4078.53	407.85	0.05	6743.00	8229.00	10697.70	1069.77	0.13	158.88
Cowpea	0.00	0.00	0.00	0.00	0.00	8819.00	5345.00	5879.50	1175.90	0.16	0
Rapeseed & Mustard	5340.50	2900.50	5220.90	2610.45	0.34	4242.33	1693.83	3048.90	1524.45	0.20	-41.26
Linseed	553.50	205.50	304.14	60.83	0.01	200.83	72.00	106.56	21.31	0.00	-78.47
Sunflower	688907.00	563621.50	1127243.00	1127243.00	124.00	14576.50	14050.50	28101.00	28101.00	3.09	-97.51
Sesamum	64091.17	15263.67	38159.17	15263.67	1.88	51707.50	13636.50	34091.25	13636.50	1.68	-10.78
Groundnut	1436807.83	1146988.50	2638073.55	316568.83	38.62	831791.33	704108.83	1619450.32	194334.04	23.69	-38.66
Safflower	646.50	253.50	760.50	152.10	0.02	291.50	72.83	218.50	43.70	0.00	-76.18
Castor seed	26505.00	16941.17	69458.78	41675.27	5.21	33751.67	17184.17	70455.08	42273.05	5.29	1.59
Niger seed	13274.50	5309.00	5627.54	562.75	0.07	5752.50	2146.67	2275.47	227.55	0.03	-61.09
Oilseeds	0.00	0.00	0.00	0.00	0.00	1101301.33	2612898.67	5225797.33	5225797.33	494.36	0

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Soyabean	889.00	1016.00	1727.20	293.62	0.04	0.00	0.00	0.00	0.00	0.00	-100.00
Dry chillies	125972.17	493793.00	740689.50	592551.60	77.03	162355.67	717062.83	1075594.25	860475.40	111.60	44.88
Turmeric	13644.00	96241.00	28872.30	17323.38	2.30	19182.00	79729.00	23918.70	14351.22	1.91	-17.01
Coriander	24485.00	10132.50	11652.38	5826.19	0.74	2828.33	1458.33	1677.08	838.54	0.11	-85.63
Ginger	925.50	2431.50	121.58	40.12	0.01	342.50	584.33	29.22	9.64	0.00	-87.75
Arecanut	307.00	220.50	1097.40	1031.56	0.14	747.00	4024.33	5460.47	5132.84	0.68	387.62
Banana	50497.50	1254172.50	3762517.50	827753.85	110.09	55743.00	2303705.00	6911115.00	1520445.30	201.76	83.27
Cashewnut	138952.50	38664.00	88927.20	88927.20	14.41	111894.00	48288.00	111062.40	111062.40	17.99	24.86
Coconut	105000.00	170867.66	548150.74	493335.67	67.59	100571.00	214176.45	562916.34	506624.70	69.56	2.91
Sweet potato	845.00	8591.50	859.15	515.49	0.05	632.33	9666.33	966.63	579.98	0.05	5.56
Meshta	52021.50	80404.26	164828.73	82414.37	11.04	4832.50	8337.93	17092.76	8546.38	1.15	-89.63
Tapioca	18286.00	209067.50	156800.63	133280.53	14.39	7362.83	88305.33	66229.00	56294.65	6.08	-57.75
Cotton	275411.17	154539.66	1386549.69	1136970.74	137.57	579286.00	287085.40	2832874.69	2327004.21	281.33	104.50
Sugarcane	182569.83	14647360.00	732368.00	732368.00	99.60	101054.42	7889947.00	394497.35	394497.35	53.65	-46.13
Potato	1531.00	13369.50	10829.30	7147.33	0.66	1539.00	13430.33	10878.57	7179.86	0.67	1.28
Onion	24612.33	408935.17	20446.76	4498.29	0.61	35517.00	633153.00	31657.65	6964.68	0.95	55.28
Tobacco	130172.83	199090.50	199090.50	199090.50	26.48	83335.67	166542.67	166542.67	166542.67	22.15	-16.35
Guar seed	0.00	0.00	0.00	0.00	0.00	42.00	80.00	160.00	24.64	0.00	0
Total	**7664233.33**	**30731550.74**	**29627629.42**	**10432577.33**	**1314.62**	**7360010.92**	**28618520.78**	**40012003.61**	**17093819.40**	**1999.49**	**52.10**

Table 45: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Andhra Pradesh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	2421393.81	8946151.96	13419227.95	2415461.03	328.99
2	Wheat	102.00	19.00	34.20	3.42	0.00
3	Jowar	16356.89	222559.86	534143.66	53414.37	6.63
4	Bajra	16263.00	52373.11	137741.27	26170.84	3.18
5	Maize	398304.44	2651806.82	6099155.70	3415527.19	399.28
6	Gram	564965.98	582050.00	640255.00	128051.00	16.71
7	Tur (Arhar)	257838.74	106697.86	298754.01	209127.80	25.22
8	Groundnut	773573.05	608909.19	1400491.14	168058.94	20.49
9	Other Oilseeds	766852.37	1819467.77	3638935.54	3638935.54	344.24
10	Soyabean	26005.49	39380.37	66946.63	11380.93	1.42
11	Rapeseed & Mustard	4570.65	4531.65	8156.97	4078.48	0.54
12	Sunflower	13329.00	9173.00	18346.00	18346.00	2.02
13	Cotton	982078.93	476332.59	4779831.63	3919461.94	474.25
14	Mesta	2934.00	5339.16	10945.28	5472.64	0.73
15	Sugarcane	104705.28	8392104.68	419605.23	419605.23	51.95
16	Tobacco	117430.37	262338.40	262338.40	262338.40	34.79
17	Arecanut	727.39	2674.60	4321.84	4062.52	0.54
18	Banana	63457.49	4153581.05	12460743.16	2741363.49	363.78
19	Cashewnut	108863.75	65040.93	149594.14	149594.14	24.34
20	Coconut	102264.68	312105.59	1325120.89	1192608.80	163.75
21	Ginger	229.35	3695.37	184.77	60.97	0.01
22	Caster Seed	435.07	13266.32	54391.89	32635.14	4.09
23	Green Gram (Moong)	77171.65	90308.00	112885.00	33865.50	4.32
24	Ragi	19549.81	19916.40	25891.32	2589.13	0.32
25	Sesamum	31501.25	12815.39	32038.46	12815.39	1.57
26	Tapioca	6443.65	130339.09	97754.32	83091.17	8.99
27	Black Gram (Urad)	343453.46	317211.12	412374.46	206187.23	18.79
28	Potato	2170.61	28485.95	23073.62	15228.59	1.42
	Total	**7222972.16**	**29328675.24**	**46433282.48**	**19169535.83**	**2302.34**

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Cotton with 474.25 MWe, followed by Maize (399.28 MWe), Banana (363.78 MWe), Other Oilseeds (344.24 MWe) and Rice (328.11 MWe)

Trend Analysis for Biomass Power Potential for the state of Andhra Pradesh – Crop-wise

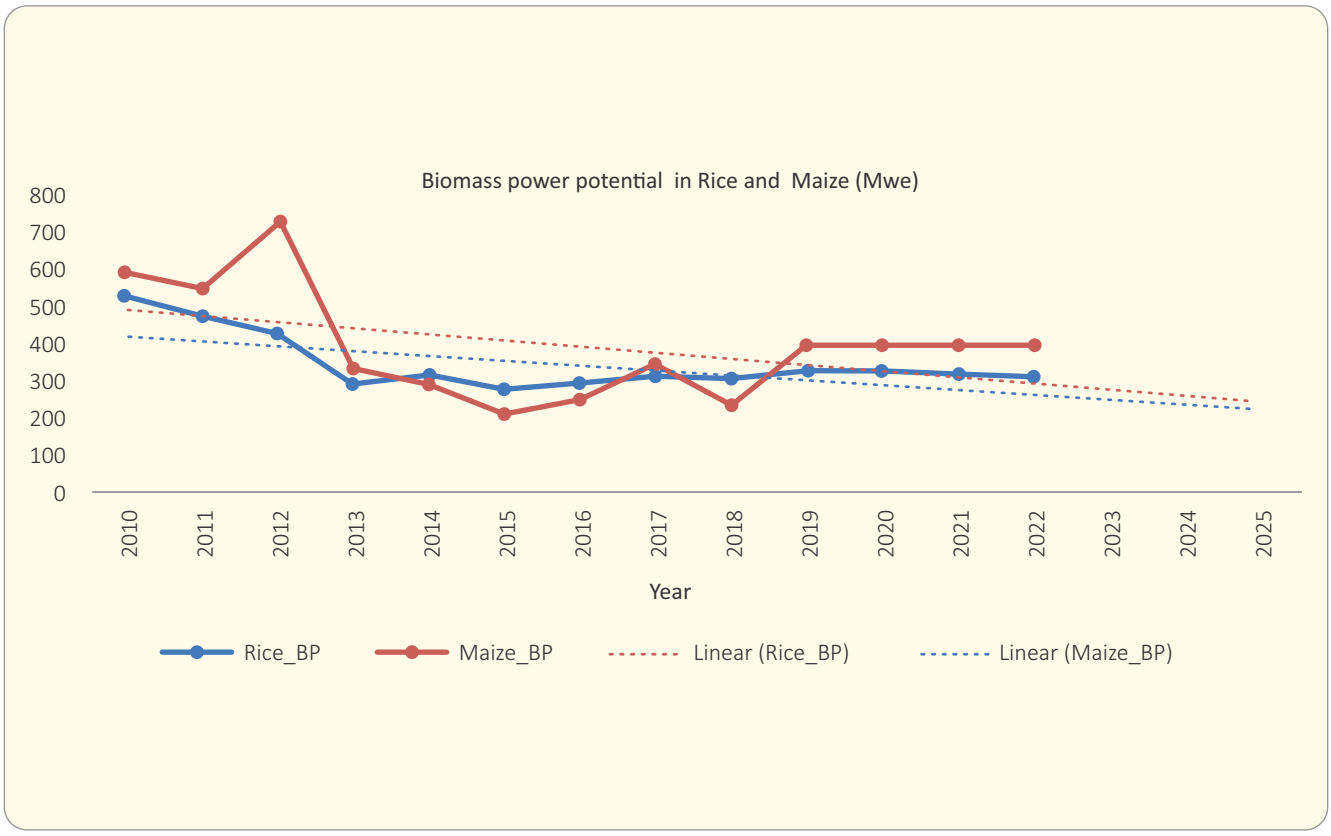


Figure 19: Biomass Power Potential for Rice and Maize in Andhra Pradesh (Mwe)

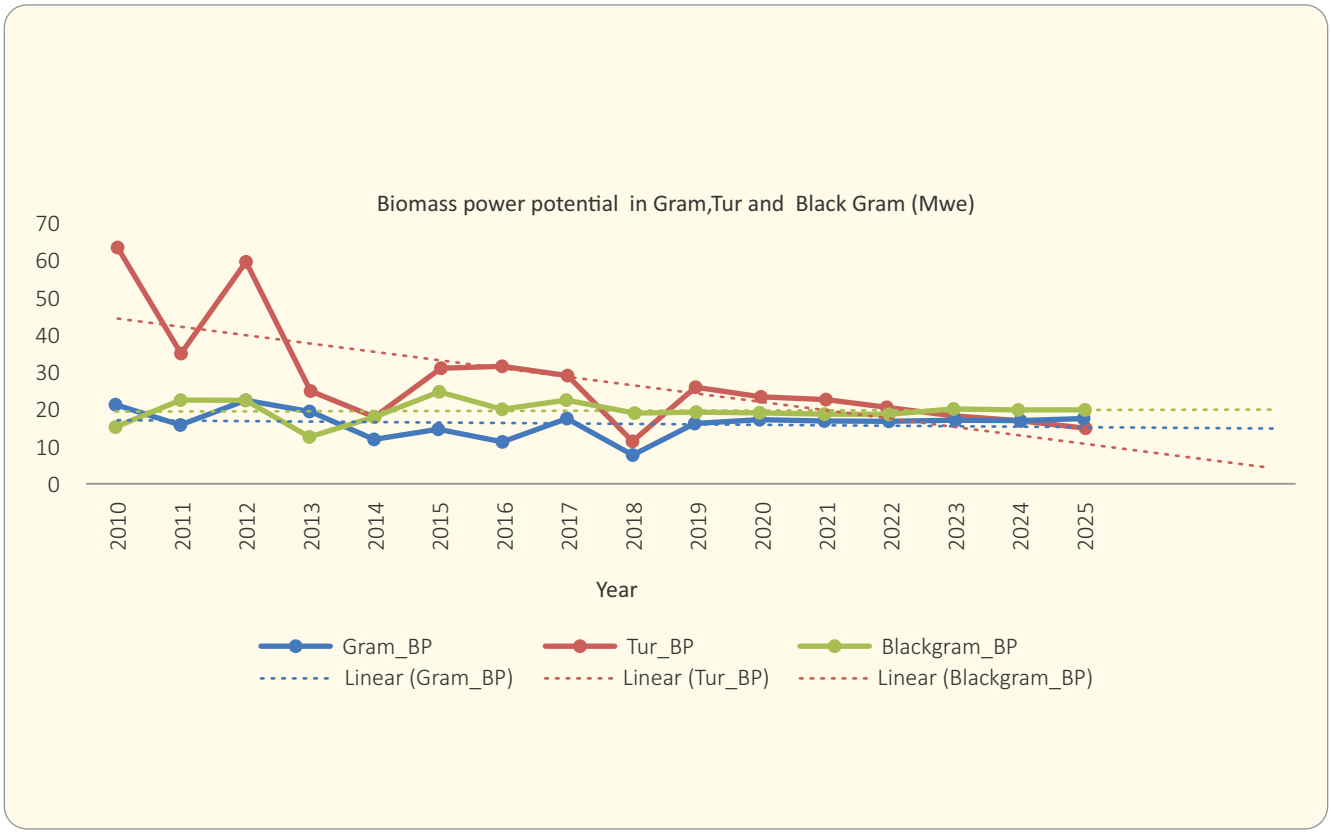


Figure 20: Biomass power potential for Gram, Tur and Black gram in Andhra Pradesh (Mwe)

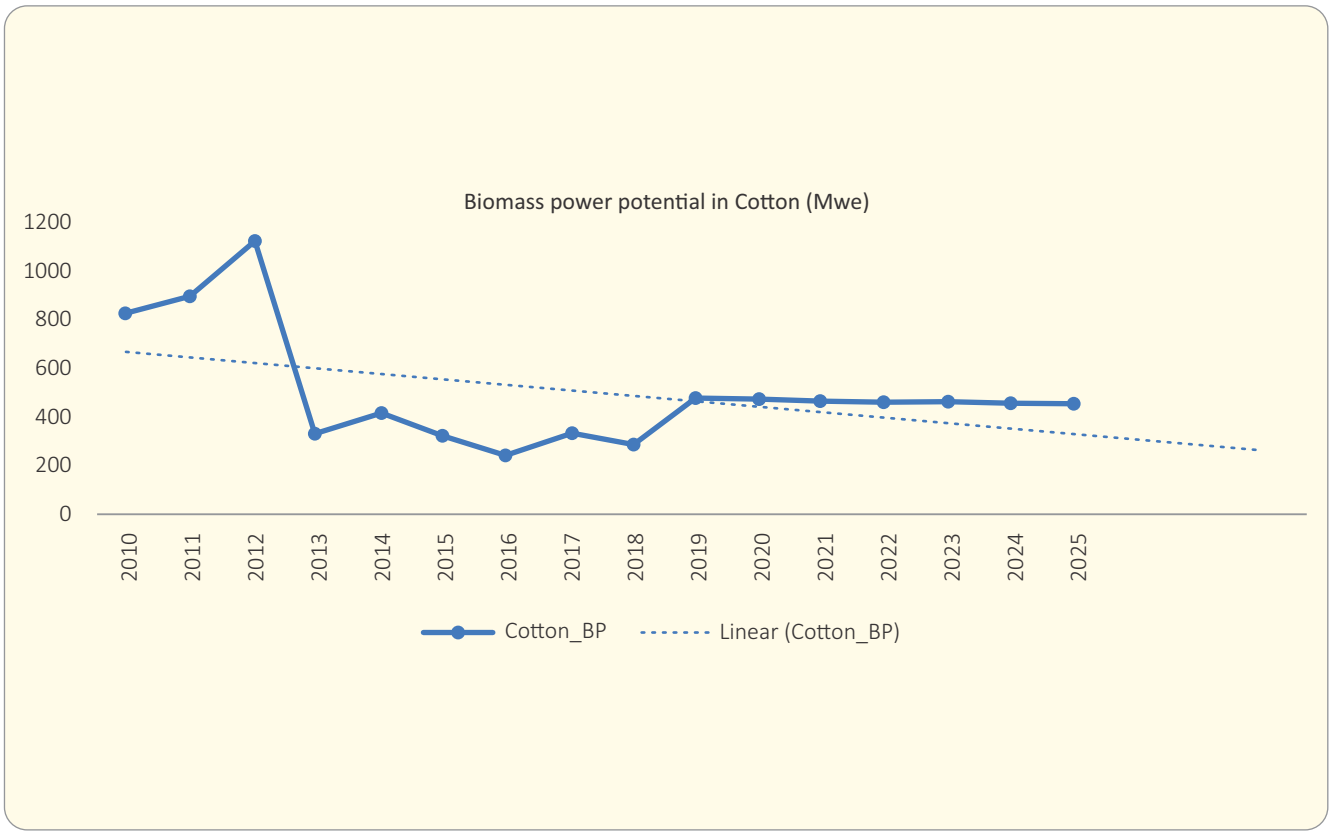


Figure 21: Biomass Power Potential for Cotton in Andhra Pradesh (Mwe)

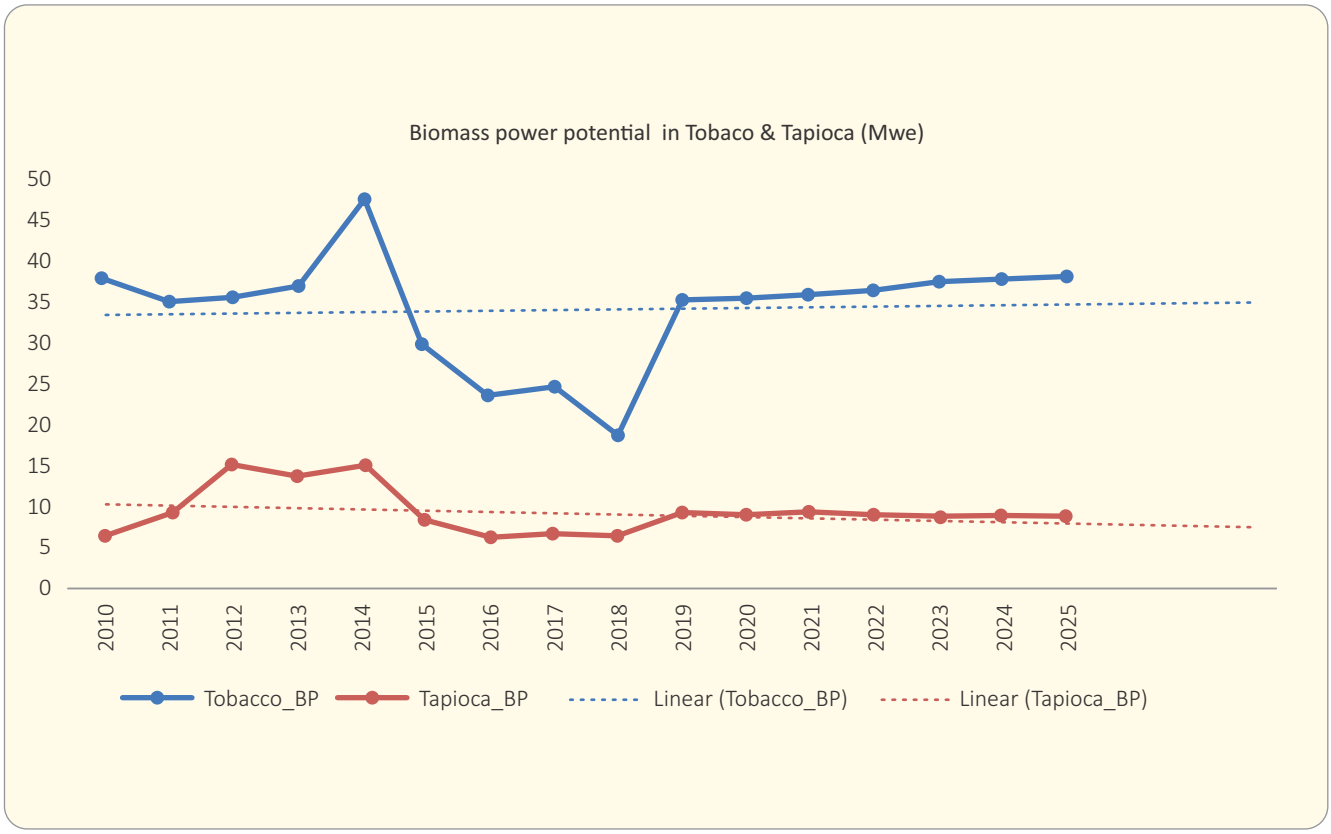


Figure 22: Biomass Power Potential for Tabaco and Tapioca in Andhra Pradesh (Mwe)

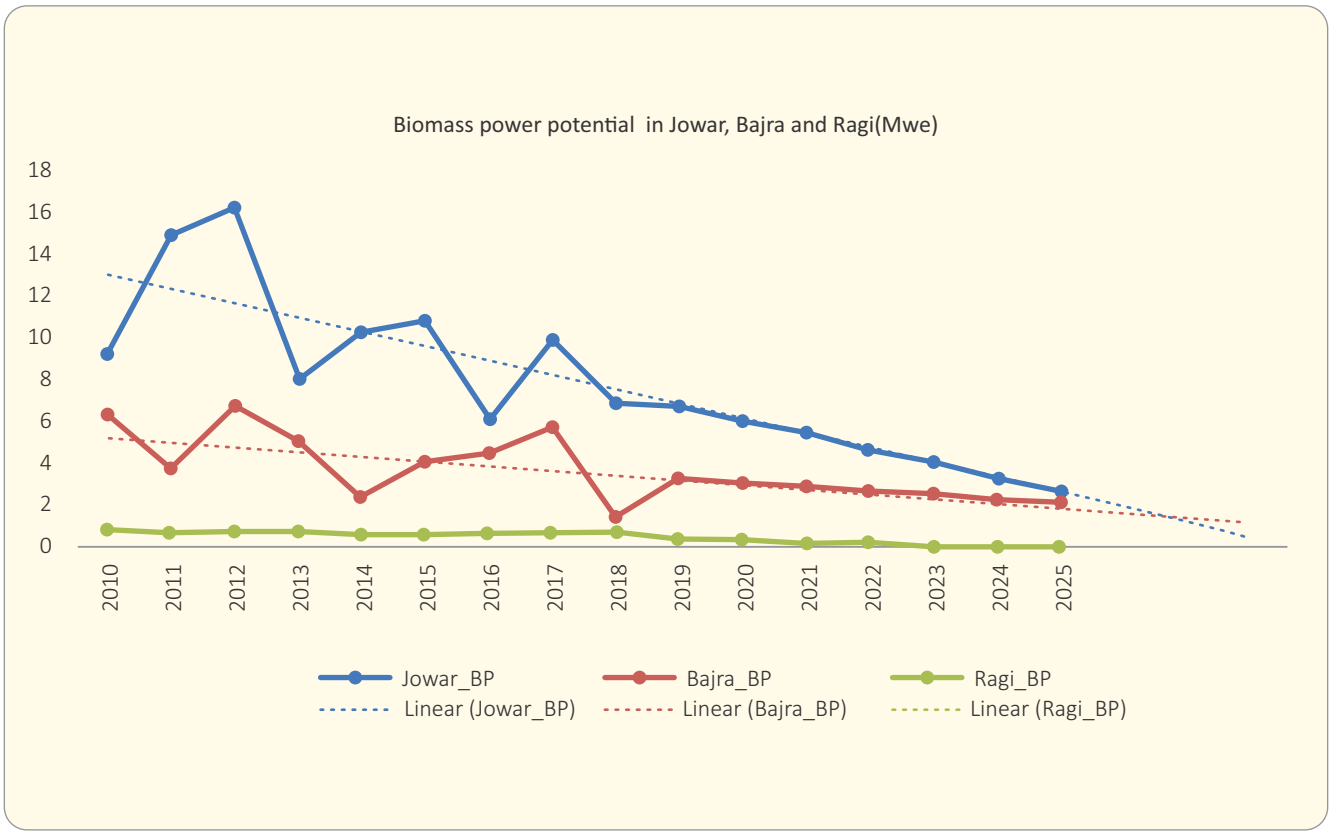


Figure 23: Biomass Power Potential for Jowar, Bajra and Ragi in Andhra Pradesh

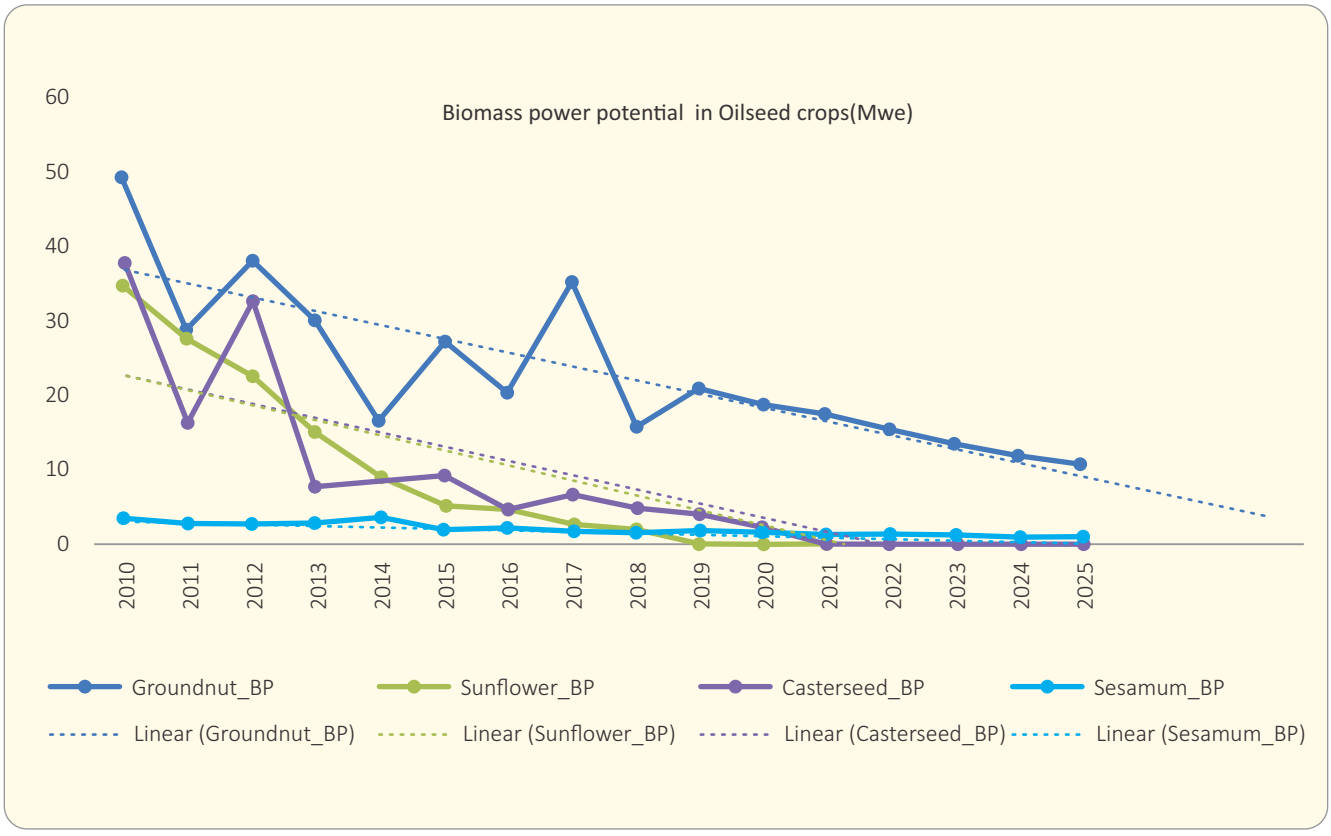


Figure 24: Biomass Power Potential for Oil Seeds in Andhra Pradesh

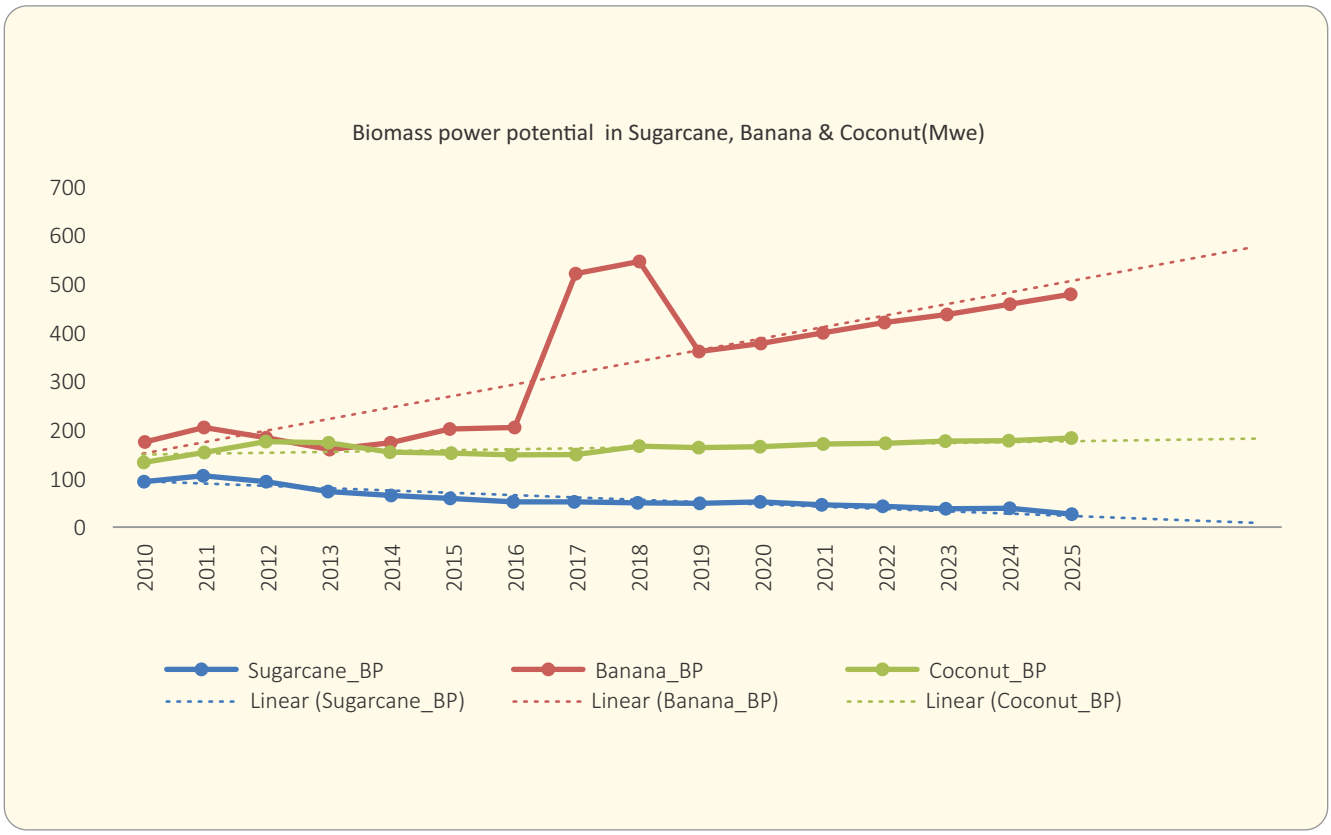


Figure 25: Biomass Power Potential for Sugarcane, Banana and Cotton in Andhra Pradesh

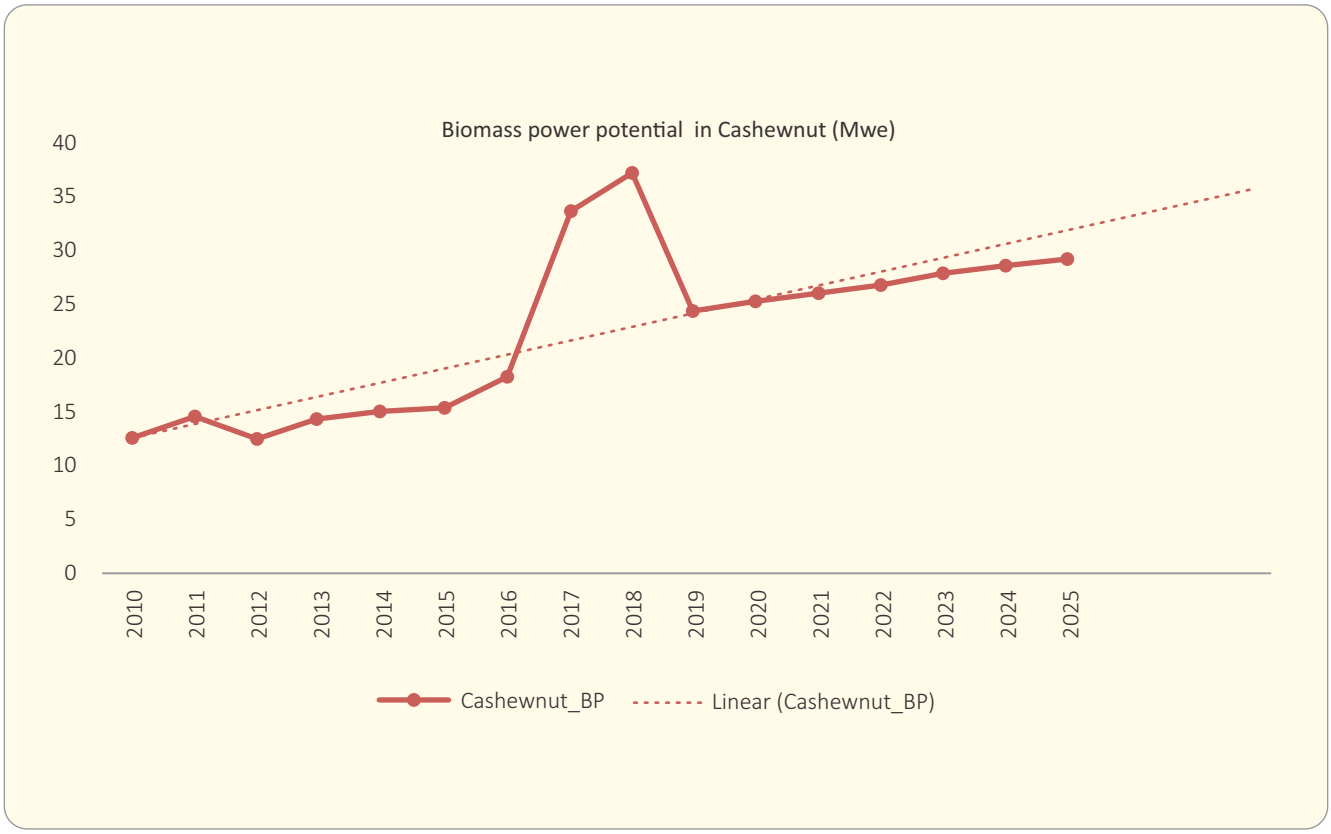
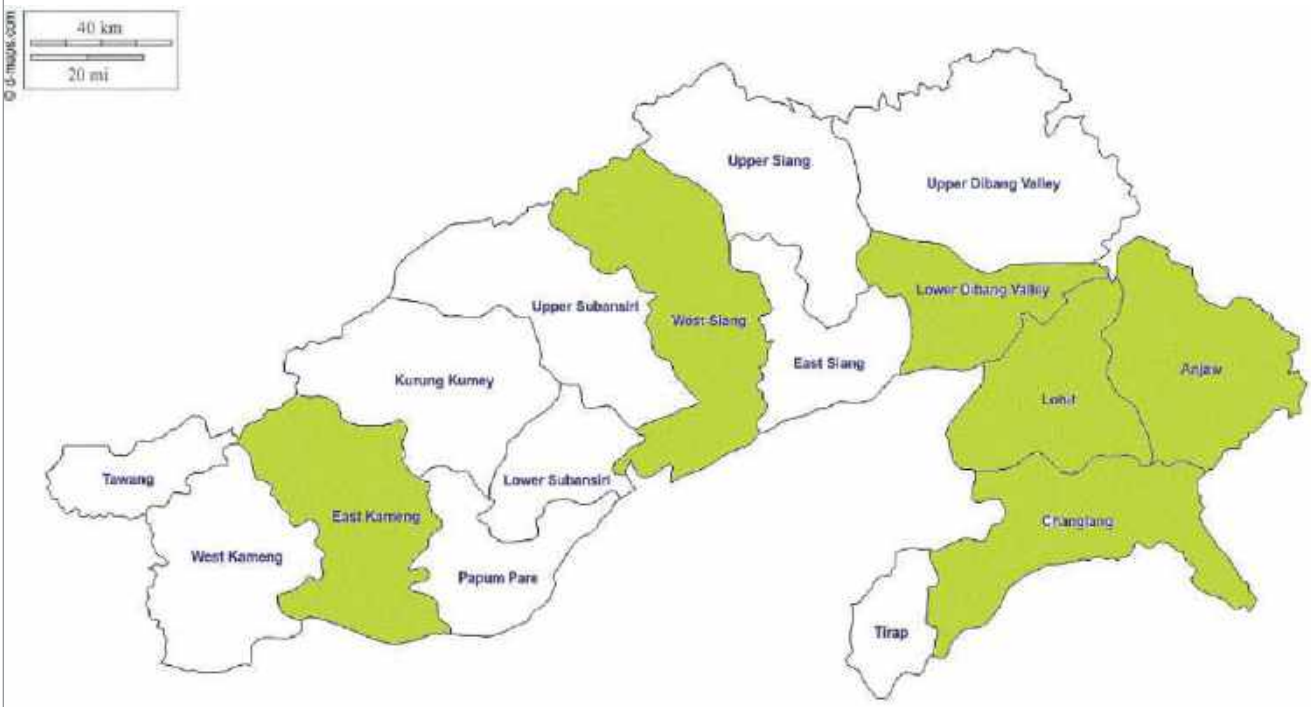


Figure 26: Biomass Power Potential for Cashewnut in Andhra Pradesh

Arunachal Pradesh



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Arunachal Pradesh collected information and samples from all six (06) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Arunachal Pradesh was calculated, which was the input to arrive at biomass power potential in Arunachal Pradesh. Thus, the total biomass power potential for the state of Arunachal Pradesh for 2018 was 18.46 MWe, and for 2019-20 is 11.10 MWe.

Districts Selected for a primary field survey	06 (Chanhlang, East Siang, Lower Diband Vally, Lohit, Nimsai, and West Siang)
Average Rain fall	2782mm (2004- 2010)
Type of soil	Black Soil, Coarse Loamy, Fine loamy, Sandy Loam, Mountain Black Soil, Mountain Brown and Red soil
Major source of irrigation	Canals, Tube well, and River
Major Rivers	Brahmaputra, Dibang, Namchikl, Noa Dehing, Sipu, Tirap and Yomgo
Major Crops	Cabbage, Maize, Mustard, Other Kharif pulses, Potato, Rice, Small millets and Urad

Utilization of Crop residue at farmer's level in Arunachal Pradesh:

1. **Essential Usage**: Crop residue of Cabbage, Maize, Potato, Small Millets and other Kharif pulses are extensively used for cattle feeding.
2. **Specific Usage**: Residue of crops like Potato, Cabbage, Maize and Urad are extensively utilized for making compost fertilizer.
3. **Fuel Usage**: Residue of crops like Mustard, Other Kharif pulses and Rice is utilized as domestic fuel.
4. **Field preparation**: In order to prepare the land for the next sowing, the residue of crops (stubble) like Rice, Maize and Mustard are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Rice	4000 - 5000
	Mustard	3000 - 5000
	Other Kharif pulses	2000 - 4000

Survey Images:

Kabu, West Siang, Arunachal Pradesh

Lamrung, Pasighat, East Siang, Arunachal Pradesh

Wakhetna, Bordumsa, Changlang, Arunachal Pradesh

Table 46: Crop-wise change in Area, Production and Biomass Potential in Arunachal Pradesh

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	124622.00	155773.00	233659.50	9346.38	1.27	134836.50	215103.76	322655.63	14370.38	1.96	54.11
Wheat	3621.50	5611.17	10100.10	2020.02	0.27	3985.00	7867.33	14161.20	2832.24	0.38	41.61
Maize	43971.33	59928.00	137834.40	15161.78	1.77	51926.17	79154.50	182055.35	20228.37	2.36	33.48
Small millets	22092.67	19925.00	23910.00	2391.00	0.30	26935.67	27830.00	33396.00	3339.60	0.42	40.26
Other Kharif pulses	0.00	0.00	0.00	0.00	0.00	48215.00	49754.00	64680.20	12936.04	1.57	0
Oilseeds total	31564.67	29616.33	59232.67	59232.67	5.63	39324.00	39350.00	78700.00	78700.00	7.45	32.24
Turmeric	600.33	2280.83	684.25	410.55	0.05	834.00	3925.00	1177.50	706.50	0.09	87.93
Ginger	6164.33	45806.00	2290.30	755.80	0.10	8221.33	61135.67	3056.78	1008.74	0.13	28.21
Dry chillies	2216.83	3467.67	5201.50	4161.20	0.54	3212.33	8963.33	13445.00	10756.00	1.40	158.34
Sugarcane	1314.83	22472.00	1123.60	280.90	0.04	2049.00	41617.67	2080.88	520.22	0.07	76.88
Potato	3963.67	31422.33	25452.09	20107.15	1.87	5885.00	44400.33	35964.27	28371.81	2.64	41.25
Total	**240132.17**	**376302.33**	**499488.41**	**113867.45**	**11.85**	**325424.00**	**579101.59**	**751372.82**	**173769.90**	**18.46**	**55.80**

Table 47: Crop-wise Area, Production, Biomass Production, Surplus biomass and Biomass Power Potential for Arunachal Pradesh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	131701.60	217380.10	326070.10	13042.81	1.77
2	Wheat	3394.37	6818.59	12273.46	2454.69	0.33
3	Maize	52071.99	79551.93	182969.40	20126.64	2.35
4	Other Oilseeds	20777.15	19796.68	39593.35	39593.35	3.74
5	Sugarcane	2207.34	45380.67	2269.033	567.25	0.07
6	Ginger	8560.22	64448.42	3222.42	1063.39	0.13
7	Potato	5552.08	45164.46	36583.22	28900.74	2.69
	Total	224264.8	478540.8	602981.1	105748.9	11.10

Major contributing crops in biomass power potential in Arunachal Pradesh (2019-20) is Other Oilseeds with 3.74 MWe followed by Potato (2.69 MWe), Maize (2.35 MWe), Rice (1.77 MWe) and Wheat (0.33 MWe)

The following graphs represent the crop-wise biomass power potential (in MWe) for Arunachal Pradesh with projections and liner trends from the year 2010 to 2025 based on the primary and secondary data.

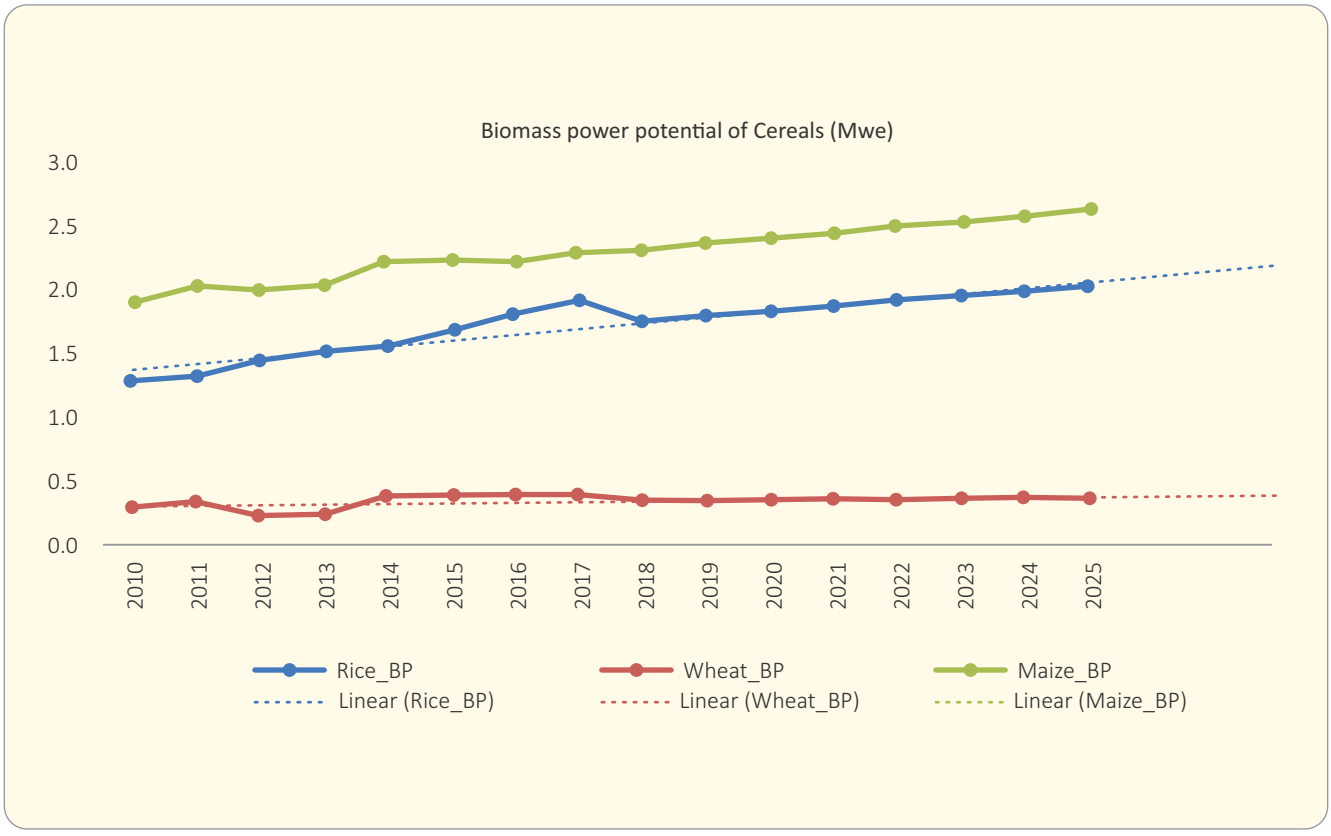


Figure 27: Biomass Power Potential for Cereals in Arunachal Pradesh

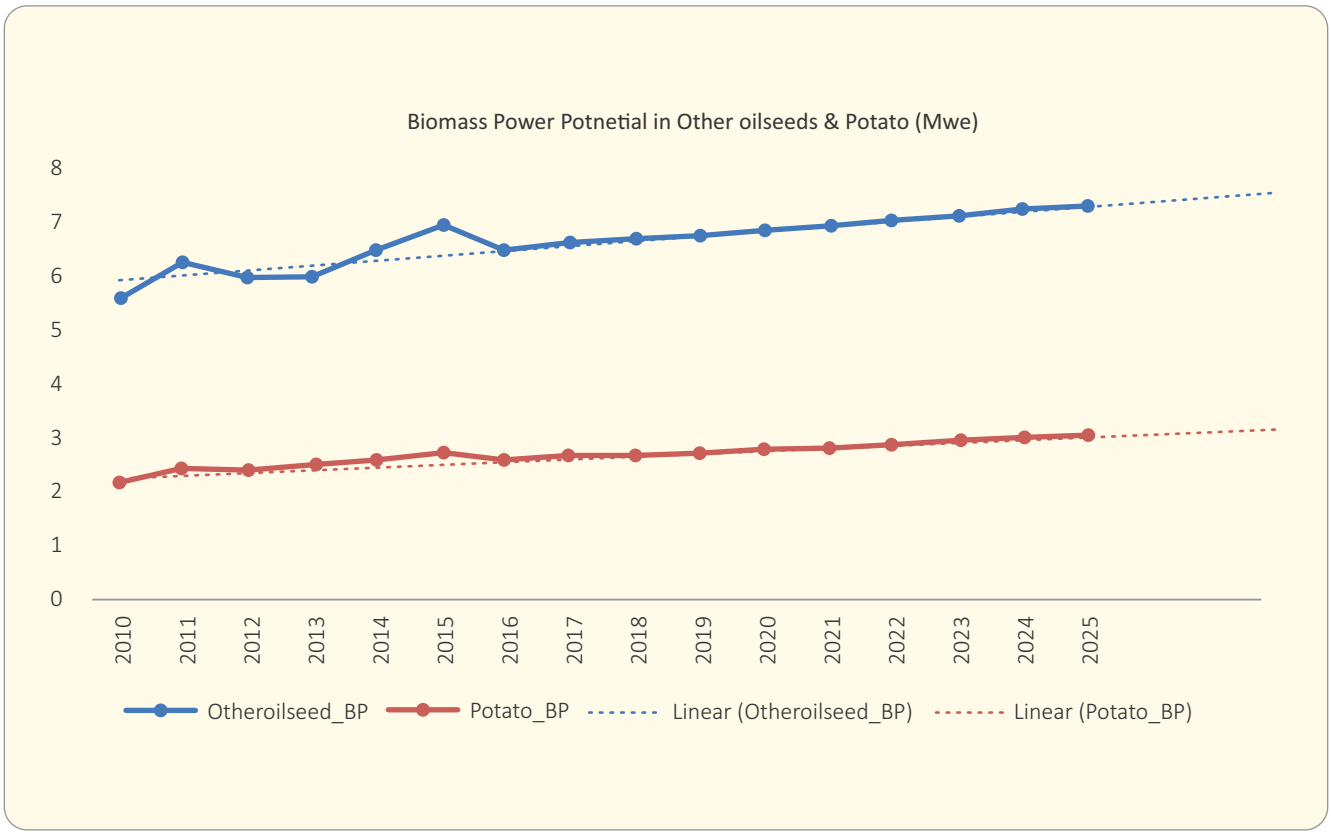


Figure 28: Biomass Power Potential for Other Oilseeds and Potato in Arunachal Pradesh

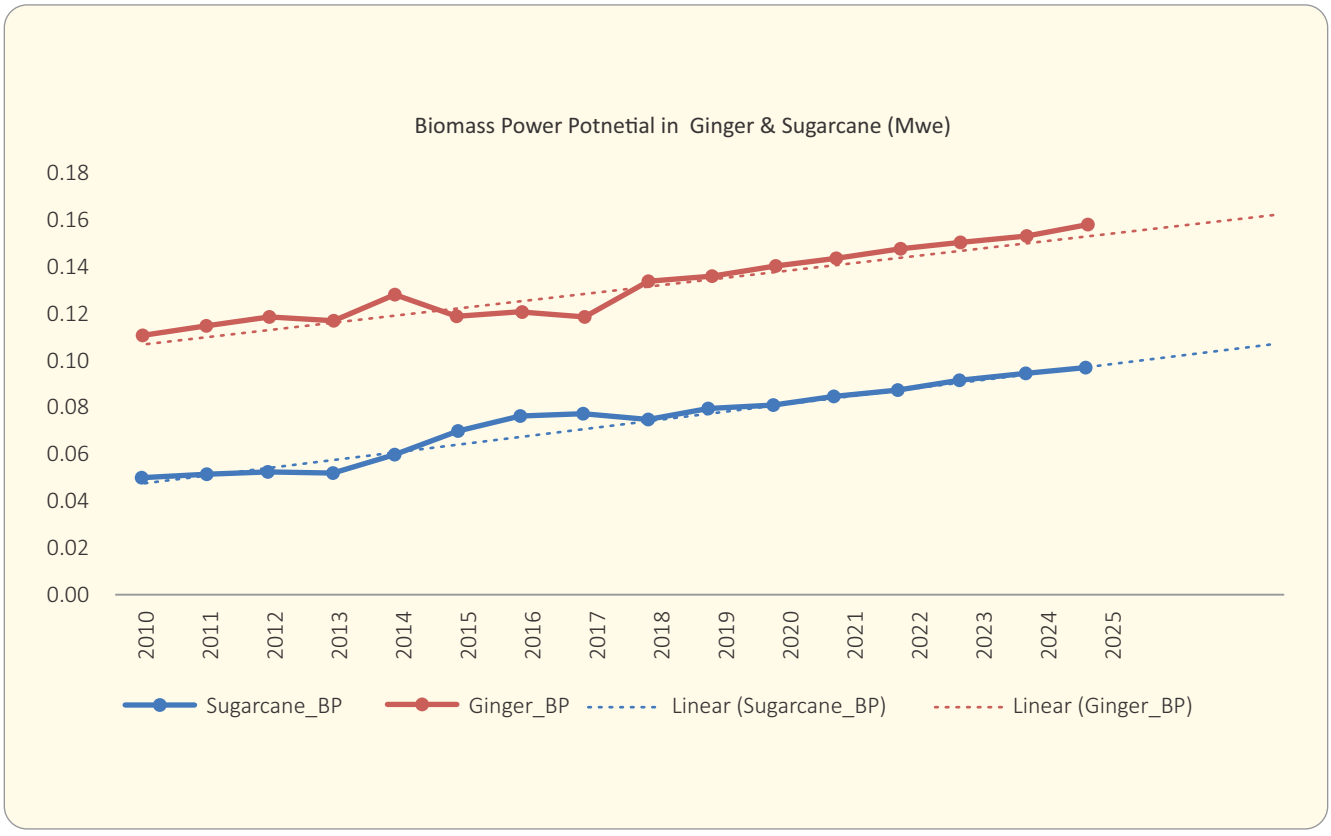


Figure 29: Biomass Power Potential for Ginger and Sugarcane in Arunachal Pradesh

Assam

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Assam collected information and samples from all eleven (11) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Assam was calculated, which was the input to arrive at biomass power potential in Assam. Thus, the total biomass power potential for the state of Assam for 2018 was 321.89 MWe and for 2019-20 is 330.13 MWe.

Districts Selected for a primary field survey	11 (Barpeta, Darrang, Dhubri, Goalpara, Kamrup, Kokrajhar, Lakhimpur, Nagaon, Nalbari, Sonitpur, and Udalguri)
Average Rain fall	2,818 mm
Type of soil	Clay loam soil, Colluvium, Gneis, Old Alluvial Soil, Red Sandy Loam
Major source of irrigation	Canals, Tube well, River
Major Rivers	Brahmaputra, Gadadhar, Kalang
Major Crops	Arecanut, Banana, Jute, Groundnut, Potato, Rapeseed & Mustard, Rice Sugarcane, Tea and Urad (Black gram)

Utilization of Crop residue at farmer's level in Assam:

1. **Essential Usage**: crop residue such as Banana, Groundnut, Sugarcane (top leaves) and Urad are extensively used for cattle feeding. Some amount of Mustard & Rapeseed is also used for cattle feeding.
2. **Specific Usage**: Residue of Banana, Urad, Jute, Groundnut and Potato are mostly used for compost manure (organic fertilizer). The residue of Arecanut and jute are also utilized for making some decorative items.
3. **Fuel Usage**: Around 60% of Rice residue is used for domestic cooking, and 35% of Mustard residue is used for domestic cooking.
4. **Field preparation**: Maximum residue of Arecanut, Jute, Rapeseed & Mustard, Potato and Urad are burnt openly. About 13% of Rice residue (Stubble) is burnt in an open field in order to clean land in a short duration.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Arecanut	7000 – 20000
	Jute	2000 – 5000
	Rapeseed & Mustard	4000 – 5000
	Potato	2000 – 3000

Survey Images:

Salmara, Birsingjarua, Dhubri, Assam

Parahkuchi, Barpeta, Assam

Mailali, Sonitpur, Assam

Table 48: Crop-wise change in Area, Production and Biomass Potential in Assam

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	2334897.33	3414360.33	5121540.50	409723.24	55.72	2461944.67	5178750.67	7768126.00	650580.55	88.61	59.03
Wheat	55249.17	64275.00	115695.00	23139.00	3.12	18737.67	24202.00	43563.60	8712.72	1.18	-62.30
Maize	18173.17	13182.33	30319.37	6063.87	0.71	30430.00	92392.33	212502.37	42500.47	4.96	599.16
Small Millets	6639.33	3400.33	4080.40	408.04	0.05	5551.83	3492.33	4190.80	419.08	0.05	5.61
Moong (Green Gram)	6909.00	3177.00	3971.25	1191.38	0.15	10977.33	7597.00	9496.25	2848.88	0.36	142.53
Masoor	21455.33	10764.50	19268.46	9634.23	0.99	26392.67	18779.50	33615.31	16807.65	1.73	75.21
Gram	1829.00	934.83	1028.32	205.66	0.03	2299.50	1563.33	1719.67	343.93	0.04	49.61
Arhar/Tur	5979.00	4270.00	11956.00	8369.20	1.01	5898.67	5060.67	14169.87	9918.91	1.20	18.44
Other Rabi Pulses	14395.00	7830.00	10179.00	1017.90	0.12	16210.50	12411.50	16134.95	1613.50	0.20	62.69
Peas & Beans (Pulses)	20866.67	12826.67	6413.33	3206.67	0.40	29327.33	26772.67	13386.33	6693.17	0.83	107.49
Urad	38364.00	20818.67	27064.27	12449.56	1.13	56819.67	37553.33	48819.33	22616.30	2.06	82.33
Linseed	7729.00	3941.67	5833.67	1166.73	0.12	5089.67	3145.83	4655.83	931.17	0.09	-21.63
Castor seed	1241.33	526.33	2157.97	1294.78	0.16	821.83	382.33	1567.57	940.54	0.12	-26.40
Rapeseed & Mustard	233205.00	121153.00	218075.40	109037.70	14.28	289993.33	191432.67	344578.80	172289.40	22.57	58.05
Sesamum	12756.33	7230.33	18075.83	7230.33	0.89	11952.67	8244.33	20610.83	8244.33	1.01	13.94
Niger Seed	8802.67	4506.33	4776.71	477.67	0.06	6160.50	3545.00	3757.70	375.77	0.04	-25.03
Ginger	15417.00	105495.50	5274.78	1740.68	0.22	17347.67	153235.67	7661.78	2528.39	0.32	46.07
Arecanut	67137.00	58534.67	248238.73	233344.41	31.03	66213.67	59596.00	246317.80	231538.73	30.79	-0.76
Black Pepper	3109.50	4681.00	2340.50	257.46	0.03	3378.67	6905.33	3452.67	391.30	0.05	59.91
Dry Chillies	16188.00	10323.67	15485.50	12388.40	1.61	20239.00	18312.33	27468.50	21974.80	2.85	77.03
Turmeric	12909.67	9221.33	2766.40	1659.84	0.22	16649.00	17906.00	5371.80	3223.08	0.43	94.85
Jute	59205.33	111770.40	223540.80	178832.64	23.96	72398.00	150579.60	301159.20	240927.36	32.28	34.74
Tobacco	520.50	278.67	278.67	278.67	0.04	217.67	109.83	109.83	109.83	0.01	-63.48
Potato	77075.33	513709.33	416104.56	266306.92	24.77	104372.33	730933.00	592055.73	380035.77	35.38	42.84

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Coconut	18847.33	23148.25	92750.52	83475.47	11.44	20286.33	23198.40	98544.13	88689.72	12.18	6.44
Banana	44276.33	611552.00	1834656.00	403624.32	53.68	51150.33	883610.33	2650831.00	583182.82	77.39	44.17
Tapioca	2775.00	13068.67	9801.50	8331.28	0.90	3196.33	29445.17	22083.88	18771.29	2.03	125.26
Sweet Potato	7122.67	25028.33	2502.83	1501.70	0.14	5331.00	29040.67	2904.07	1742.44	0.16	13.26
Cotton	1361.83	108.86	5414.45	4331.56	0.52	867.50	71.32	3453.39	2762.71	0.33	-35.77
Sugarcane	27003.33	1044982.00	52249.10	13062.28	1.78	30467.33	1129490.00	56474.50	14118.63	1.92	7.87
Mesta	5134.67	4704.12	9643.45	4821.72	0.65	3755.33	4186.26	8581.83	4290.92	0.57	-11.54
Onion	6843.33	16638.00	831.90	183.02	0.02	8369.00	80665.00	4033.25	887.32	0.12	503.37
Total	**3153418.17**	**6254158.21**	**8522315.15**	**1808756.31**	**229.97**	**3402847.00**	**8932610.41**	**12571398.57**	**2541011.48**	**321.89**	**39.97**

Table 49: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Assam in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	2453046.72	5574989.11	8362483.67	668998.69	90.98
2	Wheat	10722.05	16239.89	29231.80	5846.36	0.79
3	Maize	30236.43	90744.15	208711.55	41742.31	4.88
4	Gram	1916.10	1459.05	1604.95	320.99	0.04
5	Tur (Arhar)	5501.55	5071.47	14200.12	9940.09	1.20
6	Lentil (Masoor)	31810.76	22212.97	39983.35	19991.68	2.06
7	Rapeseed & Mustard	281327.06	190945.59	343702.07	171851.03	22.60
8	Cotton	862.73	71.96	3436.69	2749.35	3.33
9	Jute	70332.66	142144.47	284288.95	227431.16	30.43
10	Mesta	3901.73	4503.96	9233.12	7386.50	0.99
11	Sugarcane	31284.42	1156418.28	57820.91	14455.23	1.97
12	Tobacco	148.00	68.00	68.00	68.00	0.01
13	Arecanut	67430.47	62636.43	252400.54	237256.51	31.56
14	Banana	54583.55	942799.89	2828399.68	622247.93	82.57
15	Coconut	19926.67	32261.49	103902.79	93512.51	12.83
16	Ginger	24192.44	199143.54	9957.18	3285.87	0.42
17	Castor Seed	590.96	345.41	1416.16	849.70	0.11
18	Green Gram (Moong)	12919.90	8702.53	10878.16	3263.45	0.42
19	Sesamum	10744.83	8228.62	20571.54	8228.62	1.01
20	Tapioca	3693.83	34120.76	25590.57	21751.99	2.35
21	Black gram (Urad)	64361.40	41067.52	53387.78	24558.38	2.24
22	Potato	108318.90	755327.64	611815.39	391561.85	36.45
23	Peas & Beans	33095.02	29130.93	14565.46	7282.73	0.90
	Total	**3320948.17**	**9318633.66**	**13287650.43**	**2584580.90**	**330.13**

Major contributing crops in biomass power potential in Assam (2019-20) is Rice with 90.98 MWe followed by Banana (82.57 MWe), Potato (36.45 MWe), Arecanut (31.56 MWe) and Jute (30.43 MWe)

Trend Analysis for Biomass power potential for the state of Assam – Crop-wise

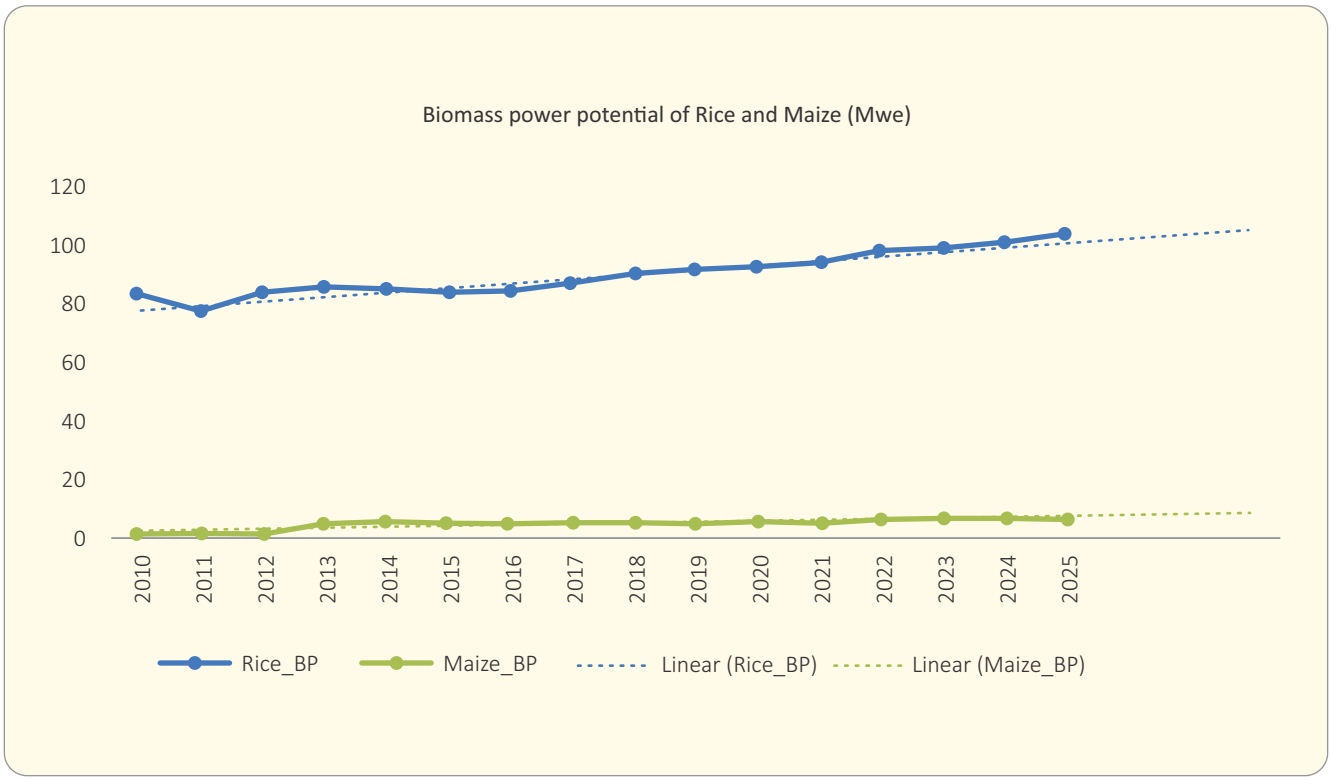


Figure 30: Biomass Power Potential for Rice and Maize in Assam

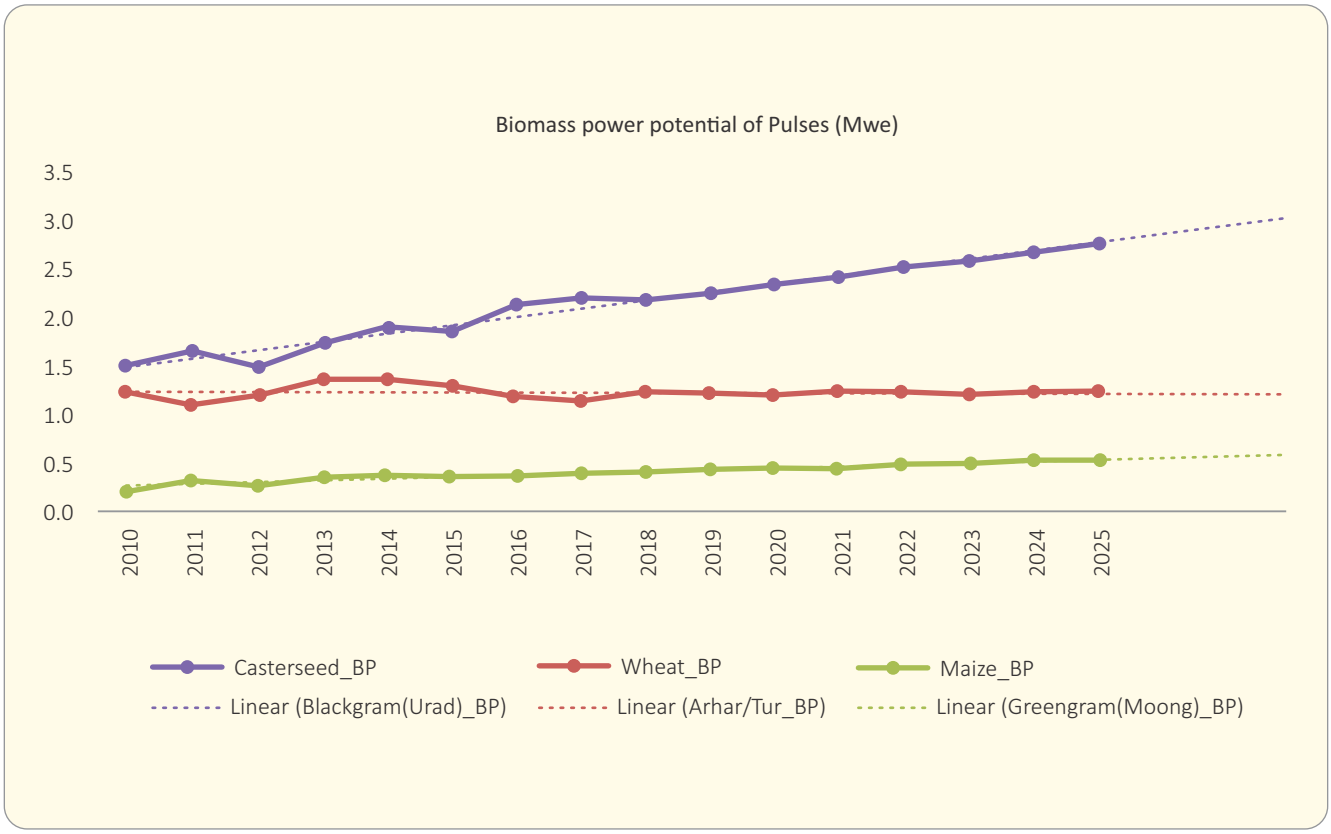


Figure 31: Biomass Power Potential for Pulses in Assam

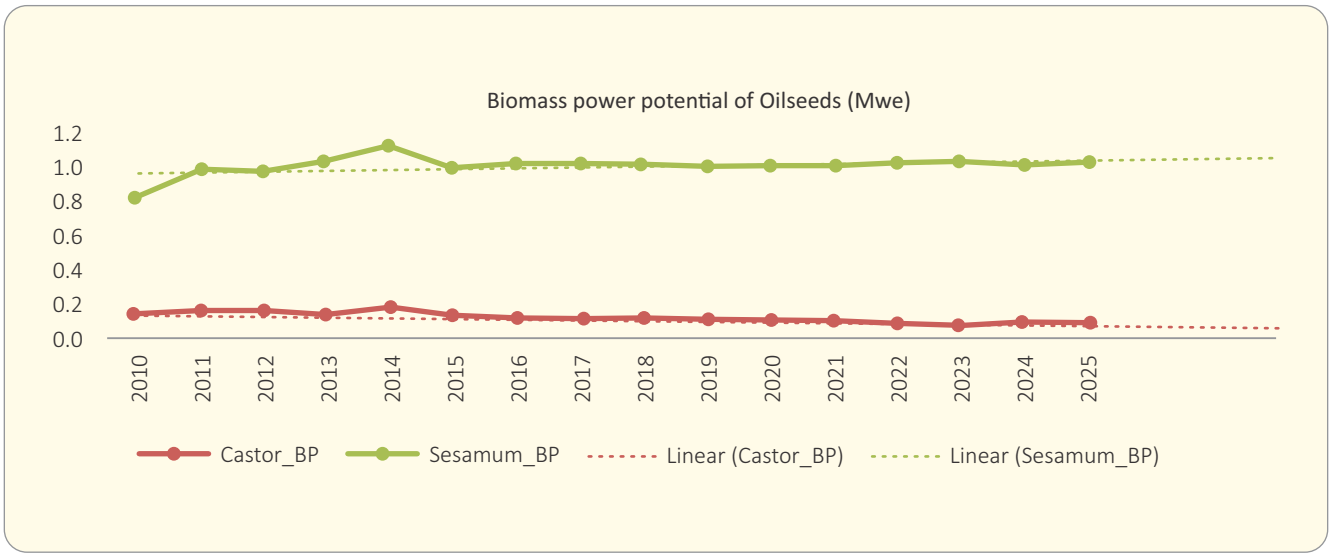


Figure 32: Biomass Power Potential for Oilseeds in Assam

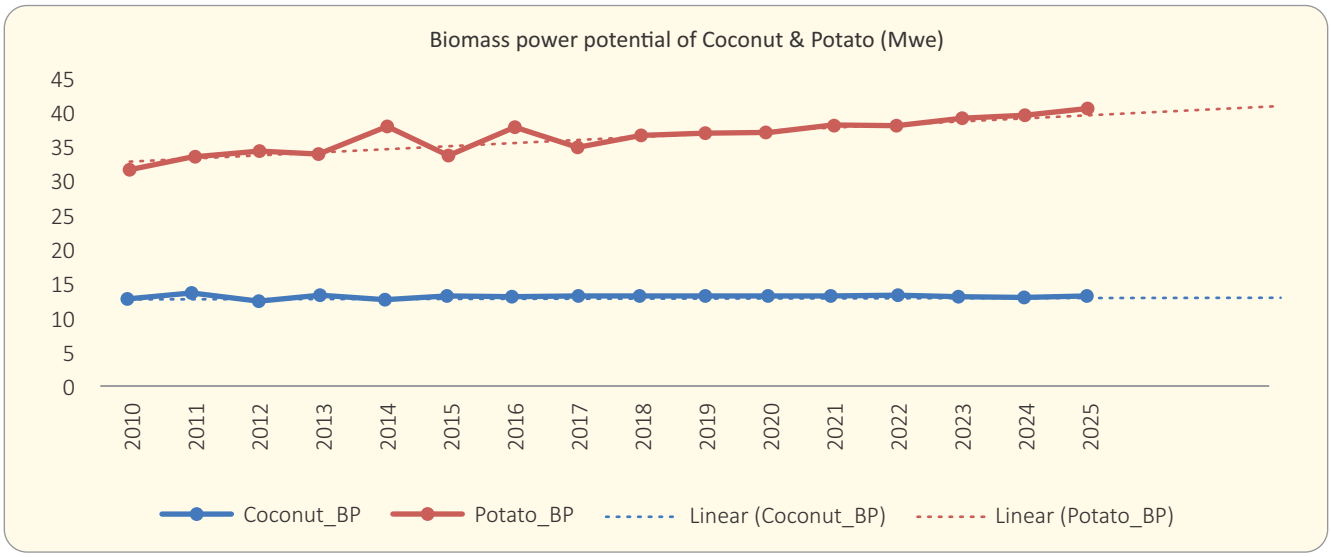


Figure 33: Biomass Power Potential for Coconut and Potato in Assam

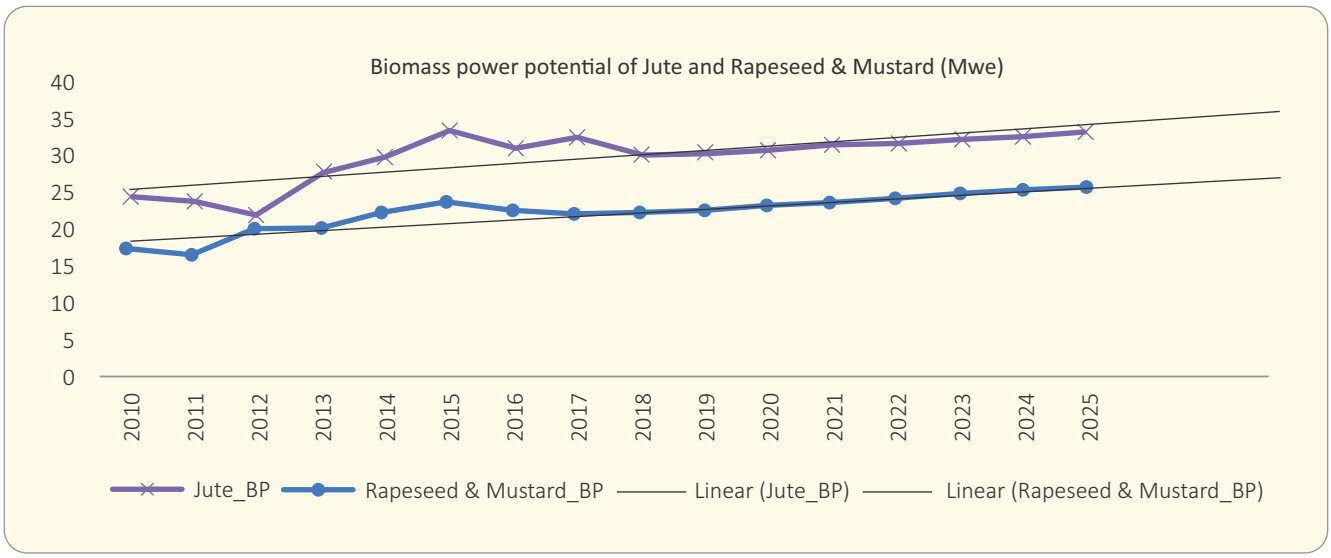


Figure 34: Biomass Power Potential for Jute and Rapeseed & Mustard in Assam

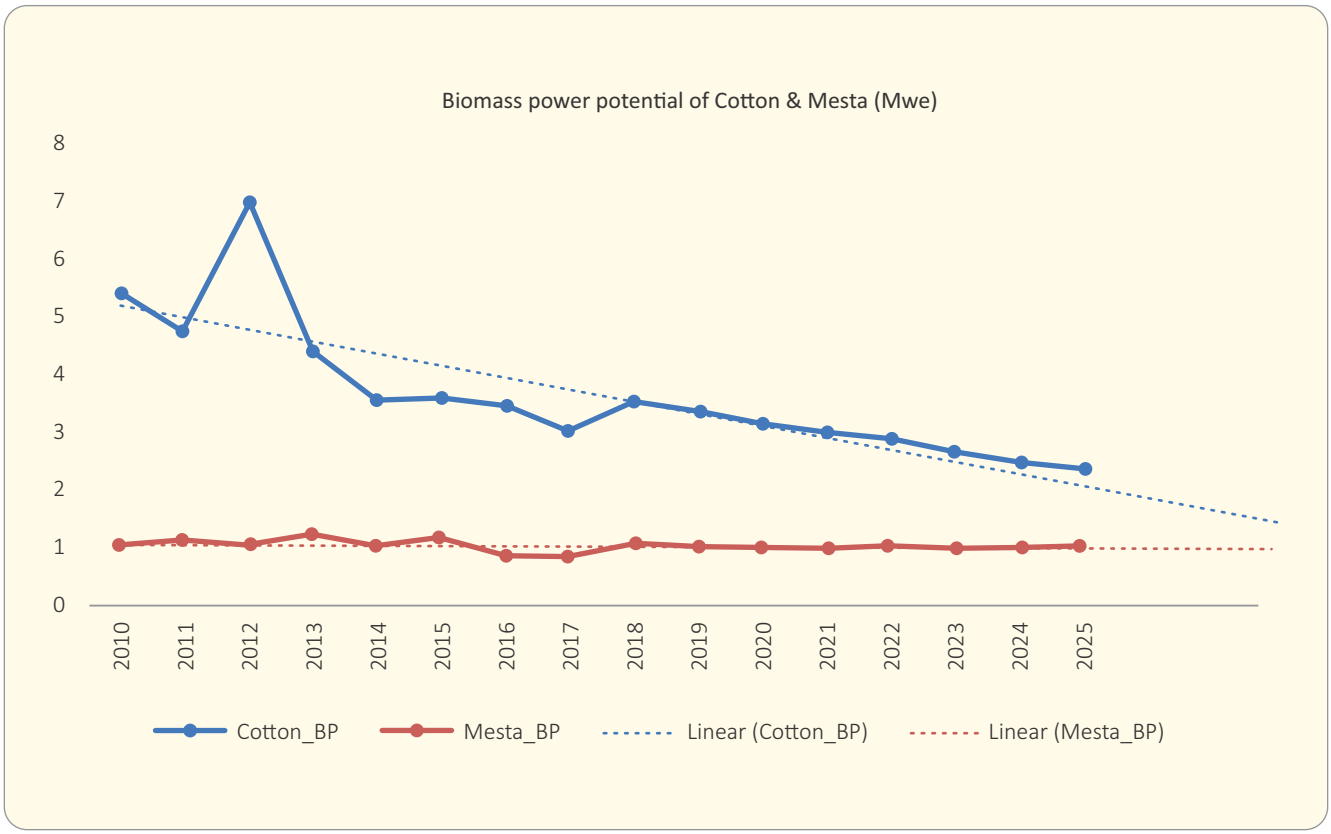


Figure 35: Biomass Power Potential for Cotton and Mesta in Assam

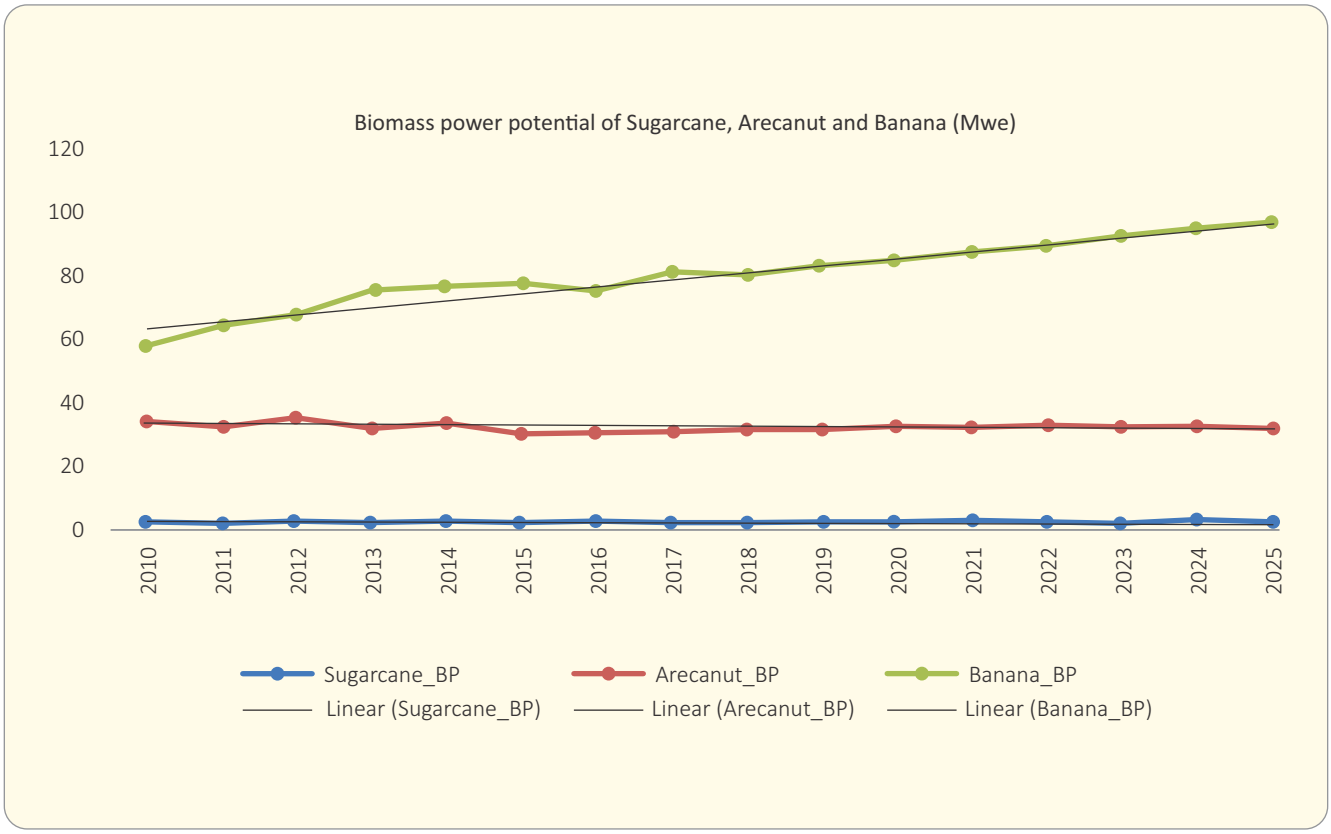


Figure 36: Biomass Power Potential for Sugarcane, Arecanut and Banana in Assam

Bihar

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Bihar collected information and samples from all thirteen (13) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Bihar was calculated, which was the input to arrive at biomass power potential in Bihar. Thus, the total biomass power potential for the state of Bihar for 2018 was 964.37 MWe and for 2019-20 is 943.40 MWe.

Districts Selected for a primary field survey	13 (Aurangabad, Darbhanga, East Champaran, Gaya, Gopalganj, Katihar, Madhepura, Muzaffarpur, Patna, Purnia, Rohtas, Vaishalil and West Champaran)
Average Rain Fall	1326 mm
Type of soil	Clay Soil, Loamy Soil, Sandy Soil, Piedmont Swamp Soil, Terri Soil
Major source of irrigation	Canals, Tube well
Major Rivers	Gandak, Ganga, Ghugri, Karcha, Mahananda, Phalagu, Punpun and Son
Major Crops	Maize, Masoor (Lentil), Moong, Potato, Rice, Sugarcane, Wheat

Utilization of Crop residue at farmer's level in Bihar:

1. **Essential Usage**: Residue of crops like Maize, Masoor, Moong, Potato, Rice and Wheat are extensively used for cattle feeding.
2. **Specific Usage**: Rice straw and husk is used for parboiling rice. The residue of Masoor, Moong and Potato are utilized for making compost fertilizer.
3. **Fuel Usage**: The stalks of rapeseed and mustard, pigeon pea, mesta, and sunflower are used as domestic fuel.
4. **Field preparation**: Stubble of Rice and Rapeseed & Mustard are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue.

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Rice (Animal feed)	3000
	Sugarcane (Brick kiln)	2000
Expected Cost against the sale of crop residue in Future	Rice (Stubble)	5000
	Rapeseed & Mustard	3000 – 4000

Survey Images:

Bazarverma, Aurangabad, Bihar

Mokkardih, Darbhanga, Bihar

Rahata, Katihar, Bihar

Table 50: Crop-wise change in Area, Production and Biomass Potential in Bihar

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	3457956.00	5047496.83	7571245.25	757124.53	102.97	3294561.83	7714405.17	11571607.75	1106708.57	150.73	46.39
Wheat	2125816.67	4523055.33	8141499.60	1628299.92	219.82	2105957.33	5608864.00	10095955.20	2019191.04	272.59	24.01
Maize	905022.33	2139761.00	4921450.30	1279577.08	149.71	703592.33	3169182.33	7289119.37	1860643.63	217.32	45.16
Barley	16341.00	18268.50	23749.05	2374.91	0.28	10716.00	15686.83	20392.88	2039.29	0.24	-15.52
Ragi	13486.33	10236.17	13307.02	1330.70	0.17	5469.83	5983.50	7778.55	777.86	0.10	-43.17
Small Millets	7743.50	5783.50	6940.20	694.02	0.09	4204.67	3176.00	3811.20	381.12	0.05	-46.64
Bajra	3758.50	4192.17	11025.40	2094.83	0.26	4032.50	4572.17	12024.80	2276.12	0.28	6.45
Jowar	3673.17	3919.50	9406.80	940.68	0.12	1686.33	1795.00	4308.00	430.80	0.05	-55.41
Moong (Green Gram)	170747.67	102181.50	127726.88	38318.06	4.90	174395.33	114513.33	143141.67	42942.50	5.48	11.91
Masoor	164291.50	127754.67	166081.07	149472.96	15.40	144983.33	144935.33	259434.25	233980.32	24.15	56.80
Gram	64292.00	59029.50	64932.45	24025.01	3.15	59004.50	64097.17	70506.88	26087.55	3.40	8.08
Arhar/Tur	31579.33	40069.00	112193.20	78535.24	9.50	21154.83	33217.33	93008.53	65105.97	7.85	-17.35
Peas & Beans (Pulses)	23976.67	23728.83	11864.42	5932.21	0.74	16635.67	17218.33	8609.17	4304.58	0.53	-27.87
Horse Gram	0.00	0.00	0.00	0.00	0.00	8488.67	7862.33	10221.03	1022.10	0.13	0
Urad	24195.67	19310.50	25103.65	12551.83	1.14	11779.33	10431.67	13561.17	6780.58	0.62	-45.81
Other Kharif Pulses	1491.00	920.50	1196.65	239.33	0.03	2124.33	1710.67	2223.87	444.77	0.05	79.39
Other Rabi Pulses	3653.50	2707.00	3519.10	351.91	0.04	2081.00	2092.50	2720.25	272.03	0.03	-17.71
Khesari	99725.83	81310.50	86024.15	25807.25	3.20	51885.17	52622.17	55672.73	16701.82	2.07	-35.28
Safflower	216.00	174.00	522.00	104.40	0.01	106.33	86.50	259.50	51.90	0.01	-43.43
Castor Seed	195.50	187.00	766.70	460.02	0.06	108.33	104.00	426.40	255.84	0.03	-46.61
Sannhamp	3391.83	11100.42	27973.05	5594.61	0.69	1183.00	955.67	2408.28	481.66	0.06	-91.34
Groundnut	1684.50	1016.50	2337.95	467.59	0.06	717.83	729.67	1678.23	335.65	0.04	-31.81
Linseed	27407.50	23021.83	34072.31	6814.46	0.69	13376.33	11348.00	16795.04	3359.01	0.34	-50.83
Sunflower	22325.33	30621.00	61242.00	55117.80	6.06	10409.50	14832.67	29665.33	26698.80	2.94	-51.54

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rapeseed & Mustard	86862.83	86418.33	155553.00	77776.50	10.19	83851.00	96856.33	174341.40	87170.70	11.42	12.06
Sesamum	3116.67	2458.50	6146.25	2458.50	0.30	2238.83	1952.83	4882.08	1952.83	0.24	-19.93
Garlic	2584.50	3922.00	1176.60	1176.60	0.16	1866.00	2830.00	849.00	849.00	0.12	-28.05
Ginger	747.00	1185.00	59.25	19.55	0.00	379.00	697.00	34.85	11.50	0.00	0
Turmeric	3143.00	3343.00	1002.90	601.74	0.08	3063.00	3082.00	924.60	554.76	0.07	-7.77
Coriander	2167.00	1573.00	1808.95	904.48	0.11	2852.00	2548.00	2930.20	1465.10	0.19	68.89
Dry chillies	2537.50	3401.00	5101.50	4081.20	0.53	0.00	0.00	0.00	0.00	0.00	-100.00
Sweet Potato	7502.00	102181.00	10234.09	6140.45	0.56	0.00	0.00	0.00	0.00	0.00	-100.00
Meshta	20116.50	32071.98	65747.56	32873.78	4.41	18953.17	25591.83	52463.25	26231.63	3.52	-20.29
Jute	2.00	219352.41	438704.82	350963.86	47.03	89649.17	105262.44	210524.88	168419.90	22.57	-52.01
Banana	17872.00	233609.00	700827.00	154181.94	20.51	0.00	0.00	0.00	0.00	0.00	-100.00
Onion	15175.00	138469.50	6923.48	1523.16	0.21	13634.00	161682.00	8084.10	1778.50	0.24	15.18
Tobacco	13330.00	22428.00	22428.00	22428.00	2.98	10020.00	17552.33	17552.33	17552.33	2.33	-21.66
Potato	305834.00	2184604.00	1769529.24	1716443.36	159.63	164701.00	2145943.00	1738213.83	1686067.42	156.97	-1.66
Sugarcane	109631.50	4499013.00	224950.65	197956.57	26.92	239256.00	12931977.00	646598.85	570592.99	77.60	188.26
Total	7895815.50	19809875.47	24834372.47	6645759.02	792.69	7279117.50	32496397.10	32572729.45	7983920.16	964.37	21.66

Table 51: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential, for Bihar in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	3118869	7785730	11678595	1167859	158.8289
2	Wheat	2146593	6142456	11056421	2211284	298.8108
3	Jowar	1145.544	1352.526	3246.063	324.6063	0.040316
4	Bajra	4661.456	5372.421	14129.47	2684.599	0.326447
5	Maize	721814	3351974	7709541	2004481	234.1634
6	Gram	53530.33	64406.86	70847.55	26213.59	3.420874
7	Tur (Arhar)	14230.42	28807.3	80660.44	56462.3	6.809354
8	Lentil (Masur)	145441.2	156076.5	280937.7	252843.9	26.0935
9	Groundnut	871.2632	904.3684	2080.047	416.0095	0.050712
10	Rapeseed & Mustard	81884.07	114671.1	206407.9	103203.9	13.57132
11	Sunflower	11570.88	16700.23	33400.46	30060.41	3.305743
12	Jute	82504.49	122296.1	244592.1	195673.7	26.17919
13	Mesta	15622.32	22556.05	46239.89	23119.95	3.093449
14	Sugarcane	277299.3	16771754	838587.7	737957.2	100.3622
15	Tobacco	8870.667	19531.32	19531.32	19531.32	2.597665
16	Green Gram (Moong)	173398.4	115581.3	144476.6	43342.99	5.5349
17	Ragi	1317.965	2942.053	3824.668	382.4668	0.047491
18	Sesamum	1691.421	1668.895	4172.237	1668.895	0.205274
19	Black Gram (Urad)	7243.474	8557.14	11124.28	5562.141	0.506155
20	Potato	47303.44	803004.1	650433.3	630920.3	58.73868
21	Barley	8077.228	14575.95	18948.73	1894.873	0.219805
22	Peas & Beans	14861.72	16137.11	8068.553	4034.276	0.499564
	Total	**6938802**	**35567056**	**33126266**	**7519922**	**943.4058**

Major contributing crops in biomass power potential in Bihar (2019-20) is Wheat with 298.81 MWe followed by Maize (234.16 MWe), Rice (158.82 MWe), Sugarcane (100.36 MWe) and Potato (58.73 MWe)

Trend Analysis for Biomass power potential for the state of Bihar – Crop-wise

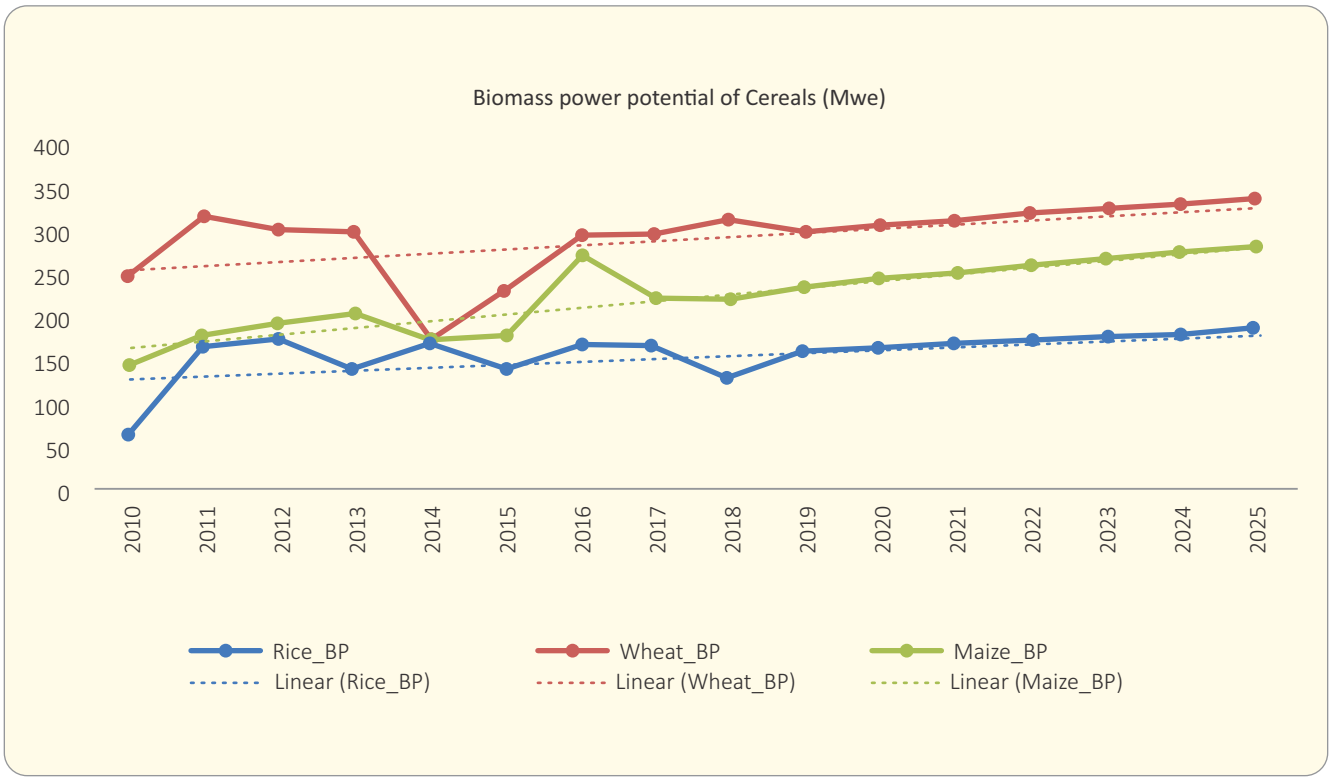


Figure 37: Biomass Power Potential for Cereals in Bihar

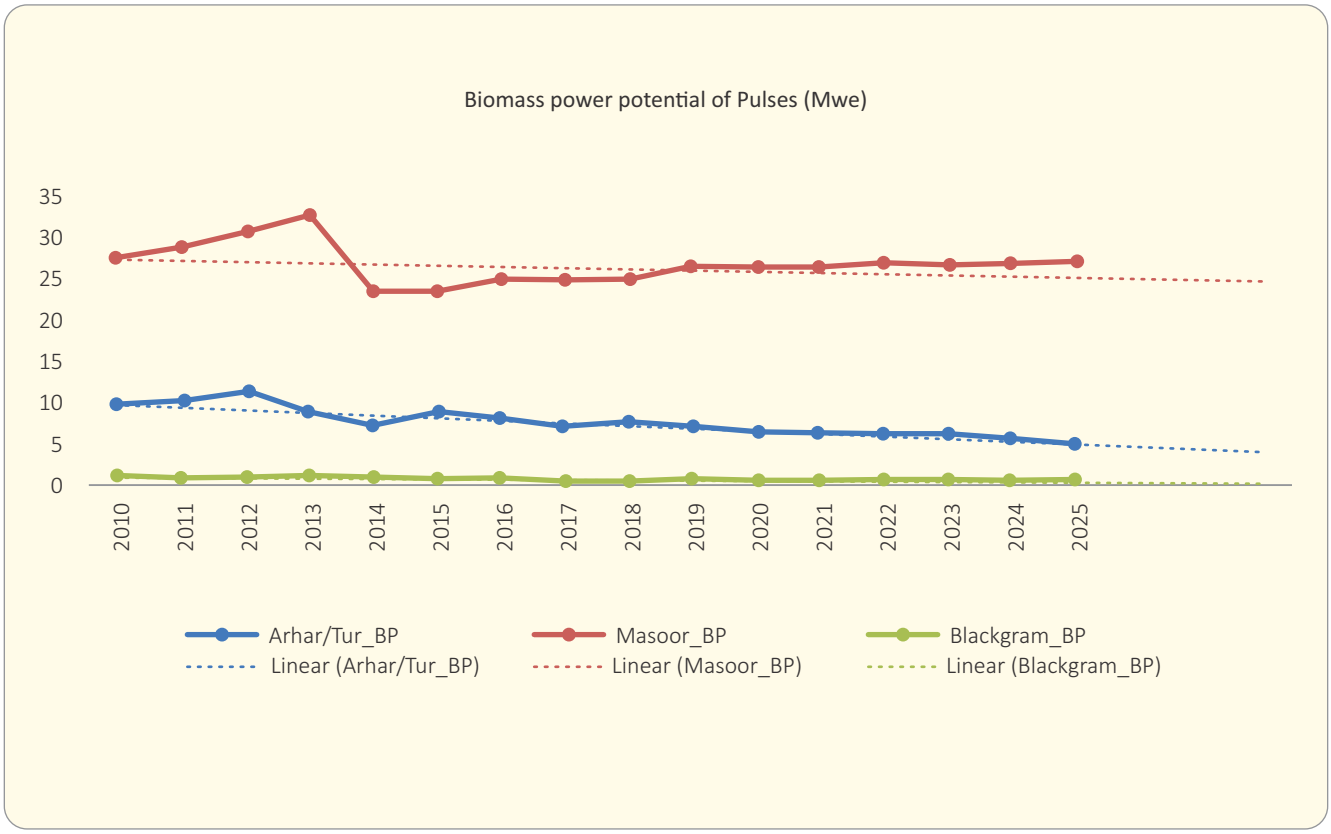


Figure 38: Biomass power potential for Pulses in Bihar

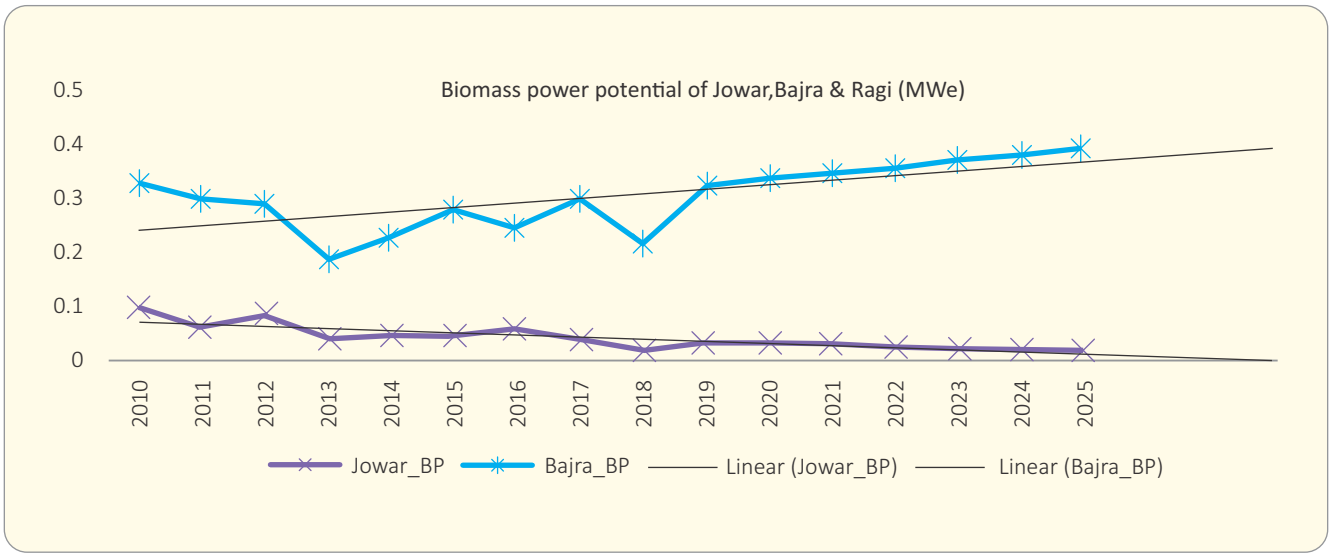


Figure 39: Biomass power potential for Jowar and Bajra in Bihar

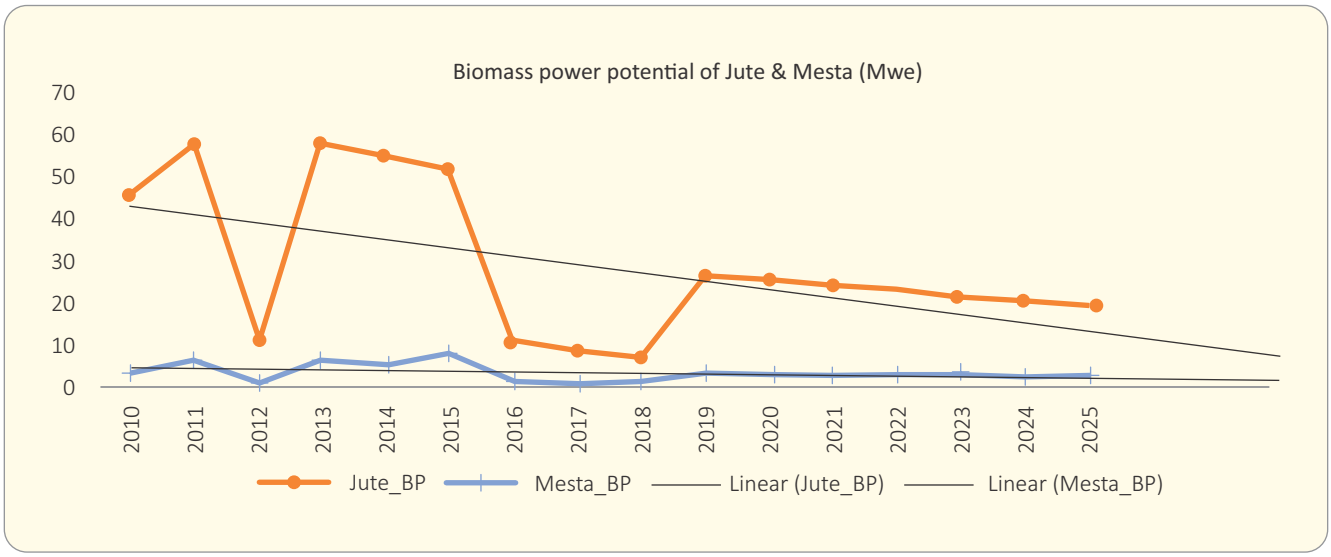


Figure 40: Biomass power potential for Jute & Mesta in Bihar

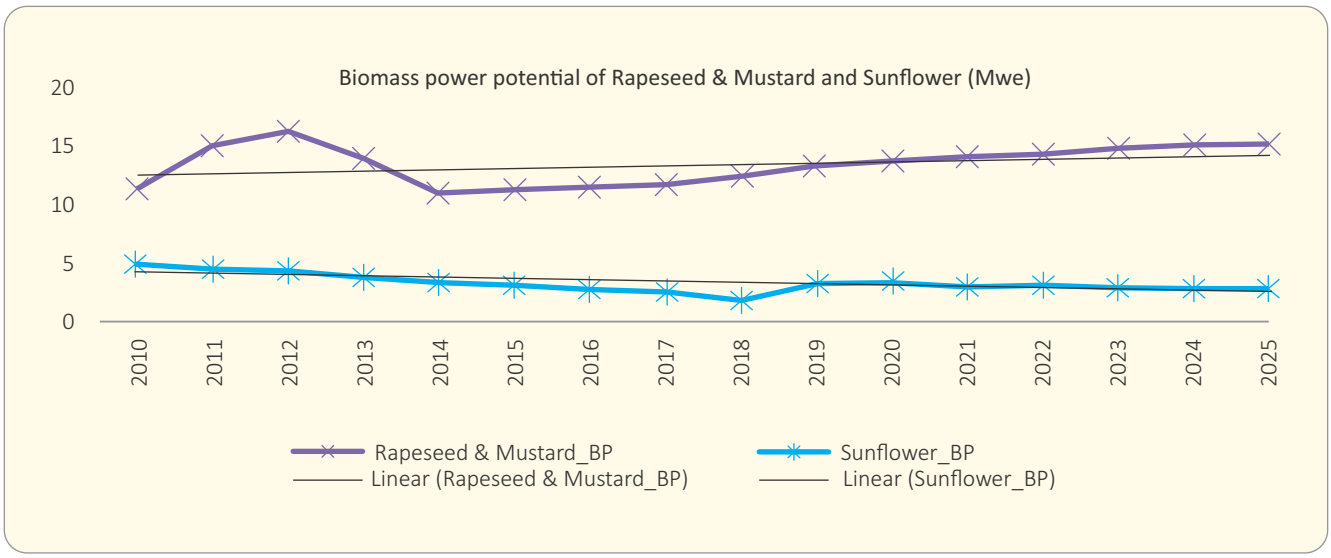


Figure 41: Biomass power potential of Rapeseed & Mustard and Sunflower in Bihar

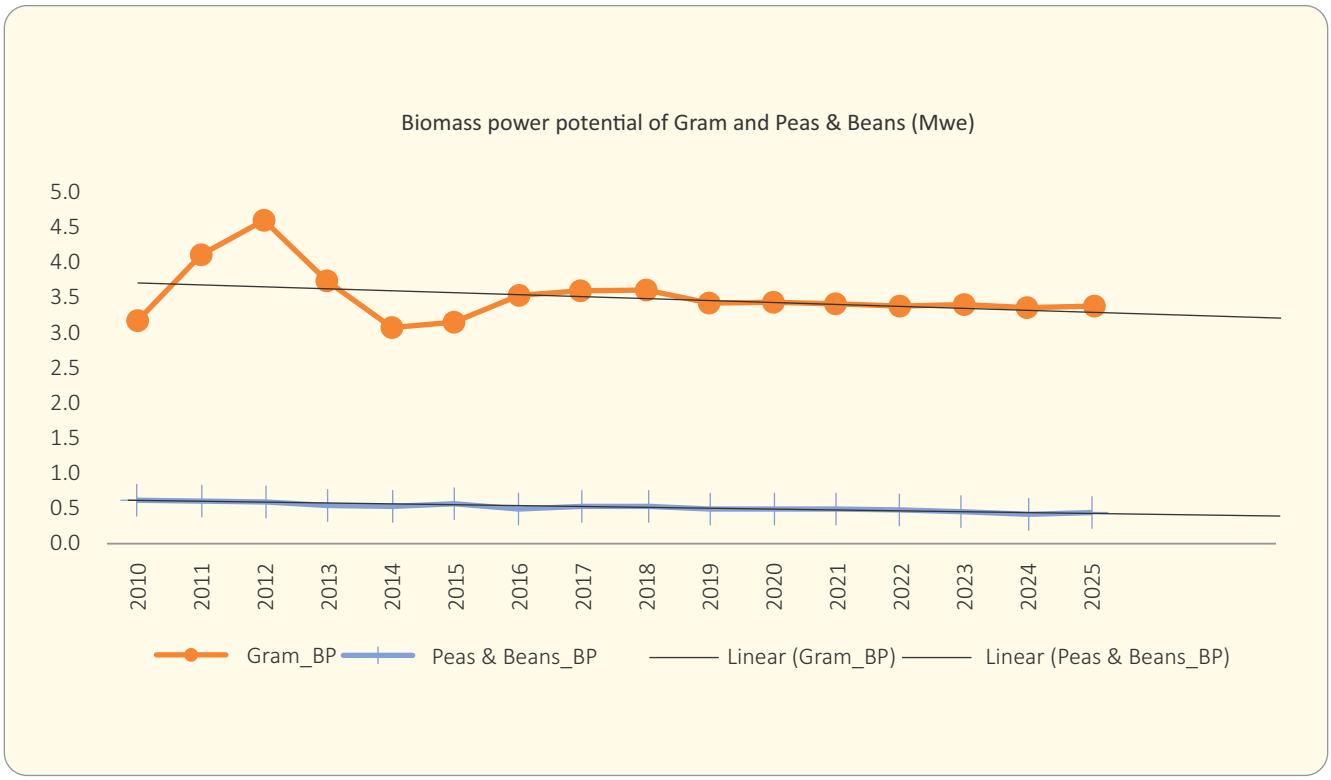


Figure 42: Biomass power potential for Gram and Peas & Beans in Bihar

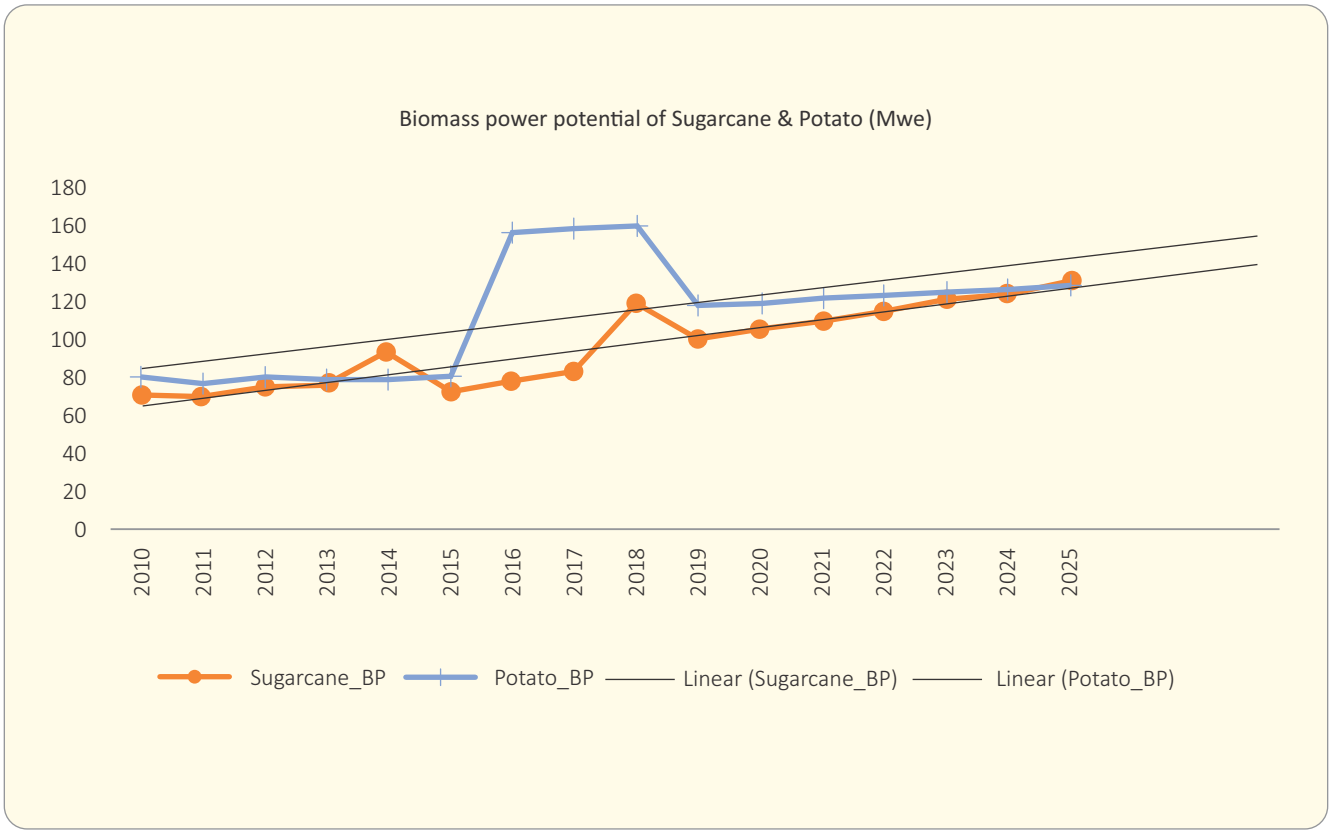
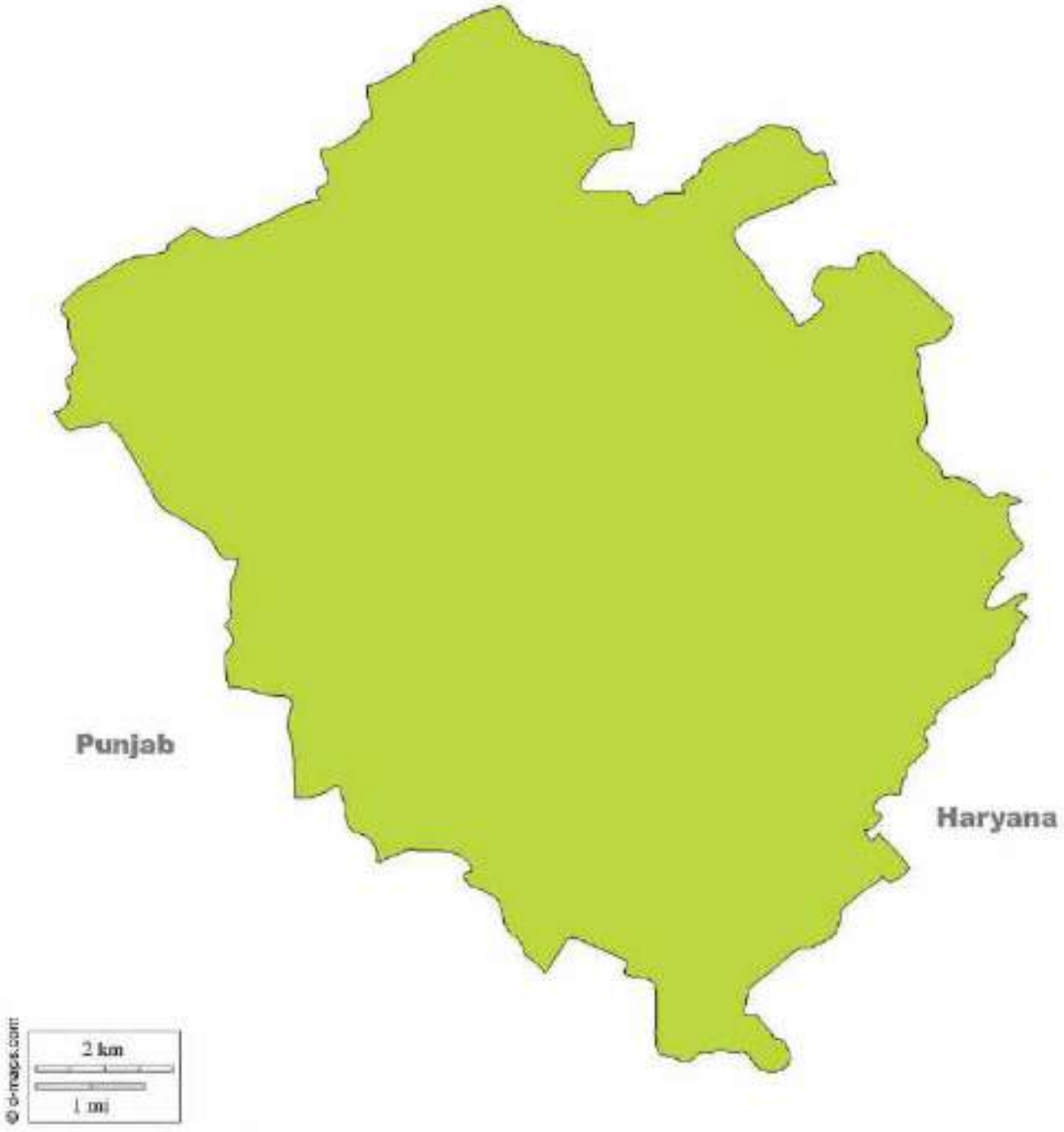


Figure 43: Biomass power potential for Sugarcane & Potato in Bihar

Chandigarh



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Chandigarh collected information and samples from one (01) district to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Chandigarh was calculated, which was the input to arrive at biomass power potential in Chandigarh. Thus, the total biomass power potential for the state of Chandigarh for 2018 was 0.15 MWe and for 2019-20 is 0.122 MWe.

Districts Selected for Primary Field Survey	01 (Chandigarh)
Average Rainfall	617 mm
Type of soil	Sandy, Silt, Loamy
Major source of irrigation	Deep bore wells, tube wells
Major Rivers	Ghaggar
Major Crops	Wheat, Rice

Utilization of Crop residue at farmer's level in Chandigarh:

1. **Essential Usage**: Most of the residue from Rice and Wheat are utilized for cattle feeding.
2. **Specific Usage**: Some of the Rice and Wheat residue are used for making compost fertilizer
3. **Field preparation**: Stubble of Rice and Wheat are burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant or brick kiln and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Rice (cowshed)	2000 – 4000
	Wheat (cowshed)	2000 – 4000
Expected Cost against the sale of crop residue in Future	Rice	5000 – 6000
	Wheat	5000 – 6000

Survey Images:

Baltana, Chandigarh

Raipurkalan, Chandigarh

Baltana, Chandigarh

Table 52: Crop-wise change in Area, Production and Biomass Potential in Chandigarh

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	40.00	200.00	300.00	240.00	0.03	16.00	81.67	122.50	98.00	0.01	-59.17
Wheat	600.00	2766.67	4980.00	996.00	0.13	550.00	2538.33	4569.00	913.80	0.12	-8.25
Maize	33.33	68.33	157.17	31.43	0.00	22.50	45.00	103.50	20.70	0.00	-34.15
Potato	10.00	176.67	143.10	94.45	0.01	10.00	152.50	123.53	81.53	0.01	-13.68
Onion	3.33	57.67	2.88	0.63	0.00	3.00	70.00	3.50	0.77	0.00	21.39
Total	**686.67**	**3269.33**	**5583.15**	**1362.51**	**0.18**	**601.50**	**2887.50**	**4922.03**	**1114.80**	**0.15**	**-11.84**

Table 53: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Chandigarh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	10	55	82.5	66	0.008976
2	Wheat	503.4183	2334.829	4202.692	840.5383	0.113582
3	Potato	0	0	0	0	0
	Total	**513.4183**	**2389.829**	**4285.192**	**906.5383**	**0.122558**

The major contributing crops in biomass power potential in Chandigarh (2019-20) is Wheat with 0.11 MWe, followed by Rice (0.0089 MWe).

Chhattisgarh

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Chhattisgarh collected information and samples from all ten (10) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Chhattisgarh was calculated, which was the input to arrive at biomass power potential in Chhattisgarh. Thus, the total biomass power potential for the state of Chhattisgarh for 2018 was 353.68 MWe and for 2019-20 is 377.08 MWe.

Districts Selected for Primary Field Survey	10 (Bemetara, Dantewada, Durg, Kabirdham, Kanker, Kondagaon, Mahasamund, Mungeli, Raigarh and Rajnadgaon)
Average Rainfall	1292 mm
Type of soil	Black Soil, Red Sandy Soil, Red-Yellow Soil
Major source of irrigation	Canals, Tube wells, River
Major Rivers	Indravati and Mahanadi
Major Crops	Gram, Groundnut, Maize, Paddy, Soyabean and Wheat

Utilization of Crop residue at farmer's level in Chhattisgarh:

1. **Essential Usage**: Residue of Maize and Gram are extensively utilized for cattle feeding; apart from that residue of Rice, Soyabean and Wheat are also used for cattle feeding.
2. **Specific Usage**: some part of crop residue of Gram, Groundnut, Maize, Rice, Soyabean and Wheat are also utilized for compost fertilizer.
3. **Fuel Usage**: The residue of Rice, Soyabean and Wheat are also used for domestic cooking.
4. **Field preparation**: In order to prepare the land for future sowing in a short duration and with less effort, the residue of crops like Rice, Wheat and Soyabean are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Rice	3000
	Wheat	3000
Expected Cost against the sale of crop residue in Future	Rice	4000 – 5000
	Soyabean	4000 – 5000
	Wheat	5000 – 6000

Survey Images:

Baghra, Kabirdham, Chhattisgarh

Bedma, Kondagaon, Chhattisgarh

Bijtarai, Mungeli, Chhattisgarh

Table 54: Crop-wise change in Area, Production and Biomass Potential in Chhattisgarh

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	3912338.33	5261332.00	7891998.00	1578399.60	214.66	4016011.00	7308449.00	10962673.50	2189539.43	298.22	38.92
Wheat	94356.67	98641.83	177555.30	35511.06	4.79	103698.50	148910.00	268038.00	53607.60	7.24	51.09
Maize	100037.00	140154.33	322354.97	48353.25	5.66	123992.33	260671.33	599544.07	86933.89	10.15	79.40
Ragi	9240.67	2574.67	3347.07	334.71	0.04	7621.67	1751.67	2277.17	227.72	0.03	-29.29
Small millets	196572.33	42845.33	51414.40	5141.44	0.65	114494.50	23182.00	27818.40	2781.84	0.35	-46.08
Bajra	92.33	42.33	111.34	21.15	0.00	127.00	79.00	207.77	39.33	0.00	0
Barley	3366.67	3228.00	4196.40	419.64	0.05	2290.83	2163.83	2812.98	281.30	0.03	-34.74
Jowar	6121.17	6236.33	14967.20	1496.72	0.19	4830.67	4699.17	11278.00	1127.80	0.14	-26.28
Moong (Green Gram)	16290.00	4188.00	5235.00	1570.50	0.20	15501.17	5719.67	7149.58	2144.88	0.27	36.95
Masoor	16326.00	5355.67	9586.64	4793.32	0.49	16547.33	5761.67	10313.38	5156.69	0.53	8.61
Gram	237439.67	198728.67	218601.53	13116.09	1.72	288283.00	289439.00	318382.90	20467.47	2.67	55.29
Arhar/Tur	51132.00	25944.00	72643.20	50850.24	6.15	61306.67	34907.00	97739.60	68417.72	8.25	34.17
Peas & Beans (Pulses)	16476.00	5922.33	2961.17	1480.58	0.18	13445.00	5140.67	2570.33	1285.17	0.16	-11.47
Urad	113381.00	33997.67	44196.97	22098.48	2.01	95739.33	29859.33	38817.13	19408.57	1.77	-12.03
Horse-gram	52489.50	16564.33	21533.63	2153.36	0.27	44456.00	15242.83	19815.68	1981.57	0.25	-6.79
Other Kharif pulses	6827.67	1816.00	2360.80	472.16	0.06	8163.00	1699.50	2209.35	441.87	0.05	-10.89
Other Rabi pulses	2678.67	399.00	518.70	51.87	0.01	2588.00	393.00	510.90	51.09	0.01	-38.18
Sunhamp	1536.67	512.00	1290.24	258.05	0.03	1327.33	562.00	1416.24	283.25	0.04	17.08
Groundnut	31595.50	38482.33	88509.37	17701.87	2.16	28289.17	41655.67	95808.03	19161.61	2.34	8.14
Niger seed	71944.33	12780.50	13547.33	1354.73	0.16	62865.67	10994.33	25067.08	2506.71	0.30	87.53
Rapeseed &Mustard	52620.00	20707.00	37272.60	18636.30	2.44	45254.00	22993.67	41388.60	20694.30	2.71	11.10
Linseed	56040.33	15432.00	22839.36	4567.87	0.46	26238.00	10316.50	15268.42	3053.68	0.31	-32.95
Sunflower	5760.67	2299.33	4598.67	4138.80	0.46	2588.50	624.33	1248.67	1123.80	0.12	-73.13
Sesamum	20846.33	6418.67	16046.67	6418.67	0.79	18446.00	7709.33	19273.33	7709.33	0.95	20.03

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Safflower	749.33	179.00	537.00	107.40	0.01	765.00	240.33	721.00	144.20	0.02	57.18
Castor seed	108.00	39.50	161.95	97.17	0.01	168.50	47.50	194.75	116.85	0.01	46.30
Soyabean	72902.33	75921.33	129066.27	21941.27	2.74	0.00	0.00	0.00	0.00	0.00	-100.00
Turmeric	891.67	792.33	237.70	142.62	0.02	1894.00	1644.33	493.30	295.98	0.04	96.83
Coriander	3285.33	923.67	1062.22	531.11	0.07	2340.17	677.67	779.32	389.66	0.05	-29.42
Garlic	916.17	2519.00	755.70	755.70	0.10	1197.50	3105.00	931.50	931.50	0.13	26.31
Ginger	1861.33	2079.00	103.95	34.30	0.00	1939.67	2366.33	118.32	39.04	0.00	0
Dry chillies	6095.67	3176.67	4765.00	3812.00	0.50	6868.67	3677.67	5516.50	4413.20	0.57	14.48
Khesari	413827.00	329773.67	349560.09	104868.03	13.00	305983.00	235174.00	249284.44	74785.33	9.27	-28.67
Mesta	1391.33	494.49	1013.70	506.85	0.07	1129.83	358.23	734.37	367.19	0.05	-29.71
Onion	4396.33	22081.17	1104.06	242.89	0.03	5017.67	30105.33	1505.27	331.16	0.05	50.13
Tobacco	21.33	14.33	14.33	14.33	0.00	25.00	13.00	13.00	13.00	0.00	0
Sugarcane	9330.33	23266.67	1163.33	290.83	0.04	21017.83	77550.00	3877.50	969.38	0.13	229.59
Potato	11606.50	48016.00	38892.96	25669.35	2.39	12624.33	72624.00	58825.44	38824.79	3.61	51.24
Banana	383.00	14246.33	42739.00	9402.58	1.25	1147.67	31316.50	93949.50	20668.89	2.74	119.42
Sweet potato	2679.00	15149.67	1517.34	910.40	0.08	2553.50	14371.67	1439.42	863.65	0.08	-1.76
Cotton	66.33	17.68	290.96	232.77	0.03	76.33	22.30	339.12	271.30	0.03	9.33
Total	**5606020.50**	**6483292.84**	**9600672.10**	**1988900.08**	**263.99**	**5468853.33**	**8706218.36**	**12990351.87**	**2651851.72**	**353.68**	**33.98**

Table 55: Crop-wise Area, Crop Production, Biomass Production, Surplus biomass and Biomass Power Potential for Chhattisgarh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	4060859.00	8007828.00	12011743.00	2402349.00	326.71
2	Wheat	108160.70	160153.80	288276.80	57655.36	7.79
3	Jowar	3185.97	3913.64	9392.74	939.27	0.11
4	Bajra	181.05	93.11	244.90	46.53	0.00
5	Maize	128090.50	302551.80	695869.20	104380.40	12.19
6	Gram	335510.10	349982.40	384980.70	23098.84	3.01
7	Tur (Arhar)	60864.28	33331.91	93329.35	65330.54	7.87
8	Lentil (Masur)	15838.66	5582.89	10049.21	5024.60	0.51
9	Groundnut	25585.29	40566.23	93302.33	18660.47	2.27
10	Soyabean	136365.60	98336.04	167171.30	28419.12	3.55
11	Rapeseed & Mustard	44257.34	24065.17	43317.31	21658.65	2.84
12	Sunflower	2601.54	395.46	790.93	711.84	0.07
13	Cotton	132.36	40.11	591.25	473.00	0.05
14	Mesta	1090.23	345.04	707.34	353.67	0.47
15	Sugarcane	23954.23	74266.36	3713.31	928.32	0.12
16	Tobacco	5.57	2.96	2.96	2.96	0.00
17	Banana	1368.80	36032.12	108096.40	23781.20	3.15
18	Ginger	2082.67	2652.32	132.61	43.76	0.00
19	Caster Seed	50.21	16.93	69.42	41.65	0.00
20	Green Gram (Moong)	14631.75	5279.66	6599.58	1979.87	0.25
21	Ragi	6715.47	1595.85	2074.60	207.46	0.02
22	Sesamum	16003.64	7138.92	17847.30	7138.92	0.87
23	Black Gram (Urad)	86874.20	28119.94	36555.93	18277.96	1.66
24	Potato	13308.44	65553.71	53098.50	35045.01	3.26
25	Barley	1362.38	1129.43	1468.26	146.82	0.01
26	Peas & Beans	14042.98	5260.44	2630.22	1315.11	0.16
	Total	**5103123**	**9254235**	**14032055**	**2818010**	**377.08**

Major contributing crops in biomass power potential in Chhattisgarh (2019-20) is Rice with 326.71 MWe followed by Maize (12.19 MWe), Arhar/Tur (7.87 MWe), Wheat (7.79 MWe) and Soyabean (3.55 MWe)

Trend Analysis for Biomass power potential for the state of Chhattisgarh – Crop-wise

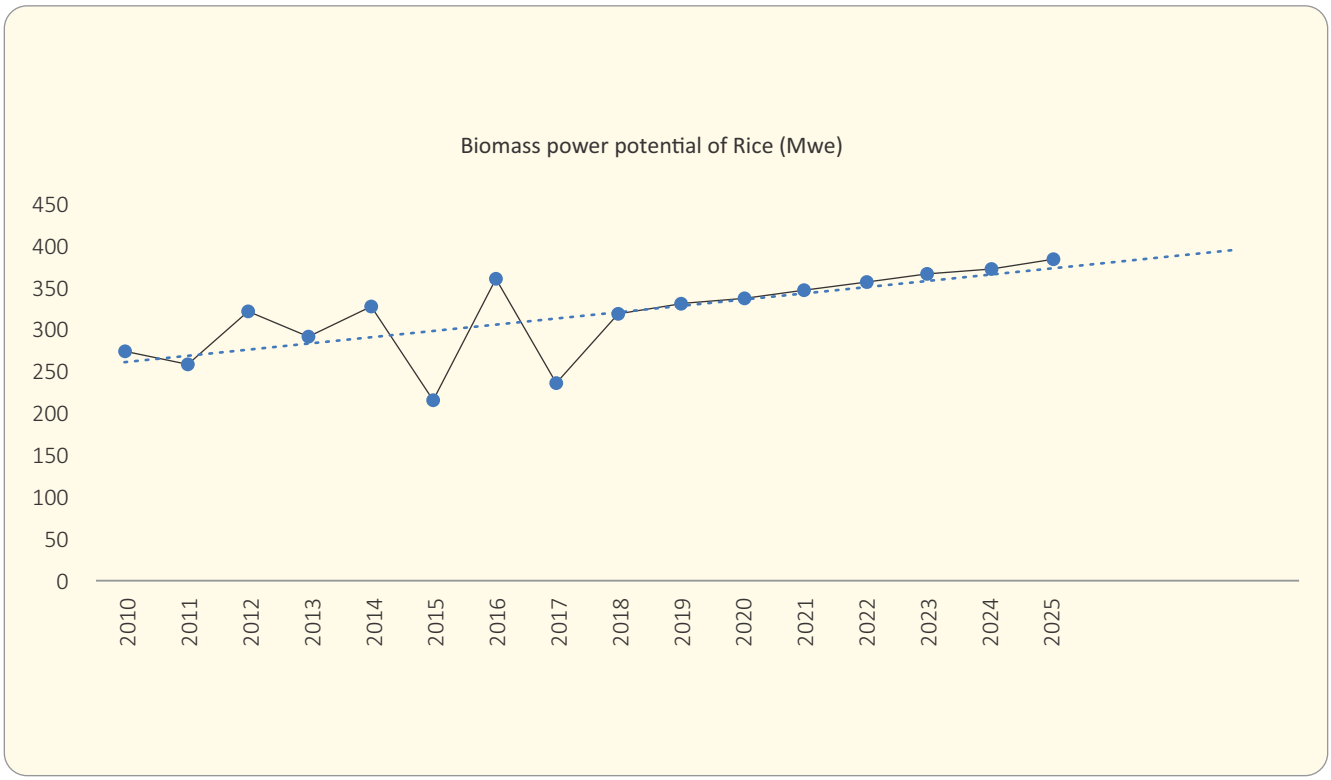


Figure 44: Biomass power potential for Rice in Chhattisgarh

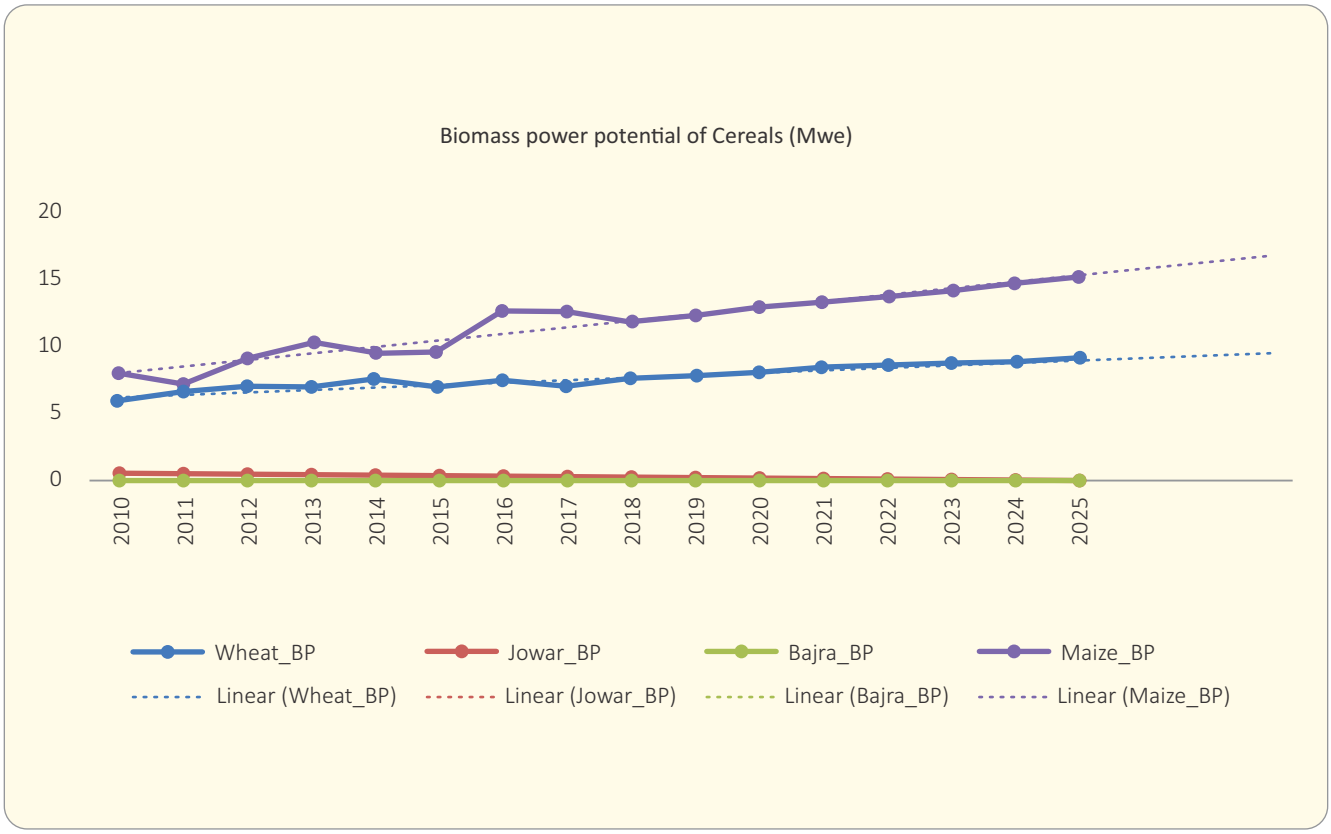


Figure 45: Biomass power potential for Cereals in Chhattisgarh

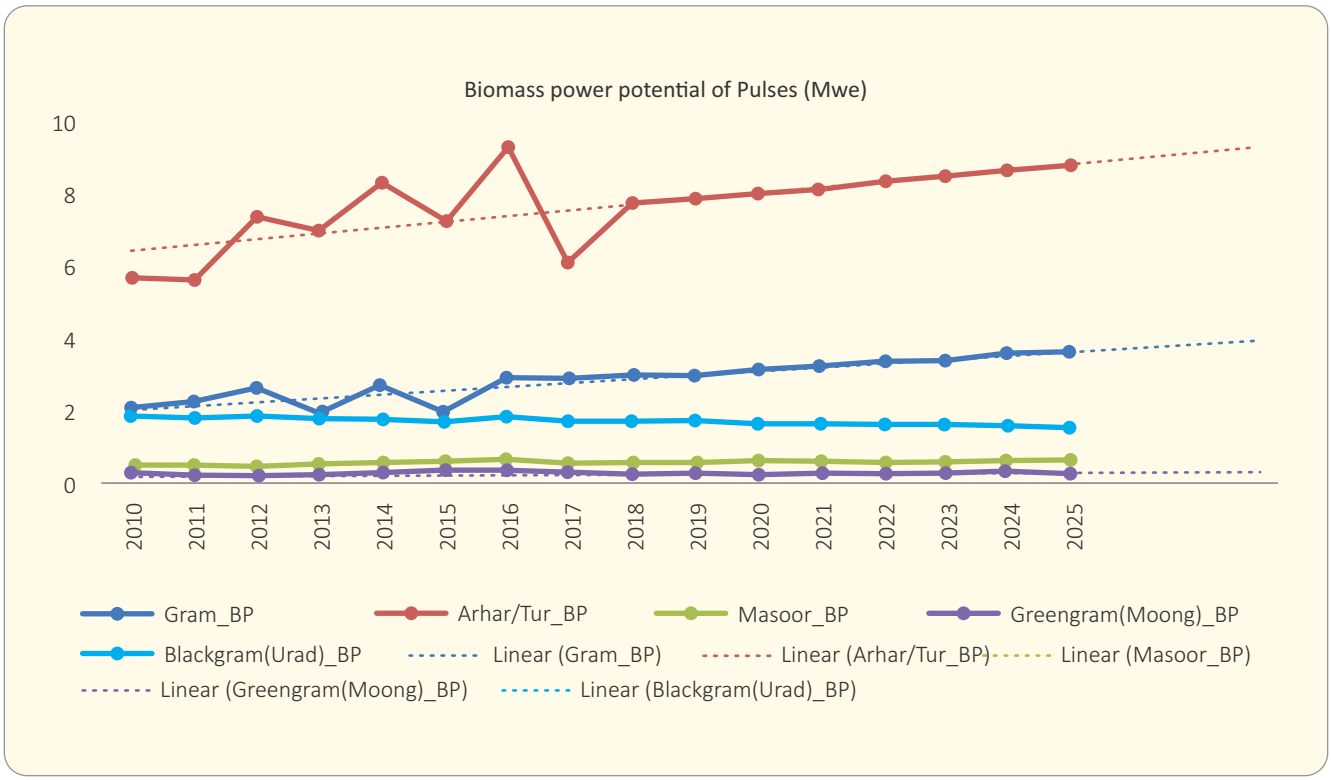


Figure 46: Biomass power potential for Pulses in Chhattisgarh

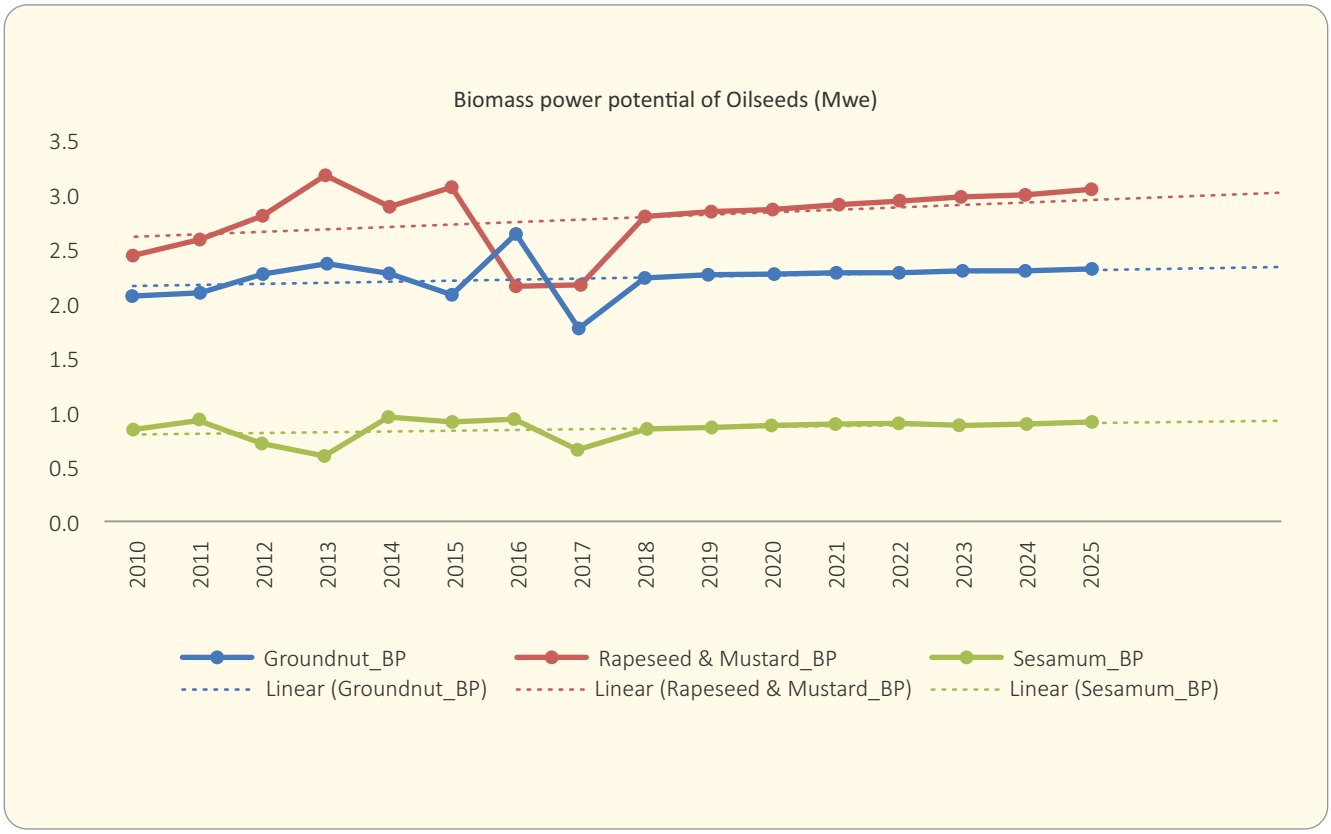


Figure 47: Biomass power potential for Oilseeds in Chhattisgarh

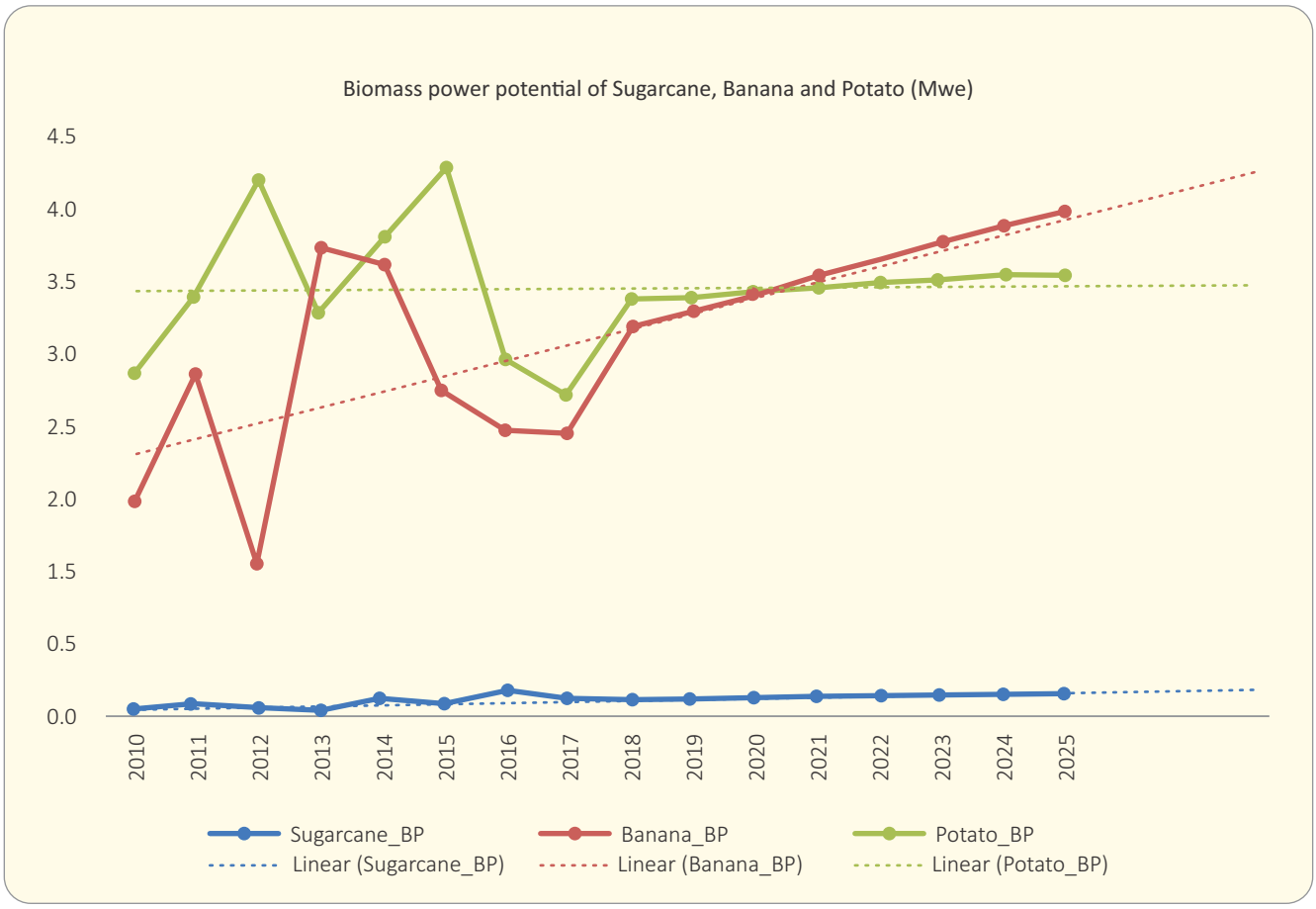
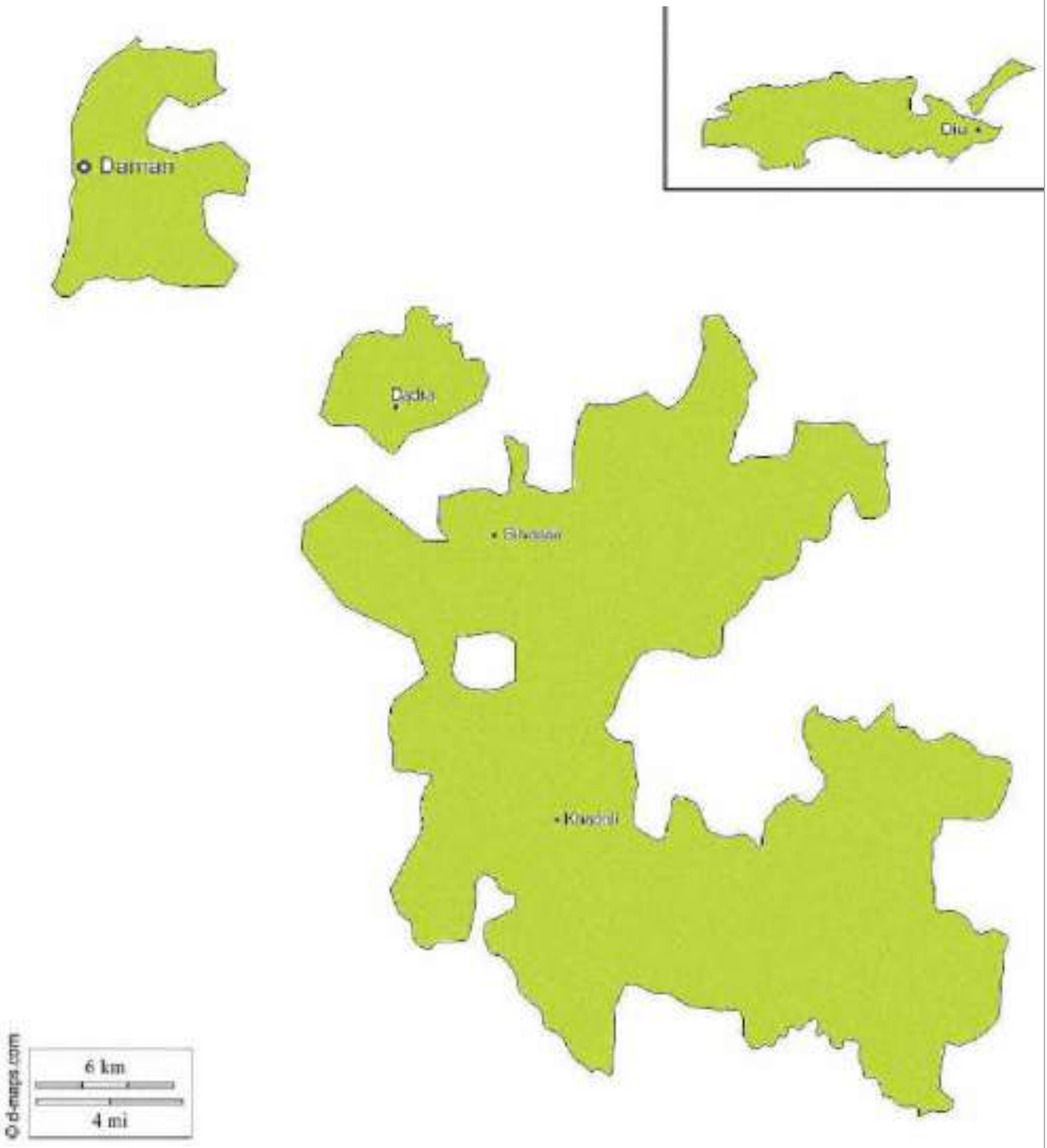


Figure 48: Biomass power potential for Sugarcane, Banana and Potato in Chhattisgarh

Dadra and Nagar Haveli



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Dadra and Nagar Haveli collected information and samples from all one (01) district to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Dadra and Nagar Haveli was calculated, which was the input to arrive at biomass power potential in Dadra and Nagar Haveli. Thus, the total biomass power potential for the state of Dadra and Nagar Haveli for 2018 was 2.16 MWe and for 2019-20 is 1.6 MWe.

Districts Selected for primary field survey	01 (Dadra and Nagar Haveli)
Average Rainfall	2110 mm
Type of soil	Clay Loam and Shallow soil
Primary source of irrigation	Canals, Dam and Open wells.
Major Rivers	Damanganga, Kalai and Kolak
Major Crops	Bajra, Banana, Coconut, Jowar, Mangoes, Maize, Moong, Paddy, Pulses, Ragi, Sapota, Small Millets and Wheat.

Utilization of Crop residue at farmer's level in Dadra and Nagar Haveli:

1. **Essential Usage**: Residue of Bajra, Banana, Jowar, Maize, Moong, Ragi and Small millets are extensively used for cattle feeding.
2. **Specific Usage**: other agricultural residues like leaves of Mango, Sapota, coconut (Fronds) and residue of Moong are mainly utilized for making compost fertilizer.
3. **Fuel Usage**: The shells of coconut, Stalk of Paddy, Pulses and Wheat are used as domestic fuel.
4. **Field preparation**: In order to prepare the land for further sowing, stubbles of Rice, Soyabean, Bajra, Jowar and Wheat are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	3000
	Paddy	5000
Expected Cost against the sale of crop residue in Future	Pulses	1000
	Ragi	1000
	Other	5000

Major contributing crops in biomass power potential in Dadra and Nagar Haveli (2019-20) is Cotton with 474.25 MWe, followed by Maize (399.28 MWe), Banana (363.78 MWe), Other Oilseeds (344.24 MWe) and Rice (328.11 MWe)

Survey Images:

Atholo, Dadar & Nagar Haveli

Bhimpura, Daman & Diu

Daman and Diu

As explained in chapter-02, based on secondary data, the survey teams in Daman and Diu collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Daman and Diu was calculated, which was the input to arrive at biomass power potential in Daman and Diu.

Districts Selected for Primary Field Survey	01 (Daman)
Average Rainfall	1899 mm
Type of soil	Black Soil, Red Soil
Major source of irrigation	Canals, Tube wells and Rivers
Major Rivers	Damanganga
Major Crops	Bajra, Coriander, Garlic, Maize, Soyabean and Wheat

Utilization of Crop residue at farmer's level in Daman and Diu:

1. **Essential Usage**: The residue of crops like Bajra, Coriander, Gram and Maize are extensively used for cattle feeding. Apart from that, Soyabean and Wheat are also used for cattle feeding.
2. **Fuel Usage**: Residue of Soyabean and Wheat is used for domestic cooking
3. **Field preparation**: The residue of crop like Garlic and Stubble of Wheat are burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Wheat	8000 – 12000
	Soyabean	8000 – 12000

Table 56: Crop-wise Area, Production, Biomass, Surplus biomass and Biomass Power Potential for Dadra & Nagar Haveli and Daman & Diu in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	15156.00	27687.30	41530.90	7060.20	1.0
2	Wheat	139.00	309.00	556.20	111.20	0.0
3	Jowar	330.20	235.60	565.50	56.60	0.0
4	Maize	96.50	97.10	223.20	44.60	0.0
5	Gram	48.10	51.20	56.30	11.30	0.0
6	Bajra	467.40	626.00	1646.40	296.30	0.0
7	Tur (Arhar)	1141.20	1605.00	4494.10	3145.80	0.4
8	Sugarcane	578.00	52890.00	2644.50	661.10	0.1
9	Black Gram (Urad)	1315.00	1186.60	1542.50	771.30	0.1
	Total	**19271.50**	**84687.80**	**53259.60**	**12158.50**	**1.6**

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Cotton with 474.25 MWe, followed by Maize (399.28 MWe), Banana (363.78 MWe), Other Oilseeds (344.24 MWe) and Rice (328.11 MWe)

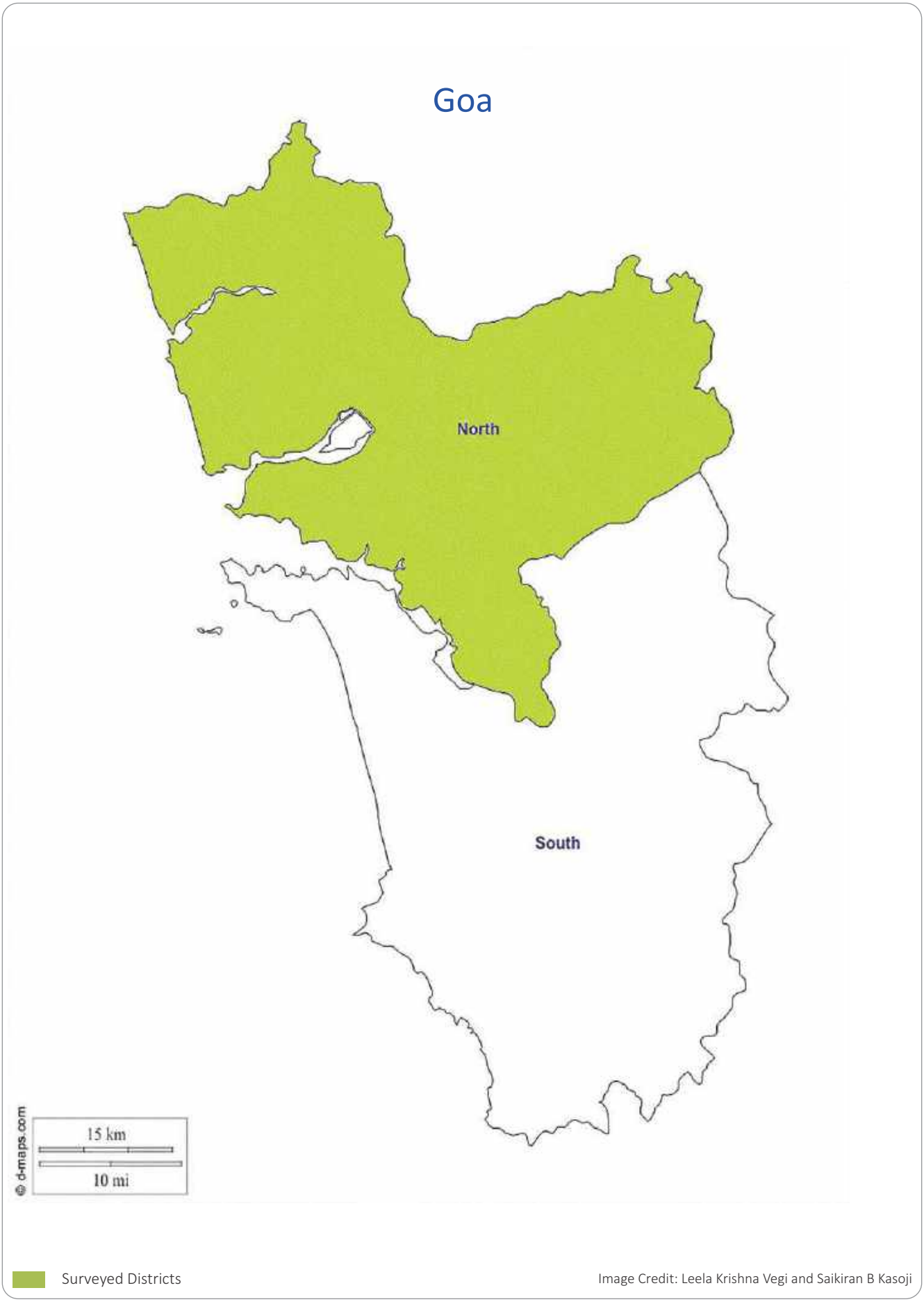


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Goa collected information and samples from all one (01) district to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Goa was calculated, which was the input to arrive at biomass power potential in Goa. Thus, the total biomass power potential for the state of Goa for 2018 was 32.97 MWe, and for 2019-20 is 25.33 MWe.

Districts Selected for Primary Field Survey	01 (North Goa)
Average Rainfall	3405.57mm
Type of soil	Mixed Red, Black, Laterite, Sandy
Major source of irrigation	River and Tube wells
Major Rivers	Baga, Chapora, Mandovi and Terekhol
Major Crops	Cashew Nut, Coconut, Rice

Utilization of Crop residue at farmer's level in Goa:

1. **Essential Usage**: Residue of Rice and vegetables are used for cattle feeding
2. **Specific Usage**: Residue of Rice and vegetables are utilized for preparing compost fertilizer
3. **Fuel Usage**: Residue of coconut is utilized for domestic cooking
4. **Field preparation**:
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Rice	5000 - 6000
	Coconut	5000 - 15000

Survey Images:

Amona, North Goa, Goa

Virnoda, North Goa, Goa

Virnoda, North Goa, Goa

Table 57: Crop-wise change in Area, Production and Biomass Potential in Goa

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	61959.33	152938.33	229407.50	22940.75	3.12	38575.67	105026.00	157539.00	26781.63	3.65	16.91
Ragi	200.00	205.00	266.50	26.65	0.00	0.00	0.00	0.00	0.00	0.00	0
Other Kharif pulses	388.00	176.00	228.80	45.76	0.01	169.00	147.97	192.37	38.47	0.00	-53.45
Other Rabi pulses	9467.00	9853.00	12808.90	1280.89	0.15	5707.67	5535.67	7196.37	719.64	0.09	-41.95
Groundnut	5497.00	11472.67	26387.13	5277.43	0.64	1216.33	2812.00	6467.60	1293.52	0.16	-75.36
Other Oilseeds	0.00	0.00	0.00	0.00	0.00	841.00	1691.00	3382.00	3382.00	0.32	0
Black Pepper	657.00	188.50	94.25	10.37	0.00	806.67	317.33	158.67	17.98	0.00	0
Cashewnut	55457.00	23161.00	53270.30	53270.30	8.63	56466.67	26664.00	61327.20	61327.20	9.94	15.12
Coconut	25506.50	25425.00	121094.75	108985.28	14.93	26154.33	26434.00	124442.83	111998.55	15.38	3.00
Sugarcane	1058.33	54519.67	2725.98	681.50	0.09	898.33	40892.67	2044.63	511.16	0.07	-22.76
Banana	0.00	0.00	0.00	0.00	0.00	2424.67	26954.00	80862.00	17789.64	2.36	0
Arecanut	0.00	0.00	0.00	0.00	0.00	1827.33	3232.00	8067.60	7583.54	1.01	0
Sweet Potato	0.00	0.00	0.00	0.00	0.00	54.00	132.00	13.20	7.92	0.00	0
Total	**160190.17**	**127377514.17**	**688995.82**	**192518.92**	**27.58**	**135141.67**	**239838.64**	**451693.47**	**231451.25**	**32.97**	**19.55**

Table 58: Crop-wise Area, Crop Production, Biomass Production, Surplus biomass, Biomass Power Potential for Goa in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Banana	1557.87	20451.84	61355.53	24542.21	3.25
2	Cashewnut	32461.96	24778.63	56990.86	56990.86	9.27
3	Coconut	14865.80	15090.44	70781.01	63702.91	8.74
4	Groundnut	2338.60	6122.24	14081.15	2816.23	0.34
5	Other Rabi Pulses	6859.66	6723.85	8741.01	874.10	0.10
6	Ragi	0	0	0	0	0
7	Rice	38525.57	103920.30	155880.40	26499.67	3.60
	Total	**96609.48**	**177087.30**	**367830**	**175426**	**25.33**

Major contributing crops in biomass power potential in Goa (2019-20) is Cashewnut with 9.27 MWe followed by Coconut (8.74 MWe), Banana (3.25 MWe), Groundnut (0.34 MWe) and Other Rabi Pulses (0.10 MWe)

Trend Analysis for Biomass power potential for the state of Goa – Crop-wise

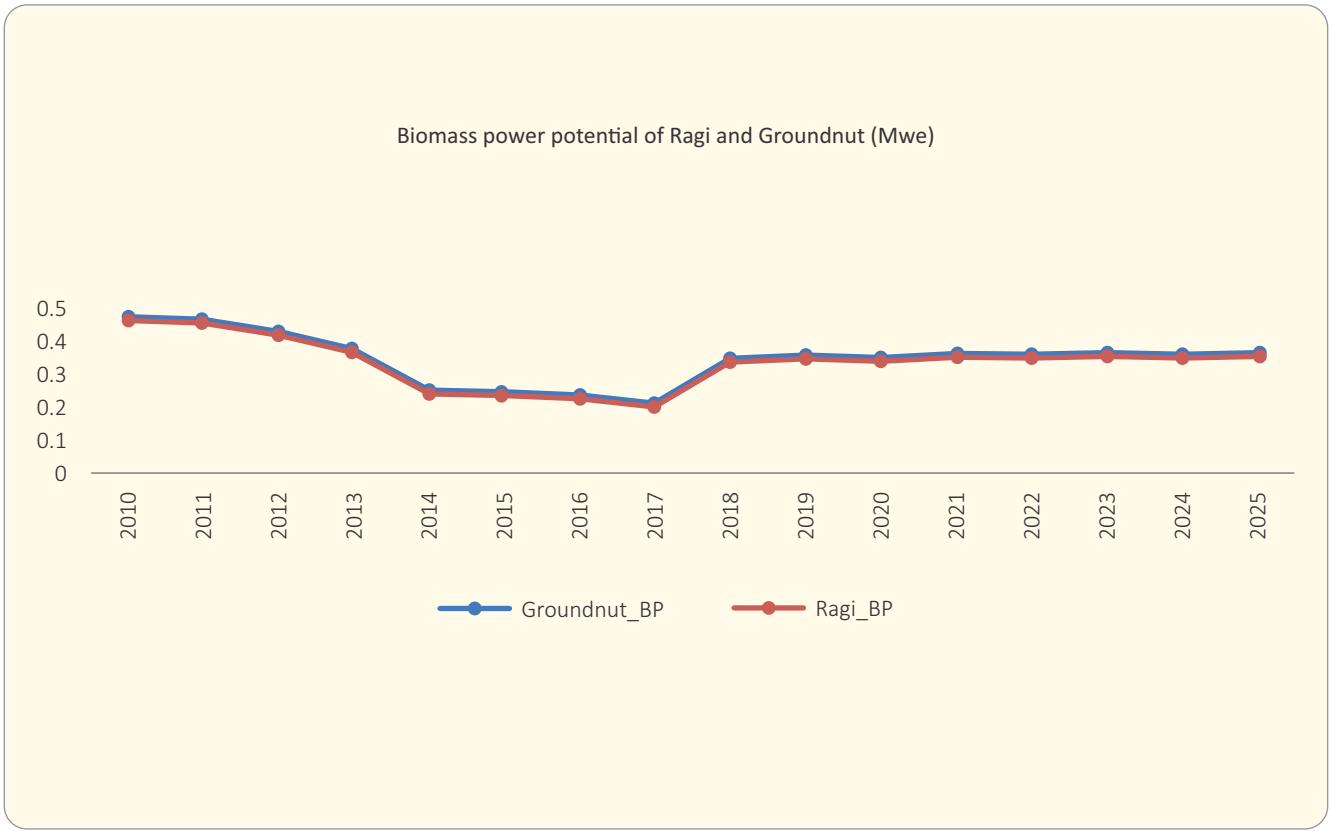


Figure 49: Biomass power potential for Ragi and Groundnut in Goa

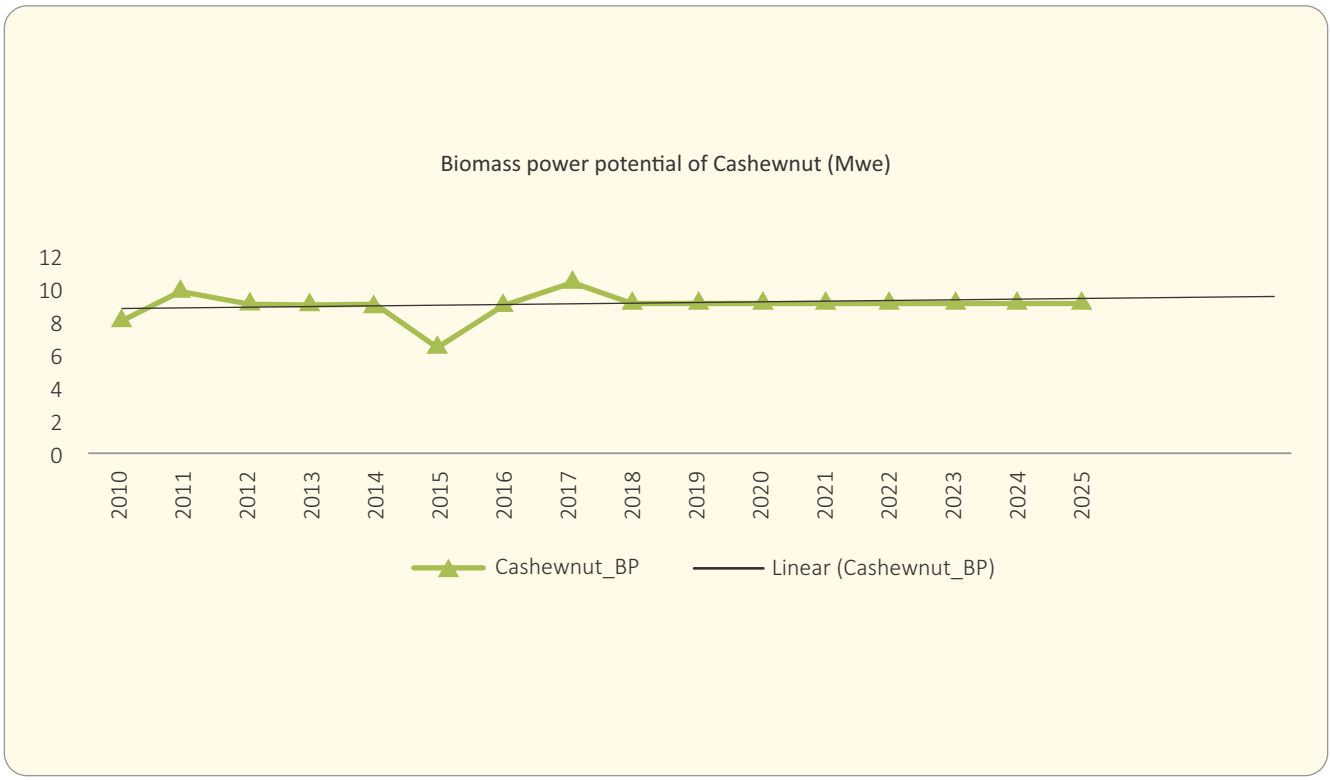


Figure 50: Biomass power potential for Cashewnut in Goa

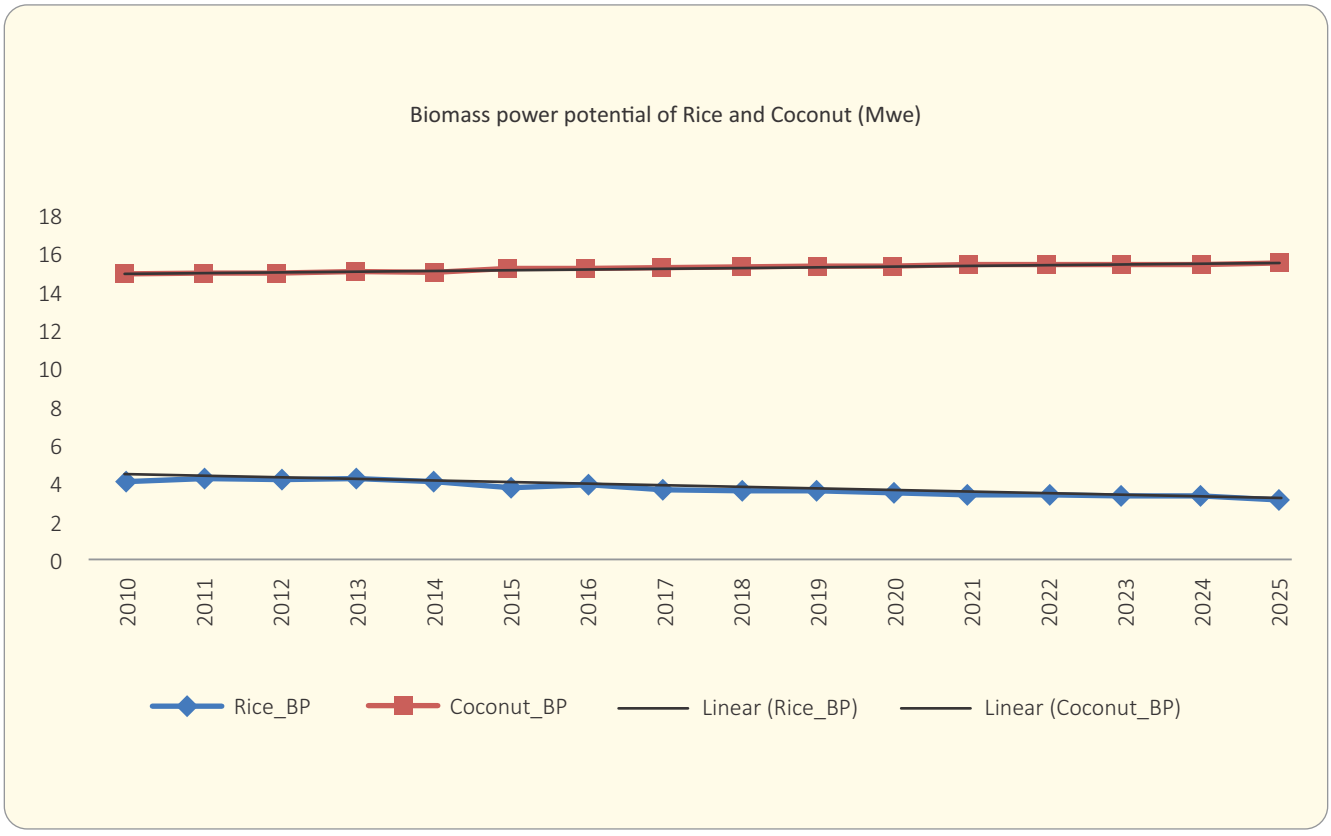


Figure 51: Biomass Power Potential for Banana and Coconut in Goa

Gujarat

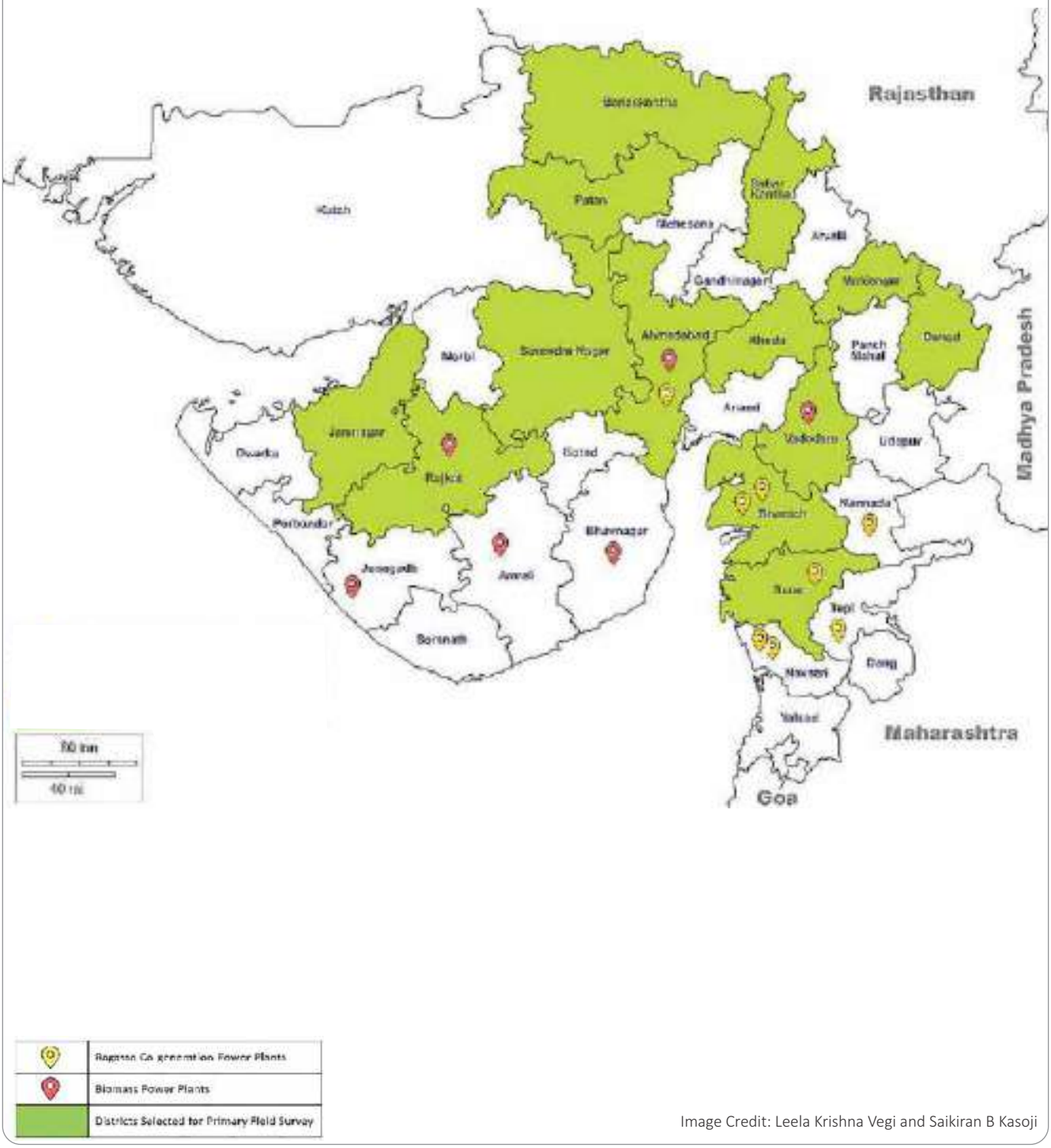


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Gujarat collected information and samples from all fourteen (14) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Gujarat was calculated, which was the input to arrive at biomass power potential in Gujarat. Thus, the total biomass power potential for the state of Gujarat for 2018 was 2637.84 MWe and for 2019-20 is 3042.50 MWe.

Districts Selected for Primary Field Survey	14 (Ahmadabad, BanasKantha, Bharuch, Dohad, Jamnagar, Kachchh, Kheda, Mahisagar, Patan, Rajkot, Sabarkantha, Surat, Surendranagar and Vadodara)
Average Rainfall	1107 mm
Type of soil	Alluvial Soil, Black cotton soil, clay loam, Medium black & Sandy loam soil
Major source of irrigation	Borewells, Canal, Tube wells, Panam reservoir and River
Major Rivers	Arjuna, Banas, Bhogavo, Dhadhar, Khari, Limdino, Meshove R, Nagmati, Narmada, Rukhumavati, Sabarmati, Umerdas, Vatrak, Vishwamitri
Major Crops	Arhar(Tur), Bajra, Banana, Castor Seed, Cotton(lint), Cumin, Gaur seed, Gram, Groundnut, Jowar, Maize, Potato, Rice, Rapeseed & Mustard, Sani, Sugarcane, sesamum and Wheat

Utilization of Crop residue at farmer's level in Gujarat:

1. **Essential Usage**: Residue of crops like Arhar (husk), Bajra, Banana, Chickpea, Gaur seed, Gram, Maize, Mustard and Tomato are used for cattle feeding
2. **Specific Usage**: Residue of Arhar, Moong, Potato, Castor seed, Cotton, Gram, Groundnut, Okra, Tomato and Maize are used for the preparation of organic fertilizer or compost fertilizer.
3. **Fuel Usage**: Stalk of Arhar, Cotton and Mustard are used for domestic cooking.
4. **Field preparation**: Stubbles of castor seed, Cotton, Jowar, Maize and Sugarcane are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Soyabean (Briquetting plant)	3000
	Paddy	4000
	Wheat	4000
Expected Cost against the sale of crop residue in Future	Castor seed	5000 - 10000
	Cotton	10000 - 20000
	Sugarcane	10000 - 20000
	Arhar	5000 - 10000
	Mustard	5000 - 10000

Survey Images:


Banas Kantha, Gujarat


Banas Kantha, Gujarat


Kosmadi, Surat, Gujarat

Table 59: Crop-wise change in Area, Production and Biomass Potential in Gujarat

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	750333.33	1335466.67	2003200.00	80128.00	10.90	825694.00	1856714.67	2785072.00	111402.88	15.15	39.20
Wheat	1149133.33	3082066.67	5547720.00	1109544.00	149.79	971948.00	2724880.33	4904784.60	980956.92	132.43	11.59
Maize	431416.67	464150.00	1067545.00	74728.15	8.74	413921.33	721304.00	1658999.20	116129.94	13.53	56.02
Ragi	20633.33	19700.00	25610.00	2561.00	0.32	16773.33	16541.67	21504.17	2150.42	0.27	16.54
Bajra	850716.67	1075483.33	2828521.17	537419.02	65.57	406563.67	920822.00	2421761.86	460134.75	55.95	14.99
Jowar	183316.67	211700.00	508080.00	111777.60	13.86	97897.67	140004.33	336010.40	73922.29	9.18	34.76
Moong (Green Gram)	189333.33	84300.00	105375.00	31612.50	4.05	154755.67	86447.33	108059.17	32417.75	4.14	2.22
Gram	196866.67	193000.00	212300.00	42460.00	5.56	190419.00	220759.33	242835.27	48567.05	6.34	13.99
Arhar/Tur	272466.67	263000.00	736400.00	522844.00	63.26	282956.00	337669.33	945474.13	671286.63	80.96	28.79
Soyabean	0.00	0.00	0.00	0.00	0.00	115530.33	101721.67	172926.83	29397.56	3.67	-
Rapeseed & Mustard	326333.33	453950.00	817110.00	433068.30	56.73	203834.33	343557.67	618403.80	327754.01	42.94	25.03
Groundnut	1878383.33	2615350.00	6015305.00	300765.25	36.69	1616798.33	2990444.67	6878022.73	343901.14	41.92	3.48
Sesamum	289033.33	110333.33	275833.33	110333.33	13.57	145064.67	74953.67	187384.17	74953.67	9.22	32.06
Sugarcane	229216.67	16703500.00	835175.00	233849.00	31.80	165605.33	11118896.33	555944.82	155664.55	21.17	33.43
Potato	60866.67	1370800.00	1110348.00	732829.68	68.15	124630.33	3323931.33	2692384.38	1776973.69	165.44	142.75
Tobacco	51733.33	84216.67	84216.67	84216.67	11.20	175119.00	454606.00	454606.00	454606.00	60.46	439.84
Banana	29033.33	2003200.00	6009600.00	1322112.00	175.84	27523.00	2075301.67	6225905.00	1369699.10	181.76	3.37
Cotton	2385900.00	1313947.00	11957103.40	10163537.89	1229.79	2579676.33	1292607.30	12646506.12	10749530.20	1300.69	5.89
Castor seed	373166.67	716533.33	2937786.67	1997694.93	249.71	614242.33	1341464.00	5500002.40	3740001.63	468.25	87.12
Other cereals	7087.96	8230.45	12345.57	1234.57	0.14	20120	24880	37320	3732	0.440376	214.55
Urad	11717.20	7045.33	9158.93	4579.47	0.41	133791	84836.3	110287.2	55143.6	5.023582	1125.26
Other Rabi Pulses	2751.84	2007.14	2609.29	260.93	0.03	24440	20400	26520	2652	0.320892	969.64
Other Kharif Pulses	4729.91	2904.76	3776.19	755.23	0.09	6290	3580	4654	930.8	0.112627	25.14
Moth	8801.03	3281.25	5906.25	1771.88	0.20	28480	150900	271620	81486	9.493119	4646.56

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Dry chillies	1110.78	1032.08	1548.12	1238.50	0.16	6650	6720	10080	8064	1.045901	553.69
Garlic	6765.88	44359.20	33269.40	33269.40	4.51	12390	76520	22956	22956	3.112834	30.98
Onion	7999.29	225787	11289.40	2483.66	0.33	58470	1604040	80202	17644.44	2.399644	627.16
Guar seed	47459.10	22718.90	45437.90	6997.43	0.86	245428	157716	315432	48576.53	5.999201	597.58
Total	**9667883.33**	**32100697.00**	**43077229.23**	**17891481.33**	**2195.54**	**9665009**	**32272219**	**50235656**	**21740353**	**2637.838**	**20.15**

Table 60: Crop-wise Area, Production, Biomass Production, Surplus biomass and Biomass Power Potential for Gujarat in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	878625.50	2105718.00	3158577.00	126343.10	17.18
2	Wheat	1286500.00	3843725.00	6918705.00	1383741.00	186.80
3	Jowar	85318.63	142199.40	341278.60	75081.29	9.32
4	Bajra	368484.70	1071631.00	2818390.00	535494.10	65.11
5	Maize	428092.80	746351.40	1716608.00	120162.60	13.99
6	Gram	232563.20	281211.20	309332.30	61866.46	8.07
7	Tur (Arhar)	238969.80	331718.30	928811.20	659456.00	79.53
8	Groundnut	1522789.00	3186519.00	7328993.00	366449.70	44.67
9	Soyabean	120507.70	146805.70	249569.60	42426.84	5.30
10	Rapeseed & Mustard	210261.30	388497.40	699295.40	370626.60	48.55
11	Cotton	2975298.00	1691306.00	15027005.00	12772954.00	1545.52
12	Sugarcane	174864.50	10568900.00	528445.00	147964.60	20.12
13	Tobacco	184892.70	411503.10	411503.10	411503.10	54.72
14	Guarseed	216629.20	165292.30	330584.60	49587.68	6.12
15	Banana	29721.05	2327523.00	6982569.00	1536165.00	203.84
16	Caster Seed	714901.60	1559002.00	6391909.00	4346498.00	544.18
17	Green Gram (Moong)	147161.70	84132.05	105165.10	31549.52	4.02
18	Ragi	14322.44	13223.46	17190.49	1719.04	0.21
19	Sesamum	91350.40	82660.53	206651.30	82660.53	10.16
20	Black Gram (Urad)	114248.60	79064.47	102783.80	51391.91	4.67
21	Potato	126884.90	3422144	2771937.00	1829478.00	170.32
	Total	**10162387**	**32649128**	**57345304**	**25003120**	**3042.50**

Major contributing crops in biomass power potential in Gujarat (2019-20) is Cotton with 1545.52 MWe followed by Castor seed (544.18 MWe), Banana (203.84 MWe), Wheat (186.80 MWe) and Potato (170.32 MWe).

Trend Analysis for Biomass power potential for the state of Gujarat – Crop-wise

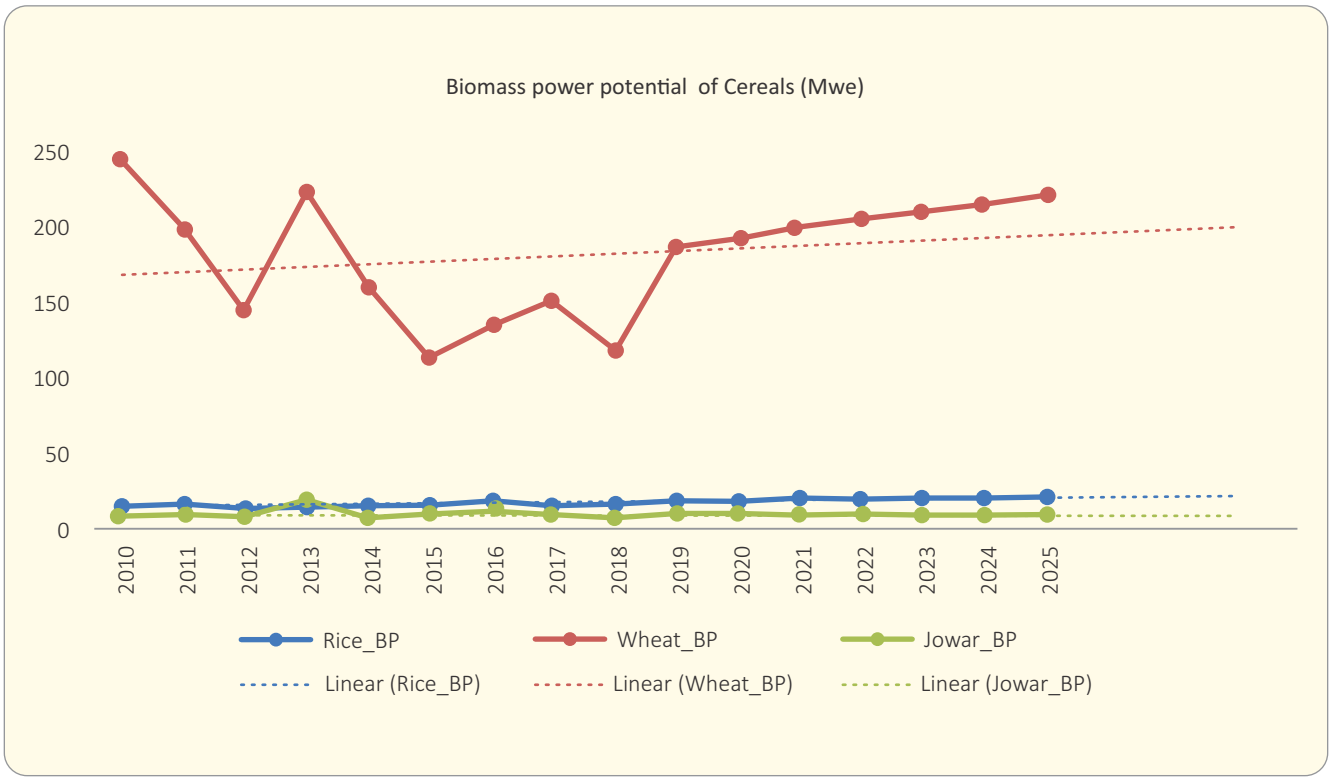


Figure 52: Biomass power potential for Cereals in Gujarat

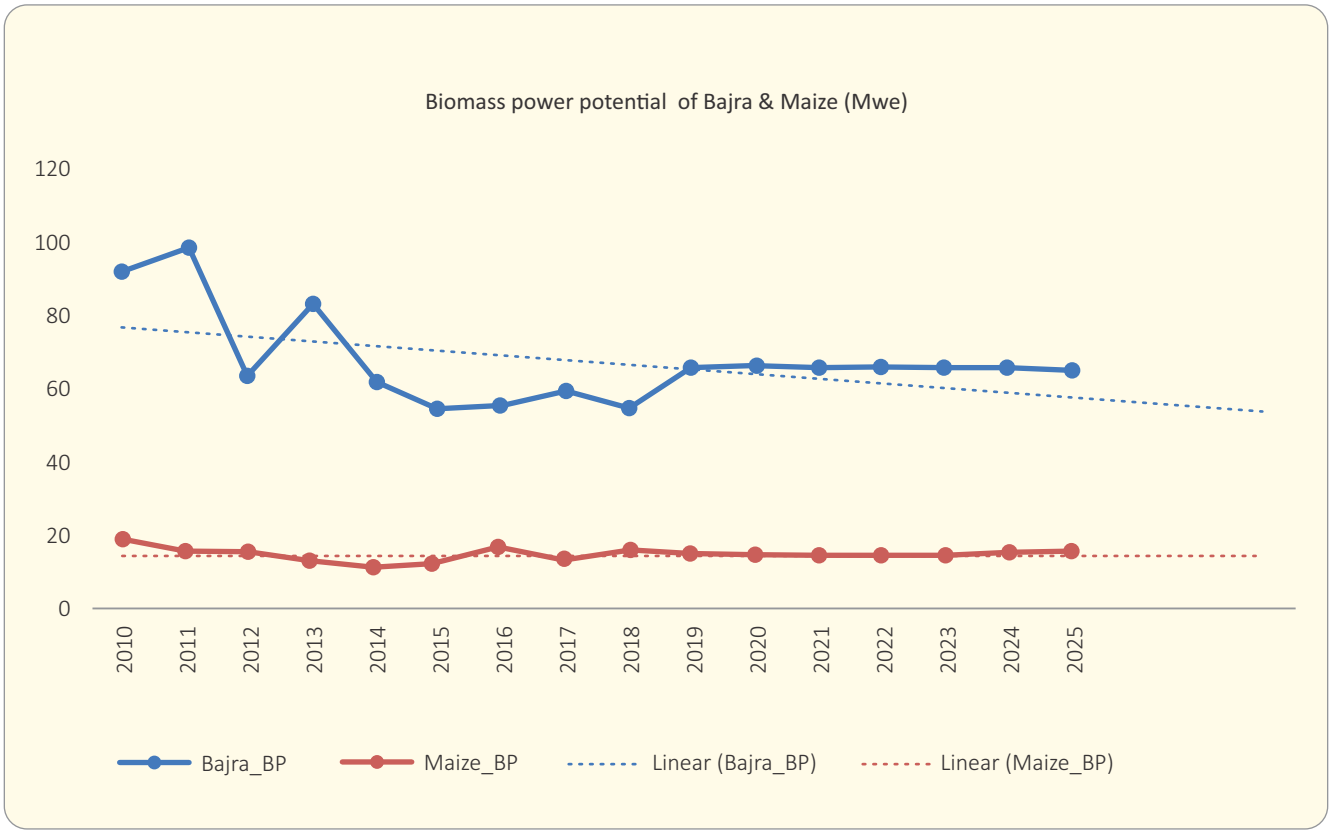


Figure 53: Biomass power potential for Bajra and Maize in Gujarat

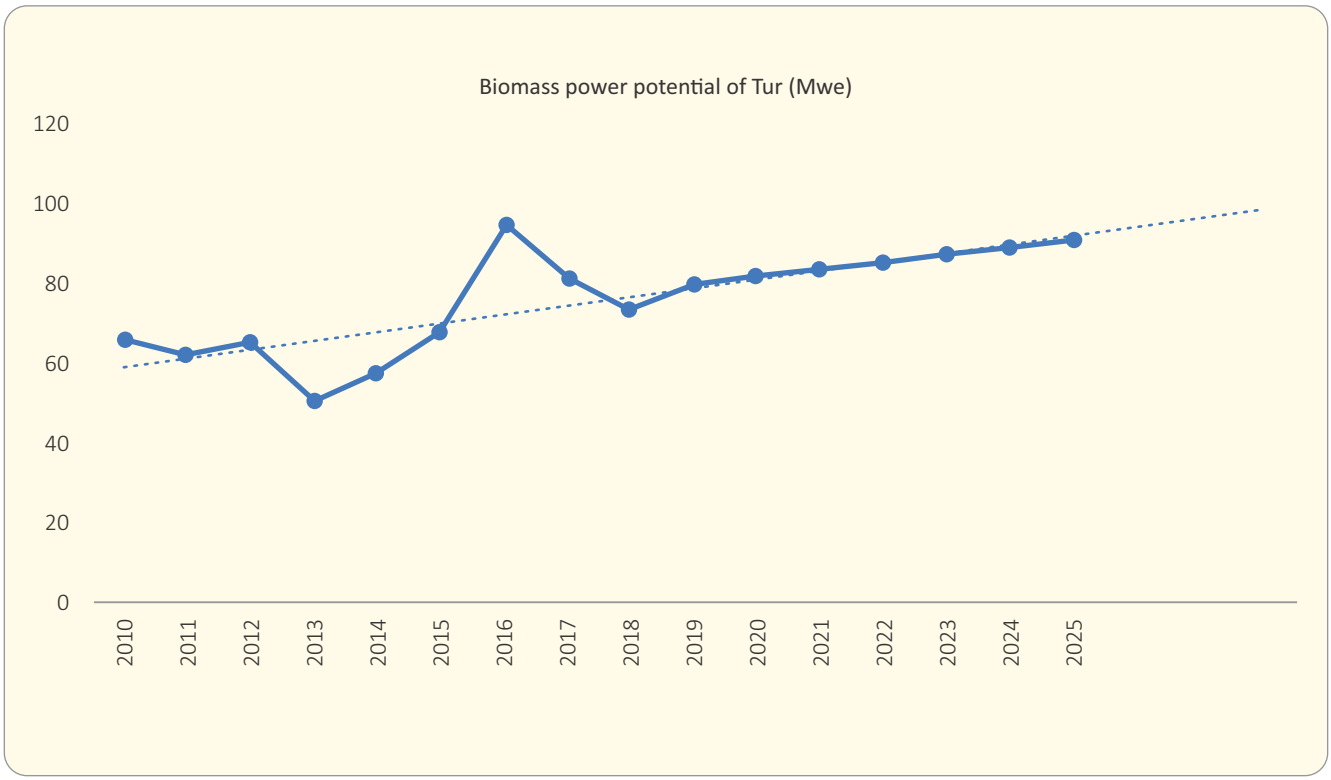


Figure 54: Biomass power potential for Arhar/Tur in Gujarat

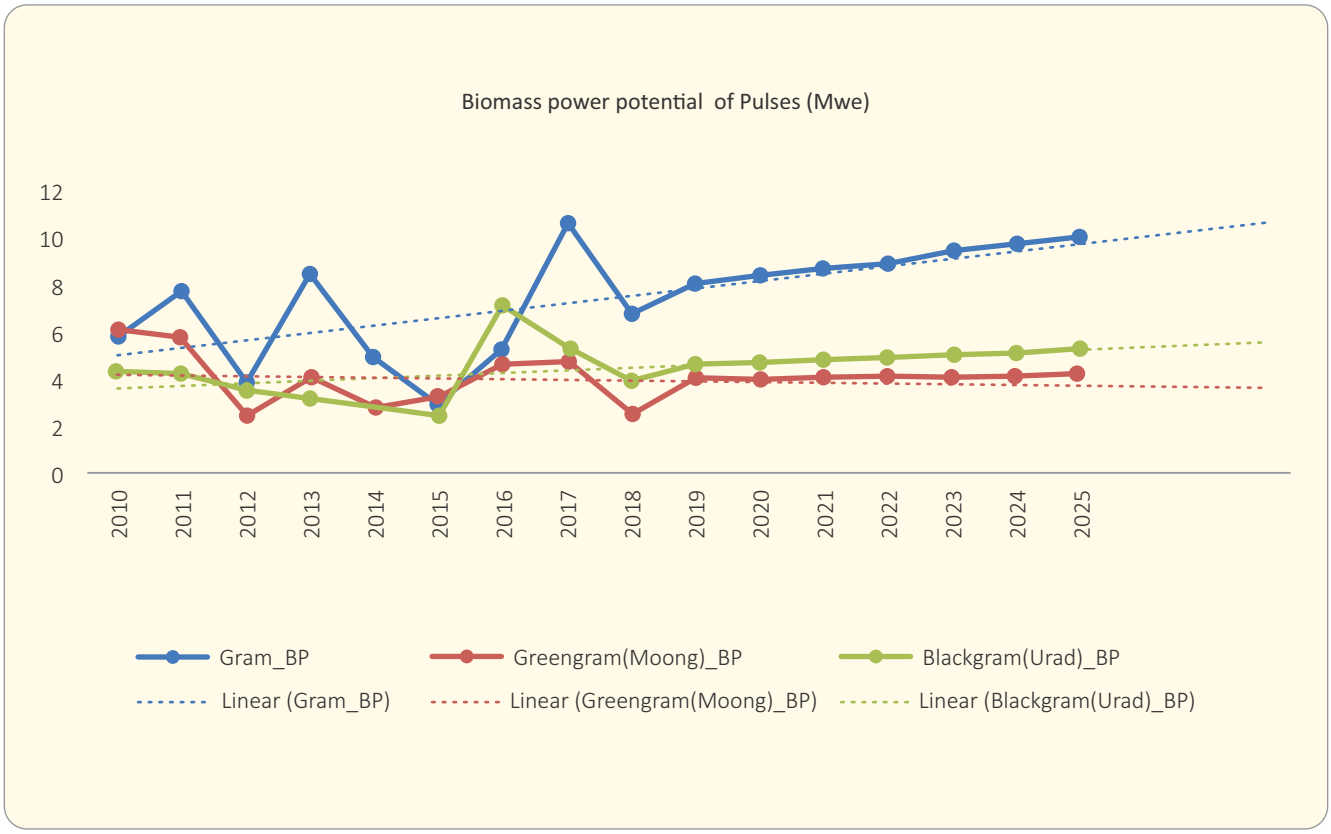


Figure 55: Biomass power potential for Pulses in Gujarat

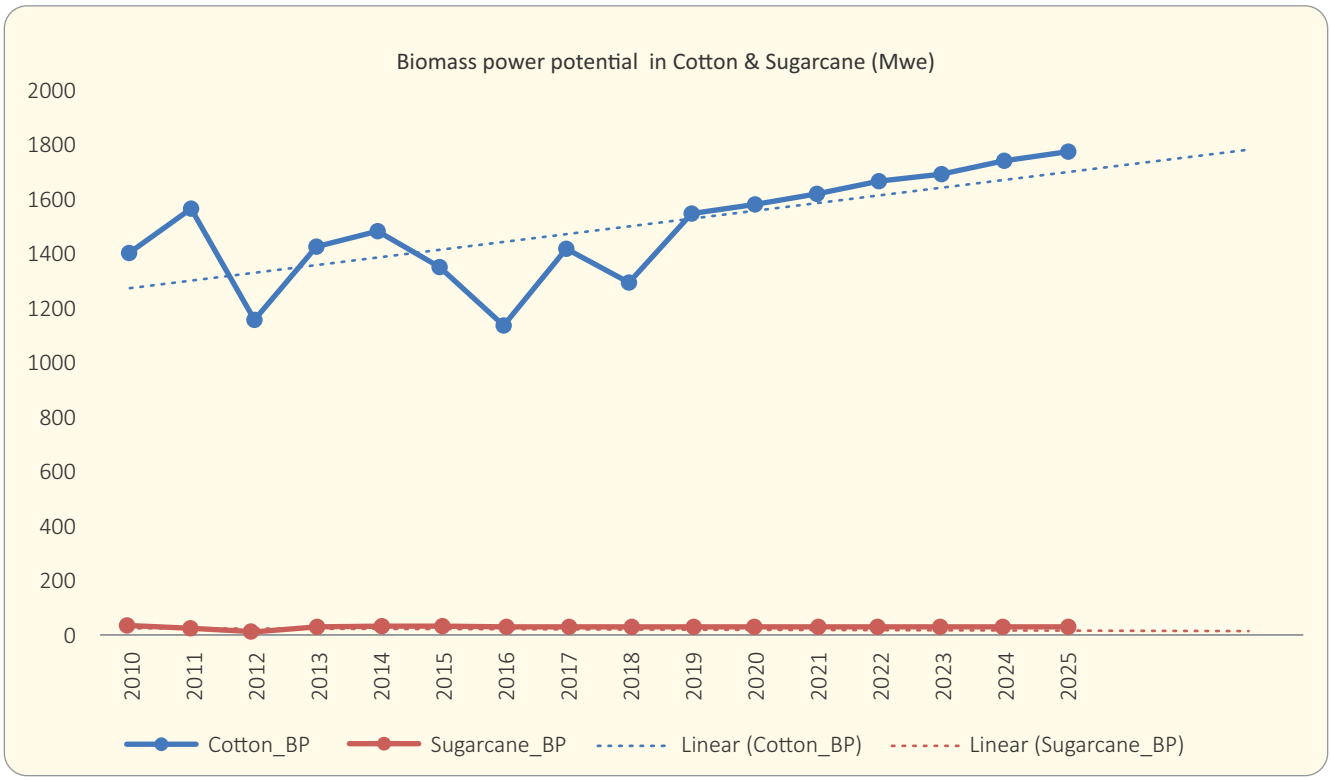


Figure 56: Biomass power potential for Cotton & Sugarcane in Gujarat

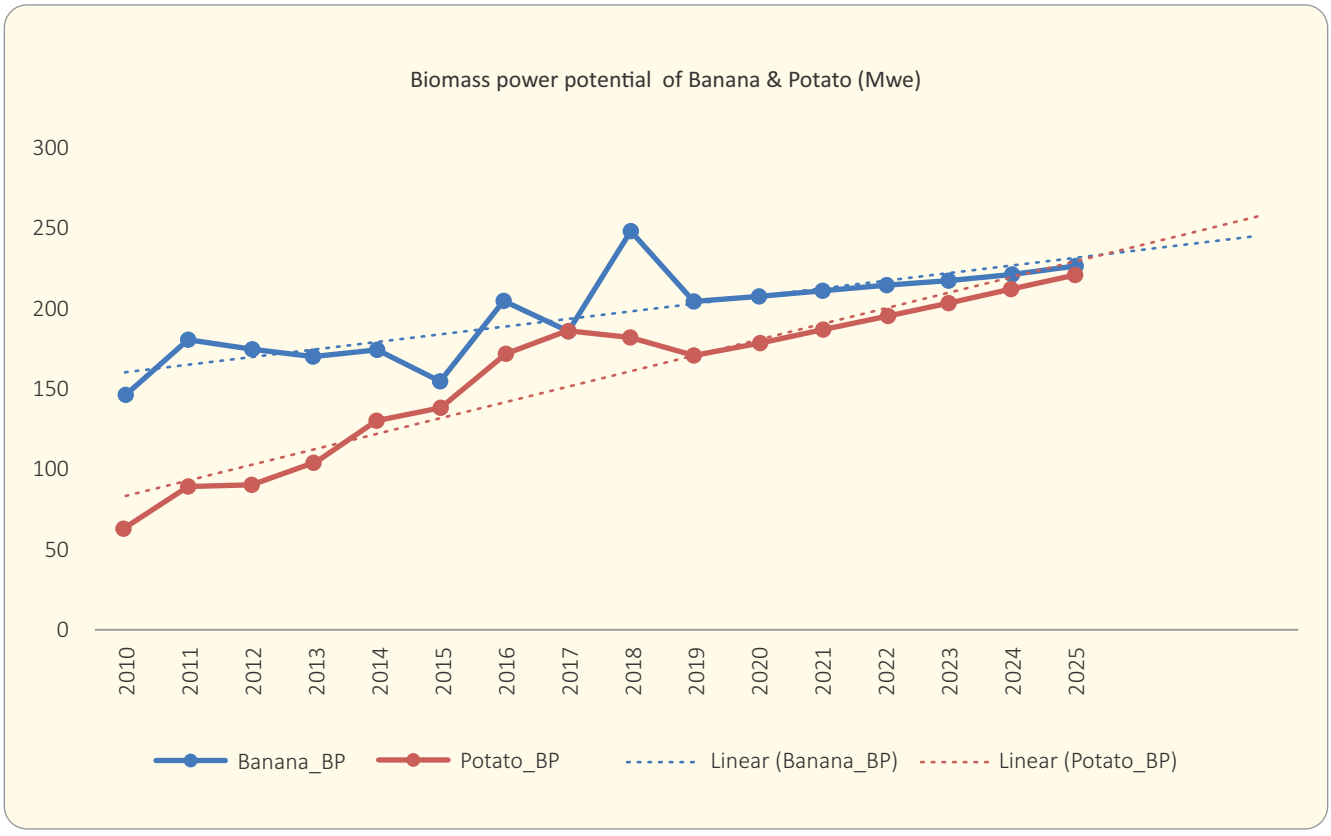


Figure 57: Biomass power potential for Banana & Potato in Gujarat

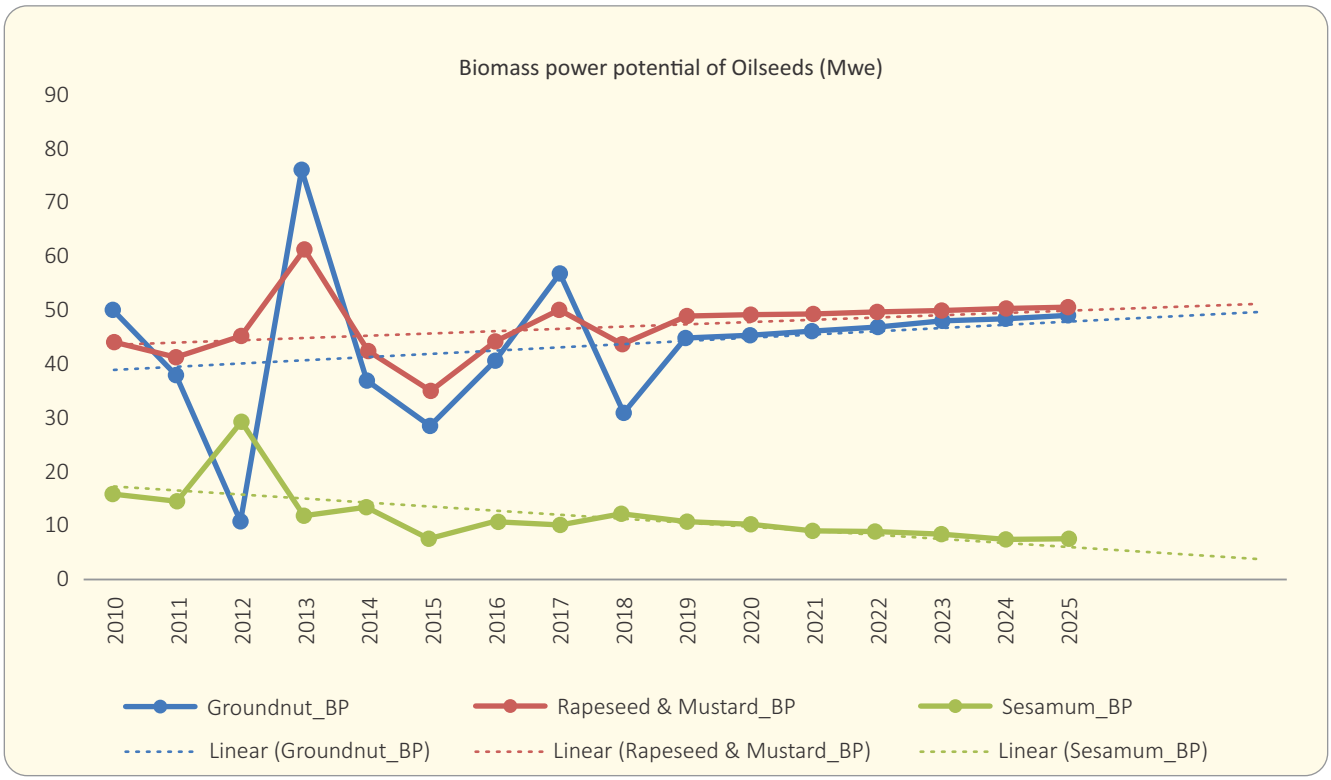


Figure 58: Biomass power potential for Oilseed in Gujarat

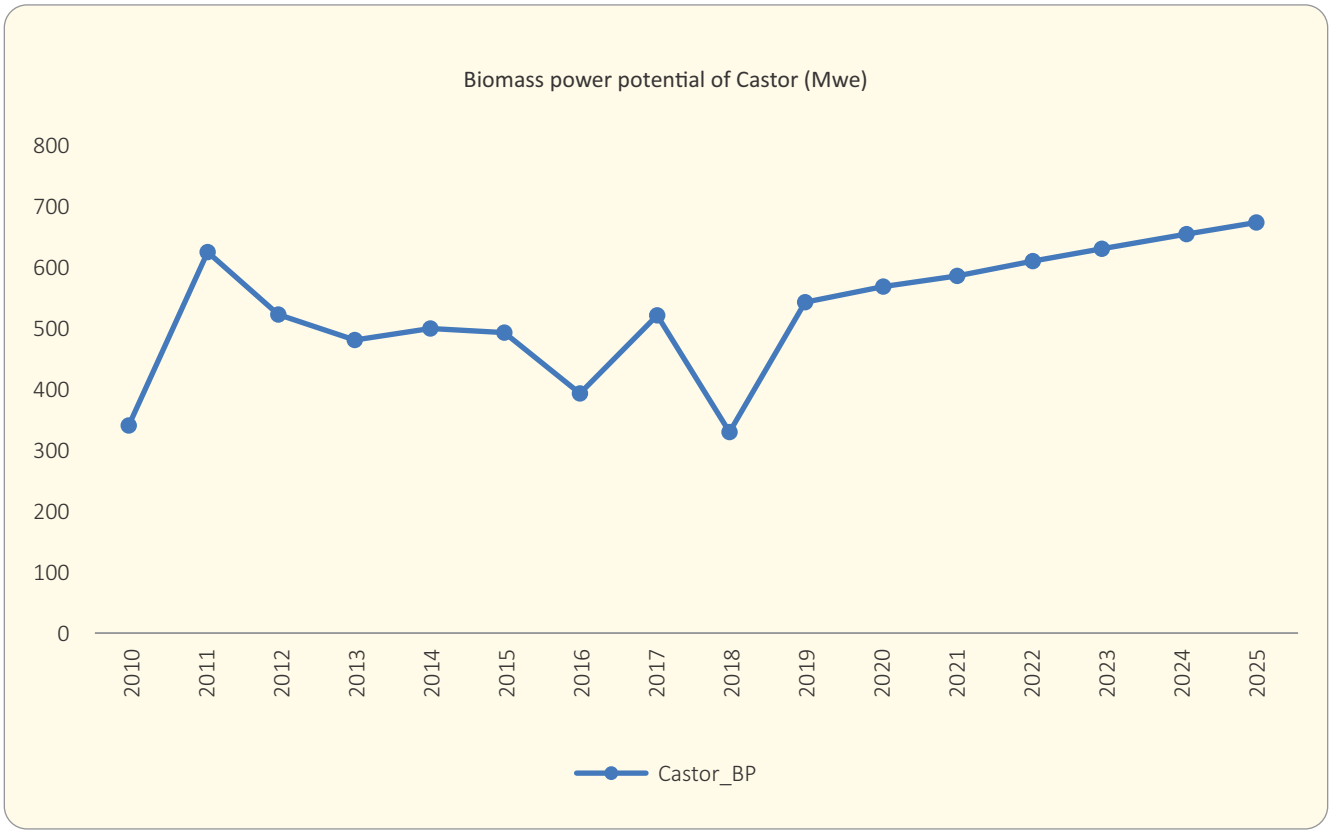


Figure 59: Biomass power potential for Castor in Gujarat

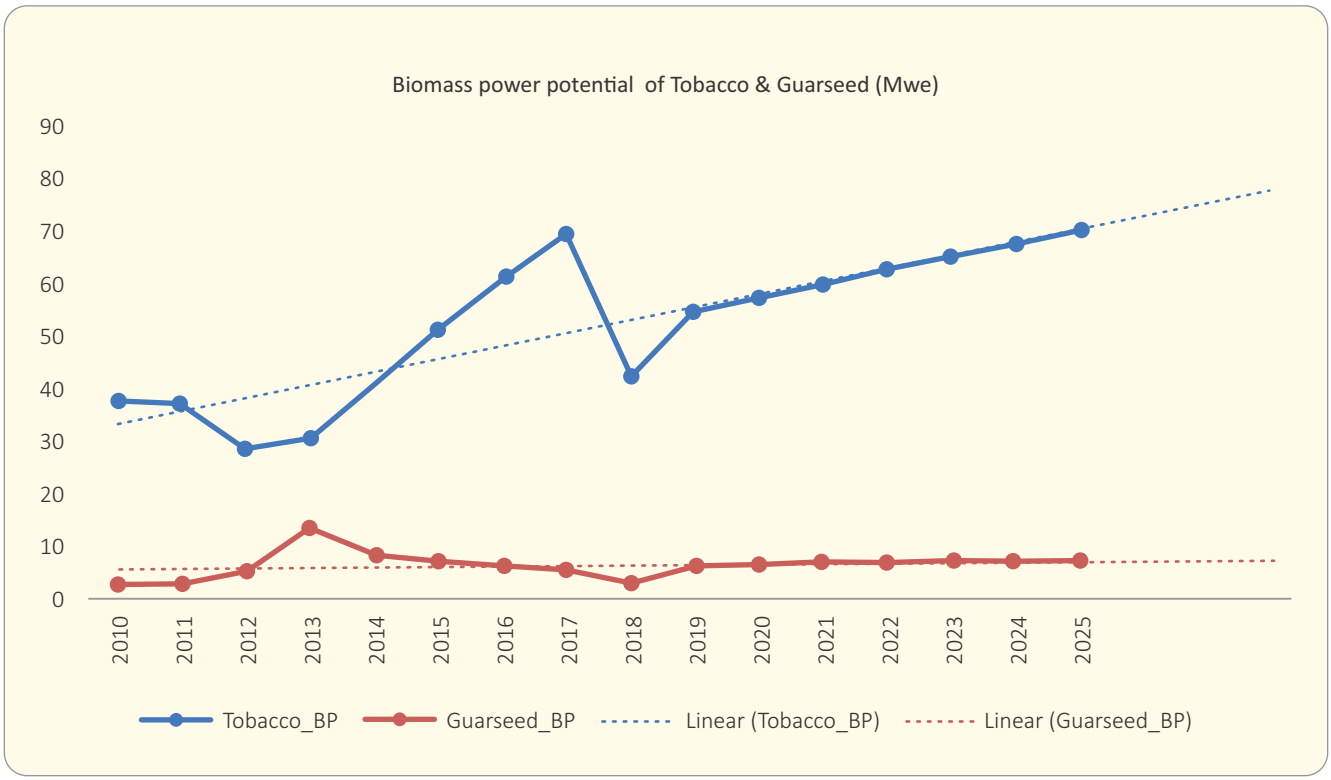
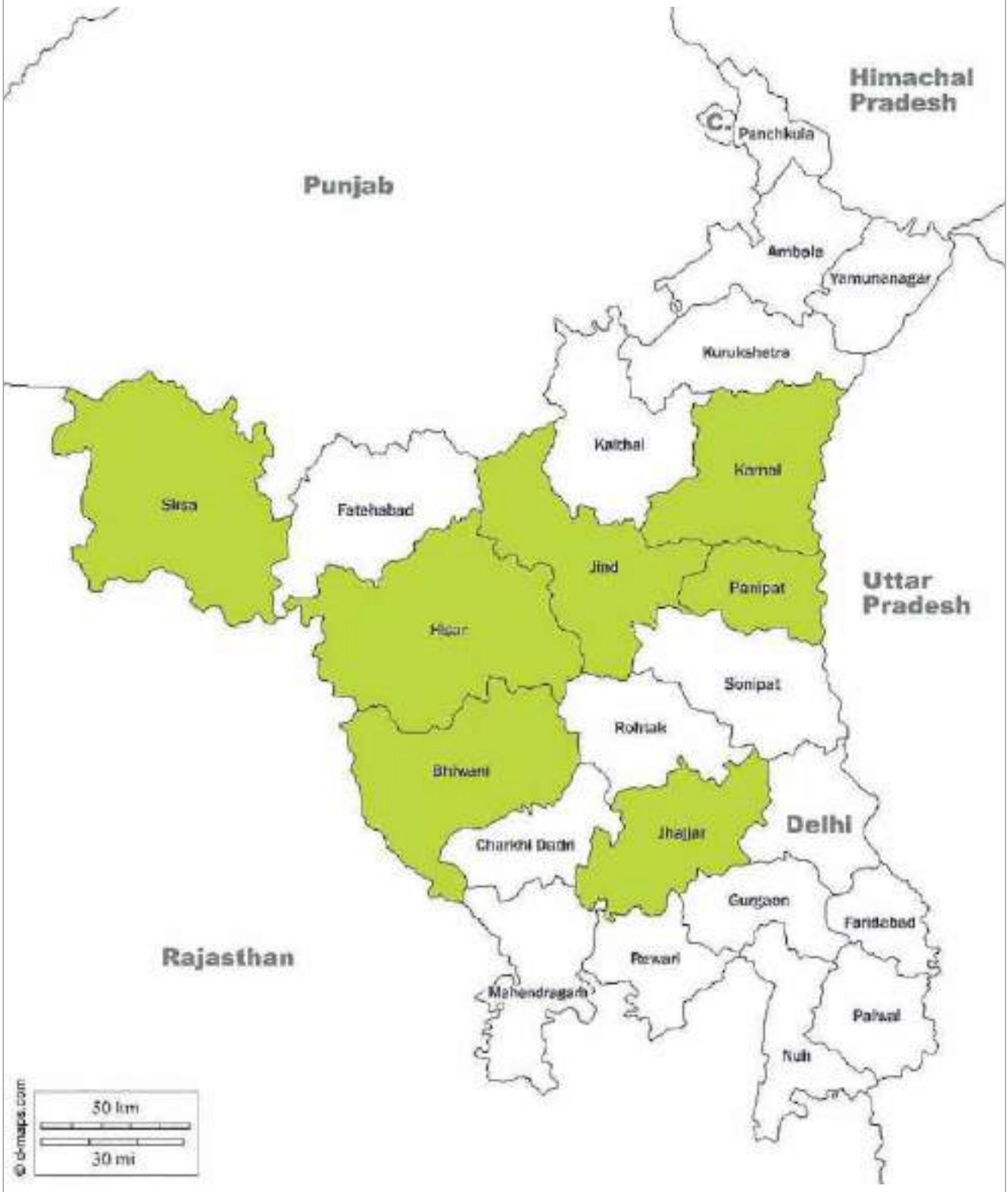


Figure 60: Biomass Power Potential for Tobacco & Guar seed in Gujarat

Haryana



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Haryana collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Haryana was calculated, which was the input to arrive at biomass power potential in Haryana. Thus, the total biomass power potential for the state of Haryana for 2018 was 1353.35 MWe and for 2019-20 is 1322.19 MWe

Districts Selected for Primary Field Survey	07 (Bhiwani, Hisar, Jind, Jhajjar, Karnal, Panipat and Sirsa)
Average Rainfall	617 mm
Type of soil	Sandy coarse loamy soil and Sandy Soil
Major source of irrigation	Canals, Tube wells
Major Rivers	Yamuna
Major Crops	Bajra, Cotton, other oilseed, Rapeseed & Mustard, Paddy and Wheat

Utilization of Crop residue at farmer's level in Haryana:

1. **Essential Usage**: Residue of Bajra, other oilseeds, Rapeseed & Mustard, Paddy and Wheat are utilized for cattle feeding.
2. **Specific Usage**: Rapeseed & Mustard, Paddy Straw and wheat straws are used for briquetting plant, brick kiln and char briquette for domestic cooking, Dhabas or industrial steam production. Bajra and maize are used for ethanol production.
3. **Fuel Usage**: Stalk of cotton and mustard are used in domestic chulha.
4. **Field preparation**: Open burning of cotton stalk, rice, and wheat is very common in Haryana state.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy (cattle feed)	3000 - 5000
Expected Cost against the sale of crop residue in Future	Cotton	6000 - 9000
	Rapeseed & Mustard	3000 - 5000
	Wheat	5000

Survey Images:

Dhandlan, Jhajjar, Haryana

Talwandi, Hisar, Haryana

Babarwas, Bhiwani, Haryana

Table 61: Crop-wise change in Area, Production and Biomass Potential in Haryana

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	1126700.67	3474666.67	5212000.00	2606000.00	354.42	1242418.33	3990333.33	5985500.00	3002725.83	408.97	15.39
Wheat	2495231.00	10861000.00	19549800.00	1954980.00	263.92	2541301.67	11124666.67	20024400.00	2002440.00	270.33	2.43
Maize	13027.50	30866.67	70993.33	14198.67	1.66	10111.17	25000.00	57500.00	11500.00	1.34	-19.08
Jowar	95840.83	40500.00	97200.00	21384.00	2.65	57608.67	29833.33	71600.00	15513.33	1.93	-27.29
Bajra	625156.67	1098000.00	2887740.00	548670.60	66.94	403499.50	770000.00	2025100.00	383322.50	46.61	-30.37
Barley	44086.67	142000.00	184600.00	18460.00	2.14	41265.83	143833.33	186983.33	18698.33	2.17	1.36
Moth	3027.83	483.33	870.00	261.00	0.03	673.67	215.33	387.60	116.28	0.01	-54.84
Moong (Green Gram)	19404.50	8533.33	10666.67	3200.00	0.41	7978.83	2920.50	3650.63	1095.19	0.14	-65.89
Masoor	4334.83	3316.67	5936.83	2968.42	0.31	2681.50	2609.50	4671.01	2335.50	0.24	-22.25
Gram	112855.50	91000.00	100100.00	20020.00	2.62	66304.33	56833.33	62516.67	12503.33	1.63	-37.72
Arhar/Tur	31564.50	33766.67	94546.67	66182.67	8.01	9909.83	9466.00	26504.80	18553.36	2.24	-72.07
Peas & Beans (Pulses)	1187.67	1300.00	650.00	325.00	4.03	2184.00	1492.00	746.00	373.00	0.05	-98.85
Urad	3177.33	1233.33	1603.33	801.67	0.07	1973.17	643.50	836.55	418.28	0.04	-45.56
Horse Gram	2249.67	700.00	910.00	91.00	0.01	689.50	424.50	551.85	55.19	0.01	-29.92
Other Kharif Pulses	2840.00	1200.00	1560.00	312.00	0.04	0.00	0.00	0.00	0.00	0.00	-100.00
Groundnut	1525.00	1250.00	2875.00	575.00	0.07	3958.83	3511.00	8075.30	1615.06	0.20	181.25
Sannhamp	431.50	150.00	378.00	75.60	0.01	60.00	15.00	37.80	7.56	0.00	-90.63
Castor seed	3155.33	2133.33	8746.67	5248.00	0.66	1002.00	663.00	2718.30	1630.98	0.20	-69.06
Sunflower	7692.67	13850.00	27700.00	24930.00	2.74	4537.83	11050.00	22100.00	19890.00	2.19	-20.15
Rapeseed & Mustard	538577.33	770666.67	1387200.00	693600.00	90.86	525153.33	843516.67	1518330.00	759165.00	99.45	9.45
Sesamum	3579.00	1266.67	3166.67	1266.67	0.16	1467.00	622.00	1555.00	622.00	0.08	-52.18
Other Oilseeds	0.00	0.00	0.00	0.00	0.00	510053.00	786500.00	1573000.00	1573000.00	148.81	0
Turmeric	51.00	500.00	150.00	90.00	0.01	2152.67	23259.50	6977.85	4186.71	0.56	5468.32
Coriander	398.00	800.00	920.00	460.00	0.06	2263.50	3269.22	3759.60	1879.80	0.24	297.26

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Garlic	657.33	6233.33	1870.00	1870.00	0.25	3336.50	29953.50	8986.05	8986.05	1.22	387.40
Ginger	0.00	0.00	0.00	0.00	0.00	522.00	6560.50	328.03	108.25	0.01	0
Dry chillies	1720.00	12316.67	18475.00	14780.00	1.92	14082.00	86517.33	129776.00	103820.80	13.47	601.33
Sweet Potato	62.67	1133.33	113.51	68.11	0.01	179.00	2300.00	230.36	138.22	0.01	25.78
Potato	11627.00	253400.00	205254.00	135467.64	12.60	24867.00	585594.50	474331.55	313058.82	29.15	131.32
Onion	2830.50	52800.00	2640.00	580.80	0.08	24901.33	558126.63	27906.33	6139.39	0.83	943.70
Sugarcane	126371.50	8081666.67	404083.33	101020.83	13.74	100300.00	7433500.00	371675.00	92918.75	12.64	-8.03
Cotton	488868.67	314443.33	2549476.27	2039581.01	246.79	602652.50	359578.33	3081151.83	2464921.47	298.01	20.75
Guar seed	0.00	0.00	0.00	0.00	0.00	387815.00	278379.00	556758.00	85740.73	10.59	0
Total	**5768232.67**	**25301176.67**	**32832225.28**	**8277468.68**	**1077.22**	**6597903.50**	**27171187.52**	**36238645.42**	**10907479.71**	**1353.35**	**25.63**

Table 62: Crop-wise Area, Production, Biomass Production, Surplus Biomass and Biomass Power Potential for Haryana in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1404088.00	4585099.00	6877648.00	3438824.00	467.68
2	Wheat	2678237.00	13590967.00	24463741.00	2446374.00	330.26
3	Jowar	32734.98	34271.81	82252.35	18095.52	2.24
4	Bajra	735869.20	1600021.00	4208056.00	799530.60	97.14
5	Maize	5515.45	14774.73	33981.87	6796.37	0.79
6	Gram	55882.45	69489.01	76437.91	15287.58	1.99
7	Tur (Arhar)	17985.65	24132.40	67570.71	47299.50	5.70
8	Lentil (Masur)	195.75	421.47	758.65	379.32	0.03
9	Groundnut	3120.53	3527.64	8113.59	1622.71	0.19
10	Rapeseed & Mustard	384158.20	753363.20	1356054.00	678026.90	88.82
11	Sunflower	7152.06	13492.31	26984.62	24286.15	2.63
12	Cotton	509208.70	554318.80	3154495.00	2523596.00	305.35
13	Sugarcane	47046.04	429292.90	21464.64	5366.16	0.72
14	Green Gram (Moong)	19526.15	12599.80	15749.75	4724.92	0.60
15	Sesamum	-1843066	220.70	551.75	220.70	0.027
16	Black Gram (Urad)	2383.50	1378.96	1792.65	896.32	0.08
17	Potato	14654.58	295296.20	239189.90	157865.30	14.69
18	Barley	52974.33	207516.50	269771.40	26977.14	3.12
19	Peas & Beans	1984.69	1744.54	872.27	436.13	0.05
	Total	**4129652**	**22191928**	**40905485**	**10196605**	**1322.197**

Major contributing crops in biomass power potential in Haryana (2019-20) is Rice with 467.68 MWe, followed by Wheat (330.26 MWe), Cotton (305.35 MWe), Bajra (97.14 MWe) and Rapeseed (88.82 MWe).

Trend Analysis for Biomass power potential for the state of Haryana – Crop-wise

The following graphs represent the biomass power potential of different crops plotted from 2010 to 2019 and projected from 2010 to 2025.

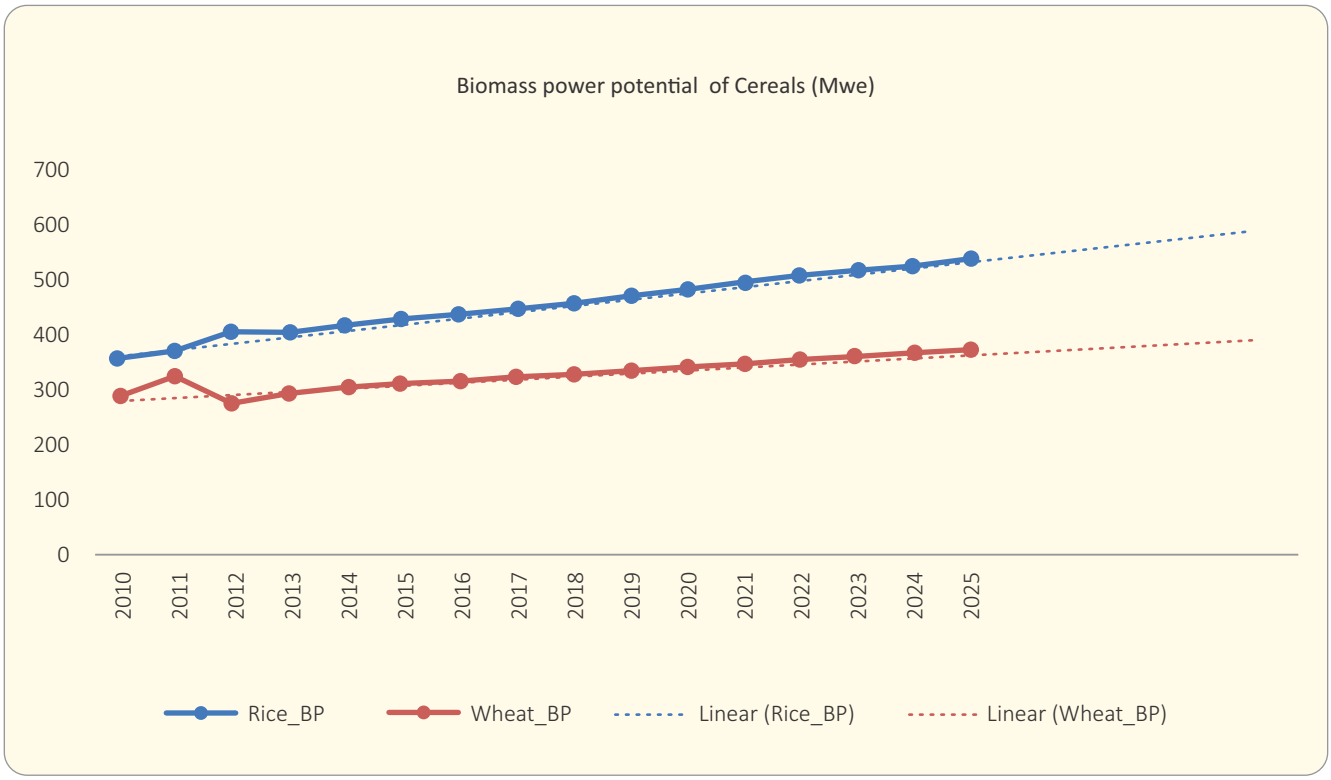


Figure 61: Biomass power potential for Cereals in Haryana

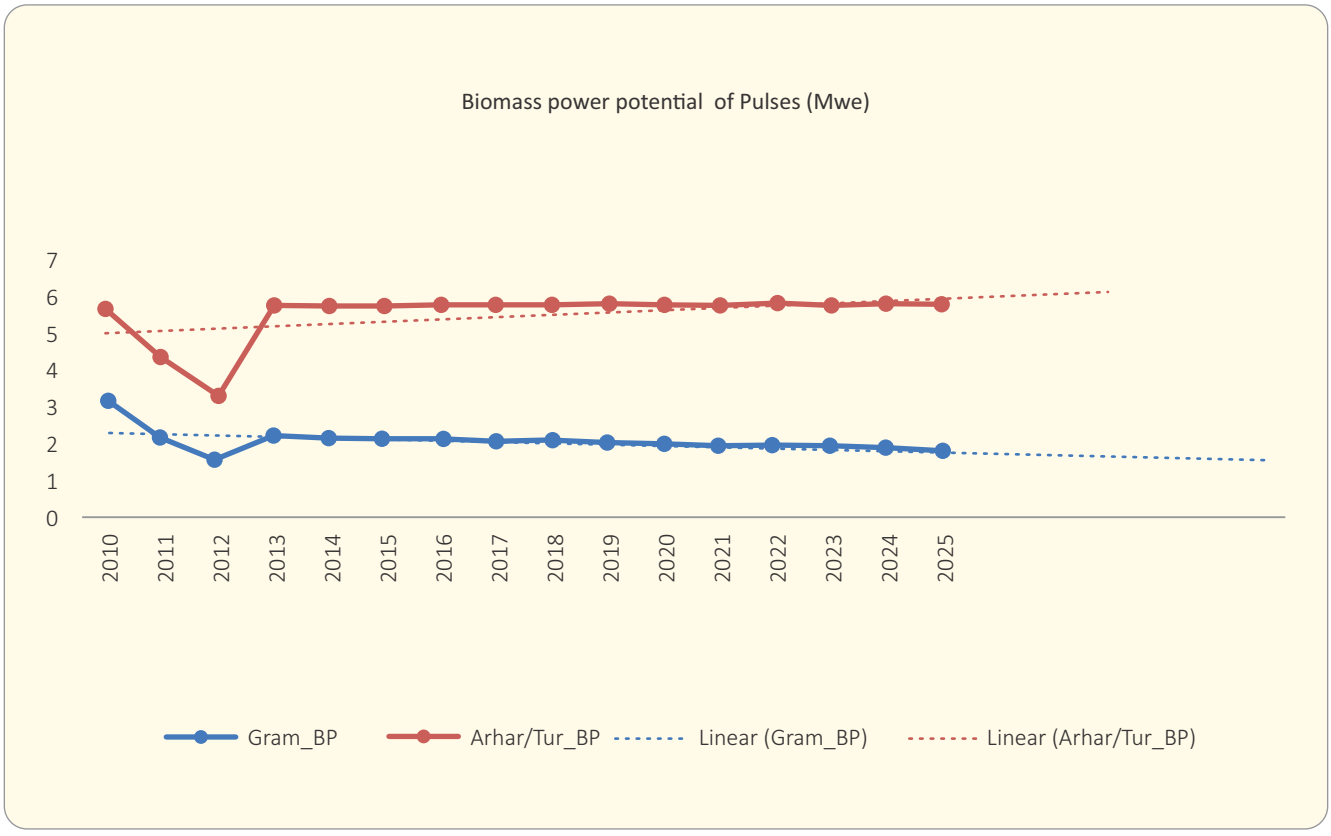


Figure 62: Biomass Power Potential for Pulses in Haryana

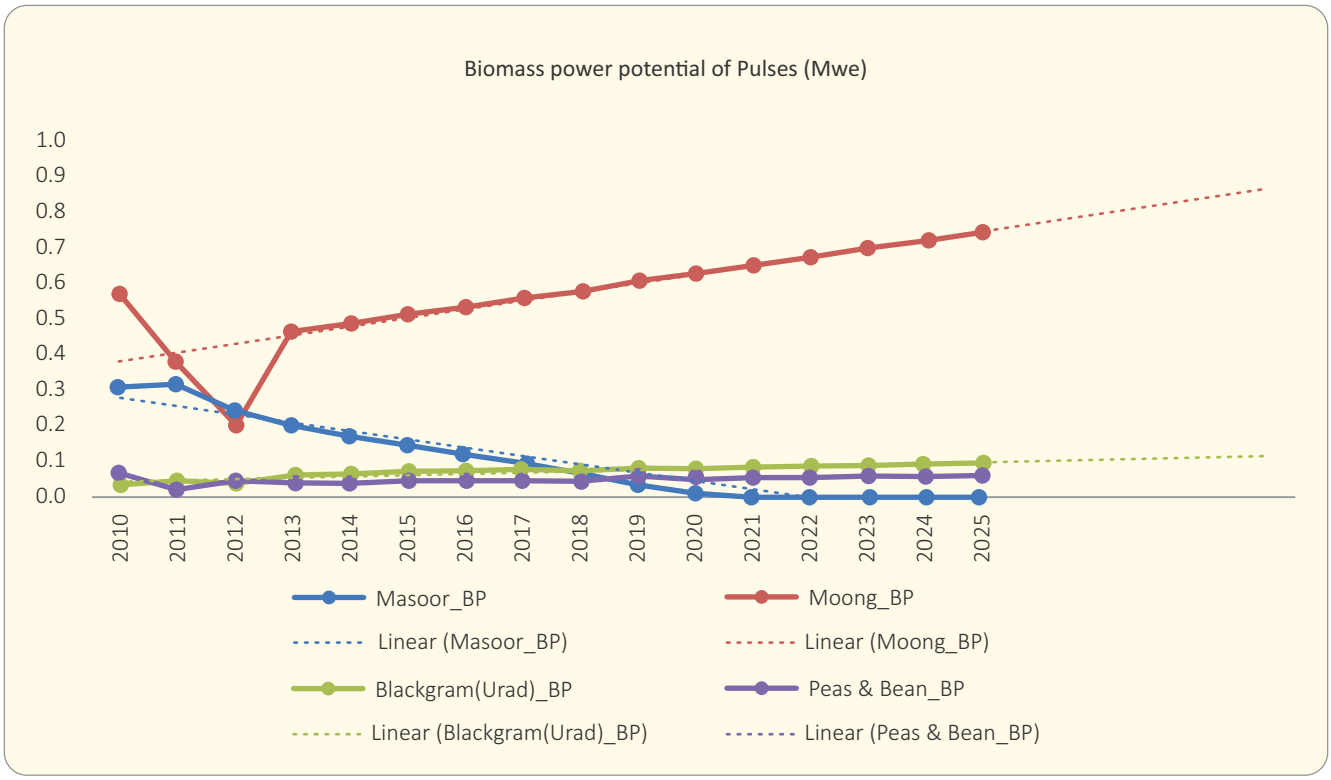


Figure 63: Biomass Power Potential for Masoor, Moong, Urad and Peas & Beans in Haryana

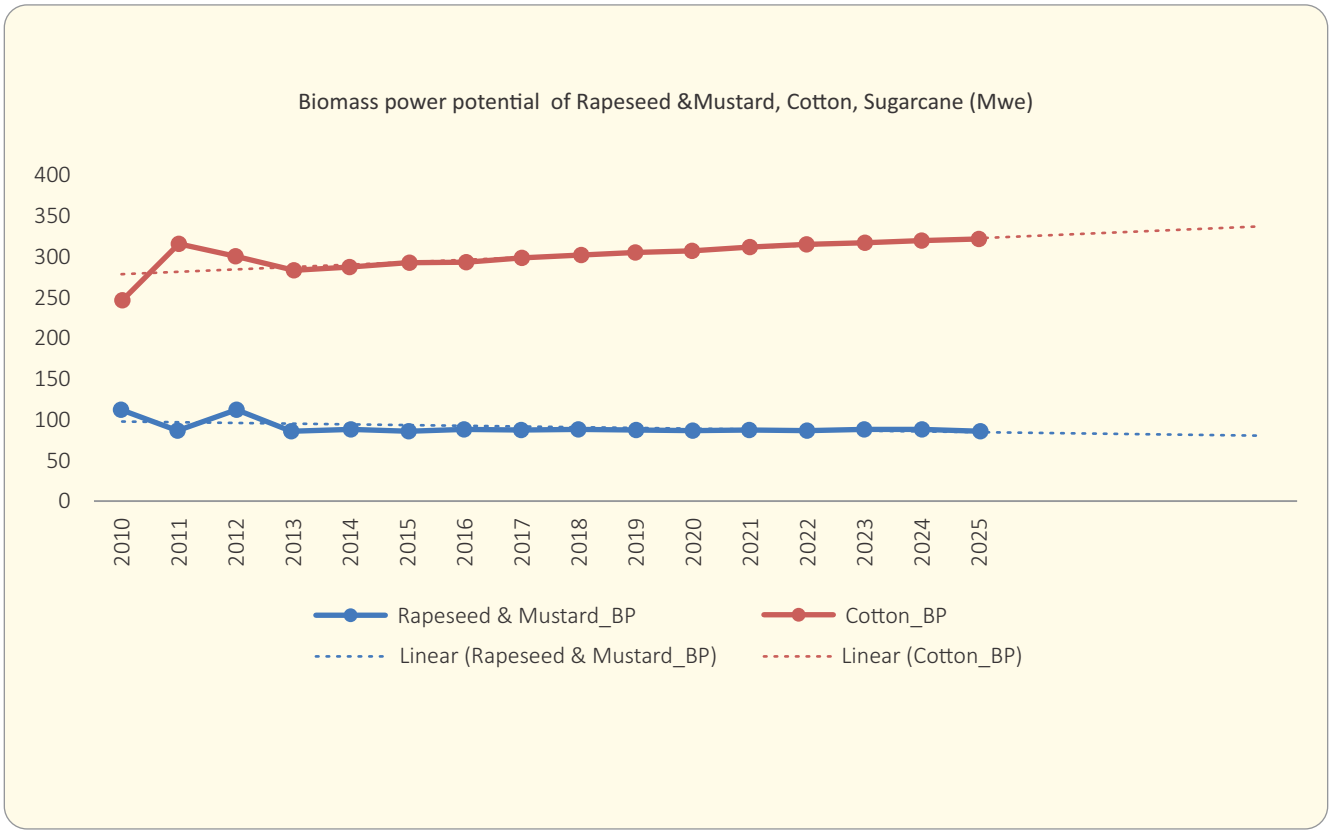


Figure 64: Biomass power potential for Rapeseed & Mustard, and Cotton in Haryana

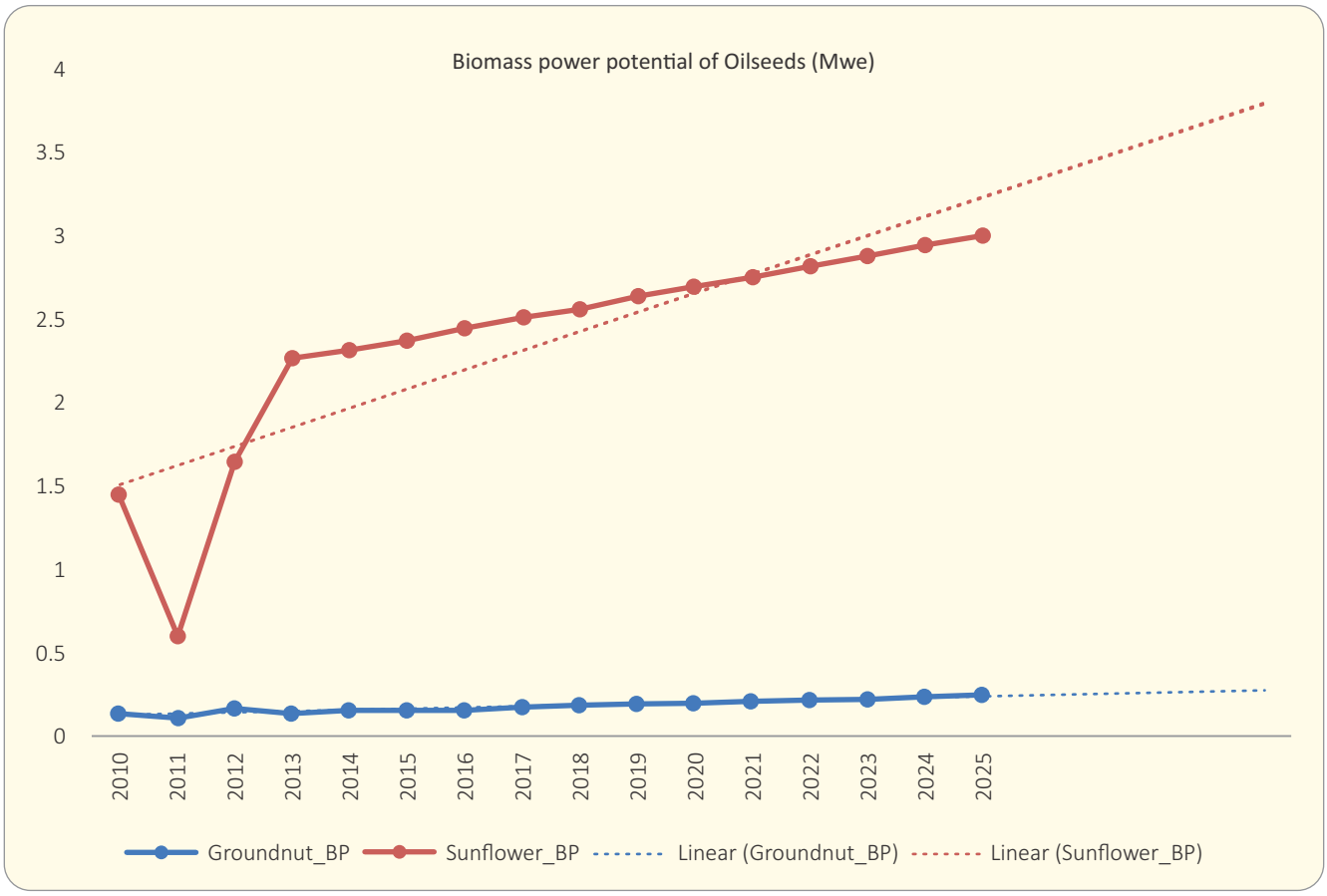


Figure 65: Biomass power potential for Groundnut and Sunflower in Haryana

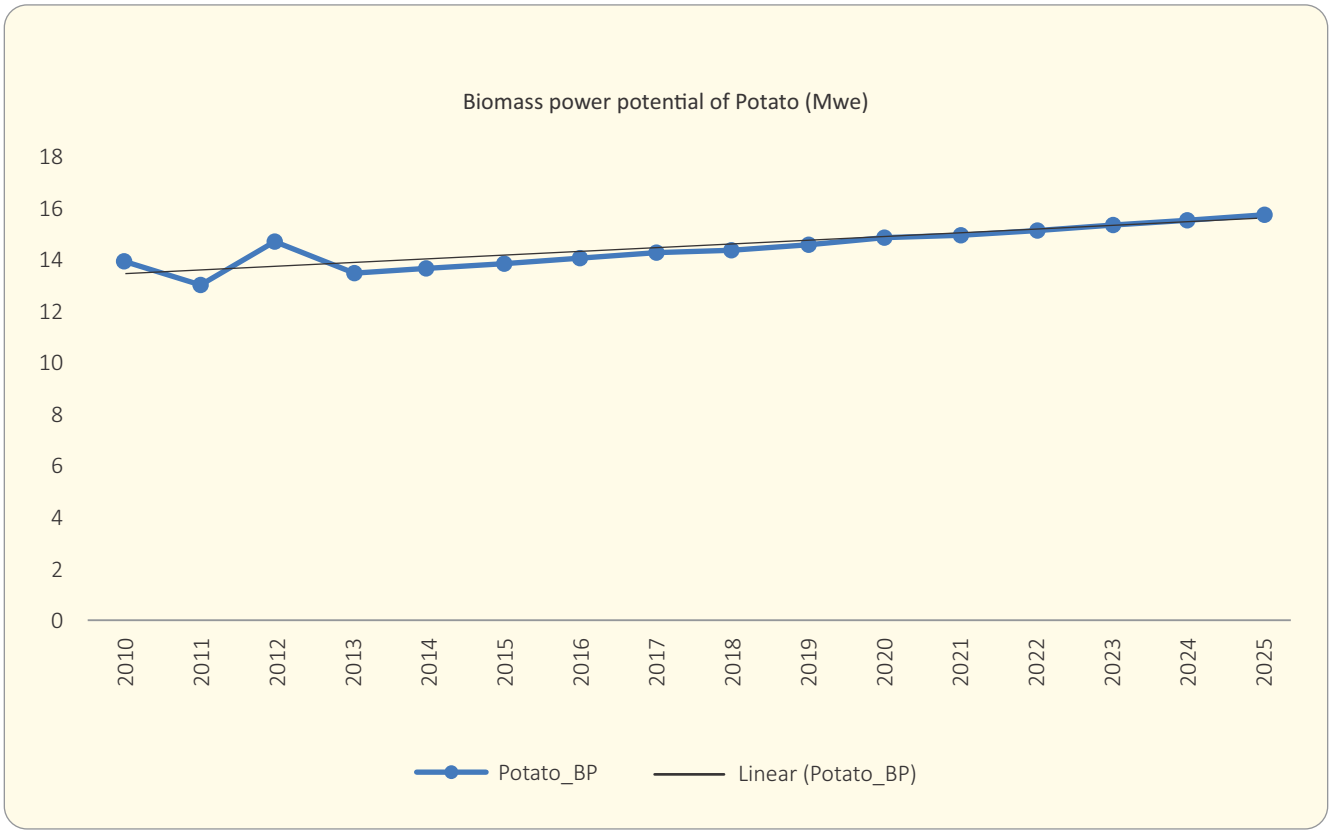


Figure 66: Biomass power potential for Potato in Haryana

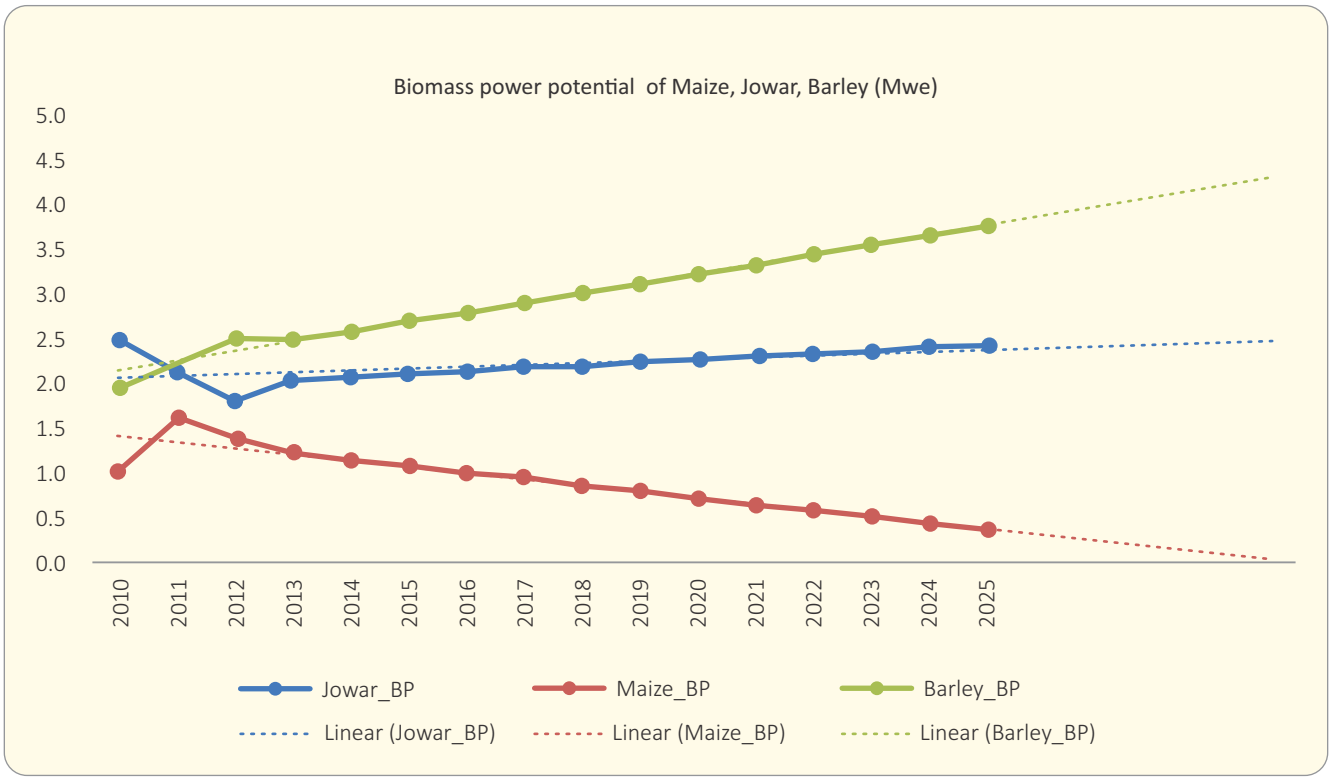


Figure 67: Biomass power potential for Maize, Jowar and Barley in Haryana

Himachal Pradesh

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Himachal Pradesh collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Himachal Pradesh was calculated, which was the input to arrive at biomass power potential in Himachal Pradesh. Thus, the total biomass power potential for the state of Himachal Pradesh for 2018 was 69.71 MWe, and for 2019-20 is 69.21 MWe.

Districts Selected for Primary Field Survey	05 (Chamba, Kangra, Kullu, Sirmaur and Solan)
Average Rainfall	1251 mm
Type of soil	Clay, Loamy yellowish-brown soil and Sandy Soil
Major source of irrigation	Canals, Tube wells and open wells
Major Rivers	Beas, Chinab, Krishna, Ravi and Tons
Major Crops	Apples, Apricot, Barley, Kiwi, Maize, oilseed, onion Paddy, Peach, Plum, Pomegranates, Pulses and Wheat

Utilization of Crop residue at farmer's level in Himachal Pradesh:

1. **Essential Usage**: Residue of Maize and Wheat are extensively utilized for cattle feeding. The residue of Apples, Apricot, Barley, kiwi, Oilseeds, Onion, Peach, Plum Pomegranate and pulses are mostly consumed for compost fertilizer.
2. **Specific Usage**: Some part of the residue of Barley, Maize, Wheat and Paddy are stored for the winter Season. The residue of Paddy and Wheat are used for Mushroom cultivation.
3. **Fuel Usage**: Residue of Apple, paddy and cotton are used for domestic cooking.
4. **Field preparation**: The Stubbles of Cotton, Paddy and Wheat are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Cotton	5000 - 6000
	Paddy	5000 - 7000
	Wheat	4000 - 5000

Survey Images:

Gad, Kullu, Himachal Pradesh

Chhudra, Chamba, Himachal Pradesh

Dhati, Kangra, Himachal Pradesh

Table 63: Crop-wise change in Area, Production and Biomass Potential in Himachal Pradesh

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	78495.33	121071.67	1.50	181607.50	30873.28	4.20	71360.67	111004.00	166506.00	28306.02	3.86	-8.21
Wheat	362932.67	494011.00	1.80	889219.80	177843.96	24.01	337086.67	512392.33	922306.20	184461.24	24.90	3.72
Maize	298968.33	684878.33	2.30	1575220.17	315044.03	36.86	274739.00	634360.67	1459029.53	291805.91	34.08	-7.53
Barley	23402.67	28329.00	1.30	36827.70	3682.77	0.43	19421.00	28530.00	37089.00	3708.90	0.43	0.05
Ragi	2713.83	3030.50	1.30	3939.65	393.97	0.05	1833.67	1917.67	2492.97	249.30	0.03	-38.07
Small millets	6937.33	4946.67	1.20	5936.00	593.60	0.07	4413.67	3290.00	3948.00	394.80	0.05	-28.94
Bajra	333.00	175.50	2.63	461.57	87.70	0.01	105.00	60.33	158.68	30.04	0.00	-63.48
Moong (Green Gram)	419.83	192.33	1.25	240.42	72.13	0.01	110.33	60.33	75.42	22.63	0.00	-71.11
Gram	1169.33	893.33	1.10	982.67	196.53	0.03	394.33	310.33	341.37	68.27	0.01	-70.30
Arhar/Tur	107.00	36.00	2.80	100.80	70.56	0.01	33.67	13.33	37.33	26.13	0.00	-68.48
Peas & beans												
(Pulses)	17394.00	35249.00	0.50	17624.50	8812.25	1.09	5460.00	8725.83	4362.92	2181.46	0.27	-75.18
Urad												
(Black Gram)	11453.50	5437.50	1.30	7068.75	3534.38	0.32	7656.00	3875.00	5037.50	2518.75	0.23	-28.29
Horse Gram	2403.67	1100.67	1.30	1430.87	143.09	0.02	1641.33	763.33	992.33	99.23	0.01	-36.99
Other Kharif Pulses	4448.00	2579.50	1.30	3353.35	670.67	0.08	4911.67	4059.67	5277.57	1055.51	0.13	59.65
Other Rabi Pulses	584.50	315.50	1.30	410.15	41.02	0.00	10078.00	40037.00	52048.10	5204.81	0.63	0
Moth Beans	21.67	6.33	1.80	11.39	3.42	0.00	16.33	6.83	12.29	3.69	0.00	0
Masoor	1305.00	661.50	1.79	1184.09	592.04	0.06	456.00	277.33	496.43	248.21	0.03	-57.31
Soyabean	671.00	1125.50	1.70	1913.35	325.27	0.04	540.00	923.00	1569.10	266.75	0.03	-16.64
Rapeseed & Mustard	8892.67	3561.00	1.80	6409.80	3204.90	0.42	7927.00	3546.33	6383.40	3191.70	0.42	-0.45
Linseed	1259.17	303.17	1.48	448.69	89.74	0.01	674.33	196.33	290.57	58.11	0.01	-41.30
Groundnut	100.33	87.17	2.30	200.48	40.10	0.00	39.67	36.33	83.57	16.71	0.00	0
Sannhamp	60.00	11.00	2.52	27.72	5.54	0.00	5.00	1.00	2.52	0.50	0.00	0

Table 63: Crop-wise change in Area, Production and Biomass Potential in Himachal Pradesh

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Sesamum	3565.00	1379.00	2.52	3475.08	1390.03	0.17	989.67	320.57	807.83	323.13	0.04	-76.62
Turmeric	194.83	102.83	0.30	30.85	18.51	0.00	173.67	101.83	30.55	18.33	0.00	0
Coriander	177.17	40.00	1.15	46.00	23.00	0.00	112.00	27.67	31.82	15.91	0.00	0
Garlic	3763.00	3082.17	0.30	924.65	924.65	0.13	3722.67	2916.67	875.00	875.00	0.12	-8.73
Ginger	2334.50	14866.00	0.05	743.30	245.29	0.03	2276.00	15390.17	769.51	253.94	0.03	7.58
Dry chillies	644.00	203.67	1.50	305.50	244.40	0.03	528.50	181.50	272.25	217.80	0.03	-5.84
Sugarcane	5538.00	114952.00	0.05	5747.60	1436.90	0.20	1900.33	40748.33	2037.42	509.35	0.07	-65.36
Onion	830.67	6421.33	0.05	321.07	70.63	0.01	724.00	6214.00	310.70	68.35	0.01	-7.04
Cotton	830.67	4.34	6.00	223.60	178.88	0.02	30.00	12.00	140.40	112.32	0.01	-32.10
Potato	830.67	252947.00	0.81	204887.07	135225.47	12.58	9871.00	85779.67	69481.53	45857.81	4.27	-66.06
Total	**830.67**	**1782000.50**		**2951324.11**			**769231.17**	**1506079.40**	**2743297.78**	**572170.62**	**69.71**	**-13.82**

Table 64: Crop-wise Area, Production, Biomass, Surplus biomass and Biomass Power Potential (MWe) for Himachal Pradesh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	69785.75	109542.90	164314.30	27933.43	3.79
2	Wheat	339131.60	533622.90	960521.20	192104.20	25.93
3	Bajra	1209.87	192.85	507.22	96.37197.00	0.01
4	Maize	276496.70	621679.50	1429863.00	285972.50	33.43
5	Gram	263.56	279.19	307.11	61.42	0.00
6	Tur (Arhar)	45.00	23.00	64.40	45.08	0.00
7	Lentil (Masur)	455.21	388.49	699.28	349.64	0.03
8	Groundnut	32.94	39.24	90.27	18.05	0.00
9	Soyabean	585.78	1005.29	1709.00	290.53	0.036
10	Rapeseed & Mustard	8687.08	4234.22	7621.61	3810.80	0.49
11	Sugarcane	1679.14	46812.06	2340.60	585.15	0.07
12	Ginger	650.21	2349.72	117.48	38.77	0.00
13	Green Gram (Moong)	186.12	109.75	137.19	41.15	0.00
14	Ragi	2589.15	2676.47	3479.41	347.94	0.04
15	Sesamum	515.50	-23.98	-59.95	-23.98	-0.00
16	Black Gram (Urad)	6243.56	4013.91	5218.08	2609.04	0.23
17	Potato	10367.04	89768.79	72712.72	47990.39	4.46
18	Barley	18609.58	29825.49	38773.14	3877.31	0.44
19	Peas & Beans	4002.87	5349.79	2674.89	1337.45	0.16
	Total	**741536.7**	**1451890**	**2691091**	**567485.40**	**69.21**

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Maize with 33.43 MWe followed by Wheat (25.93 MWe), Potato (4.46 MWe), Rice (3.79 MWe) and Rapeseed & Mustard (0.49 MWe)

Trend Analysis for Biomass power potential for the state of Himachal Pradesh – Crop-wise

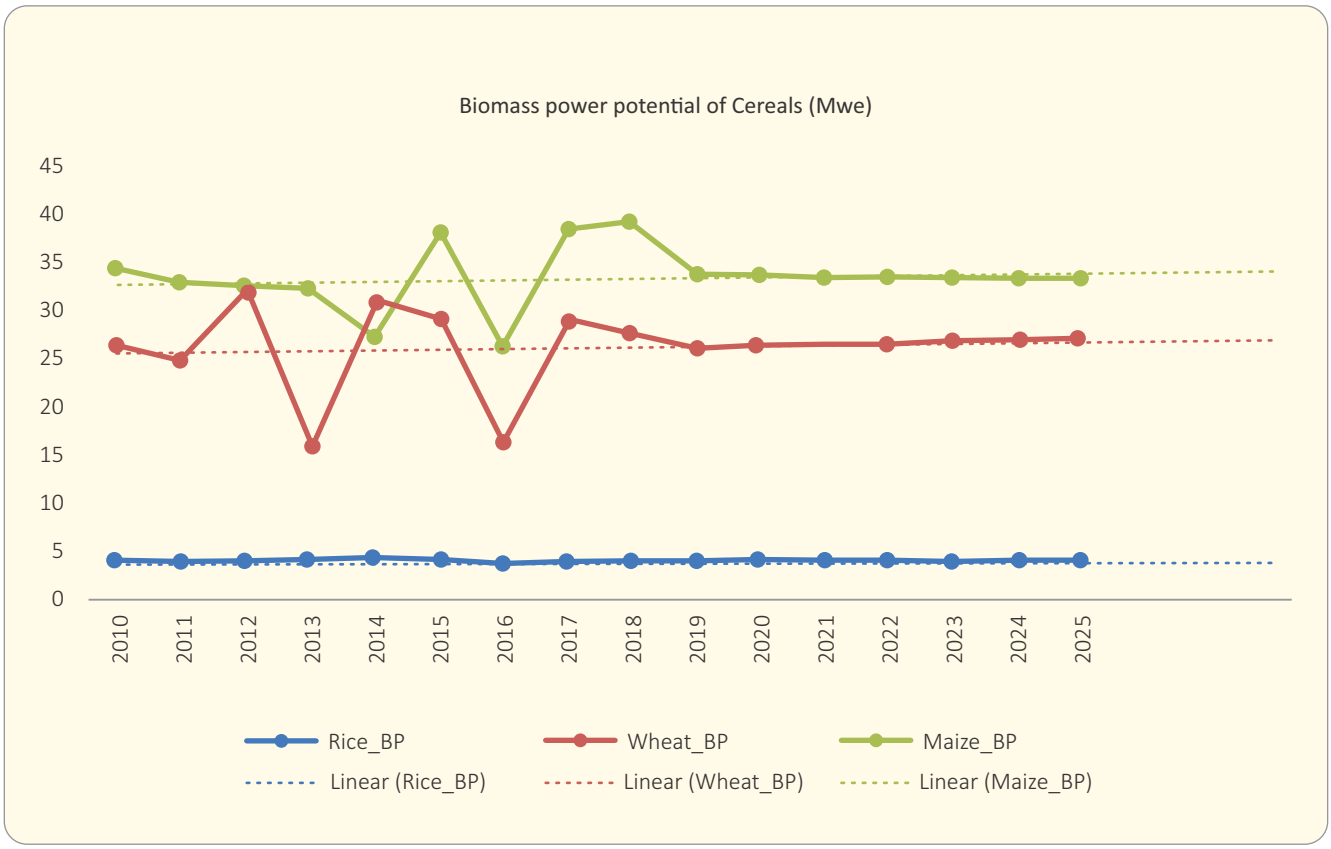


Figure 68: Biomass Power Potential for Cereals in Himachal Pradesh

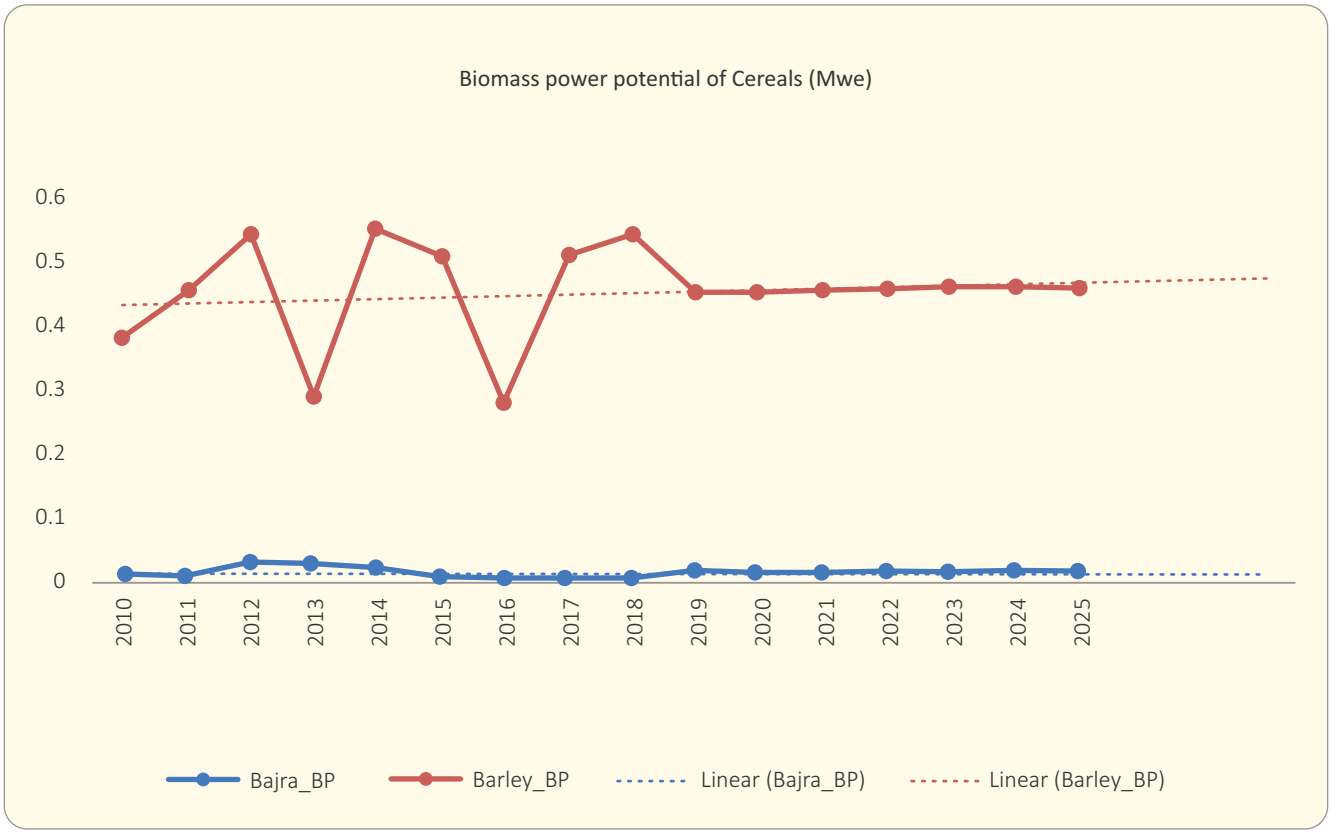


Figure 69: Biomass Power Potential for Cereals in Himachal Pradesh

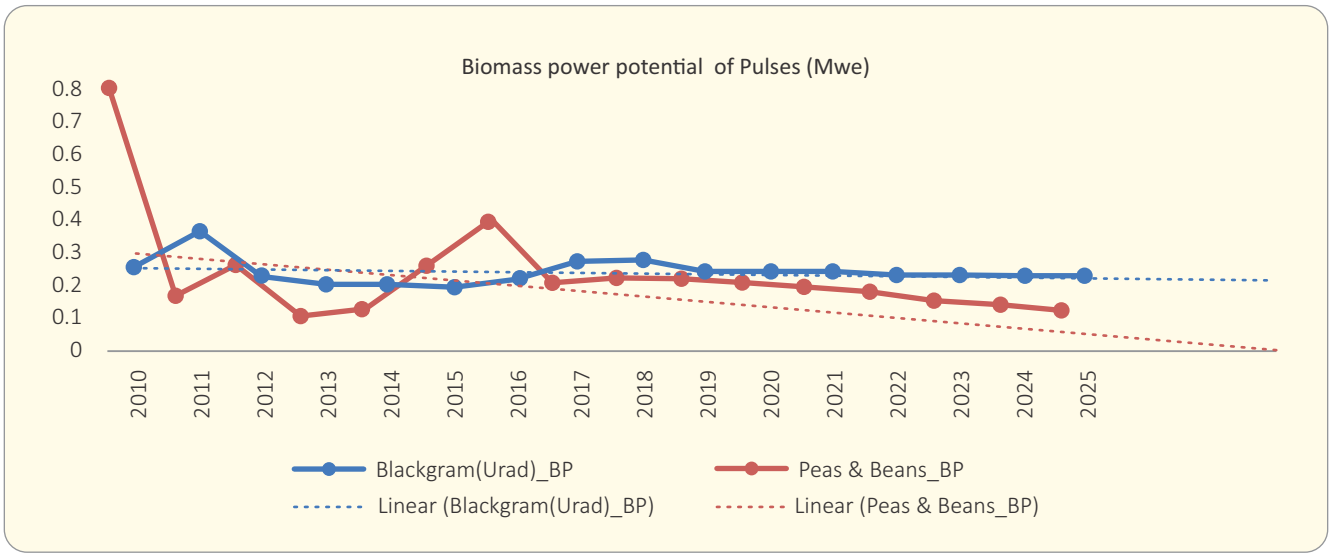


Figure 70: Biomass Power Potential for Pulses in Himachal Pradesh

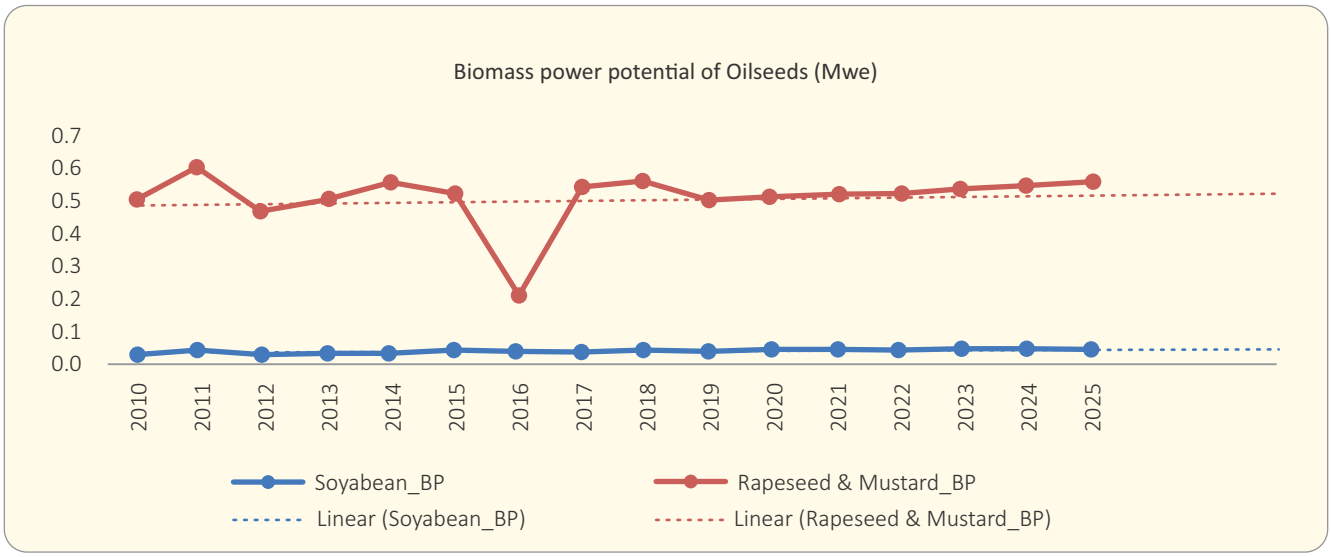


Figure 71: Biomass Power Potential for Soyabean and Rapeseed & Mustard in Himachal Pradesh

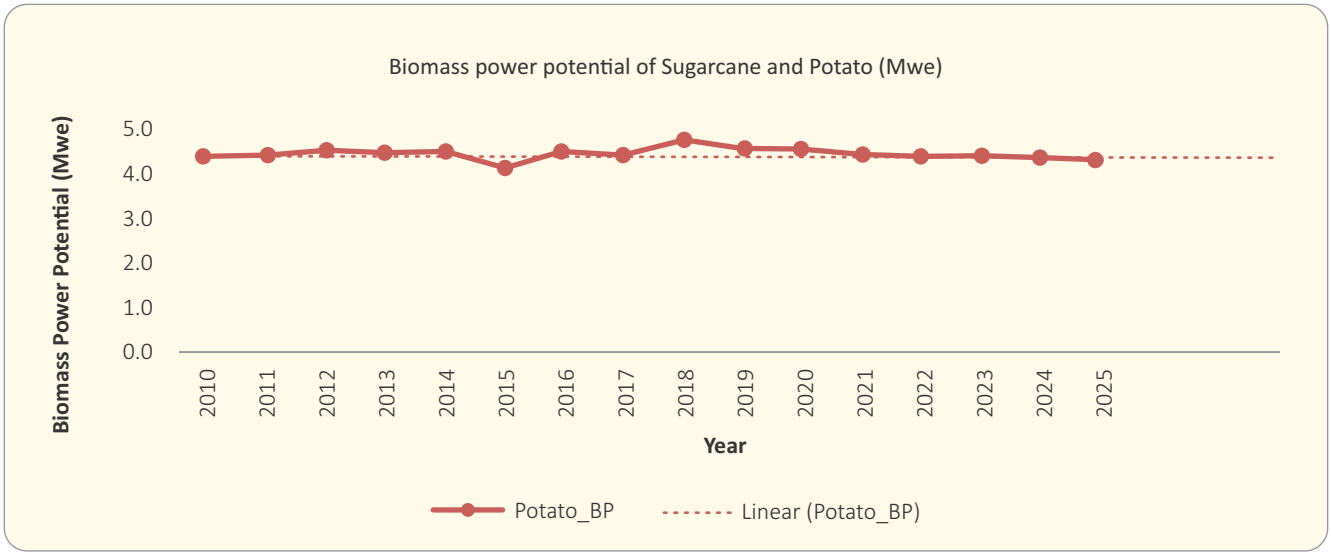
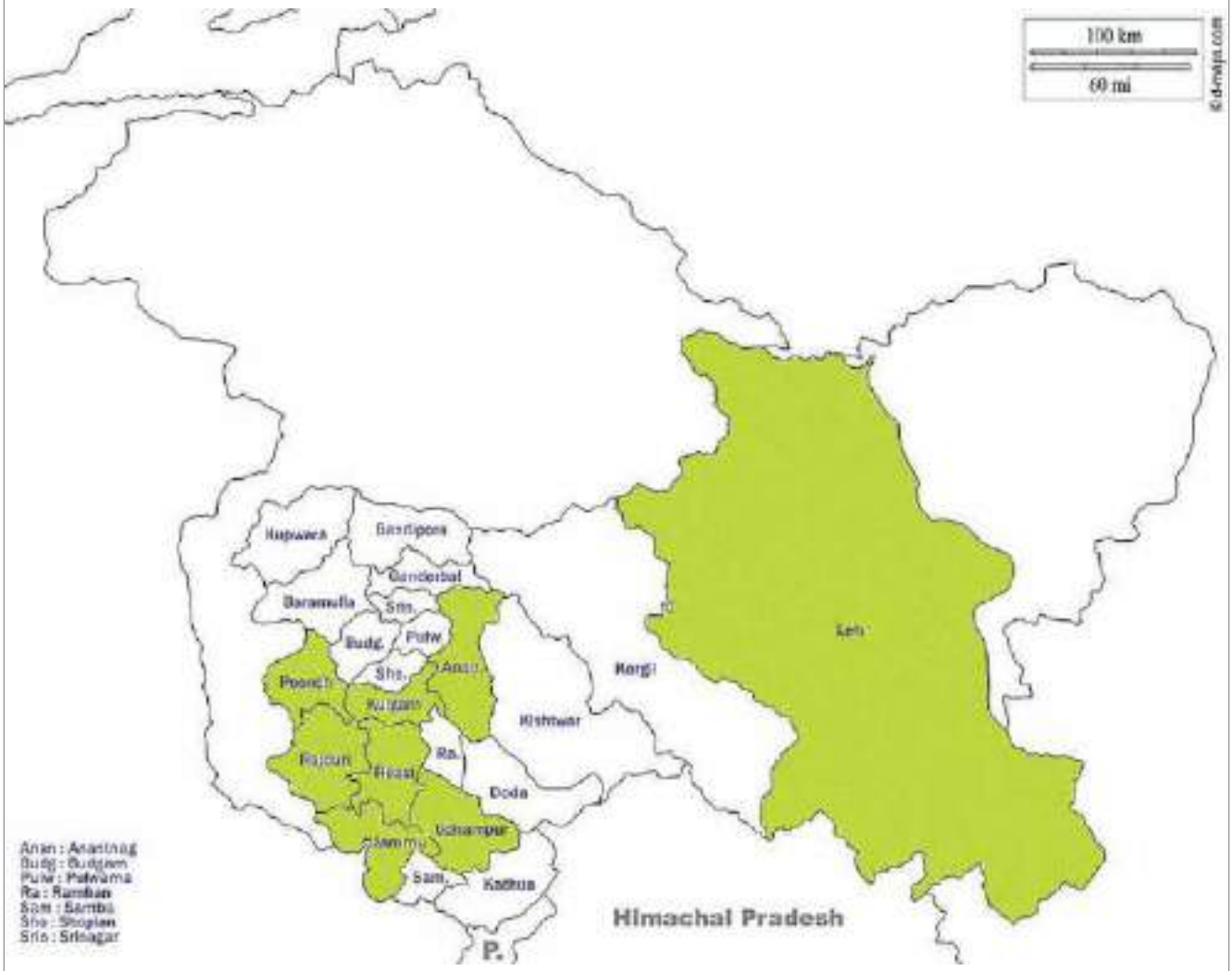


Figure72: Biomass Power Potential for Potato in Himachal Pradesh

Jammu and Kashmir



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Jammu and Kashmir collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Jammu and Kashmir was calculated, which was the input to arrive at biomass power potential in Jammu and Kashmir. Thus, the total biomass power potential for the state of Jammu and Kashmir for 2018 was 82.82 MWe, and for 2019-20 is 83.69 MWe.

Districts Selected for Primary Field Survey	05 (Jammu, Leh, Ladakh, Poonch, Rajauri, Reasi and Udhampur)
Average Rainfall	1011 mm
Type of soil	Alluvial Soil, Brown Hill, Sub Montane
Major source of irrigation	Canals and River
Major Rivers	Jhelum
Major Crops	Maize, Rapeseed & Mustard, Rice, Wheat

Utilization of Crop residue at farmer's level in Jammu and Kashmir:

1. **Essential Usage**: Residue of Maize, Paddy and Wheat is extensively utilized for cattle feeding.
2. **Specific Usage**: Organic farming is promoted by plant residues, farmyard manure, biofertilizers, vermicompost, biopesticides, biocontrol agents, associated cropping of legumes with cereals etc.
3. **Fuel Usage**: Residue of Rapeseed & Mustard, Paddy and Wheat are used for domestic cooking.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy	4000
	Rapeseed & Mustard	3000
	Wheat	4000

Survey Images:

Jerri, Reasi, J&K

Hathal, Sunderbani, Rajouri, J&K

Mandhar, Poonch, J&K

Table 65: Crop-wise change in Area, Production and Biomass Potential in Jammu and Kashmir

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	283695.5	618549.45	927824.175	157730.1	21.45129	287176.00	577238.00	865857.00	147195.69	20.05	-6.54
Wheat	284826.2	526074.067	946933.32	189386.7	25.5672	290502.00	577875.00	1040175.00	208035.00	28.08	9.85
Maize	348314	529797	1218533.1	243706.6	28.51367	297183.00	530966.00	1221221.80	244244.36	28.53	0.05
Barley	16085.5	9136.56667	11877.5367	1187.754	0.137779	6392.00	3916.00	5090.80	509.08	0.06	-57.14
Bajra	21735.5	12893.25	33909.2475	6442.757	0.786016	16319.00	6284.00	16526.92	3128.31	0.38	-51.60
Small millets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Other Cereals	11596.5	5820.2	8730.3	873.03	0.103018	0.00	0.00	0.00	0.00	0.00	-100.00
Cowpea	1569	535.1	588.61	117.722	0.015775	0.00	0.00	0.00	0.00	0.00	-100.00
Moong (Green Gram)	1414	683.3	854.125	256.2375	0.032798	0.00	0.00	0.00	0.00	0.00	-100.00
Masoor	215.6667	95.7666667	171.422333	85.71117	0.008828	0.00	0.00	0.00	0.00	0.00	-100.00
Gram	284	155.2	170.72	34.144	0.004473	0.00	0.00	0.00	0.00	0.00	-100.00
Arhar /Tur	22	12.1	33.88	23.716	0.00287	0.00	0.00	0.00	0.00	0.00	-100.00
Peas & beans (Pulses)	2071	1666.41667	833.208333	416.6042	0.051659	1969.00	2383.00	1191.50	595.75	0.07	43.00
Urad (Back Gram)	17070.5	7215.25	9379.825	4689.913	0.895773	8810.33	2993.00	3890.90	1945.45	0.18	-80.21
Horse-gram	2306	676.4	879.32	87.932	0.011167	0.00	0.00	0.00	0.00	0.00	-100.00
Moth	3175	1907.3	3429.28687	1028.786	0.120368	0.00	0.00	0.00	0.00	0.00	-100.00
Other Kharif pulses	3912.5	2783.3	3618.29	723.658	0.087563	0.00	0.00	0.00	0.00	0.00	-100.00
Other Rabi pulses	702.1667	288.85	375.505	37.5505	0.004544	0.00	0.00	0.00	0.00	0.00	-100.00
other oilseeds	171.1667	75.9166667	151.833333	151.8333	0.014424	0.00	0.00	0.00	0.00	0.00	-100.00
Groundnut	42	21	48.3	9.66	0.001179	0.00	0.00	0.00	0.00	0.00	-100.00
Linseed	217.3333	136.516667	202.044667	40.40893	0.004081	0.00	0.00	0.00	0.00	0.00	-100.00
Rapeseed &Mustard	61739.83	46439.8333	83591.7	41795.85	5.475256	48535.00	31211.00	56179.80	28089.90	3.68	-32.79
Sesamum	6866.5	2950.75	7376.875	2950.75	0.362942	4604.00	1930.00	4825.00	1930.00	0.24	-34.59
Sannhamp	405.5	215.85	543.942	108.7884	0.01349	0.00	0.00	0.00	0.00	0.00	-100.00

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Turmeric	18.5	18.75	5.625	3.375	0.000449	0.00	0.00	0.00	0.00	0.00	-100.00
Coriander	9	1.1	1.265	0.6325	8.03E-05	0.00	0.00	0.00	0.00	0.00	-100.00
Garlic	697.3333	596.616667	178.985	178.985	0.024342	0.00	0.00	0.00	0.00	0.00	-100.00
Ginger	75	88.7	4.435	1.46355	0.000186	0.00	0.00	0.00	0.00	0.00	-100.00
Dry chillies	658.5	662.85	994.275	795.42	0.103405	0.00	0.00	0.00	0.00	0.00	-100.00
Cotton	64	5.44	255.168	204.1344	0.0247	0.00	0.00	0.00	0.00	0.00	-100.00
Onion	537.3333	1091.88333	54.5941667	12.01072	0.001633	0.00	0.00	0.00	0.00	0.00	-100.00
Tobacco	14	4.8	4.8	4.8	0.000638	0.00	0.00	0.00	0.00	0.00	-100.00
Sugarcane	193	952.1	47.605	11.90125	0.001619	0.00	0.00	0.00	0.00	0.00	-100.00
Potato	2763.667	23658.6333	19163.493	12647.91	1.176255	3374.00	31117.00	25204.77	16635.15	1.55	31.67
Total	**1073468**	**1795210.26**	**3280766.81**			**964864.33**	**1765913.00**	**3240163.49**	**652308.69**	**82.82**	**-2.57**

Table 66: Crop-wise Area, Production, Biomass Production, Surplus Biomass and Biomass Power Potential for Jammu and Kashmir in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	286612.10	567831.90	851747.90	144797.10	19.69
2	Wheat	308956.80	601481.10	1082666.00	216533.20	29.23
3	Bajra	18908.82	9025.41	23736.85	4510.00	0.55
4	Maize	292245.20	498856.50	1147370.00	229474.00	26.82
5	Barley	6927.24	4477.52	5820.78	582.07	0.06
6	Black Gram (Urad)	11051.23	3527.28	4585.46	2292.73	0.20
7	Peas & Beans	1807.86	2280.65	1140.32	570.16	0.07
8	Green Gram (Moong)	507.73	206.75	258.44	77.53	0.09
9	Gram	23.00	4.80	5.28	1.05	0.00
10	Lentil (Masur)	358.54	198.94	358.09	179.04	0.01
11	Rapeseed & Mustard	51697.53	45392.07	81705.72	40852.86	5.35
12	Sesamum	4521.26	1603.46	4008.66	1603.46	0.19
13	Sugarcane	230.21	237.57	11.87	2.96	0.00
14	Potato	2853.77	27665.9	22409.38	14790.19	1.37
	Total	**986701.4**	**1762790**	**3225825**	**656266.4**	**83.69**

Major contributing crops in biomass power potential in Jammu and Kashmir (2019-20) is Wheat with 29.23 MWe, followed by Maize (26.82 MWe), Rice (19.69 MWe), Rapeseed & Mustard (5.53 MWe) and Potato (1.37 MWe)

Trend Analysis for Biomass power potential for the state of Jammu and Kashmir – Crop-wise

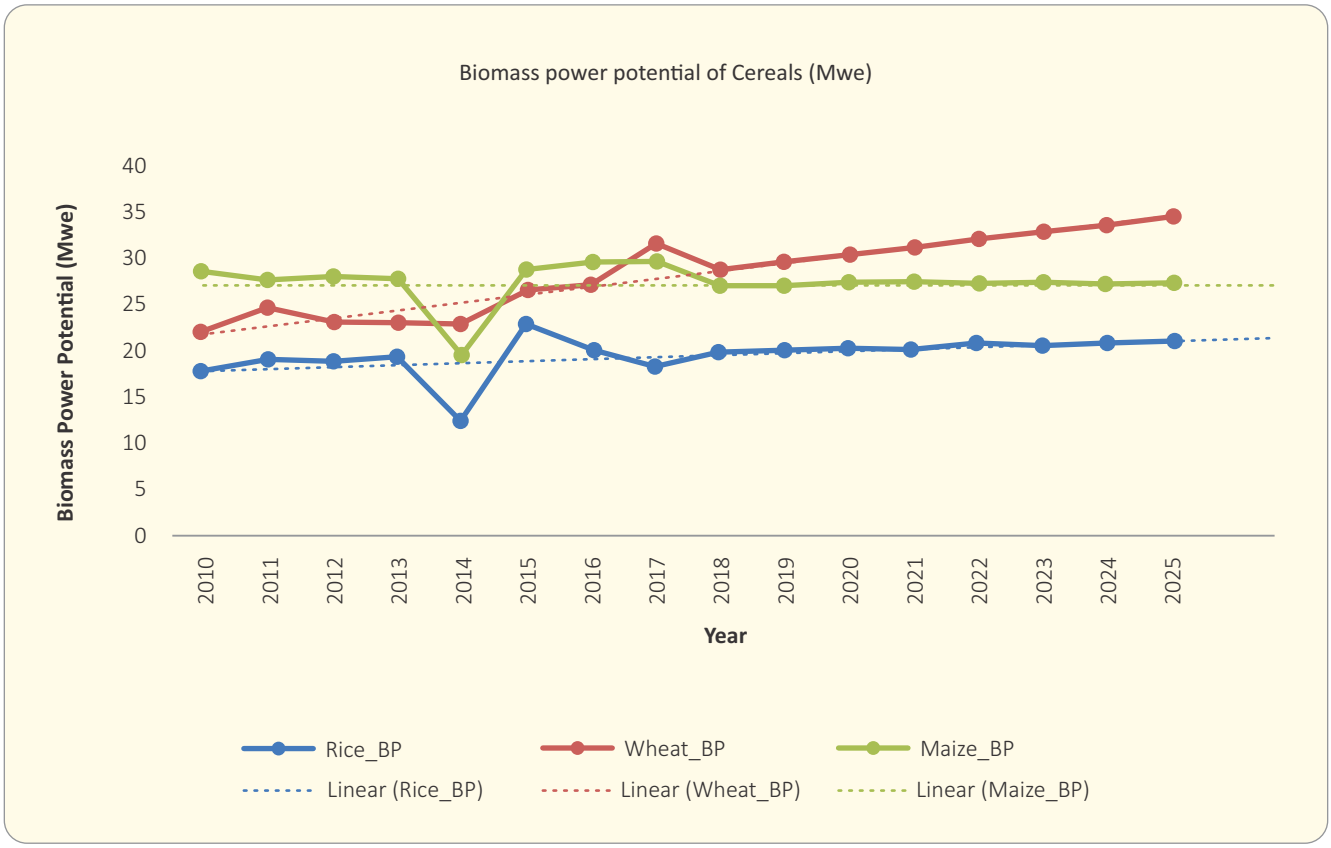


Figure 73: Biomass Power Potential for Cereals in Jammu & Kashmir

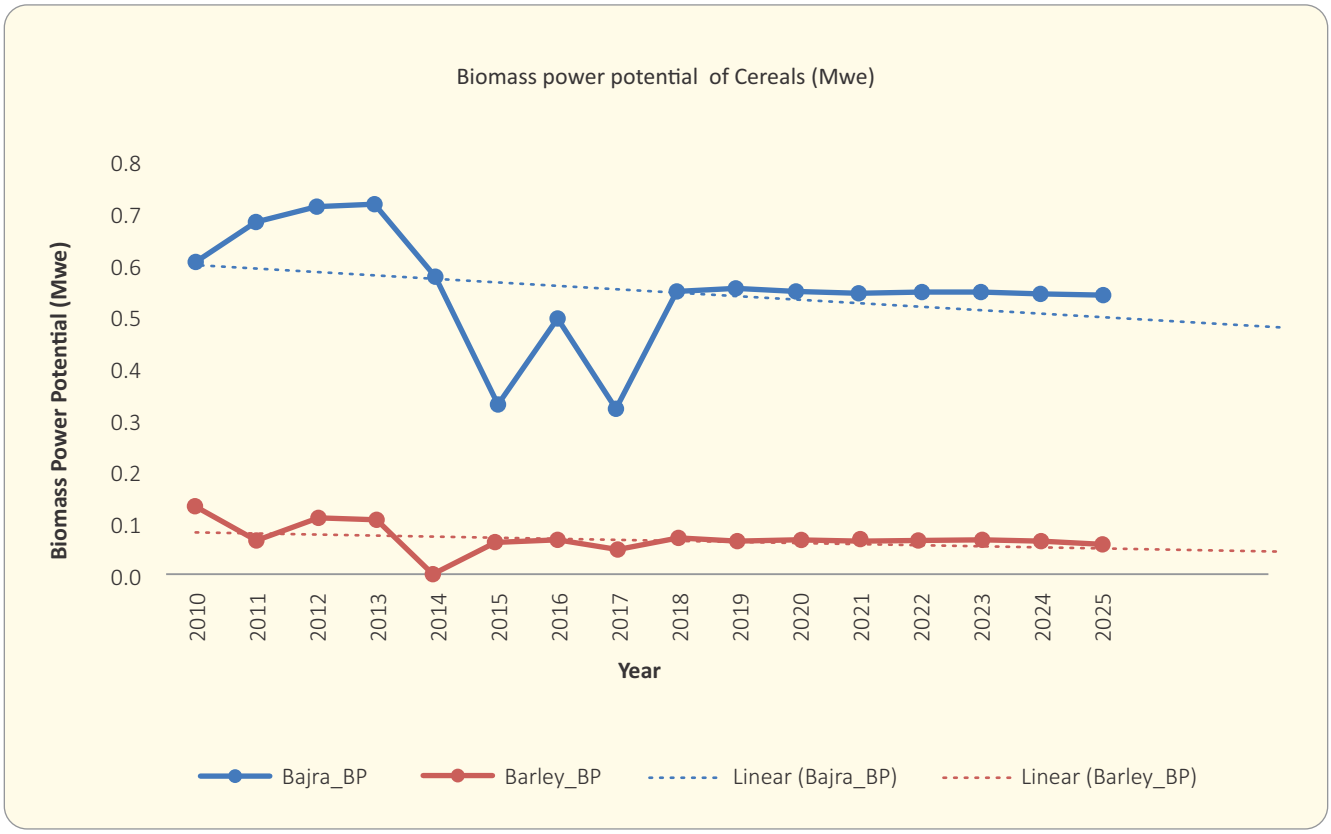


Figure 74: Biomass Power Potential for Bajra and Barley in Jammu & Kashmir

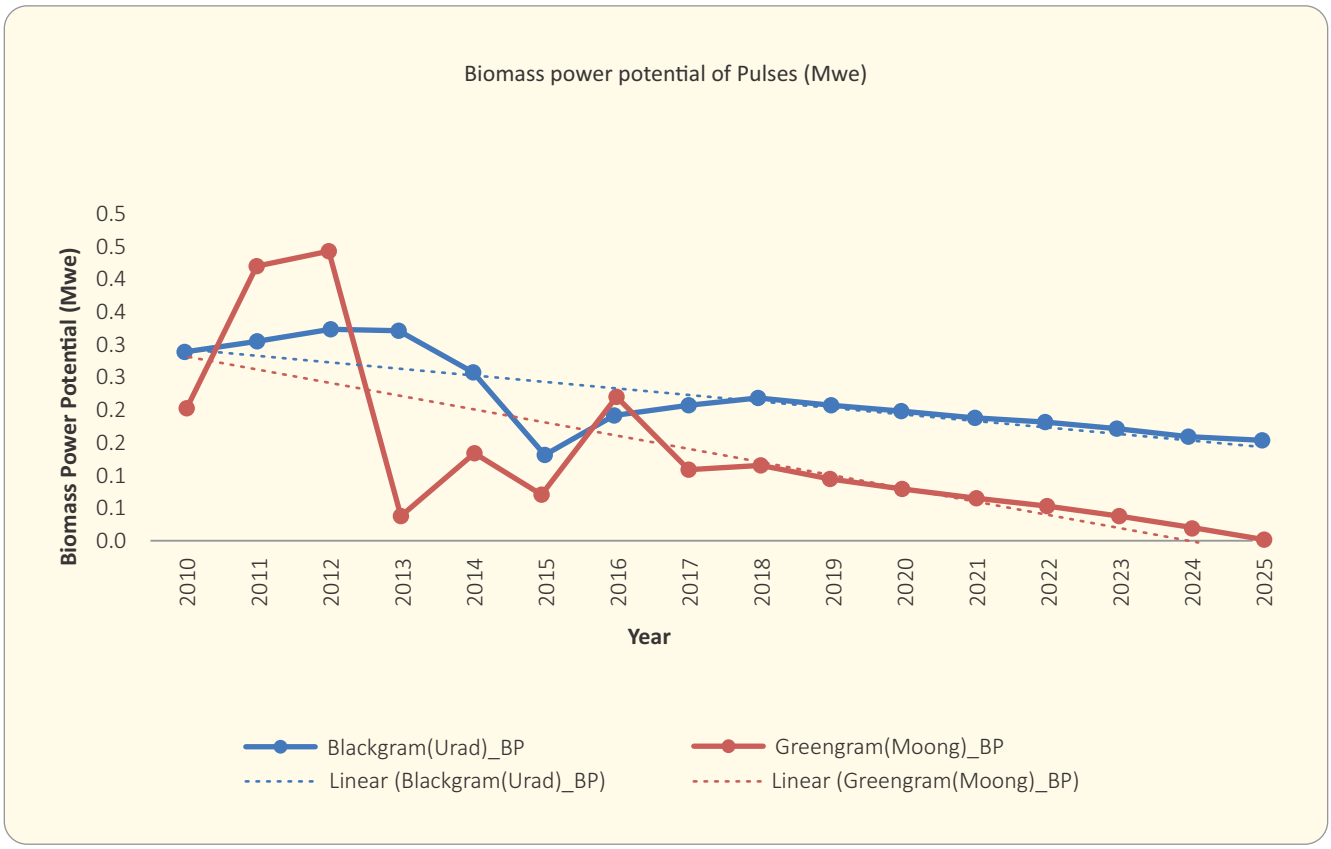


Figure 75: Biomass Power Potential for Pulses in Jammu & Kashmir

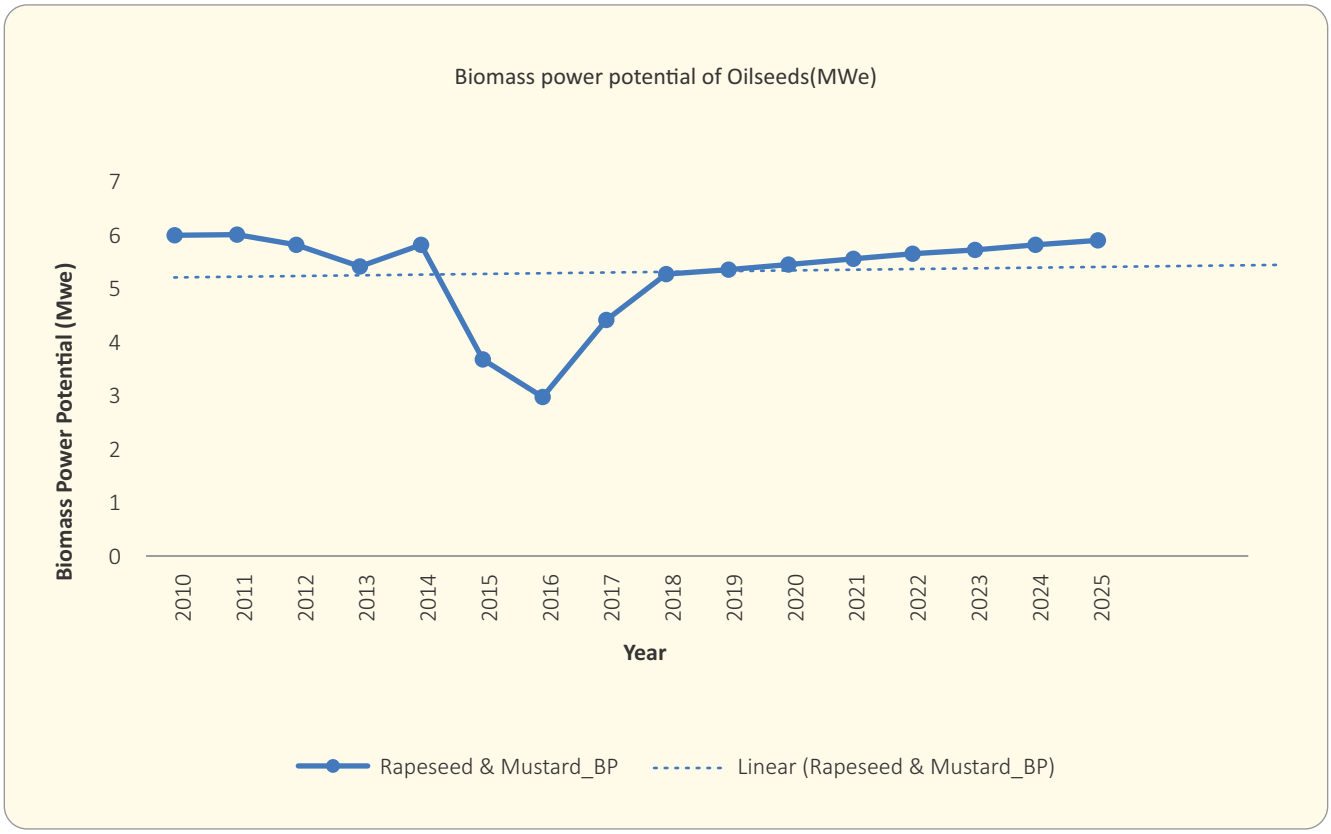


Figure 76: Biomass Power Potential for Rapeseed & Mustard in Jammu & Kashmir

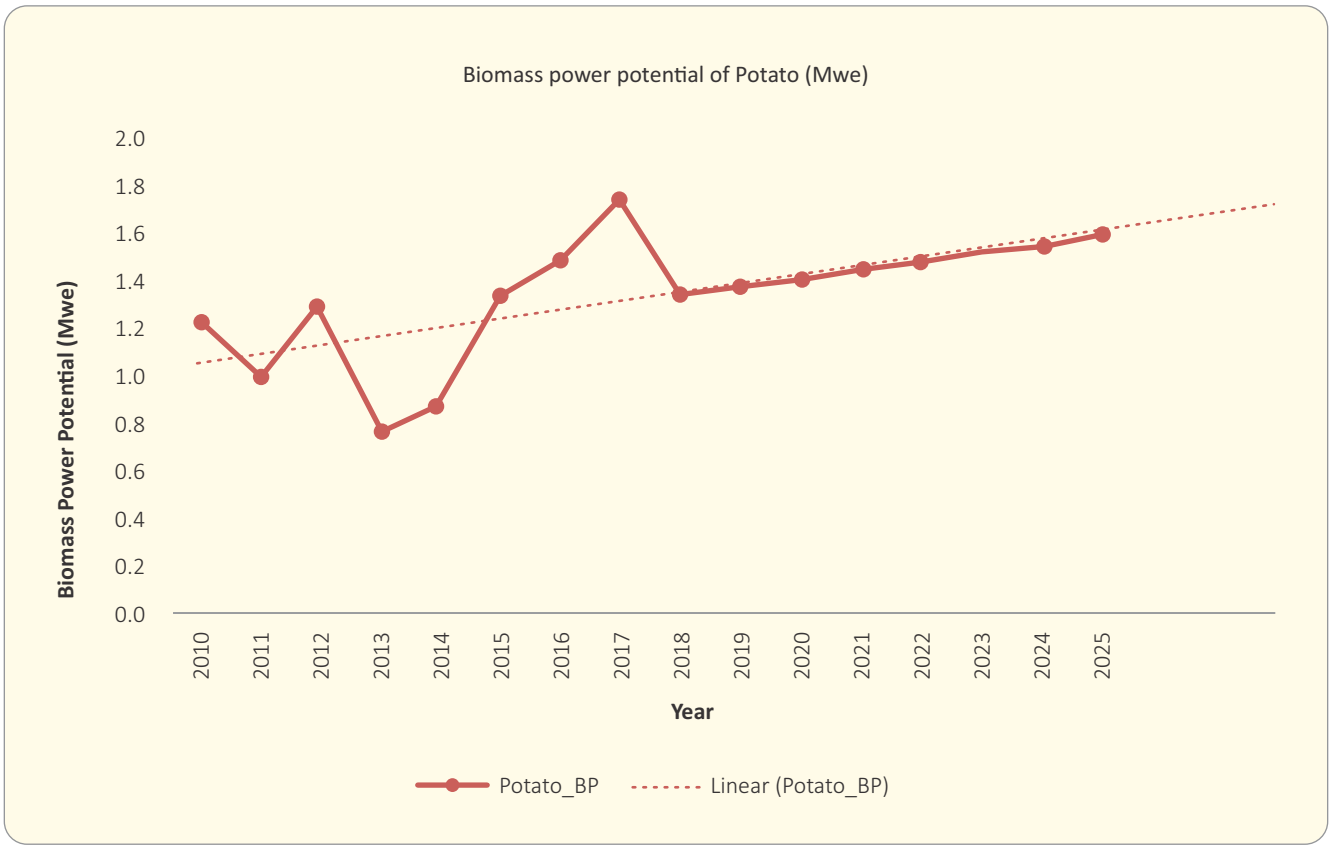


Figure 77: Biomass Power Potential for Potato in Jammu & Kashmir

Jharkhand

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Jharkhand collected information and samples from all eight (08) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Jharkhand was calculated, which was the input to arrive at biomass power potential in Jharkhand. Thus, the total biomass power potential for the state of Jharkhand for 2018 was 146.31 MWe and for 2019-20 is 132.95 MWe.

Districts Selected for Primary Field Survey	08 (Palamu, Gumla, Garhwa, Hazaribagh, Chatra, Lohardaga, Simdega, Ranchi)
Average Rainfall	1430 mm
Type of soil	Clay loamy, Laterite Soil, Red laterite to sandy clay, Sandy loamy
Major source of irrigation	Canals, Tube wells and Open wells
Major Rivers	Damodar, Mayurakshi, Sankh
Major Crops	Gram, Groundnut, Maize, Paddy, Pulses, Rapeseed & Mustard, Seasame, Sunflower, Urad and Wheat

Utilization of Crop residue at farmer's level in Jharkhand:

1. **Essential Usage**: Residue of Gram, Groundnut, Maize and Urad are extensively utilized for cattle feeding. The residue of Gram, Groundnut, Maize, Pulses, Rapeseed & Mustard, Seasame, Sunflower and Urad are used for the preparation of compost fertilizer also.
2. **Fuel Usage**: The residue of Maize, Paddy, Rapeseed & Mustard and Wheat are also utilized for domestic cooking.
3. **Field preparation**: Stubbles of Paddy, Udad, Rapeseed & Mustard, and Wheat predominantly burn on the field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	2500
Expected Cost against the sale of crop residue in Future	Paddy	2500 - 10000
	Rapeseed & Mustard	5000 - 6000
	Wheat	4000 - 10000

Survey Images:

Porsam, Palamu, Jharkhand

Kudurdega, Simdega, Jharkhand

Hesal, Lohardaga, Jharkhand

Table 67: Crop-wise change in Area, Production and Biomass Potential in Jharkhand

Crops	2006-08					2016-18					
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Growth Rate (%)
Rice	1233390.35	1513182.41	2269773.61	226977.36	30.87	1413319.33	2319506.88	3479260.33	347926.03	47.32	50.15
Wheat	80213.26	105322.00	189579.60	37915.92	5.12	98415.00	189136.33	340445.40	68089.08	9.19	79.53
Maize	76223.21	97071.67	223264.83	102701.82	12.02	179370.67	327530.33	753319.77	346527.09	40.51	237.25
Ragi	33613.57	29076.50	37799.45	7181.90	0.89	19750.00	19909.33	25882.13	4917.61	0.61	-32.92
Masoor	4437.20	2806.34	5023.35	2411.21	0.25	29003.33	25041.00	45073.80	21635.42	2.23	778.90
Arhar/Tur	18337.39	25683.17	71912.87	50339.01	6.09	103377.67	122617.00	343327.60	240329.32	28.98	375.92
Rapeseed &											
Mustard	11937.58	8297.24	14935.03	10454.52	1.37	44001.67	37883.00	68189.40	47732.58	6.25	356.42
Potato	38658.09	275104.83	222834.92	100275.71	9.33	41782.56	319114.22	258482.52	116317.13	10.83	-21.44
Urad						41370.00	61998.00	80597.40	53283.84	4.85	0
Castor seed						153.00	57.00	233.70	140.22	0.02	0
Total	**1496810.64**	**2056544.15**	**3035123.65**	**538257.45**	**65.93**	**1956887.00**	**3319678.00**	**5311037.49**	**1201784.62**	**146.31**	**121.92**

Table 68: Crop-wise Area, Production, Biomass Production, Surplus biomass and Biomass Power Potential for Jharkhand in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1182221	2132491	3198737	319873.7	43.50282
2	Wheat	89887.66	173094.9	311570.8	62314.16	8.412411
3	Maize	157541.5	299105.8	687943.3	316453.9	36.99346
4	Tur (Arhar)	93124.97	112184.6	314116.8	219881.8	26.51774
5	Lentil (Masoor)	26343.25	22801.02	41041.84	19700.08	2.033048
6	Rapeseed & Mustard	44284.81	39061.52	70310.73	49217.51	6.447494
7	Sugarcane	437.6515	24998.86	1249.943	312.4857	0.042498
8	Ragi	10608.16	11666.34	15166.24	2881.586	0.357893
9	Potato	35347.96	254769.9	206363.6	92863.64	8.645605
	Total	**1639797**	**3070174**	**4846500**	**1083499**	**132.953**

Major contributing crops in biomass power potential in Jharkhand (2019-20) is Rice with 43.50 MWe followed by Maize (36.99 MWe), Arhar / Tur (26.51 MWe), Potato (8.64 MWe) and Wheat (8.41 MWe)

Trend Analysis for Biomass power potential for the state of Jharkhand – Crop-wise

The following trend graphs represent the biomass power potential from 2000 to 2030 for the Jharkhand

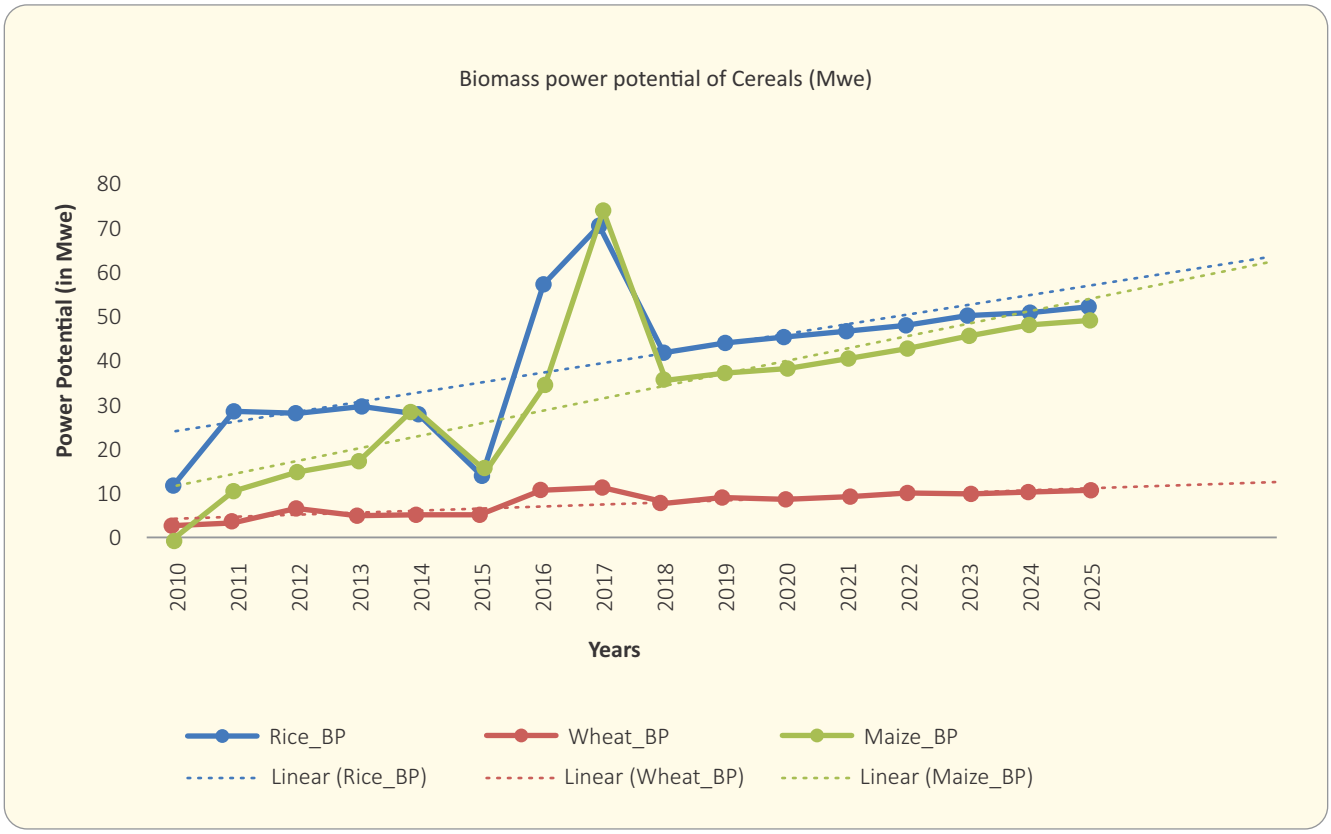


Figure 78: Biomass Power Potential for Cereals in Jharkhand

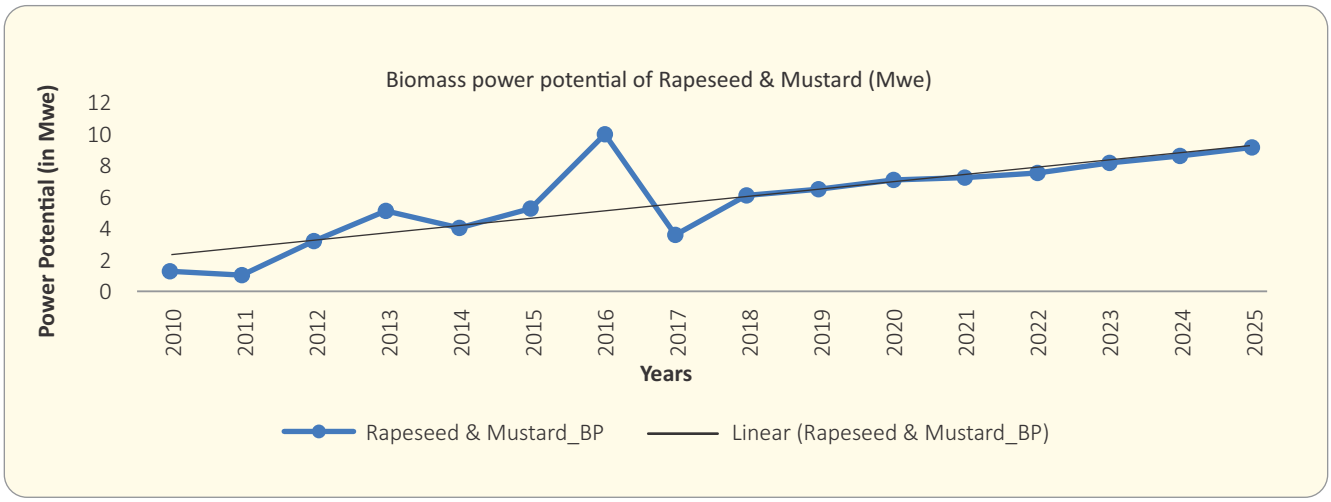


Figure 79: Biomass Power Potential for Rapeseed and Mustard in Jharkhand

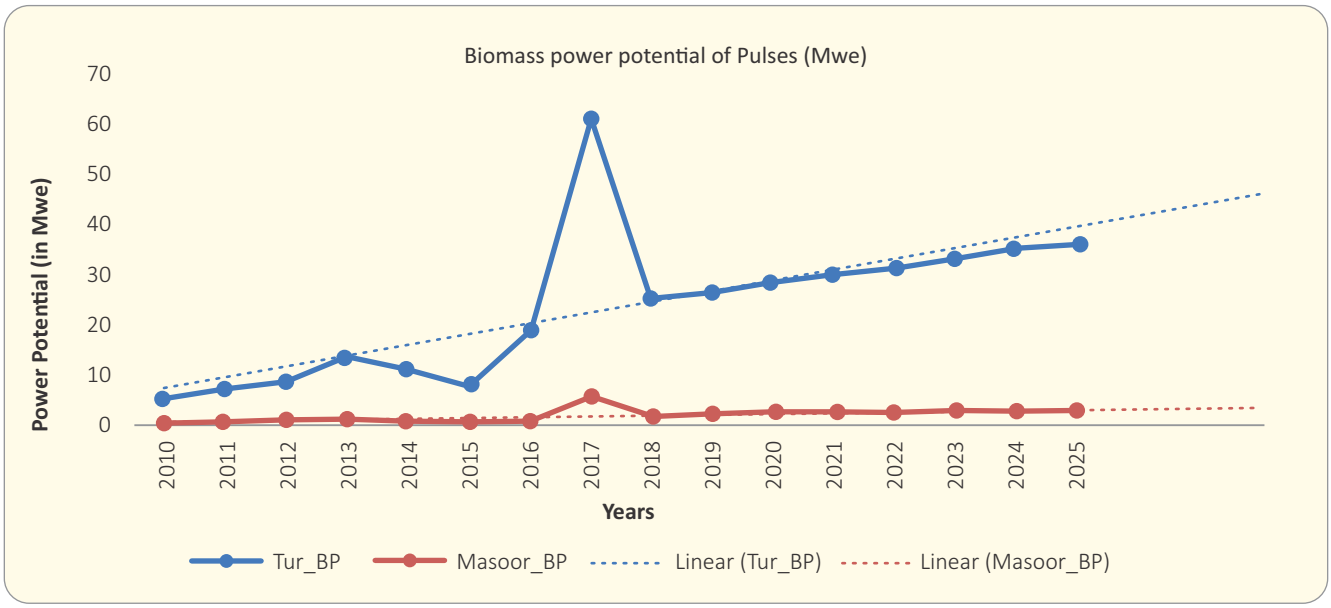


Figure 80: Biomass Power Potential for Pulses in Jharkhand

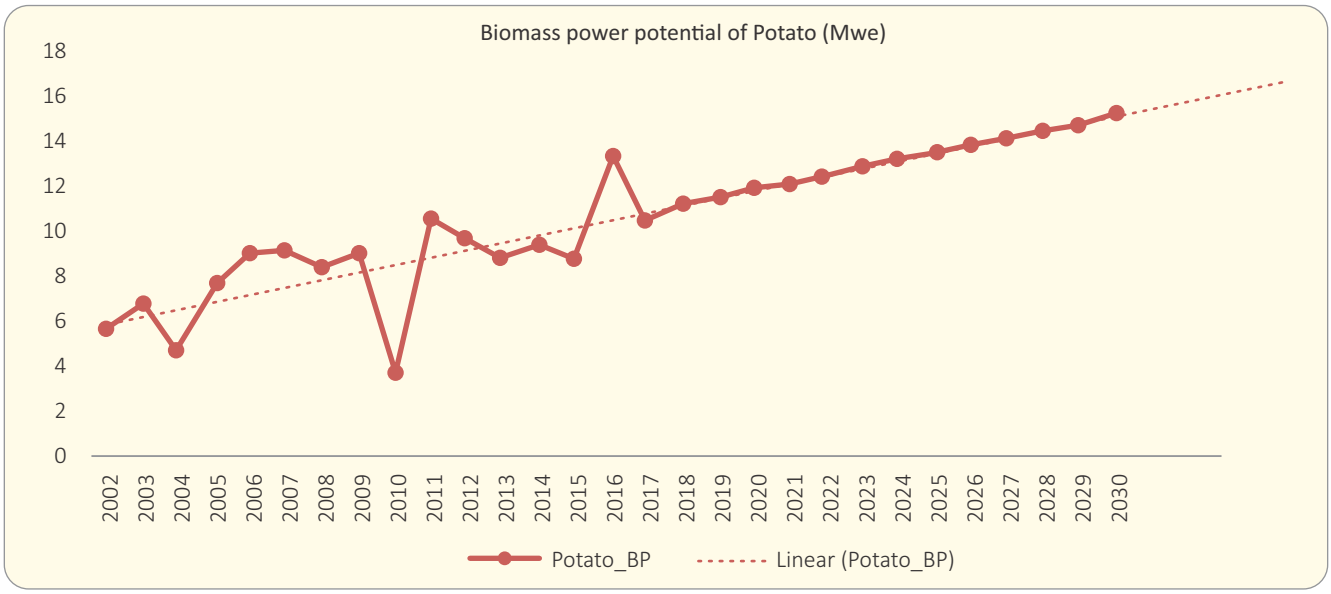


Figure 81: Biomass Power Potential for Potato in Jharkhand

Karnataka

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Karnataka collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Karnataka was calculated, which was the input to arrive at biomass power potential in Karnataka. Thus, the total biomass power potential for the state of Karnataka for 2018 was 1793.88 MWe and for 2019-20 is 2104.2 MWe.

Districts Selected for Primary Field Survey	11 (Belgaum, Bellary, Bidar, Bijapur, Chitradurg, Gulbarga, Koppal, Haveri, Hassan, Shimoga, Tumkur)
Average Rainfall	1248 mm
Type of soil	Black Cotton and Red Soil
Major source of irrigation	Canals, Tube wells, Open wells and River
Major Rivers	Bohithora, Chiki Hagori, Hagari Doni, Doodhganaga, kagna, Manjra, Mullamah, Malprabha, Tungabhadra and Varda
Major Crops	Arecanut, Arhar, Bajra, Cotton(lint), Dry chillies, Gram, Groundnut, Jowar, Maize, Moong (Green Gram), Onion, Paddy, Soyabean, Sugarcane, Sunflower and Wheat

Utilization of Crop residue at farmer's level in Karnataka:

1. **Essential Usage**: Residue of crops like Bajra, Gram, Groundnut, Jowar, Maize and Moong are extensively used for cattle feeding. The residue of Arhar, Bajra, dry chillies, bengal gram, groundnut Jowar, maize, moong, onion and sunflower are also utilized for the preparation of compost fertilizer.
2. **Specific Usage**: Arhar residue is used for thatching of the roof, construction of small huts etc.
3. **Fuel Usage**: for domestic cooking, farmers generally use Arhar stalk, cotton stalk, sunflower stalk etc.
4. **Field preparation**: Burning of Stubble of paddy & wheat are very common in-order to prepare land in a short duration of time.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy	1000 - 9000
	Soyabeab	5000
	Sunflower	4000
	Arecanut	7000 -15000

Survey Images:

Hatagatti, Belgaum, Karanataka

Aheri, Bijapur, Karanataka

Kawaspur, Shimoga, Karanataka

Table 69: Crop-wise change in Area, Production and Biomass Potential in Karnataka

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	1446584.67	3861399.53	5792099.30	984656.88	133.91	1048725.33	2942065.83	4413098.75	750226.79	102.18	-23.69
Wheat	271226.33	253791.00	456823.80	91364.76	12.33	178489.33	173180.00	311724.00	62344.80	8.42	-31.74
Maize	1059815.17	2992569.67	6882910.23	1376582.05	161.06	1299253.83	4078712.83	9381039.52	1876207.90	219.14	36.06
Ragi	802656.00	1160099.50	1508129.35	150812.94	18.70	694435.50	1083366.00	1408375.80	140837.58	17.49	-6.46
Small millets	37704.50	19525.50	23430.60	2343.06	0.30	28265.33	14203.17	17043.80	1704.38	0.21	-28.42
Bajra	361822.83	226504.00	595705.52	89355.83	10.90	213798.33	244974.67	644283.37	93622.43	11.38	4.44
Jowar	1394528.00	1427815.67	3426757.60	685351.52	84.98	1048107.67	970694.00	2329665.60	465933.12	57.87	-31.90
Moong (Green Gram)	418233.33	70836.67	88545.83	26563.75	3.40	388709.33	96003.50	120004.38	36001.31	4.60	35.22
Gram	794850.67	371717.83	408889.62	40888.96	5.36	1229535.33	706967.33	777664.07	77766.41	10.15	89.34
Arhar/Tur	628266.83	344615.33	964922.93	675446.05	81.73	918701.00	764492.00	2140577.60	1498404.32	180.71	121.10
Horse-gram	259604.00	102710.00	133523.00	13352.30	1.70	154568.00	69396.33	90215.23	9021.52	1.15	-32.60
Urad	140012.83	41888.50	54455.05	27227.53	2.48	105987.67	44923.33	58400.33	29200.17	2.66	7.26
Other Kharif pulses	135745.50	103224.17	134191.42	26838.28	3.25	53549.33	48364.67	62874.07	12574.81	1.52	-53.18
Other Rabi pulses	32843.17	8716.83	11331.88	1133.19	0.14	8240.33	5159.67	6707.57	670.76	0.08	-42.03
Cowpea	0.00	0.00	0.00	0.00	0.00	84495.67	34935.17	38428.68	7685.74	1.03	0
Rapeseed & Mustard	8952.50	3245.50	5841.90	2920.95	0.38	3176.83	582.67	1048.80	524.40	0.07	-81.92
Linseed	13199.33	4771.00	7061.08	1412.22	0.14	3400.67	519.33	768.61	153.72	0.02	-88.91
Sunflower	1086985.33	432258.67	864517.33	778065.60	85.59	241933.33	123774.33	247548.67	222793.80	24.51	-71.37
Safflower	74743.00	59608.33	178825.00	35765.00	3.90	39890.67	24343.67	73031.00	14606.20	1.59	-59.18
Castor Seed	21872.17	18178.50	74531.85	44719.11	5.59	9044.17	4858.00	19917.80	11950.68	1.50	-73.23
Sanhamp	400.50	98.00	246.96	49.39	0.01	177.33	43.17	108.78	21.76	0.00	-73.02
Groundnut	857968.00	485608.00	1116898.40	223379.68	27.25	600246.00	483300.17	1111590.38	222318.08	27.10	-0.55
Sesamum	76818.33	42644.17	106610.42	42644.17	5.25	40665.33	26201.83	65504.58	26201.83	3.22	-38.61
Niger Seed	28584.67	8741.33	9265.81	926.58	0.11	5846.50	1308.17	3270.42	327.04	0.04	-64.41

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Soyabean	126177.50	94010.00	159817.00	27168.89	3.40	284177.17	266817.67	453590.03	77110.31	9.64	183.49
Garlic	6127.67	7709.67	2312.90	2312.90	0.31	5620.67	5560.83	1668.25	1668.25	0.23	-27.03
Ginger	19246.17	447988.50	22399.43	7391.81	0.94	24577.33	743168.00	37158.40	12262.27	1.56	65.80
Dry chillies	262092.00	268457.00	402685.50	322148.40	41.88	110170.83	185148.67	277723.00	222178.40	28.82	-31.19
Arecanut	176295.83	840998.50	1201686.30	1129585.12	150.23	260680.67	2682693.50	2928196.80	2752504.99	366.08	143.68
Black pepper	15840.67	51318.50	25659.25	2822.52	0.35	38084.33	256400.17	128200.08	14529.34	1.78	408.94
Turmeric	11751.00	70251.33	21075.40	12645.24	1.68	17898.17	104654.83	31396.45	18837.87	2.51	49.13
Coriander	6725.67	2431.83	2796.61	1398.30	0.18	2768.17	1178.33	1355.08	677.54	0.09	-52.27
Cardamom	21618.00	1782.33	13835.52	5534.21	0.84	16323.67	1683.67	10447.15	4178.86	0.63	-24.78
Tobacco	108446.83	49720.17	49720.17	49720.17	6.61	92562.00	77284.50	77284.50	77284.50	10.28	55.50
Sugarcane	286406.17	24691432.33	1234571.62	1160497.32	157.83	401566.00	32609170.00	1630458.50	1524478.70	207.33	31.36
Potato	131531.00	816922.00	661706.82	436726.50	40.62	31904.67	289855.33	234782.82	154956.66	14.43	-64.48
Mesta	1694.00	406.47	833.26	416.63	0.06	322.50	74.16	152.03	76.01	0.01	-83.02
Onion	309854.00	1782877.00	89143.85	19611.65	2.67	180728.33	1376424.67	68821.23	15140.67	2.06	-22.88
Banana	53527.00	987840.33	2963521.00	651974.62	86.71	0.00	0.00	0.00	0.00	0.00	-100.00
Cashewnut	62303.00	38310.20	88113.46	88113.46	14.27	64615.50	41973.17	96538.28	96538.28	15.64	9.59
Coconut	414029.17	443511.27	1988750.12	1789875.11	245.21	442233.00	474923.75	2125124.81	1912612.33	262.60	7.09
Sweet potato	2839.33	25208.83	2524.83	1514.90	0.14	3116.17	42767.00	4283.39	2570.04	0.23	67.05
Tapioca	847.50	7457.67	5593.25	4754.26	0.51	1208.00	8939.17	6704.38	5698.72	0.62	20.68
Cotton	396011.67	117088.69	1762439.45	1057463.67	127.95	567088.50	228110.34	2656779.04	1594067.42	192.72	50.62
Total	**12367629.33**	**42793747.99**	**33544700.62**			**10944888.50**	**51339197.57**	**34093556.03**	**14048470.71**	**1793.88**	**17.18**

Table 70: Crop-wise Area, Production, Biomass, Surplus biomass and Biomass Power Potential for Karnataka in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1184704.2	3591616.0	5387424.0	915862.1	124.6
2	Wheat	178060.4	204332.4	367798.2	73559.6	9.9
3	Jowar	866703.5	1027995.1	2467188.2	493437.6	61.3
4	Bajra	286907.8	320487.1	842881.2	126432.2	15.4
5	Ragi	587096.6	971586.7	1263062.8	126306.3	15.7
6	Maize	1563171.5	4790708.7	11018629.9	2203726.0	257.6
7	Black Gram (Urad)	83575.9	41394.6	53813.0	26906.5	2.4
8	Green Gram (Moong)	346918.2	90966.3	113707.8	34112.3	4.4
9	Gram	1267219.2	760260.3	836286.3	83628.6	10.9
10	Tur (Arhar)	1085497.6	836330.6	2341725.8	1639208.1	197.7
11	Groundnut	530127.8	393953.4	906092.9	181218.6	22.1
12	Soyabean	302757.3	293504.0	498956.9	84822.7	10.6
13	Caster Seed	5908.5	1279.4	5245.6	3147.4	0.4
14	Sesamum	30201.3	20599.6	51498.9	20599.6	2.5
15	Rapeseed & Mustard	1796.4	362.4	652.4	326.2	0.0
16	Sunflower	174084.7	119451.6	238903.2	215012.9	23.7
17	Cotton	656710.8	294749.2	3143949.4	1886369.6	228.3
18	Sugarcane	455774.6	39231760.2	1961588.0	1843892.7	250.8
19	Tobacco	86719.3	72982.4	72982.4	72982.4	9.7
20	Arecanut	324784.2	3467629.8	3748456.6	3523549.2	468.6
21	Banana	3515.3	163576.7	490730.2	107960.6	14.3
22	Cashewnut	83046.0	64809.4	149061.7	149061.7	24.3
23	Coconut	502087.9	918920.5	2697541.8	2427787.7	333.3
24	Ginger	29728.5	750527.3	37526.4	12383.7	1.6
25	Tapioca	823.8	7958.4	5968.8	5073.5	0.5
26	Potato	31494.6	275220.1	222928.3	147132.7	13.7
	Total	**10669416.0**	**58712962.5**	**38924600.8**	**16404500.5**	**2104.2**

Major contributing crops in biomass power potential in Karnataka (2019-20) is Arecanut with 468.6 MWe followed by Coconut (333.3 MWe), Maize (257.6 MWe), Sugarcane (250.8 MWe) and Cotton (228.3 MWe)

Trend Analysis for Biomass power potential for the state of Karnataka – Crop-wise

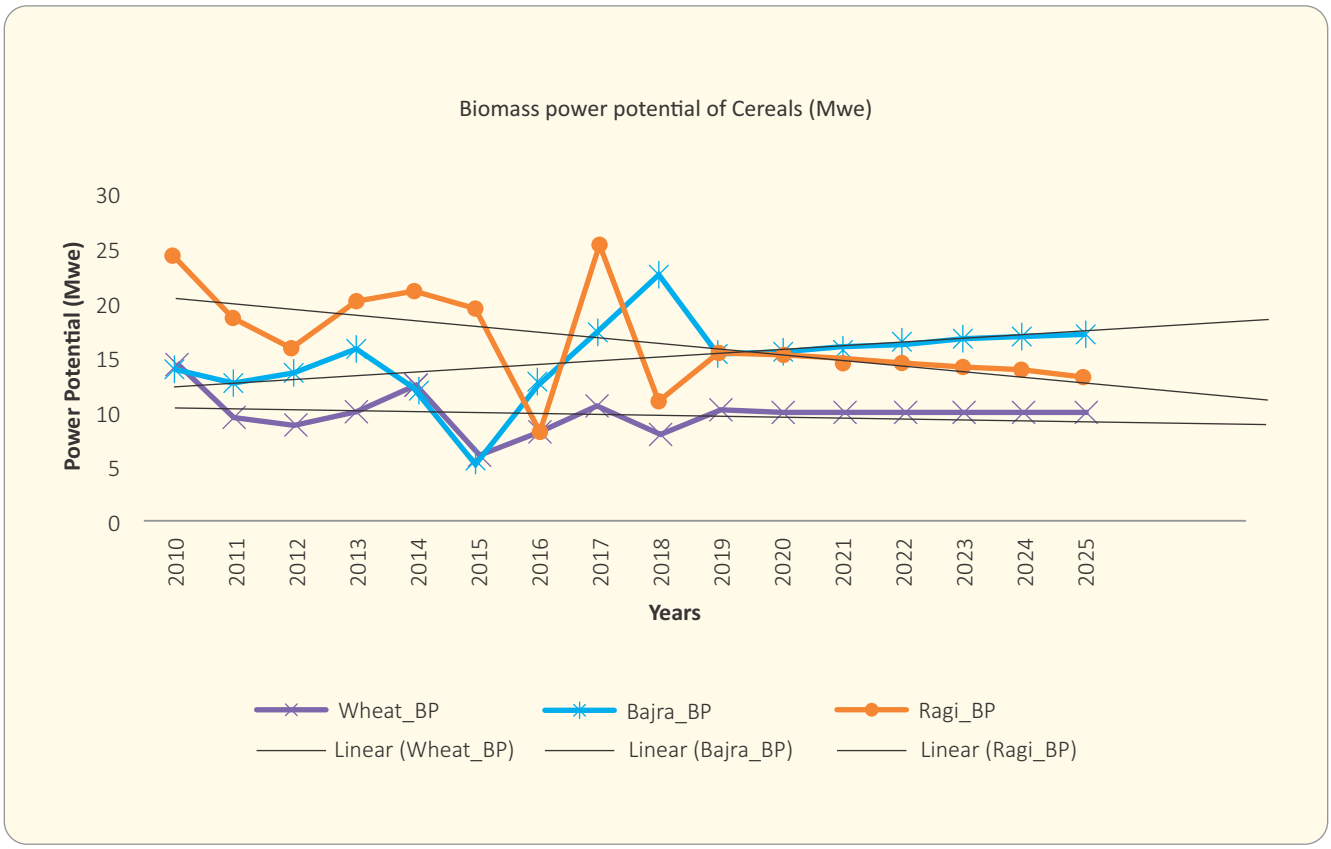


Figure 82: Biomass Power Potential for Cereals in Karnataka

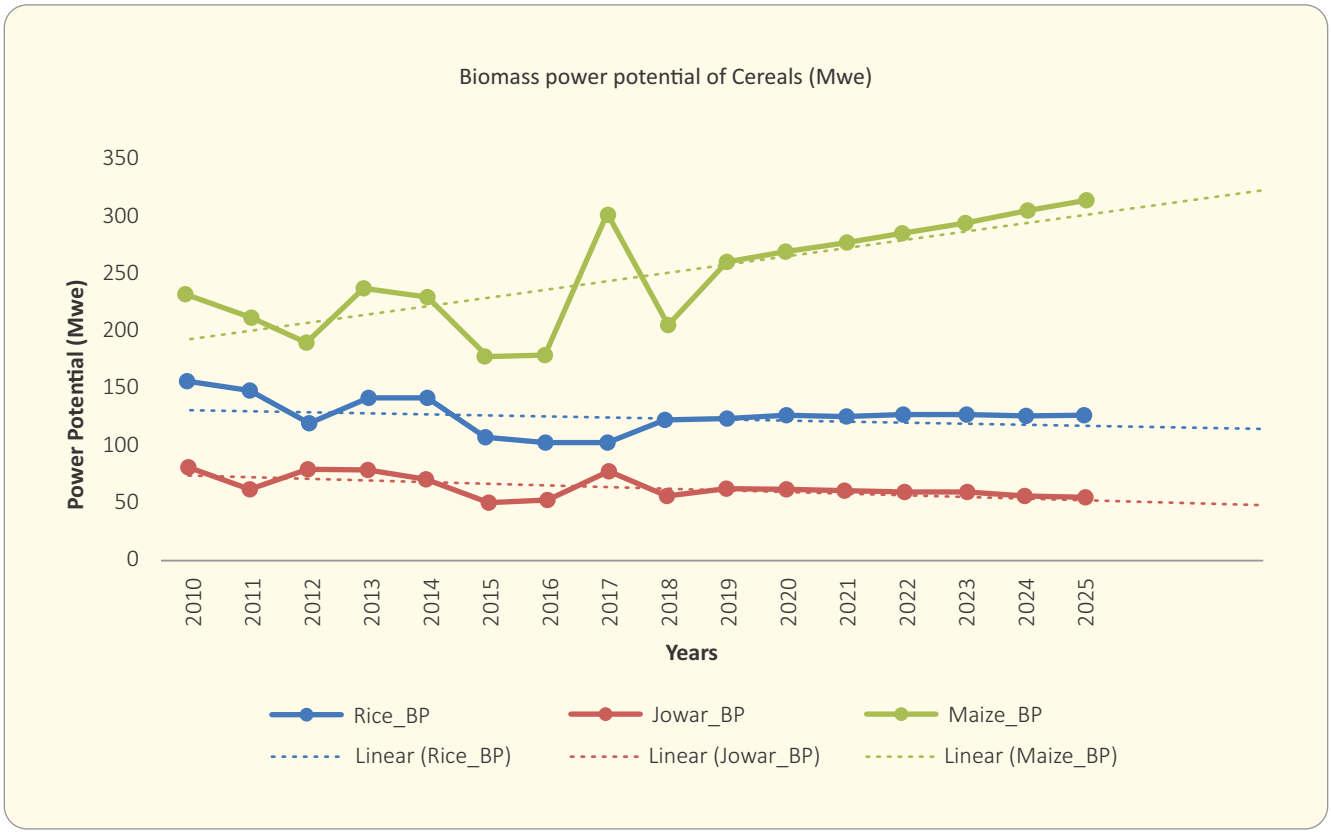


Figure 83: Biomass Power Potential for Cereals in Karnataka

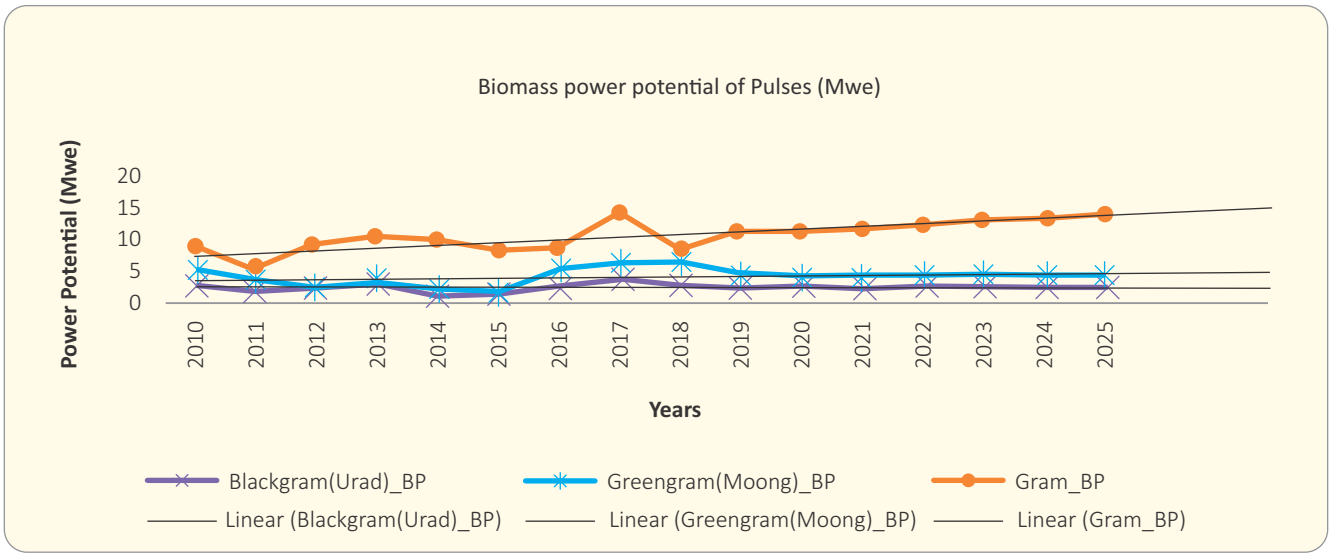


Figure 84: Biomass Power Potential for Pulses in Karnataka

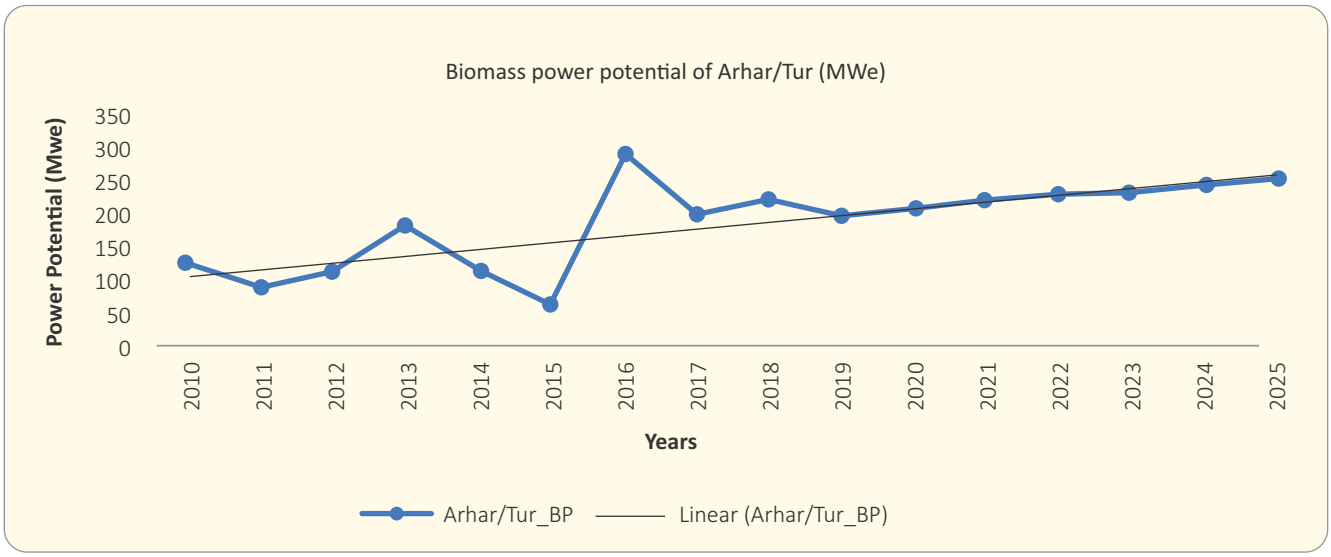


Figure 85: Biomass Power Potential for Arhar/Tur in Karnataka

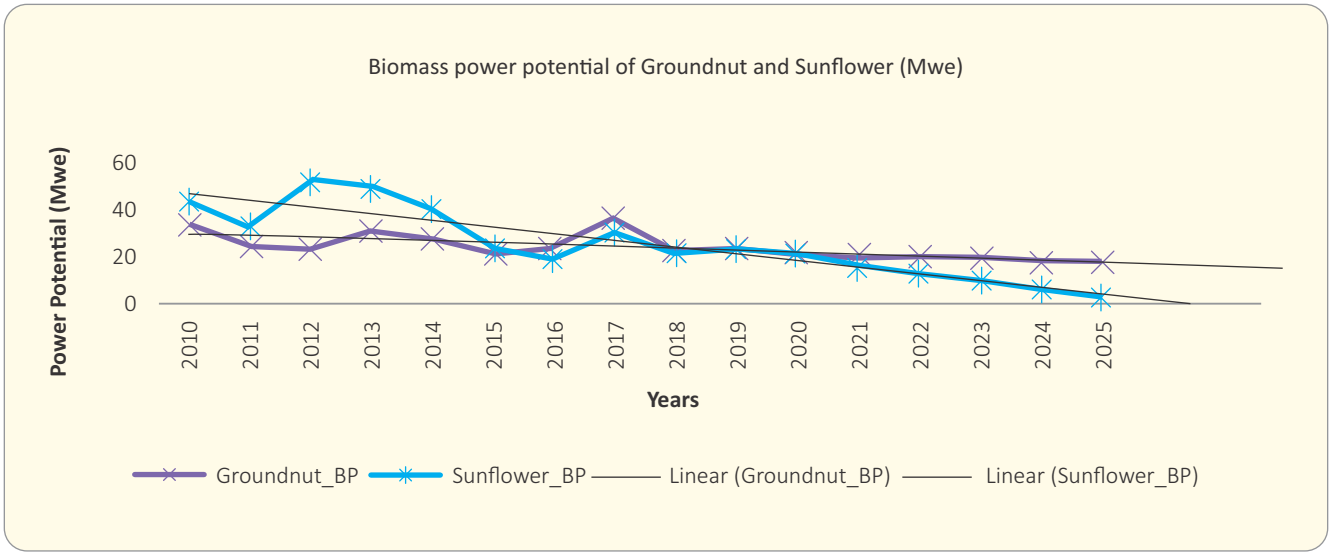


Figure 86: Biomass Power Potential for Groundnut and Sunflower in Karnataka

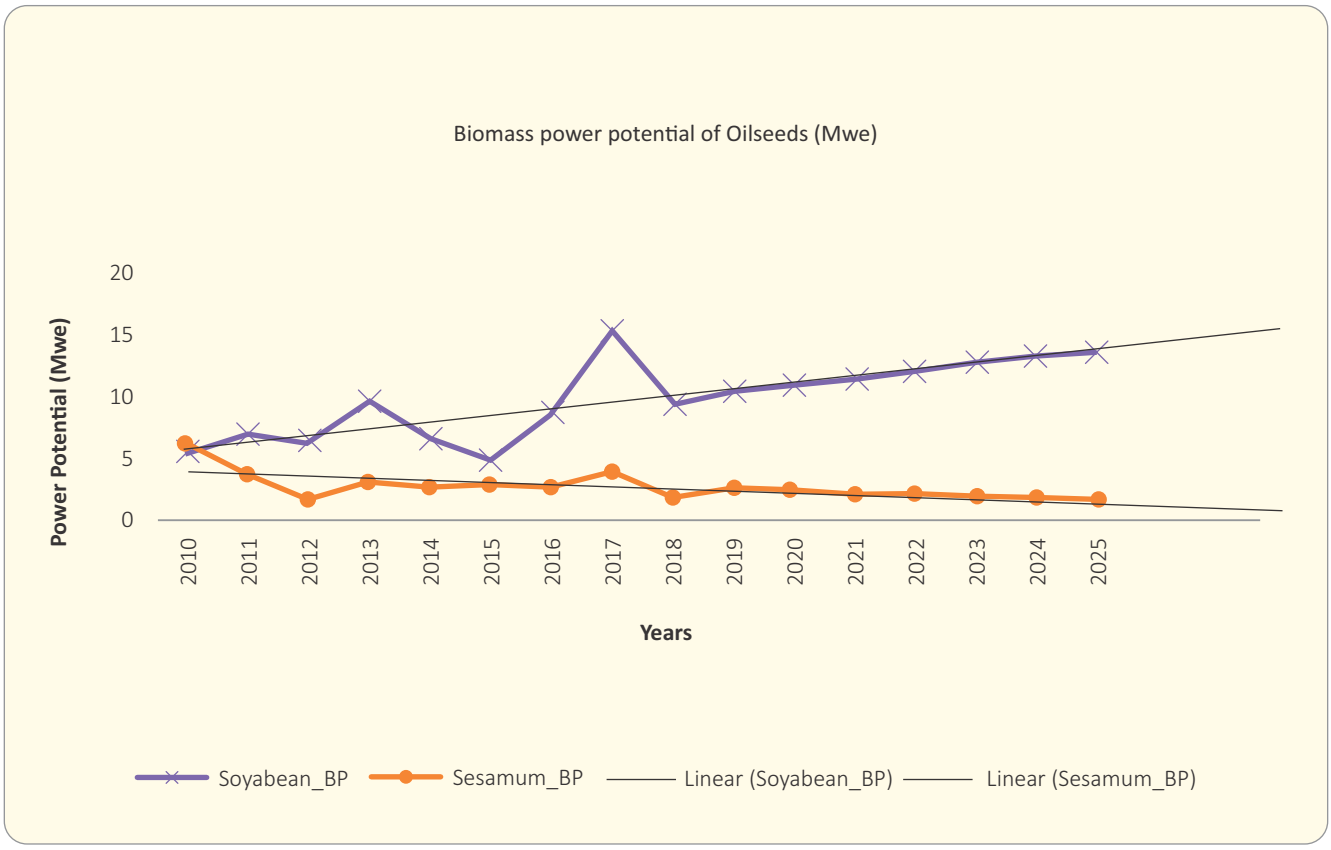


Figure 87: Biomass Power Potential for Soyabean and Sesamum in Karnataka

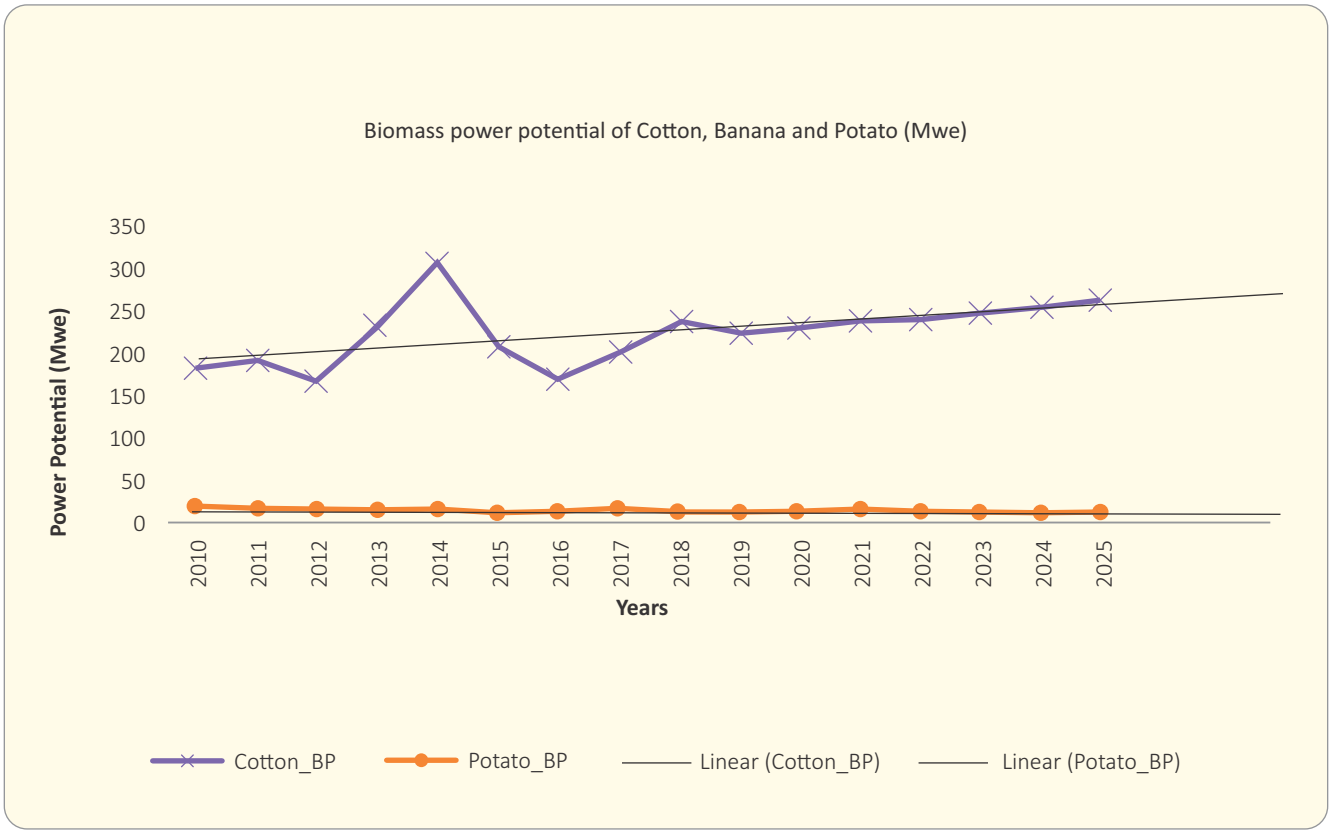


Figure 88: Biomass Power Potential for Cotton and Potato in Karnataka

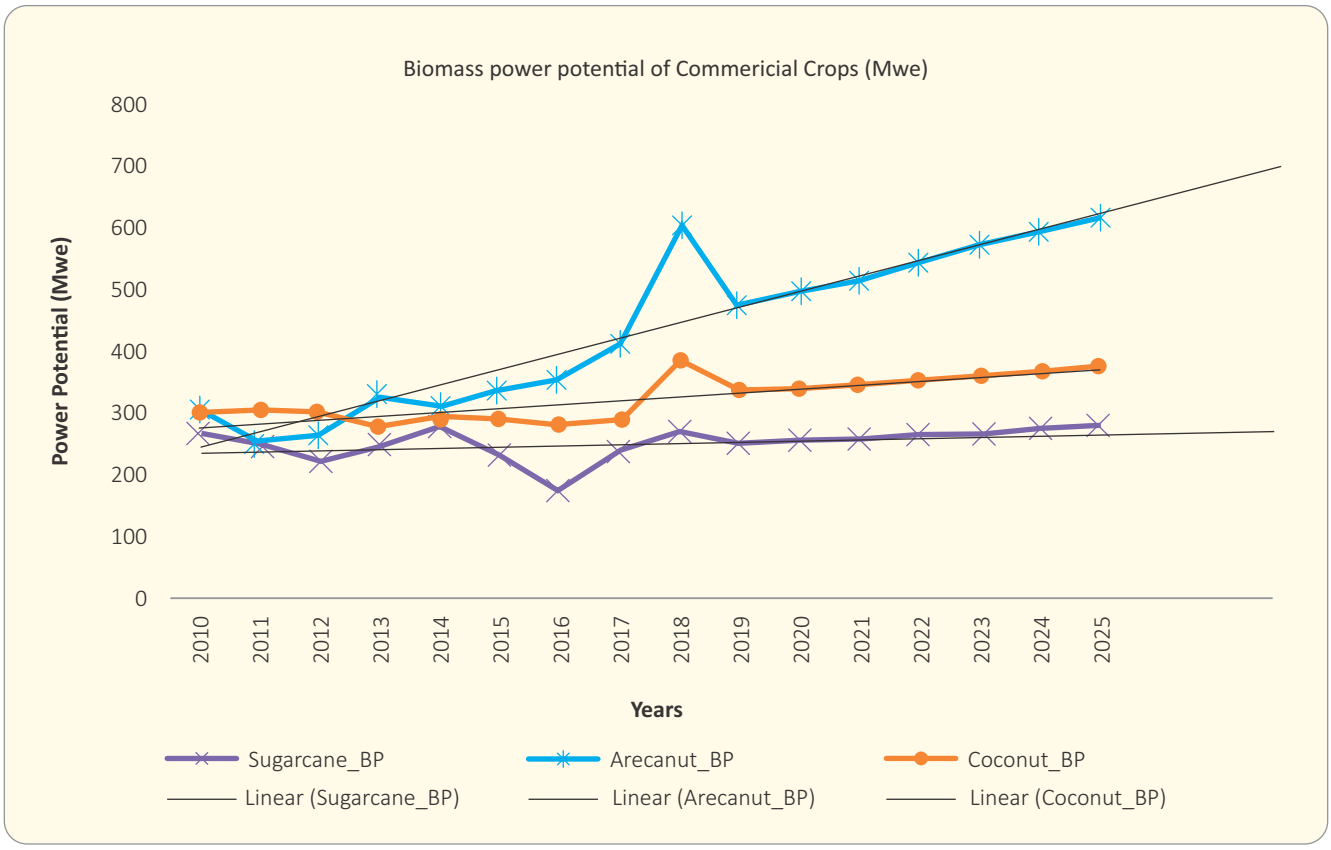


Figure 89: Biomass Power Potential for Commercial Crops in Karnataka

Kerala

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Kerala collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Kerala was calculated, which was the input to arrive at biomass power potential in Kerala. Thus, the total biomass power potential for the state of Kerala for 2018 was 778.41 MWe and for 2019-20 is 769.20 MWe.

Districts Selected for Primary Field Survey	05 (Kozikode, Kollam, Pallakad, Thrissur and Wayanad)
Average Rainfall	3055 mm
Type of soil	Forest Soil, Laterite Soil
Major source of irrigation	Canals, Tube well, River, Backwater, Ponds, wells
Major Rivers	Bharat Punza, Bhavani, Kabani, Kallar, Karapunza, Kechery, Kutyadi, Mahe, Manali, Mupil Punza, Pulantod Thanikudam
Major Crops	Arecanut, Banana, Black pepper, Coconut, Rice, Tapioca

Utilization of Crop residue at farmer's level in Kerala:

1. **Essential Usage**: Residue of crops like Banana, Paddy and Tapioca are utilized for cattle feeding. Arecanut, Black pepper, Coconut palm and vegetable waste are converted into organic manure.
2. **Specific Usage**: Residue of Banana is utilized for Organic Mushroom production.
3. **Fuel Usage**: Residue of Arecanut and Coconut are utilized for domestic burning.
4. **Field preparation**: Residue of Black pepper, Tapioca and Rice are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Arecanut	1000
Expected Cost against the sale of crop residue in Future	Arecanut	5000 - 10000
	Black Pepper	2000
	Tapioca	2000

Survey Images:

Kunnicide, Kollam, Kerala

Kerala

Vyatheri, Wayanad, Kerala

Table 71: Crop-wise change in Area, Production and Biomass Potential in Kerala

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	229915.33	554547.33	1.50	831821.00	199637.04	27.15	184134.00	492879.00	739318.50	175906.82	23.96	-11.76
Wheat	0.00	0.00	1.80	0.00	0.00	0.00	1.33	1.67	3.00	0.60	0.00	0
Maize	0.00	0.00	2.30	0.00	0.00	0.00	65.26	47.33	108.87	21.77	0.00	0
Ragi	468.00	379.67	1.30	493.57	49.36	0.01	1184.67	76.00	98.80	9.88	0.00	-87.73
Small millets	0.00	0.00	1.20	0.00	0.00	0.00	11.50	8.00	9.60	0.96	0.00	0
Other Cereals	461.00	361.33	1.50	542.00	54.20	0.01	0.00	0.00	0.00	0.00	0.00	-100.00
Jowar	2399.00	1225.00	2.40	2940.00	588.00	0.07	164.00	127.00	304.80	60.96	0.01	-89.18
Moong												
(Green Gram)	0.00	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Other Kharif pulses	0.00	0.00	1.30	0.00	0.00	0.00	2158.50	2160.50	2808.65	561.73	0.07	0
Arhar / Tur	0.00	0.00	2.80	0.00	0.00	0.00	1040.50	1367.00	3827.60	2679.32	0.32	0
Sesamum	617.00	259.00	2.50	647.50	259.00	0.03	203.22	66.37	165.92	66.37	0.01	-72.79
Groundnut	2486.33	1839.67	2.30	4231.23	846.25	0.10	360.33	502.00	1154.60	230.92	0.03	-71.85
Turmeric	2994.33	7237.67	0.30	2171.30	1302.78	0.17	2670.96	7479.92	2243.98	1346.39	0.18	5.33
Garlic	297.00	5049.00	0.30	1514.70	1514.70	0.21	0.00	0.00	0.00	0.00	0.00	-100.00
Ginger	4232.33	14959.67	0.05	747.98	246.83	0.03	4835.67	20500.47	1025.02	338.26	0.04	43.31
Arecanut	87557.67	111516.67	3.80	351886.33	330773.15	43.99	97133.90	119269.19	386817.06	363608.04	48.36	9.93
Black Pepper	154414.67	40597.67	0.50	20298.83	2232.87	0.27	85431.92	38050.70	19025.35	2156.21	0.26	-2.09
Cardamom	36804.83	7693.67	0.64	23555.09	9422.04	1.42	39296.67	18332.33	25149.87	10059.95	1.52	7.12
Banana	46118.67	365272.67	3.00	1095818.00	241079.96	32.06	59700.20	530435.37	1591306.11	350087.34	46.46	44.91
Potato	0.00	0.00	0.81	0.00	0.00	0.00	521.67	7569.67	6131.43	4046.74	0.38	0
Onion	0.00	0.00	0.05	0.00	0.00	0.00	22.33	0.00	0.00	0.00	0.00	0
Cashewnut	59466.67	51562.33	2.30	118593.37	118593.37	19.21	41490.28	26101.84	60034.23	60034.23	9.73	-49.37
Coconut	814727.33	1157800.00	4.75	4127259.33	3714533.40	508.89	777387.33	880950.00	3770261.83	3393235.65	465.89	-8.45

STATE-WISE BIOMASS POWER POTENTIAL

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Sweet Potato	448.67	5686.00	0.10	569.49	341.69	0.03	264.00	3765.33	377.12	226.27	0.02	-31.36
Tapioca	83465.33	2500958.00	0.75	1875718.50	1594360.73	172.19	3.80	2629885.88	1972414.41	1676552.25	181.07	5.16
Sugarcane	2513.67	166835.00	0.05	8341.75	2085.44	0.28	1158.38	12212.23	610.61	152.65	0.02	-92.59
Cotton	1251.00	275.85	6.00	5360.68	4288.54	0.52	191.00	54.74	846.23	676.98	0.08	-84.26
Tobacco	37.67	60.67	1.00	60.67	60.67	0.01	10.33	16.33	16.33	16.33	0.00	-78.28
Total	**1530676.50**	**4994116.85**		**8472571.33**			**1299441.77**	**4791858.86**	**8584059.92**	**6042076.61**	**778.41**	**-3.50**

Table 72: Crop-wise Area, Production, Biomass Production, Surplus biomass and Biomass Power Potential for Kerala in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	153420.5	481810.1	722715.1	144543.0	19.7
2	Jowar	205.0	167.5	402.0	80.4	0.0
3	Ragi	224.7	271.5	352.9	35.3	0.0
4	Groundnut	187.3	239.4	550.6	110.1	0.0
5	Sesamum	377.7	158.0	395.0	158.0	0.0
6	Cotton	59.4	15.2	259.2	207.4	0.0
7	Sugarcane	1060.7	124390.9	6219.5	1554.9	0.2
8	Tobacco	7.3	11.7	11.7	11.7	0.0
9	Arecanut	99046.4	120308.0	393385.5	369782.4	49.2
10	Banana	61120.8	543848.3	1631544.9	358939.9	47.7
11	Cashewnut	28300.0	15097.1	34723.2	34723.2	5.7
12	Coconut	738035.8	1113417.8	3787206.6	3408485.9	468.0
13	Ginger	2856.5	16234.9	811.7	267.9	0.0
14	Tapioca	57098.8	2595272.9	1946454.7	1654486.5	178.7
	Total	**1142000.9**	**5011243.1**	**8525032.6**	**5973386.4**	**769.2**

Major contributing crops in biomass power potential in Kerala (2019-20) is Coconut with 468.0 MWe followed by Tapioca (178.7 MWe), Arecanut (49.2 MWe), Banana (47.7 MWe) and Rice (19.7 MWe)

Trend Analysis for Biomass Power Potential for the state of Andhra Pradesh – Crop-wise

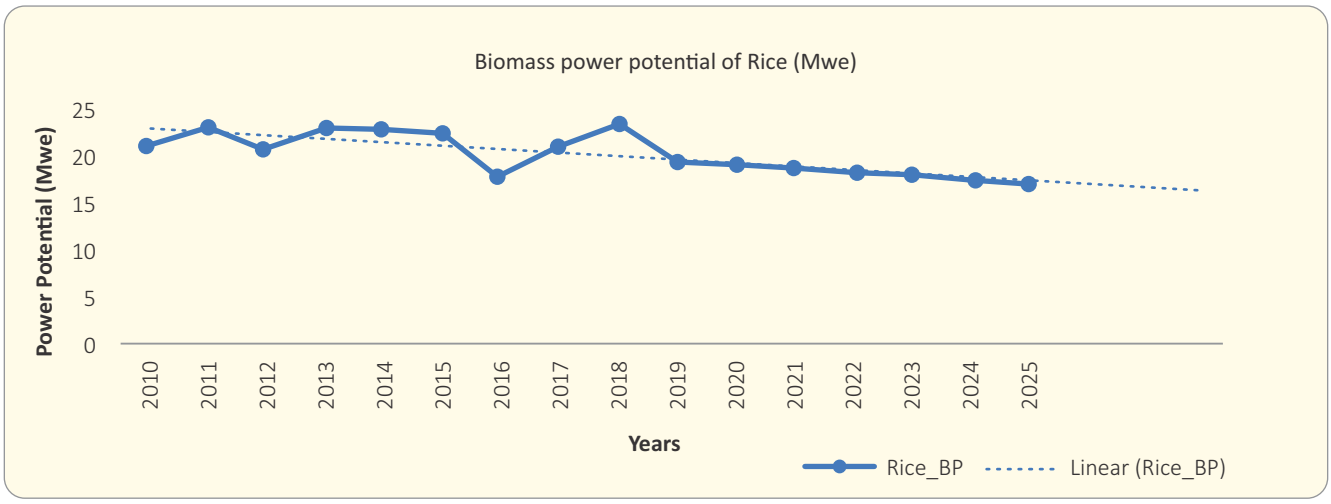


Figure 90: Biomass Power Potential for Rice in Kerala

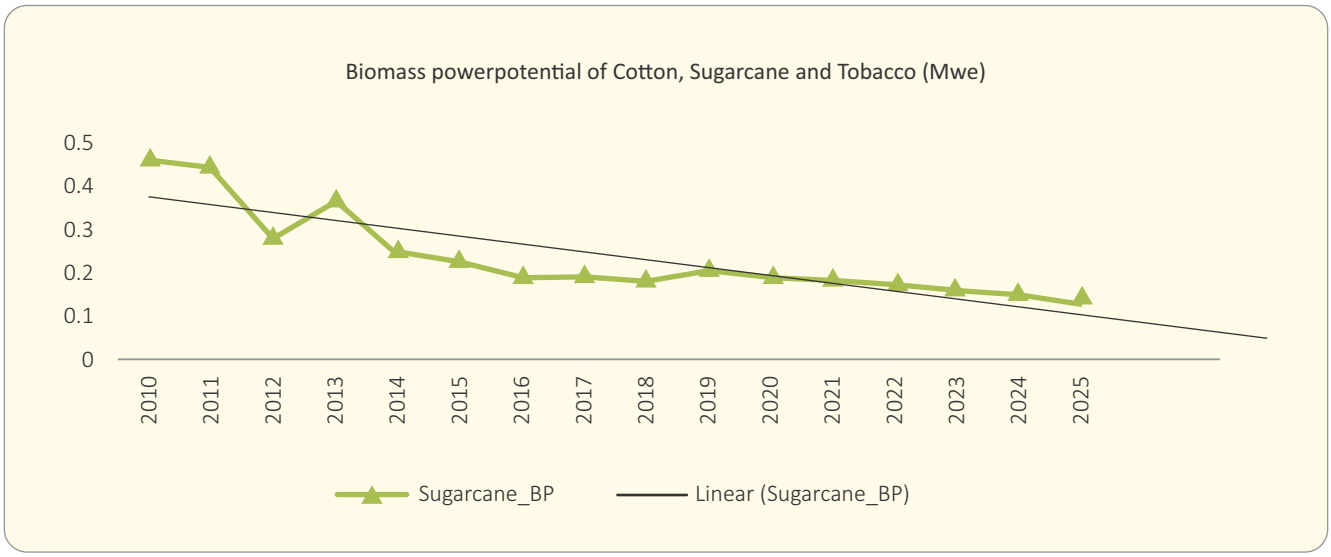


Figure 91: Biomass Power Potential for Sugarcane in Kerala

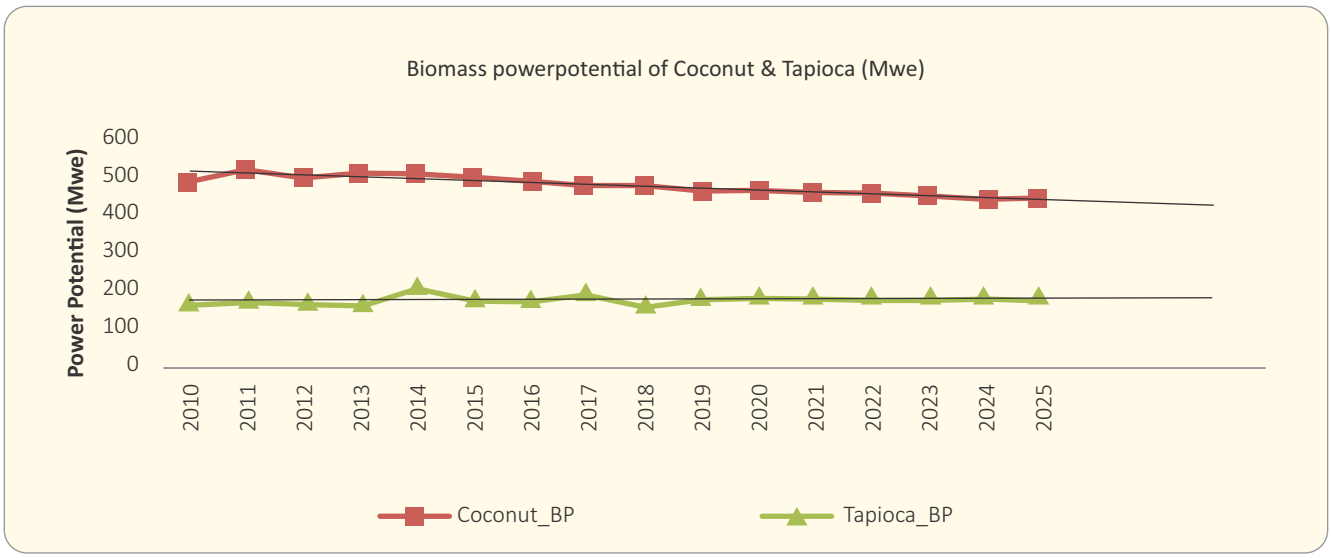


Figure 92: Biomass Power Potential for Coconut and Tapioca in Kerala

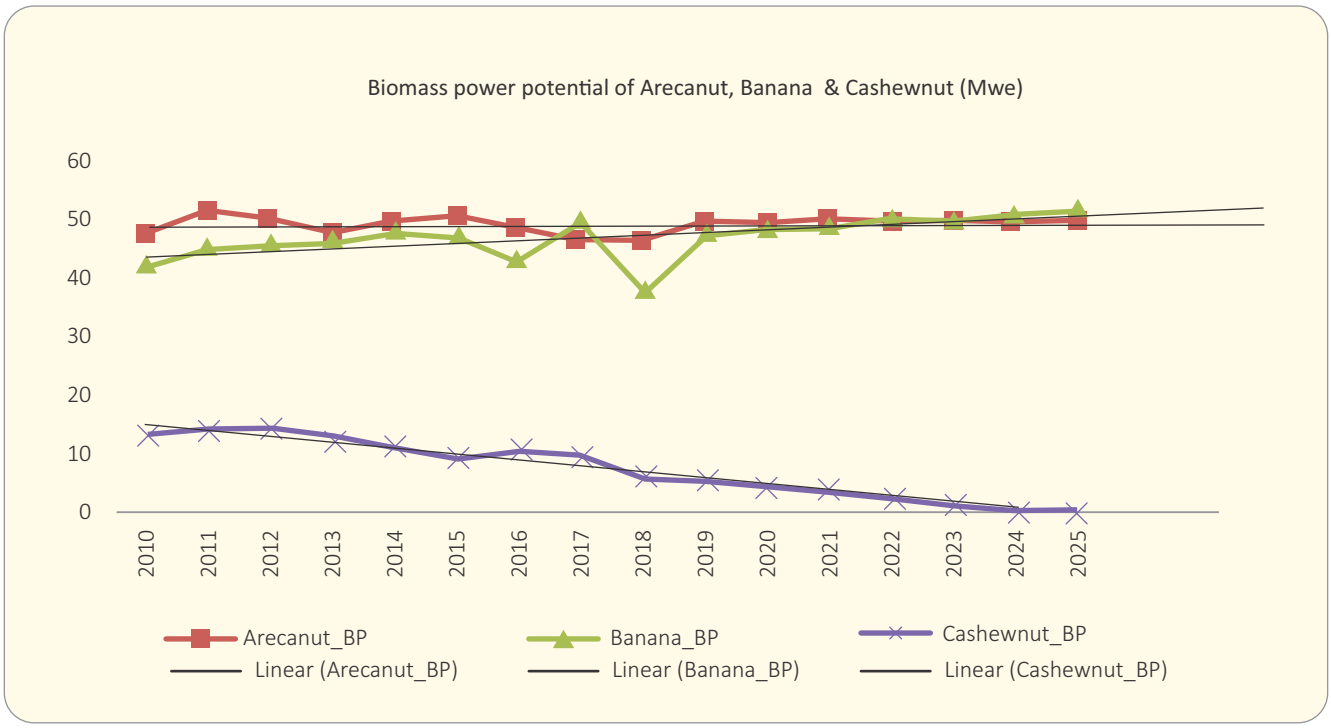
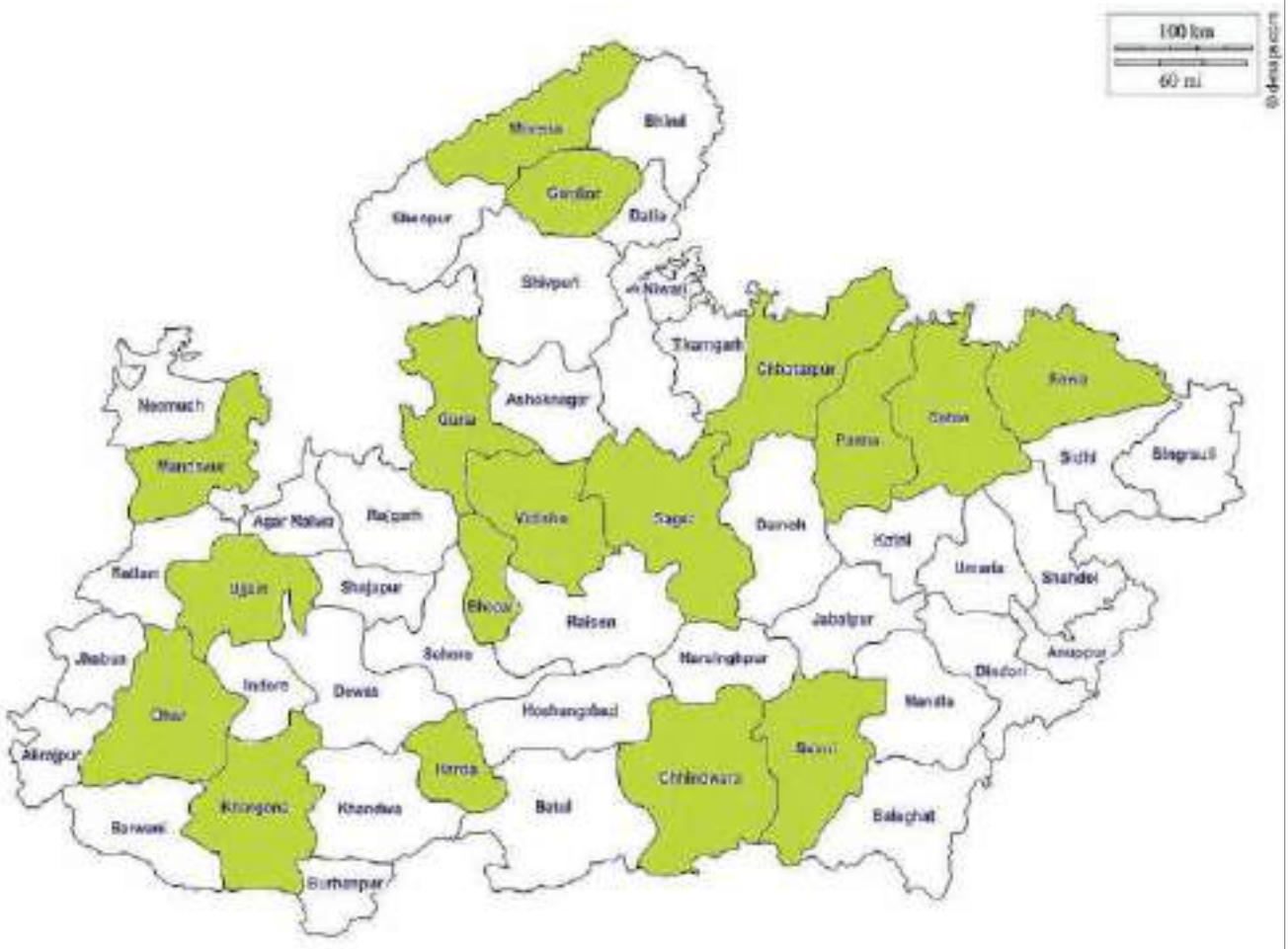


Figure 93: Biomass Power Potential for Arecanut, Banana, & Cashewnut in Kerala

Madhya Pradesh



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Madhya Pradesh collected information and samples from all seventeen (17) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Madhya Pradesh was calculated, which was the input to arrive at biomass power potential in Madhya Pradesh. Thus, the total biomass power potential for the state of Madhya Pradesh for 2018 was 2516.42 MWe and for 2019-20 is 3301.10 MWe.

Districts Selected for Primary Field Survey	17 (Bhopal, Chhatarpur, Chindwara, Dhar, Guna, Gwalior, Harda, Khargone, Mandsaur, Morena, Panna, Rewa, Sagar, Satna, Seoni, Ujjain and Vidisha)
Average Rainfall	1017 mm
Type of soil	Alluvial soil, Black Cotton Soil, Mixed Red and Black Soil, Shallow and Medium Black
Major source of irrigation	Canals, Tube well
Major Rivers	Betwa, Dhashan, Jam, Ganjaal & the Maachak, Kuns, Krushna, Koyna, Maan, Narmada, Shahanoor, sonar, Tapi, Vaina and Wardha
Major Crops	Arhar, Cotton(lint), Gram, Jowar, Masoor, Paddy, Rapeseed & Mustard, Soyabean, Urad and Wheat

Utilization of Crop residue at farmer's level in Madhya Pradesh:

1. **Essential Usage**: The residue of Maize, Jowar and urad are extensively used for cattle feeding. Some parts of the residue of Soyabean, Paddy and Wheat are also utilized for cattle feeding. The residue of crops like Bajra, Bengal Gram, Groundnut, Jowar, Masoor and Urad are extensively utilized for the preparation of compost fertilizer.
2. **Specific Usage**: Crop residue like Soyabean and Wheat are predominantly selling to Brick kiln and briquetting plant.
3. **Fuel Usage**: Stalk of Arhar, Cotton, Paddy and Wheat are used for domestic cooking.
4. **Field preparation**: Burning of stubbles of Paddy, Urad and wheat are a prevalent issue in Madhya Pradesh.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	2000
	Soyabean	2500
	Wheat	3000
Expected Cost against the sale of crop residue in Future	Paddy	5000
	Soyabean	5000
	Wheat	5000 - 7000
	Rapeseed & Mustard	3000 - 5000

Survey Images:

Saroi Village, Sagar, Madhya Pradesh

Jogipura, Guna, Madhya Pradesh

Makrahandi, Chhindwara, Madhya Pradesh

Table 73: Crop-wise change in Area, Production and Biomass Potential in Madhya Pradesh

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	1710103.83	1445568.50	1.50	2168352.75	823974.05	112.06	1990178.83	3420993.33	5131490.00	1940820.97	264.34	135.89
Wheat	4147319.00	7316783.00	1.80	13170209.40	2634041.88	355.60	6012014.67	17530907.33	31555633.20	6311126.64	852.00	139.60
Maize	891992.83	1079914.67	2.30	2483803.73	993521.49	116.24	1029959.83	2311470.17	5316381.38	2152276.98	251.39	116.26
Barley	77332.00	90460.00	1.30	117598.00	11759.80	1.36	84660.33	170841.67	222094.17	22209.42	2.58	89.43
Ragi	473.00	145.50	1.30	189.15	18.92	0.00	336.00	192.00	249.60	24.96	0.00	0
Small Millets	293449.50	82132.33	1.20	98558.80	9855.88	1.24	167471.33	104580.33	125496.40	12549.64	1.58	27.52
Bajra	202023.67	270669.50	2.63	711860.79	135253.55	16.50	249901.67	501659.67	1319364.92	249736.93	30.37	84.05
Jowar	532058.83	589446.83	2.40	1414672.40	0.00	0.00	230853.17	364251.17	874202.80	0.00	0.00	0
Moong (Green Gram)	75002.00	23704.00	1.25	29630.00	8889.00	1.14	261668.00	98363.17	122953.96	36886.19	4.71	313.19
Masoor	531547.33	249405.67	1.79	446436.14	446436.14	45.98	512023.00	424523.67	759897.36	759897.36	78.42	70.56
Gram	2718727.67	2437046.00	1.10	2680750.60	643380.14	84.28	2862774.33	2794832.00	3074315.20	746619.41	97.43	15.61
Horse-gram	31282.83	10449.67	1.30	13584.57	1358.46	0.17	22437.83	10804.50	14045.85	1404.59	0.18	4.93
Arhar/Tur	316775.00	222078.33	2.80	621819.33	435273.53	52.67	499676.00	463859.00	1298805.20	909163.64	109.65	108.17
Peas & Beans (Pulses)	187835.83	83557.33	0.50	41778.67	20889.33	2.59	299216.33	269980.83	134990.42	67495.21	8.37	223.14
Khesari	49966.67	35165.33	1.06	37275.25	11182.58	1.39	46730.00	26122.00	27689.32	8306.80	1.03	-25.90
Urad	564990.33	205008.83	1.30	266511.48	167902.23	15.28	794187.67	383522.33	498579.03	315011.30	28.70	87.81
Other Kharif Pulses	8164.00	1635.00	1.30	2125.50	425.10	0.05	28221.00	18770.00	24401.00	4880.20	0.59	1081.01
Other Rabi Pulses	2051.00	647.00	1.30	841.10	84.11	0.01	4062.00	826.00	1073.80	107.38	0.01	29.93
Rapeseed & Mustard	717600.67	701090.33	1.80	1261962.60	630981.30	82.66	647490.33	649247.33	1168645.20	584322.60	76.55	-7.40
Linseed	119346.00	45838.67	1.48	67841.23	13568.25	1.37	83295.83	46559.50	68908.06	13781.61	1.39	1.60
Sannhamp	4775.00	2582.00	2.52	6506.64	1301.33	0.16	3091.00	7033.00	17723.16	3544.63	0.44	174.71
Groundnut	207314.67	210112.00	2.30	483257.60	96651.52	11.79	224788.83	328900.50	756471.15	151294.23	18.44	56.43
Sunflower	655.17	297.50	2.00	595.00	535.50	0.06	76.00	35.00	70.00	63.00	0.01	-88.45
Sesamum	274260.00	104823.33	2.50	262058.33	104823.33	12.89	328788.83	150312.00	375780.00	150312.00	18.49	43.43

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Safflower	444.17	111.33	3.00	334.00	66.80	0.01	16020.00	6010.50	18031.50	3606.30	0.39	3830.87
Castor Seed	1962.17	763.33	4.10	3129.67	1877.80	0.23	2458.00	1191.00	4883.10	2929.86	0.37	59.49
Niger Seed	104164.17	23862.00	1.06	25293.72	2529.37	0.30	60248.83	22753.50	24118.71	2411.87	0.29	-3.77
Soyabean	5060982.67	5357209.00	1.70	9107255.30	1457160.85	182.15	6052610.67	5049933.67	8584887.23	1409352.32	176.17	-3.28
Turmeric	692.83	603.00	0.30	180.90	108.54	0.01	1392.00	1525.00	457.50	274.50	0.04	265.09
Coriander	132196.67	51293.33	1.15	58987.33	29493.67	3.75	143986.00	94851.00	109078.65	54539.33	6.92	84.42
Dry chillies	47381.00	40748.00	1.50	61122.00	48897.60	6.36	71877.00	132326.00	198489.00	158791.20	20.60	223.82
Garlic	48242.33	205512.00	0.30	61653.60	61653.60	8.38	81132.00	424434.00	127330.20	127330.20	17.27	106.04
Ginger	6005.00	7401.00	0.05	370.05	122.12	0.02	10668.00	20629.00	1031.45	340.38	0.04	116.31
Banana	10090.50	445857.17	3.00	1337571.50	294265.73	39.14	18637.00	1510351.00	4531053.00	996831.66	132.28	237.97
Sweet potato	3944.83	22312.83	0.10	2234.78	1340.87	0.12	4776.00	30914.00	3096.24	1857.74	0.17	40.88
Cotton	623449.67	62960.83	6.00	2507622.56	2006098.05	242.74	604615.17	151707.58	2631294.30	2105035.44	254.50	4.84
Sugarcane	63977.50	2783540.00	0.05	139177.00	34794.25	4.73	91549.50	3756065.00	187803.25	46950.81	6.39	35.00
Potato	54566.00	677345.67	0.81	548649.99	362108.99	33.68	80955.00	1047072.00	848128.32	559764.69	52.11	54.73
Jute	4608.00	1557.00	2.00	3114.00	2491.20	0.33	0.00	0.00	0.00	0.00	0.00	-100.00
Mesta	523.00	213.48	2.05	437.63	218.82	0.03	299.00	118.08	242.06	121.03	0.02	-45.94
Onion	40093.67	606369.67	0.05	30318.48	6670.07	0.91	79260.00	1476852.00	73842.60	16245.37	2.21	142.79
Tobacco	198.83	82.50	1.00	82.50	82.50	0.01	100.00	49.00	49.00	49.00	0.01	-34.83
Total	**19868569.83**	**25496303.48**		**40275754.08**			**23704487.00**	**43805368.82**	**70233077.30**	**19928267.38**	**2516.42**	**74.95**

Table 74: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Madhya Pradesh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	2207765.0	4768689.3	7153034.0	2718152.9	369.7
2	Wheat	6886424.0	22823087.9	41081558.2	8216311.6	1088.7
3	Jowar	103648.0	391300.8	939121.9	0.0	0.0
4	Barley	80514.7	233226.6	303194.6	66702.8	7.7
5	Bajra	306960.1	707866.4	1861688.7	353720.9	43.0
6	Maize	1180282.8	3608910.3	8300493.6	3320197.5	388.1
7	Green Gram (Moong)	243876.5	141929.7	177412.1	21289.5	2.7
8	Gram	3255765.6	4173658.0	4591023.8	1101845.7	143.8
9	Peas & Beans	367162.7	320731.3	160365.7	80182.8	9.9
10	Black Gram (Urad)	1564921.8	995549.2	1294214.0	815354.8	74.3
11	Tur (Arhar)	563788.8	579989.0	1623969.2	1136778.4	137.1
12	Masoor	699586.1	577442.3	1033621.7	1033621.7	106.7
13	Groundnut	227396.1	389176.8	895106.6	179021.3	21.8
14	Sesamum	403244.6	198459.4	496148.4	198459.4	24.4
15	Soyabean	6067593.8	6788483.0	11540421.1	1846467.4	230.8
16	Rapeseed & Mustard	766156.0	988392.3	1779106.1	889553.1	117.0
17	Sunflower	220.9	596.8	1193.7	1074.3	0.1
18	Caster Seed	3145.0	1677.9	6879.3	4127.6	0.5
19	Cotton	591289.7	179839.6	2642548.1	2114038.5	255.8
20	Sugarcane	95137.4	2989824.3	149491.2	37372.8	5.1
21	Banana	22493.8	1600510.8	4801532.3	1056337.1	140.5
22	Ginger	19644.8	281334.6	14066.7	4642.0	0.6
23	Potato	132589.7	2668547.5	2161523.5	1426605.5	132.8
	Total	**25789607.7**	**55409223.8**	**93007714.6**	**26621857.5**	**3301.1**

Major contributing crops in biomass power potential in Madhya Pradesh (2019-20) is Wheat with 1088.7 MWe followed by Maize (388.1 MWe), Rice (369.7 MWe), Cotton (255.8 MWe) and Soyabean (230.8 MWe)

Trend Analysis for Biomass power potential for the state of Madhya Pradesh – Crop-wise

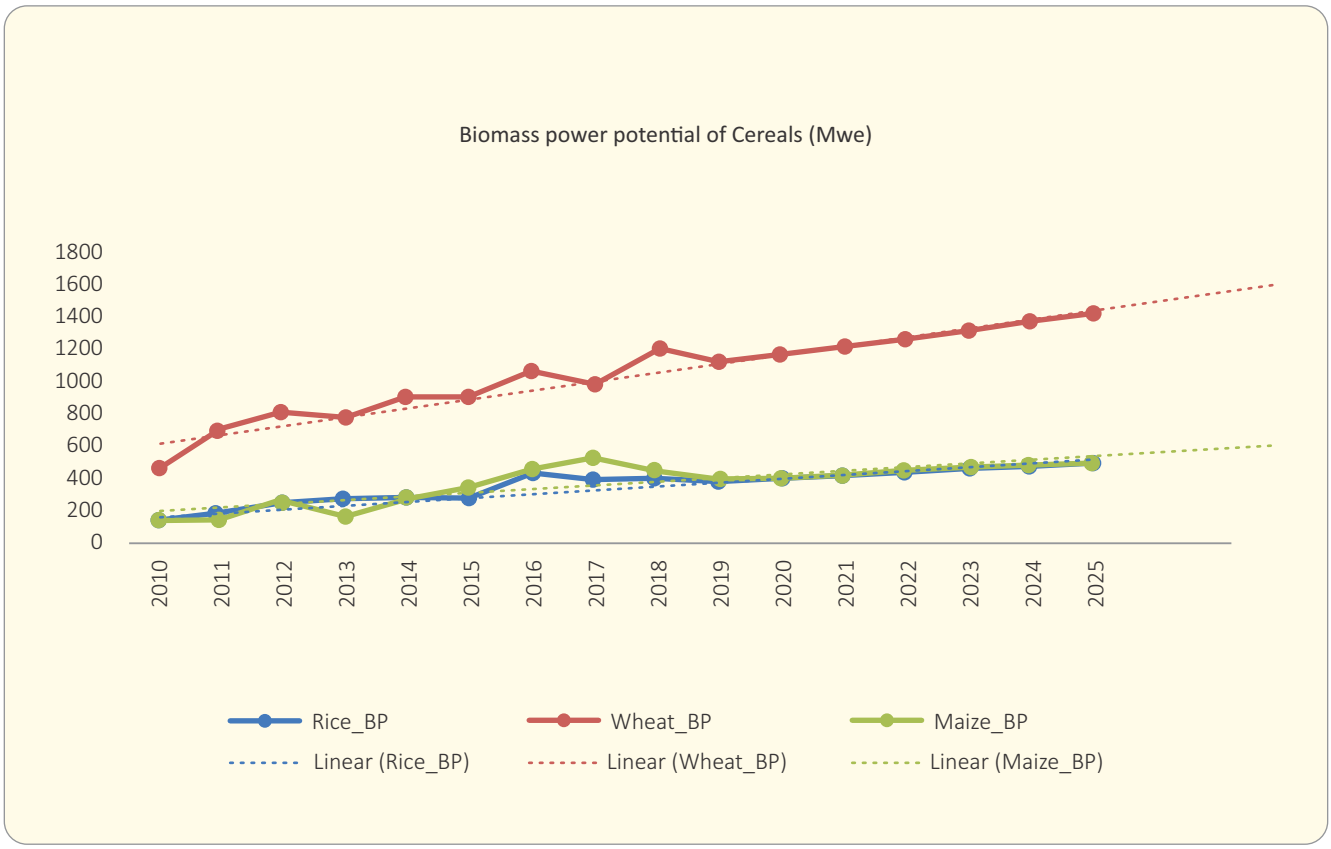


Figure 94: Biomass Power Potential for Rice, Wheat and Maize in Madhya Pradesh

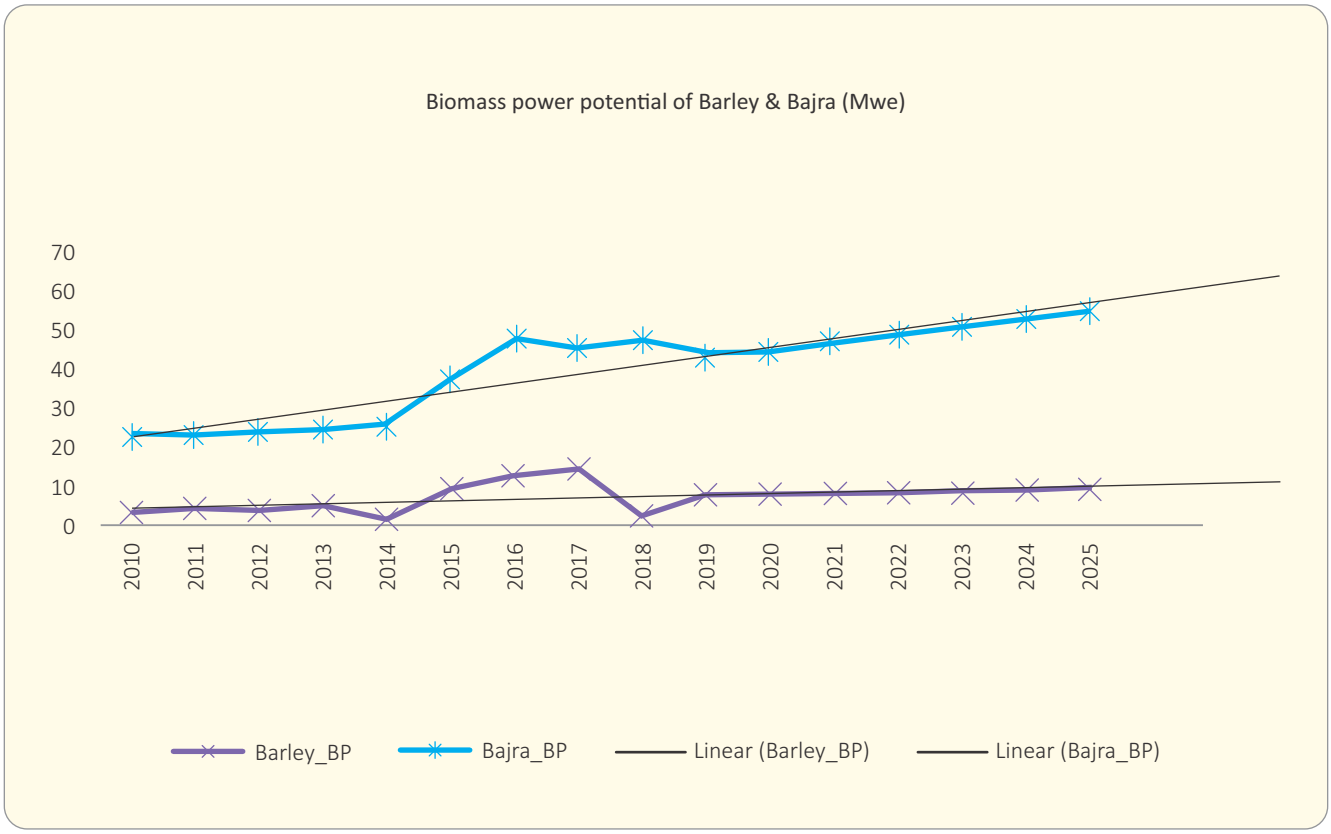


Figure 95: Biomass Power Potential for Barley and Bajra in Madhya Pradesh

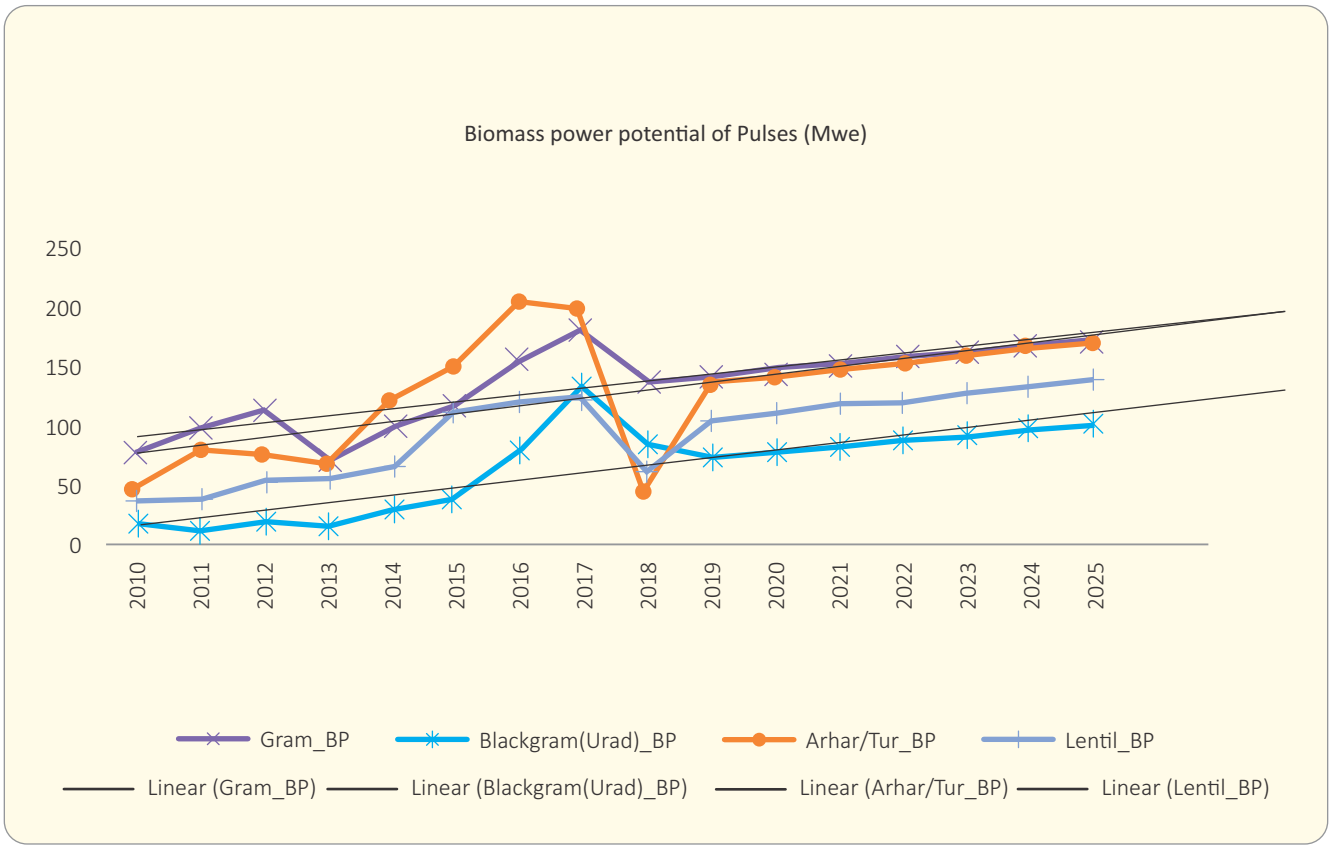


Figure 96: Biomass Power Potential for Pulses in Madhya Pradesh

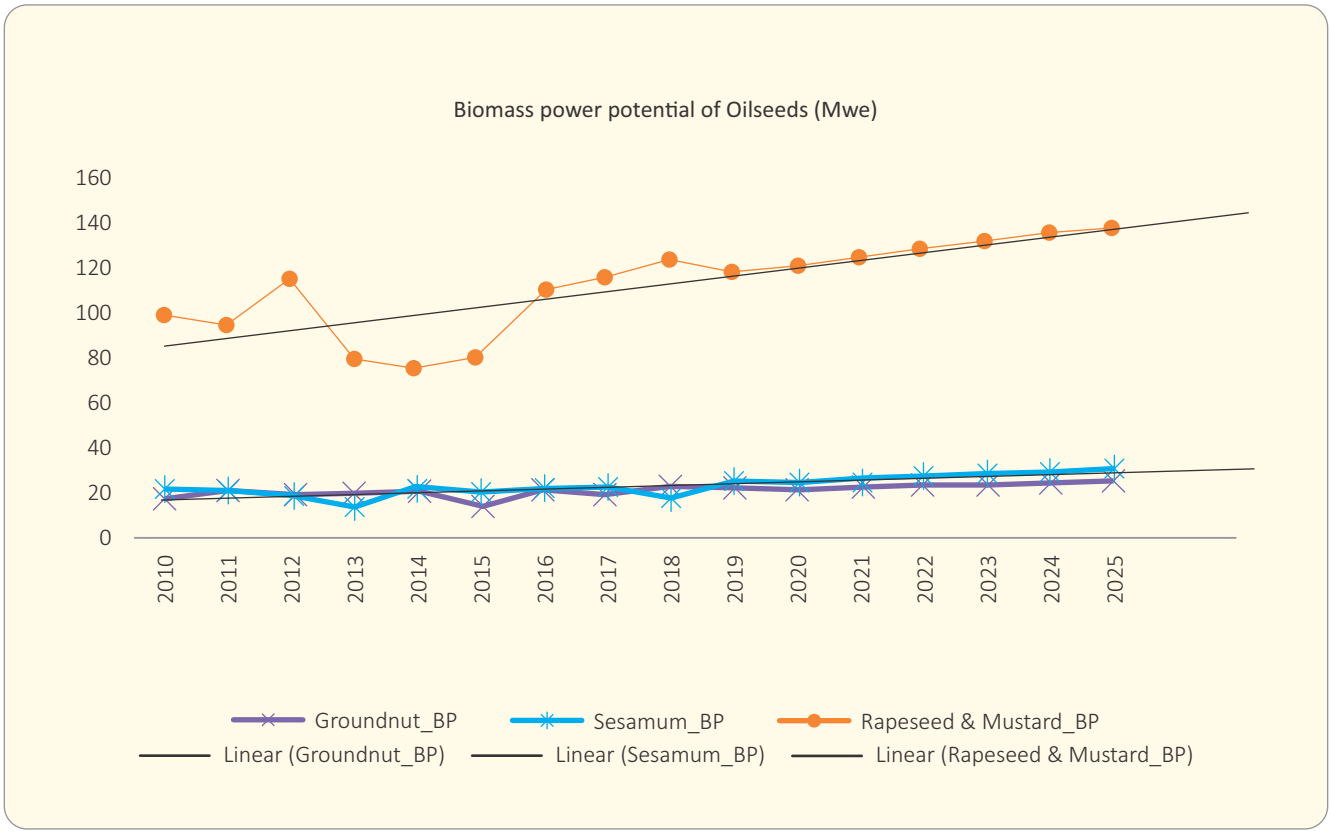


Figure 97: Biomass Power Potential for Oilseeds in Madhya Pradesh

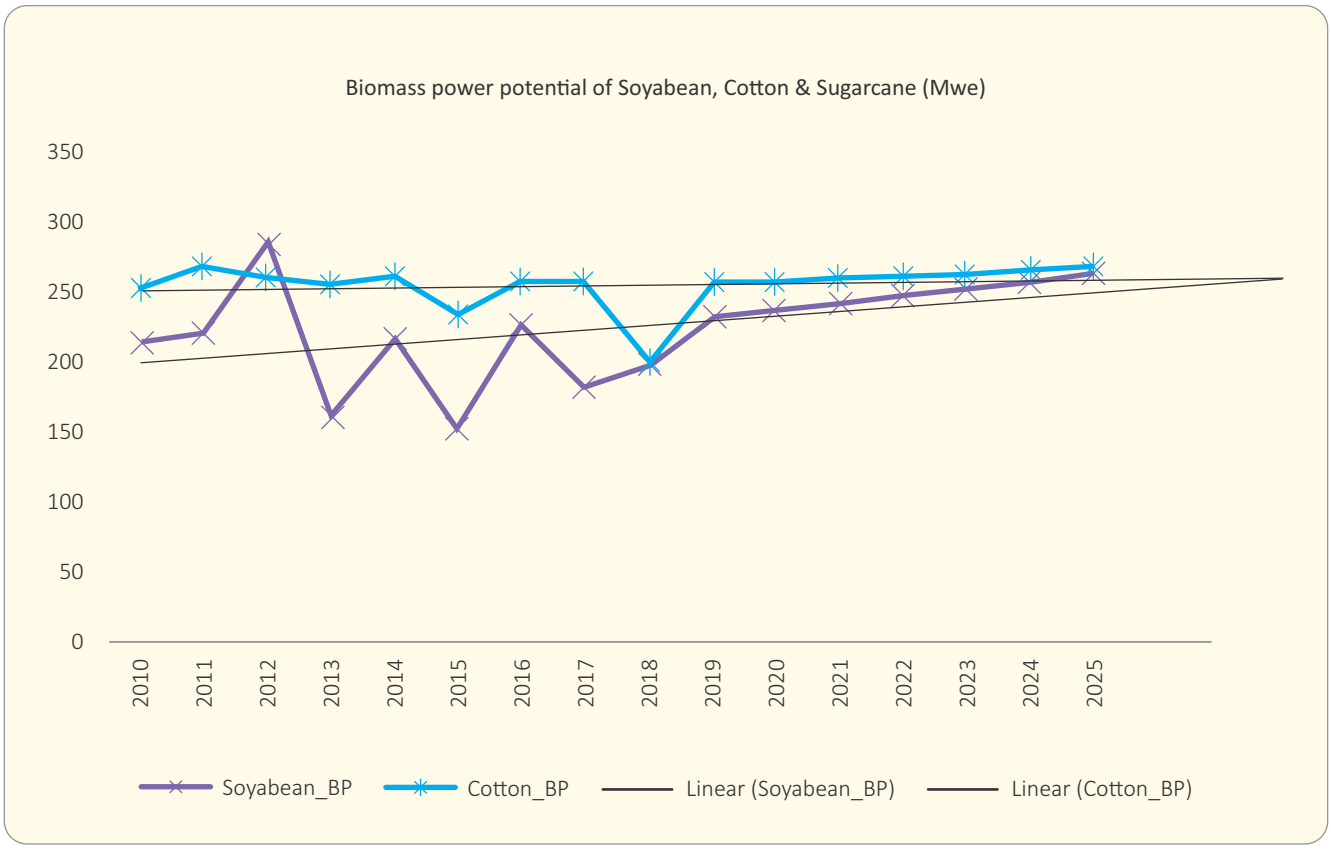


Figure 98: Biomass Power Potential for Soyabean, Cotton and Sugarcane in Madhya Pradesh

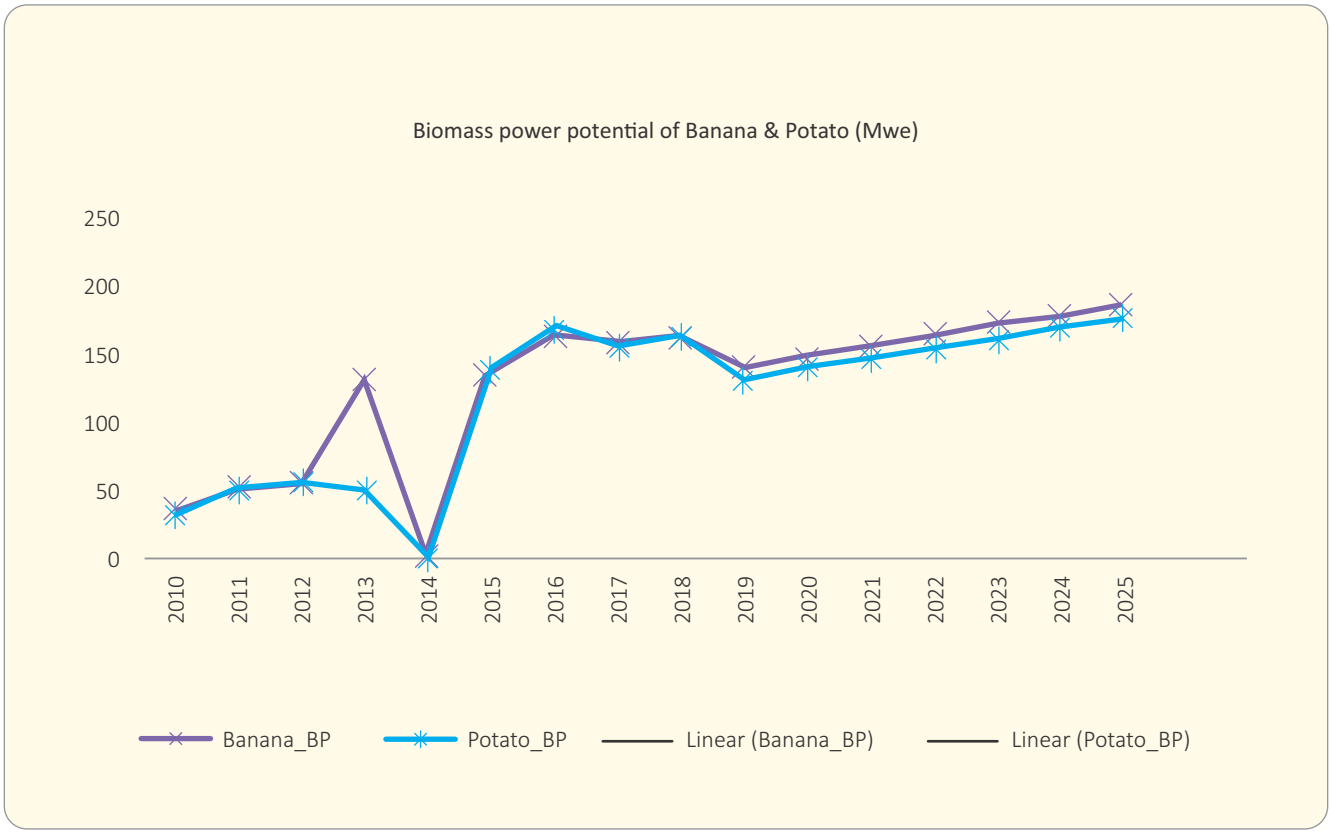


Figure 99: Biomass Power Potential for Banana and Potato in Madhya Pradesh

Maharashtra

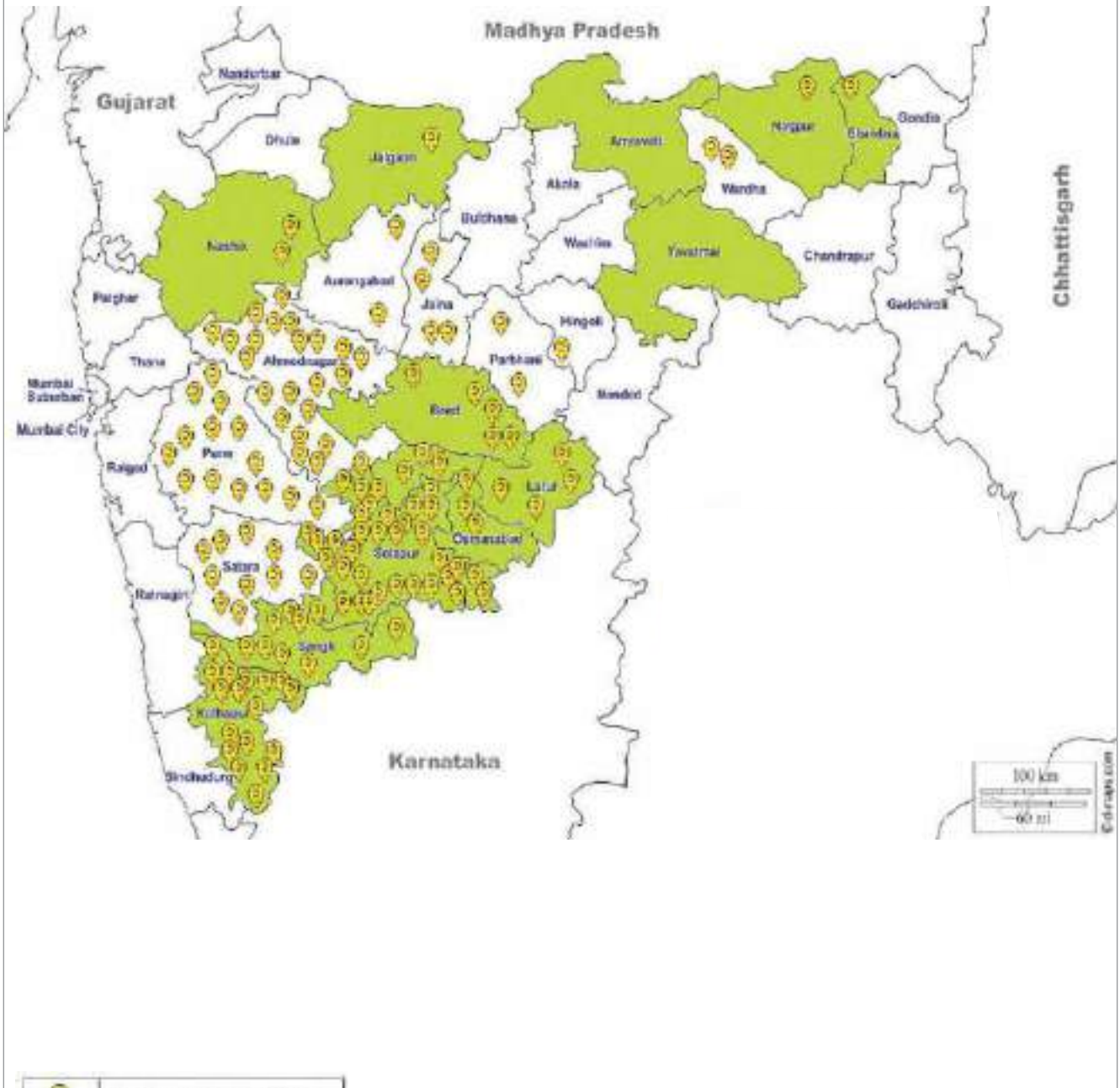


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Maharashtra collected information and samples from all twelve (12) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Maharashtra. Thus, the total biomass power potential for the state of Maharashtra for 2018 was 2629.55 MWe and for 2019-20 is 3074.00 MWe.

Districts Selected for Primary Field Survey	12 (Ahmadnagar, Bhandara, Sangli, Latur, Beed, Kolhapur, Nashik, Jalgaon and Nagpur)
Average Rainfall	1328.5 mm
Type of soil	Black cotton Soil, Red and yellow soil
Major source of irrigation	The co-operative pipeline, Canals, River, Tube wells and Open wells
Major Rivers	Aruawati,Bembla, Bhoogawati, Bindusara, Doodhganga, Godavari, Girha, Hiranyakeshi, Jam, Kanhan, Koyna, Krushna, Manjra, Maan, Nalganga, Painganga, Panchganga, Pench, Purna, Shahanoor, Sindhpana, Tapi, Terna, Vaina, Vedganga, Wardha, Wagnur and Wainganga
Major Crops	Arhar, Bajra, Cotton, Bengal Gram, Green gram (Moong), Groundnut, Jowar, Maize, Oranges (Nagpur), Ragi, Rice, Soyabean, Sugarcane and Wheat.

Utilization of Crop residue at farmer's level in Maharashtra:

1. **Essential Usage**: Residue of Bajra, Gram, Groundnut, Green gram, Jowar, Maize, Ragi and Wheat are extensively utilized for cattle feeding. Soyabean husk and Arhar husk residue can be utilized for cattle feeding. Crop residue of Arhar, Bajra, chia seed, Jowar, Green gram, Groundnut, chillies, Moth beans and Shatavani are mostly used for the preparation of compost fertilizer.
2. **Specific Usage**: Arhar stalk is also used for the construction of small huts. The residue of Soyabean is also used for fuel for making bricks in a brick kiln. Sugarcane top leaves are used for cattle feeding, and bagasse is used for energy generation in the sugar mills. In some parts of Bhandara and Nagpur, district rice residue is used to prepare raw material for an Incense stick
3. **Fuel Usage**: The cotton stalk and Arhar stalk is used for domestic cooking in open chulhas
4. **Field preparation**: Cotton stubbles burnt in an open field in order to prepare a seedbed for the next sowing.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Arhar	5000
	Soyabean	1000
Expected Cost against the sale of crop residue in Future	Cotton	5000

Survey Images:

Nandura, Amravati, Maharastra

Talegaon, Jalgaon, Maharastra

Kheri Pannase, Nagpur, Maharastra

Table 75: Crop-wise change in Area, Production and Biomass Potential in Maharashtra

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	1542783.33	2623316.67	3934975.00	39349.75	5.35	1500866.33	2970679.00	4456018.50	43122.76	5.87	9.78
Wheat	1168466.67	1919500.00	3455100.00	691020.00	93.29	1106870.50	1693407.67	3048133.80	609626.76	82.30	-11.78
Maize	632866.67	1495083.33	3438691.67	34386.92	4.02	1064134.67	2709434.33	6231698.97	38948.12	4.55	13.16
Ragi	130016.67	123900.00	161070.00	16107.00	2.00	92517.33	103496.33	134545.23	13454.52	1.67	-16.45
Small millets	71616.67	37316.67	44780.00	4478.00	0.56	808606.00	600638.83	780830.48	78083.05	9.84	1656.87
Bajra	1200333.33	949200.00	2496396.00	474315.24	57.87	808606.00	600638.83	1579680.13	299010.88	36.36	-37.17
Jowar	4279000.00	3712366.67	8909680.00	1781936.00	220.96	3432983.00	2044774.00	4907457.60	981491.52	121.90	-44.83
Other Cereals	0.00	0.00	0.00	0.00	0.00	76368.50	55975.90	72768.67	7276.87	0.86	0
Moong (Green Gram)	553500.00	236400.00	295500.00	59100.00	7.56	417016.17	163237.00	204046.25	40809.25	5.21	-31.07
Gram	1268233.33	938233.33	1032056.67	206411.33	27.04	1868413.67	1588839.00	1747722.90	349544.58	45.62	68.70
Urad	459233.33	206600.00	268580.00	80574.00	7.33	325649.00	122265.17	158944.72	47683.42	4.34	-40.74
Arhar /Tur	1096733.33	831766.67	2328946.67	1397368.00	169.08	0.00	0.00	0.00	0.00	0.00	-100.00
Other Kharif pulses	151233.33	55533.33	72193.33	14438.67	1.75	96033.83	43640.90	56733.17	11346.63	1.37	-21.55
Other Rabi Pulses	131150.00	59250.00	77025.00	7702.50	0.93	105816.33	54893.00	71360.90	7136.09	0.86	-7.15
Other Summer Pulses	0.00	0.00	0.00	0.00	0.00	2294.00	1156.50	1503.45	300.69	0.04	0
Rapeseed & Mustard	10900.00	4233.33	7620.00	3810.00	0.50	9233.00	3317.00	5970.60	2985.30	0.39	-21.79
Linseed	58050.00	14500.00	21460.00	4292.00	0.43	13789.50	3570.80	5284.78	1056.96	0.11	-75.17
Sunflower	307750.00	186316.67	372633.33	335370.00	36.89	50785.83	22820.68	45641.37	41077.23	4.52	-87.75
Sesamum	84333.33	23566.67	58916.67	23566.67	2.90	32933.67	43331.83	108329.58	43331.83	5.33	83.79
Groundnut	395550.00	420466.67	967073.33	125719.53	15.34	318843.67	366580.00	843134.00	108402.94	13.21	-13.86
Safflower	232116.67	142750.00	428250.00	85650.00	9.34	57645.67	29140.50	87421.50	17484.30	1.91	-79.60
Castor Seed	11716.67	3800.00	15580.00	9348.00	1.17	10202.50	2362.10	9684.61	5810.77	0.73	-37.82
Niger seed	46500.00	11766.67	12472.67	1247.27	0.15	14398.00	2261.17	2396.84	239.68	0.03	-80.87
Soyabean	2749300.00	2902566.67	4934363.33	690810.87	86.35	3745523.00	3395616.33	5772547.77	836695.13	104.59	21.12

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Other Oilseeds	0.00	0.00	0.00	0.00	0.00	15701.67	4195.62	8391.23	8391.23	0.79	0
Sugarcane	903333.33	71787633.33	3589381.67	897345.42	122.04	840891.17	68675628.00	3433781.40	858445.35	116.75	-4.34
Tobacco	0.00	0.00	0.00	0.00	0.00	989.00	1536.33	1536.33	1536.33	0.20	0
Cotton	3149433.33	928466.33	11967859.87	10890752.48	1317.78	4256866.67	1176550.28	18764503.95	17040515.15	2060.20	56.34
Total	**20634150.00**	**89614533.00**	**48890605.20**			**21073978.67**	**86479987.11**	**52540068.74**	**21493807.34**	**2629.55**	**20.04**

Table 76: Crop-wise Area, Production, Biomass, Surplus biomass and Biomass Power Potential for Maharashtra the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1515447.5	3223366.1	4835049.2	48350.5	6.6
2	Wheat	1125701.3	1778207.5	3200773.4	640154.7	86.4
3	Ragi	87519.3	101168.5	131519.0	13151.9	1.6
4	Jowar	2768270.9	1685405.4	4044972.9	808994.6	100.5
5	Bajra	533693.7	534404.6	1405484.1	267042.0	32.6
6	Maize	1190961.9	3066537.7	7053036.8	70530.4	8.2
7	Green Gram (Moong)	328926.8	145325.8	181657.2	36331.4	4.6
8	Black Gram (Urad)	257769.4	119566.7	155436.8	46631.0	4.2
9	Gram	1905089.1	1681667.8	1849834.5	369966.9	49.6
10	Tur (Arhar)	1337578.8	1104423.6	3092386.1	1917279.4	232.0
11	Groundnut	265786.9	319070.2	733861.5	95402.0	11.6
12	Caster Seed	9500.1	2854.6	11703.8	7022.3	0.9
13	Sesamum	39192.0	6550.0	16375.0	6550.0	0.8
14	Soyabean	4359737.0	4375265.0	7437950.5	1041313.1	130.2
15	Rapeseed & Mustard	3838.8	1636.1	2945.0	1472.5	0.2
16	Sunflower	16311.0	3047.0	6094.0	5484.6	0.6
17	Cotton	4569622.0	1381037.2	20402845.5	18566589.4	2246.6
18	Sugarcane	1090270.3	92240193.1	4612009.7	1153002.4	156.8
	Total	**21405216.7**	**111769727.0**	**59173935.1**	**25095269.1**	**3074.0**

Major contributing crops in biomass power potential in Maharashtra (2019-20) is Cotton with 2246.6 MWe followed by Arhar/Tur (232.0 MWe), Sugarcane (156.8 MWe), Soyabean (130.2 MWe) and Jowar (100.5 MWe)

Trend Analysis for Biomass power potential for the state of Maharashtra – Crop-wise

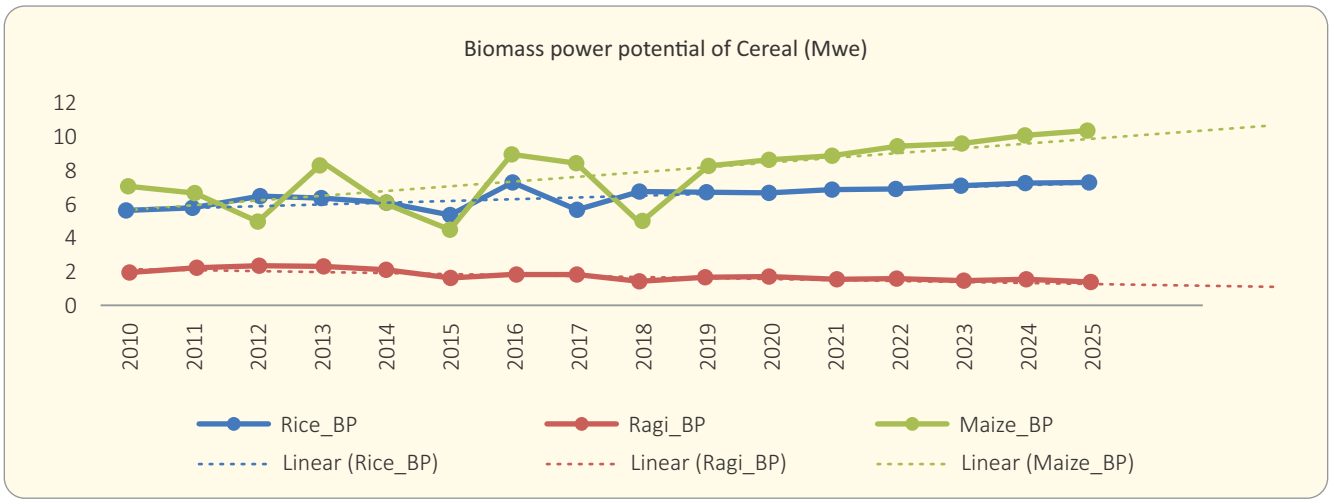


Figure 100: Biomass Power Potential for Rice, Ragi and Maize in Maharashtra

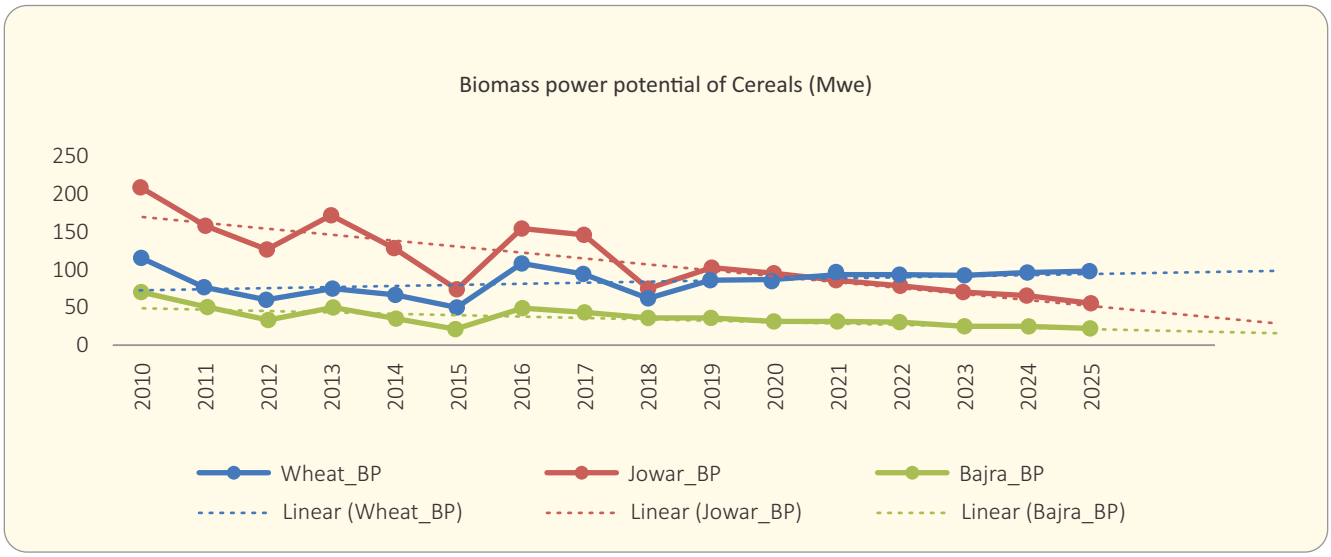


Figure 101: Biomass Power Potential for Wheat, Jowar and Bajra in Maharashtra

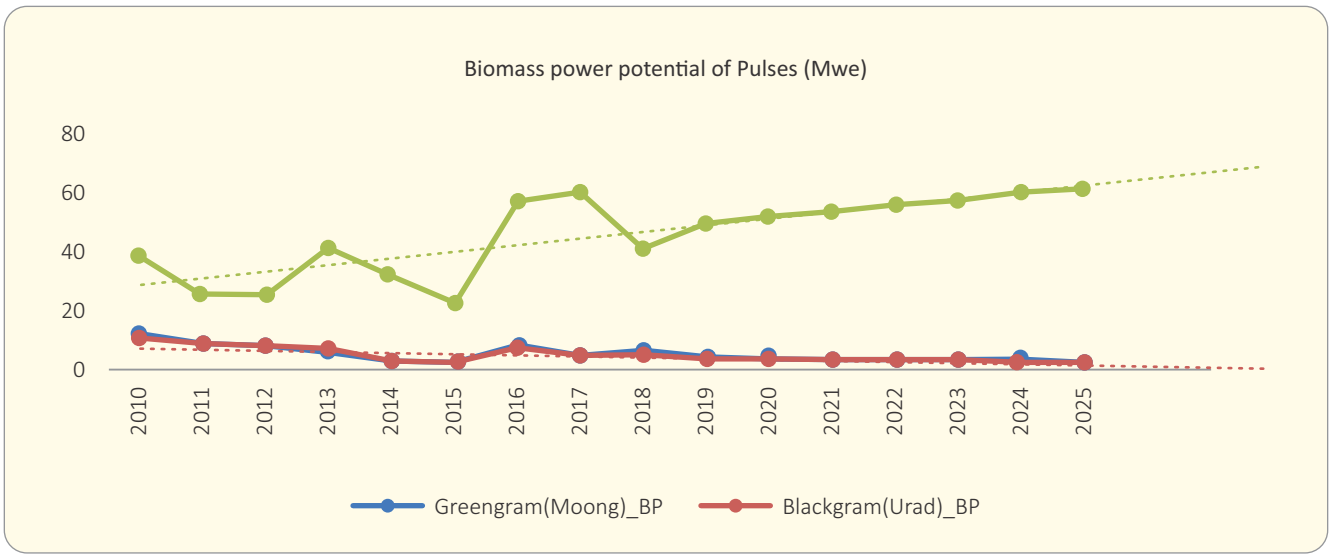


Figure 102: Biomass Power Potential for Pulses in Maharashtra

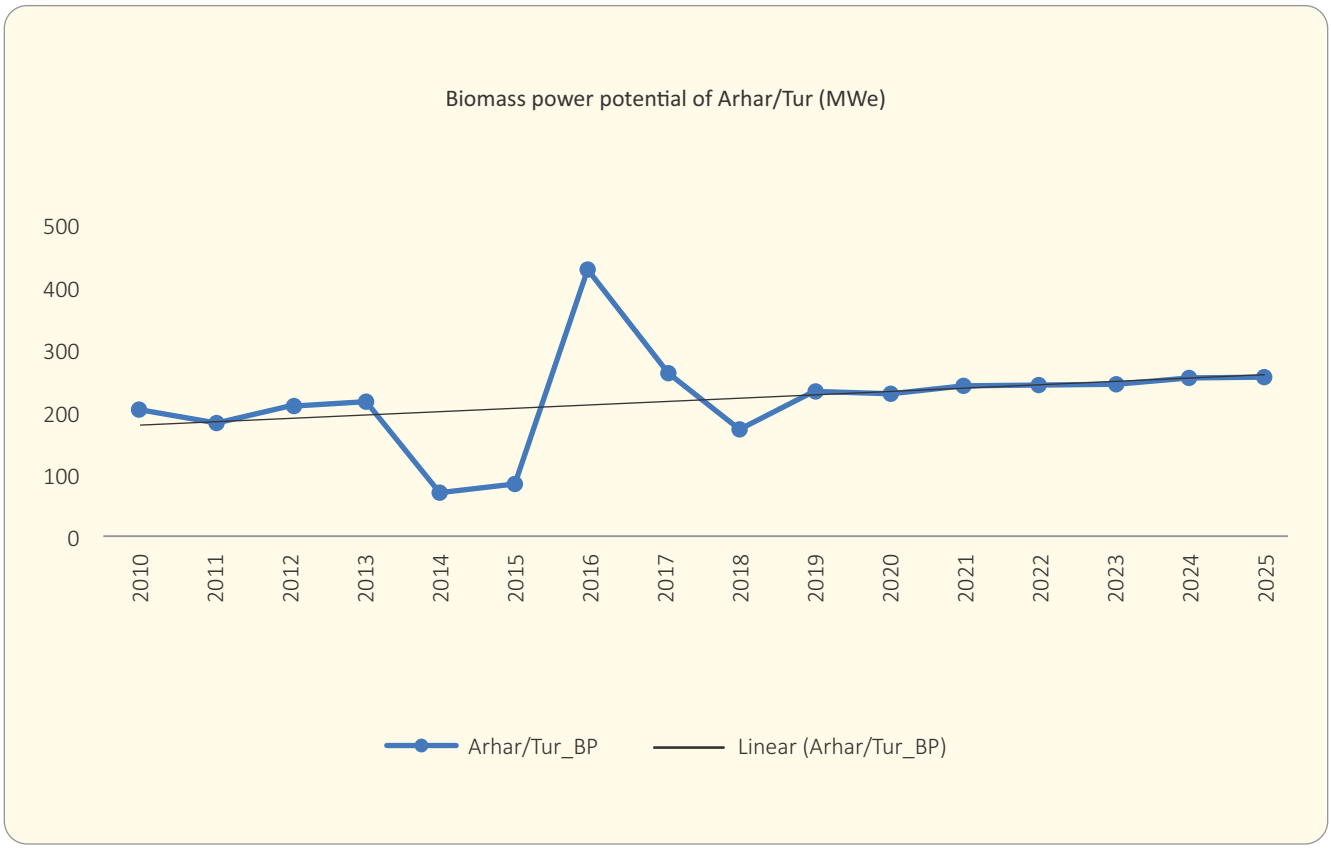


Figure 103: Biomass Power Potential for Arhar/ Tur in Maharashtra

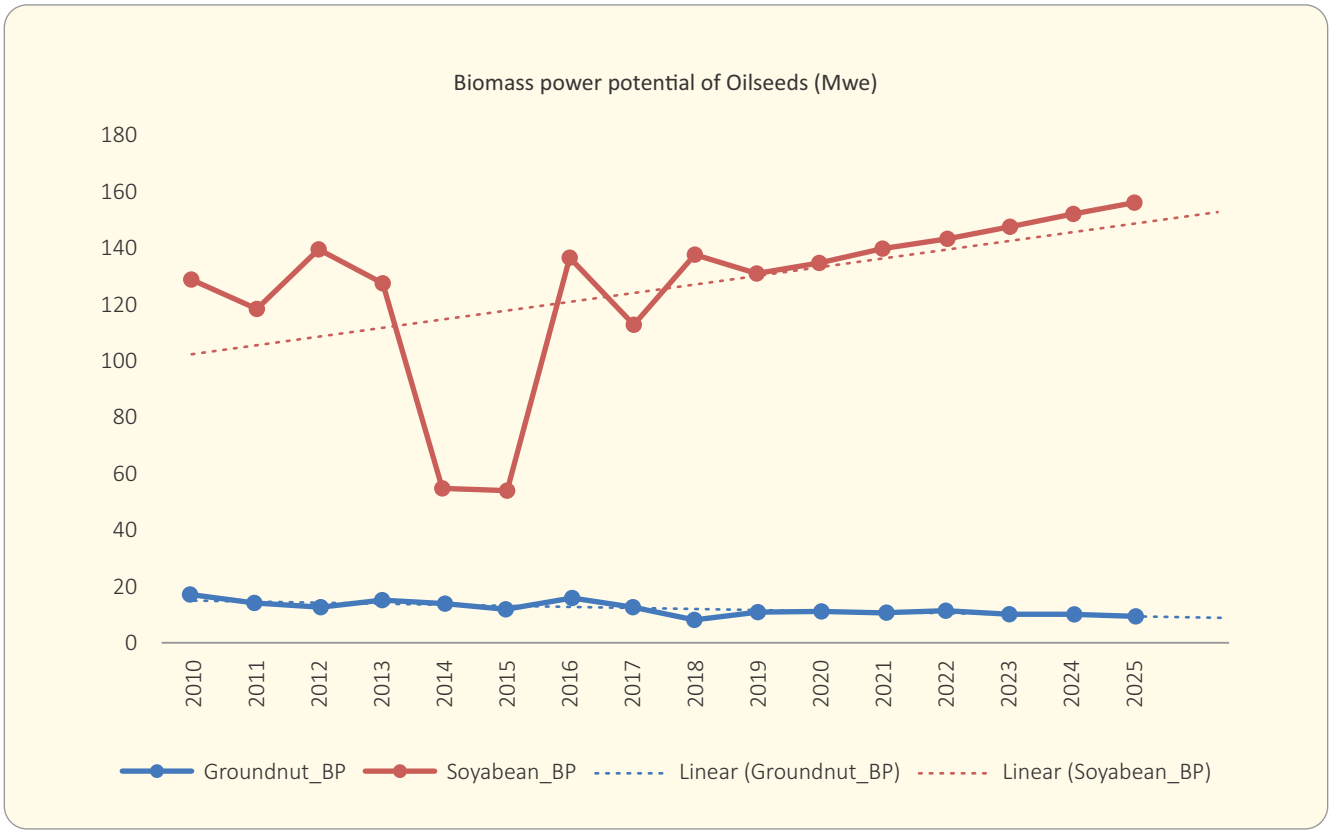


Figure 104: Biomass Power Potential for Groundnut and Soyabean in Maharashtra

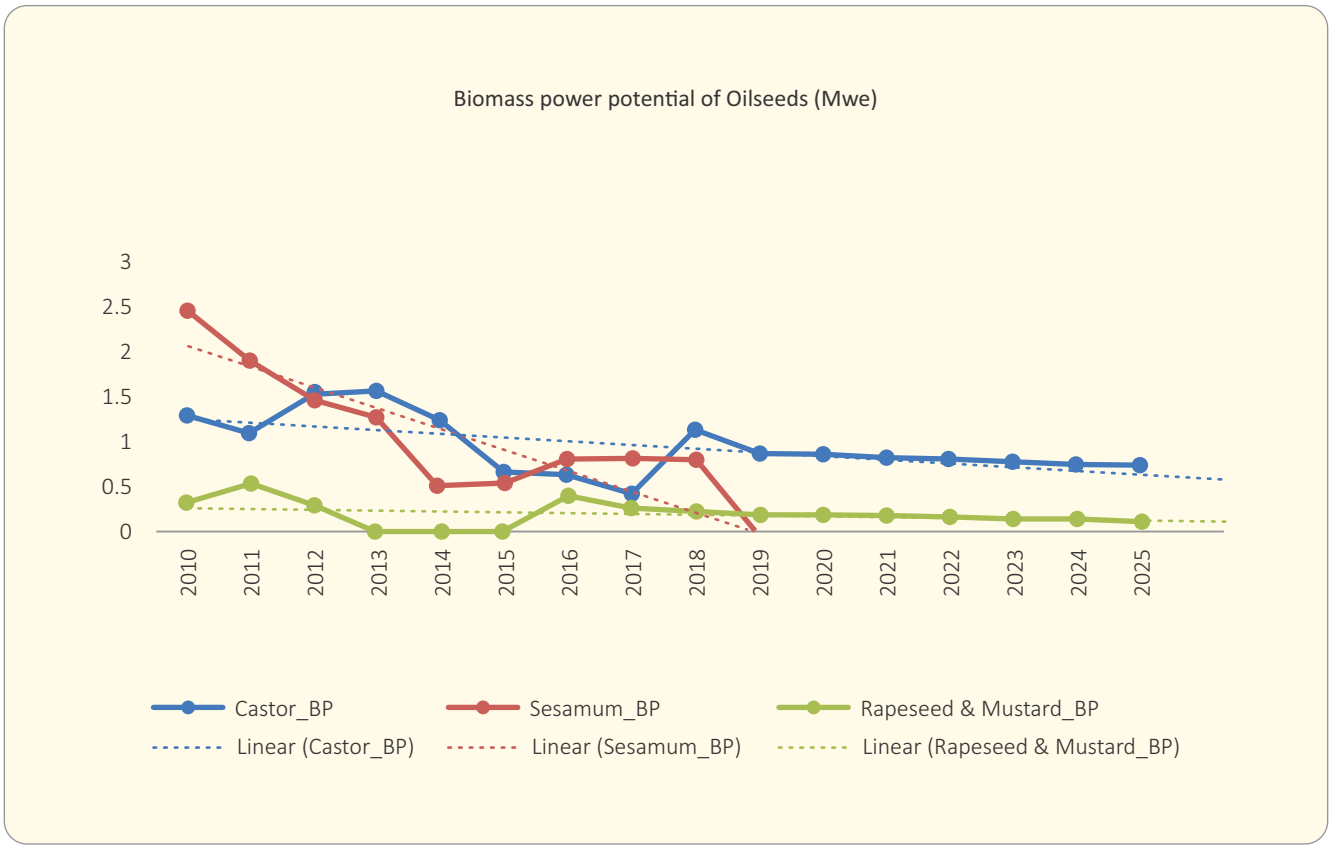


Figure 105: Biomass Power Potential for Castor, Sesamum, Rapeseed & Mustard in Maharashtra

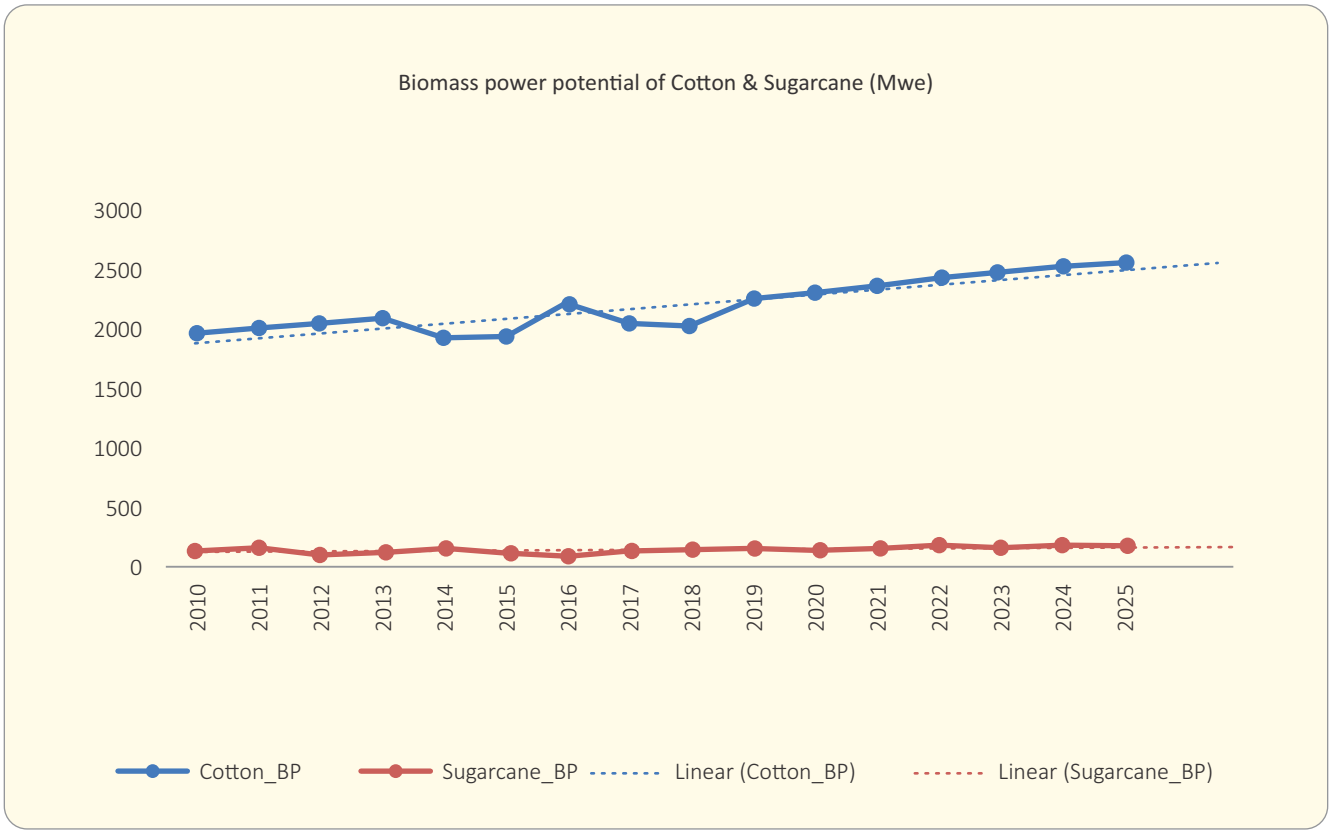
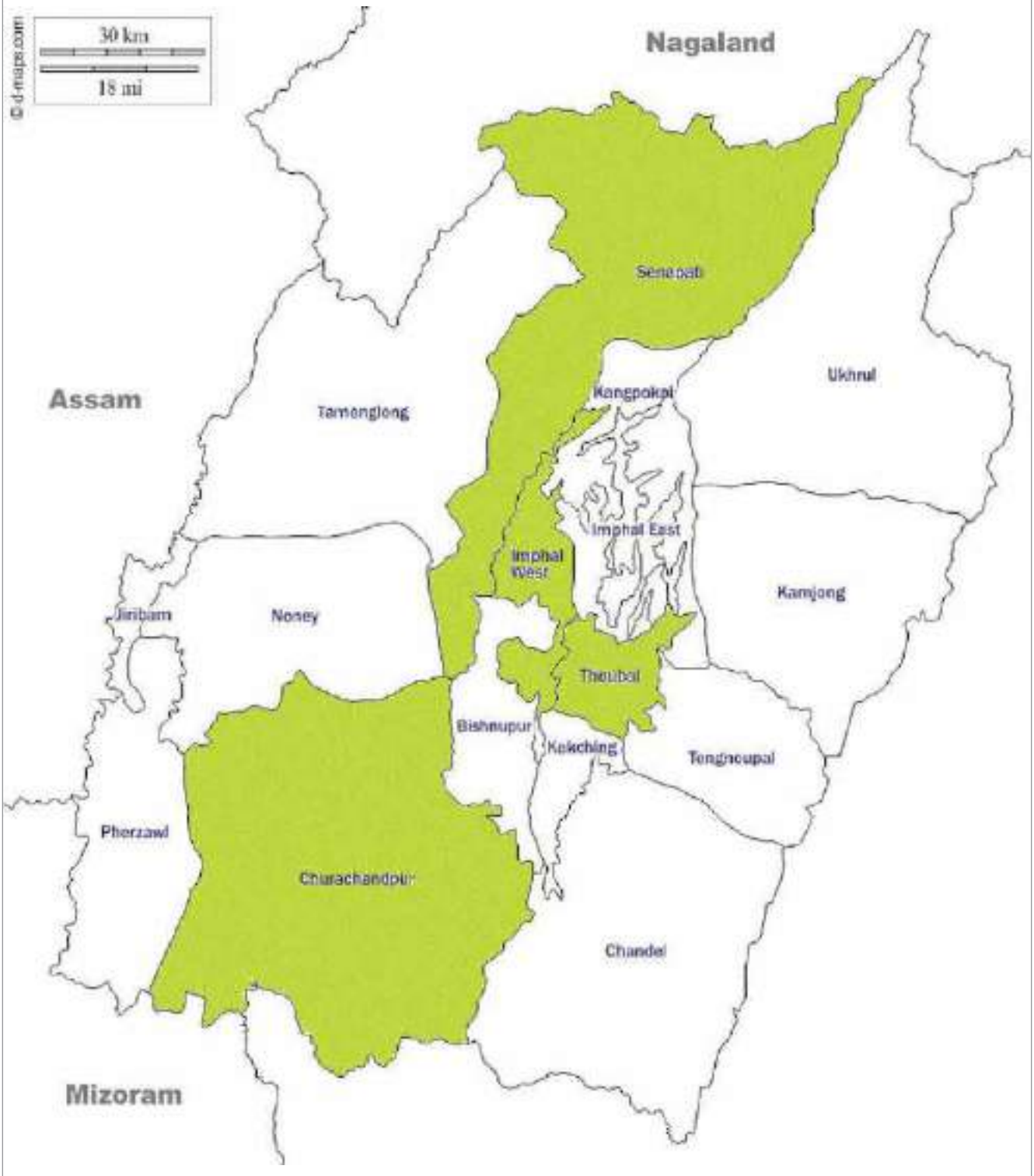


Figure 106: Biomass Power Potential for Cotton and Sugarcane in Maharashtra

Manipur



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Manipur collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Manipur was calculated, which was the input to arrive at biomass power potential in Manipur. Thus, the total biomass power potential for the state of Manipur for 2018 was 62.31 MWe, and for 2019-20 is 81.90 MWe.

Districts Selected for Primary Field Survey	05 (Churachandpur, Imphal East, Imphal West, Senapati and Thoubal)
Average Rainfall	1881 mm
Type of soil	Mountain Soil, Red and Yellow Soil
Major source of irrigation	Rainfed and River
Major Rivers	Barak, Imphal River, Khuga, Tuila, Tuili, Leimatak, Tuivai
Major Crops	Rice, Rapeseed & Mustard, Maize, Peas & beans (Pulses), Potato

Utilization of Crop residue at farmer's level in Manipur:

1. **Essential Usage**: Some part of the Paddy residue is utilized for cattle feeding and preparation of compost fertilizer. The residue of potato and peas & beans are extensively used for compost fertilizer.
2. **Fuel Usage**: Residue of paddy and rapeseed & mustard are used for domestic cooking.
3. **Field preparation**: Stubble of paddy and mustard are mostly burnt in an open field in order to prepare the land for the next sowing.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy, Rapeseed & Mustard	5000 & 3000

Survey Images:

Heigrujam, Imphal East, Manipur

M. Ningthoupham, Senapati, Manipur

Churachandpur, Manipur

Table 77: Crop-wise change in Area, Production and Biomass Potential in Manipur

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	191496.67	465036.67	697555.00	306924.20	41.74	228060.00	535930.00	803895.00	352106.01	47.96	14.89
Wheat	2050.00	5120.00	9216.00	1843.20	0.25	2190.00	5546.67	9984.00	1996.80	0.27	7.83
Maize	13976.67	24780.00	56994.00	11398.80	1.33	26270.00	58921.33	135519.07	27103.81	3.17	138.02
Moong (Green Gram)	0.00	0.00	0.00	0.00	0.00	443.00	419.65	524.56	157.37	0.02	0
Peas & beans (Pulses)	6585.00	3360.00	1680.00	840.00	0.10	18394.00	17458.45	8729.23	4364.61	0.54	441.21
Other Kharif Pulses	3210.00	1640.00	2132.00	426.40	0.05	1527.00	1723.85	2241.01	448.20	0.05	8.46
Other Rabi Pulses			0.00	0.00	0.00	666.67	575.98	748.77	74.88	0.01	0
Masoor	0.00	0.00	0.00	0.00	0.00	590.00	486.70	871.19	435.60	0.04	0
Cowpea	0.00	0.00	0.00	0.00	0.00	953.00	986.80	1085.48	217.10	0.03	0
Gram	705.00	593.40	652.74	130.55	0.02	705.00	593.40	652.74	130.55	0.02	-14.82
Arhar/Tur	520.50	509.60	1426.88	998.82	0.12	520.50	509.60	1426.88	998.82	0.12	0.38
Urad	1440.50	1662.80	2161.64	1080.82	0.10	1440.50	1662.80	2161.64	1080.82	0.10	-1.54
Soyabean	220.00	260.00	442.00	75.14	0.01	5055.00	4298.00	7306.60	1242.12	0.16	1452.65
Rapeseed &Mustard	1175.00	525.00	945.00	472.50	0.06	28270.00	23580.00	42444.00	21222.00	2.78	4533.47
Groundnut			0.00	0.00	0.00	3325.00	2832.00	6513.60	1302.72	0.16	0
Sesamum	1405.00	695.00	1737.50	695.00	0.09	0.00	0.00	0.00	0.00	0.00	-100.00
Turmeric	400.00	310.00	93.00	55.80	0.01	0.00	0.00	0.00	0.00	0.00	-100.00
Ginger	4205.00	6945.00	347.25	114.59	0.01	0.00	0.00	0.00	0.00	0.00	-100.00
Dry chillies	8020.00	4815.00	7222.50	5778.00	0.75	0.00	0.00	0.00	0.00	0.00	-100.00
Potato	16295.00	125230.00	101436.30	66947.96	6.23	14950.00	126670.00	102602.70	67717.78	6.30	1.20
Sugarcane	10905.00	615765.00	30788.25	7697.06	1.05	5900.00	342206.67	17110.33	4277.58	0.58	-44.60
Sweet potato	450.00	1580.00	158.00	94.80	0.01	0.00	0.00	0.00	0.00	0.00	-100.00
Cotton(lint)	210.00	11.90	824.18	659.34	0.08	0.00	0.00	0.00	0.00	0.00	-100.00
Onion	1300.00	2765.00	138.25	30.42	0.00	0.00	0.00	0.00	0.00	0.00	0

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Onion	1300.00	2765.00	138.25	30.42	0.00	0.00	0.00	0.00	0.00	0.00	0
Banana	8015.00	103085.00	309255.00	68036.10	9.05	0.00	0.00	0.00	0.00	0.00	-100.00
Total	**269918.33**	**1361923.57**	**1225205.49**			**339259.67**	**1124401.89**	**1143816.80**	**484876.77**	**62.31**	**2.04**

Table 78: Crop-wise Area, Production, Biomass Production, Surplus Biomass, Biomass Power Potential for Manipur in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	238762.5	593544.4	890316.6	391739.3	53.3
2	Wheat	3526.8	8585.3	15453.5	3090.7	0.4
3	Maize	33289.3	72384.9	166485.3	33297.1	3.9
4	Gram	1067.3	959.0	1055.0	211.0	0.0
5	Tur (Arhar)	684.0	717.1	2008.0	1405.6	0.2
6	Lentil (Masur)	917.5	821.1	1469.8	734.9	0.1
7	Groundnut	4323.2	3752.1	8629.9	1726.0	0.2
8	Soyabean	6474.0	5543.2	9423.5	1602.0	0.2
9	Rapeseed & Mustard	40570.5	33967.7	61141.9	30570.9	4.0
10	Sugarcane	7491.9	438298.6	21914.9	5478.7	0.7
11	Banana	8004.3	110948.8	332846.5	73226.2	9.7
12	Ginger	4751.7	65271.2	3263.6	1077.0	0.1
13	Green Gram (Moong)	573.7	596.3	745.3	223.6	0.0
14	Black Gram (Urad)	1887.5	2080.6	2704.8	1352.4	0.1
15	Potato	19044.9	163517.2	132448.9	87416.3	8.1
16	Peas & Beans	23884.1	22687.0	11343.5	5671.8	0.7
	Total	**395253.2**	**1523674.7**	**1661250.9**	**638823.4**	**81.9**

Major contributing crops in biomass power potential in Manipur (2019-20) is Rice with 53.3 MWe followed by Banana (9.7 MWe), Potato (8.1 MWe), Rapeseed & Mustard (4 MWe) and Maize (3.9 MWe)

Trend Analysis for Biomass power potential for the state of Manipur – Crop-wise

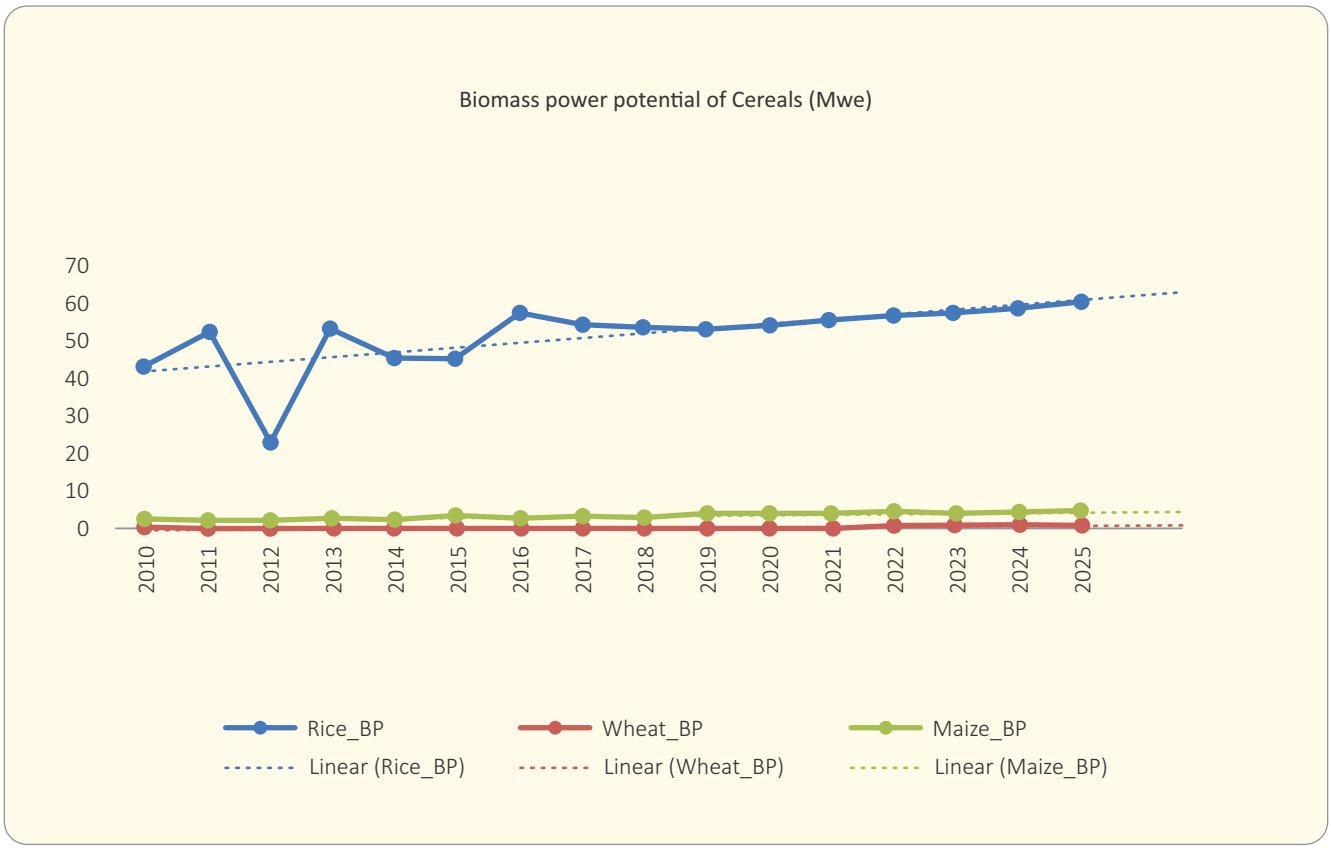


Figure 107: Biomass Power Potential for Rice, Wheat and Maize in Manipur

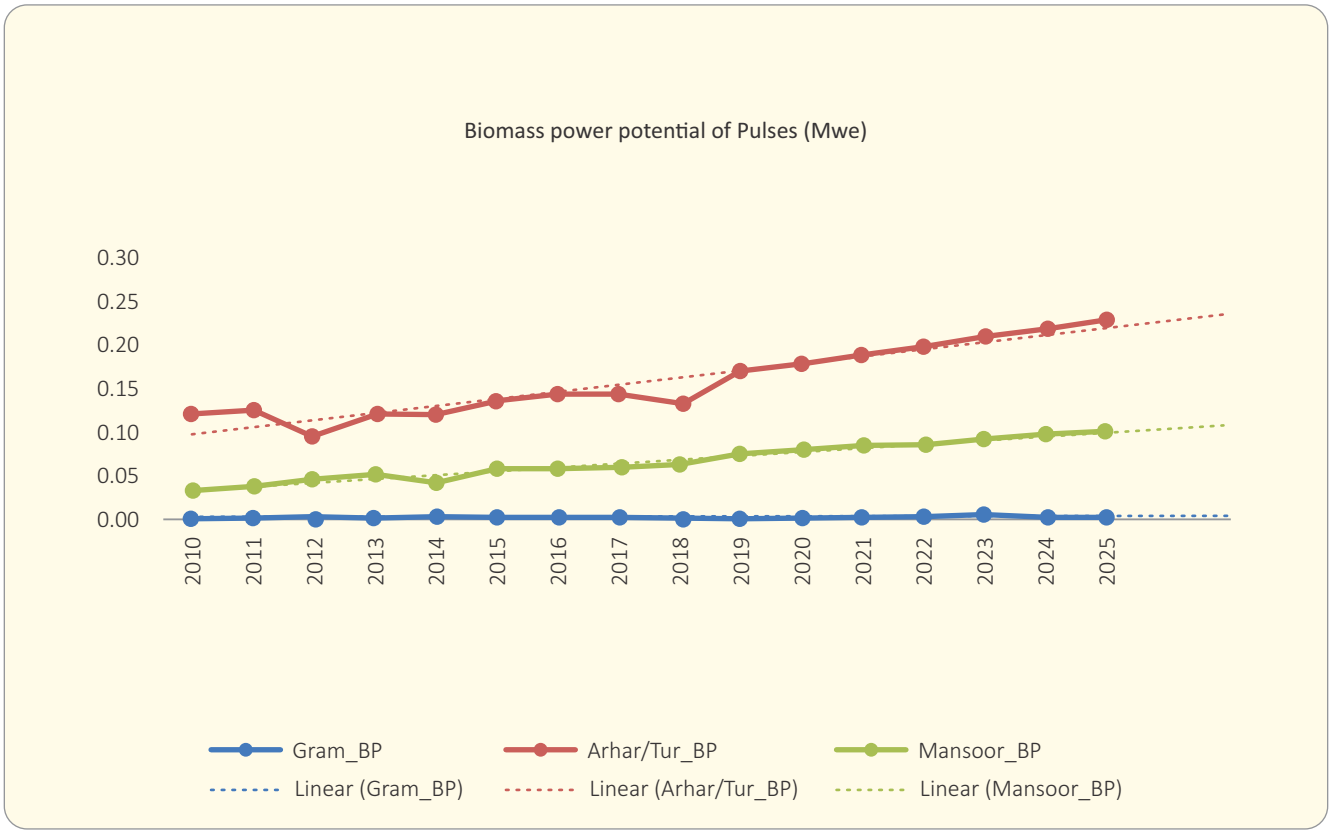


Figure 108: Biomass Power Potential for Gram, Arhar and Masoor in Manipur

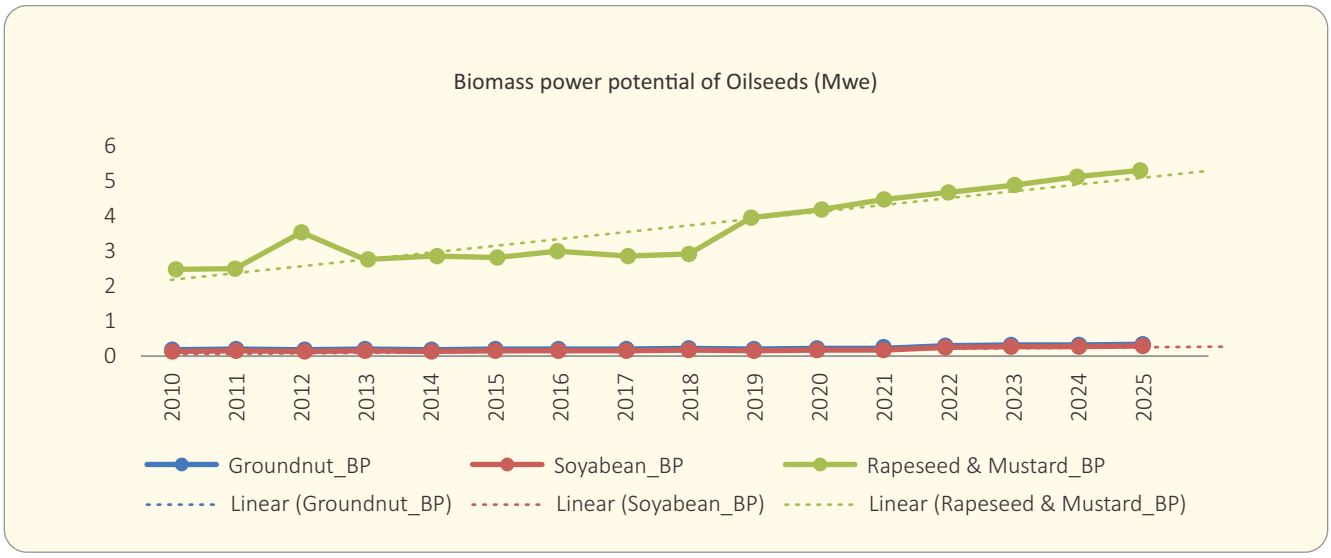


Figure 109: Biomass Power Potential for Groundnut, Soyabean, Rapeseed & Mustard in Manipur

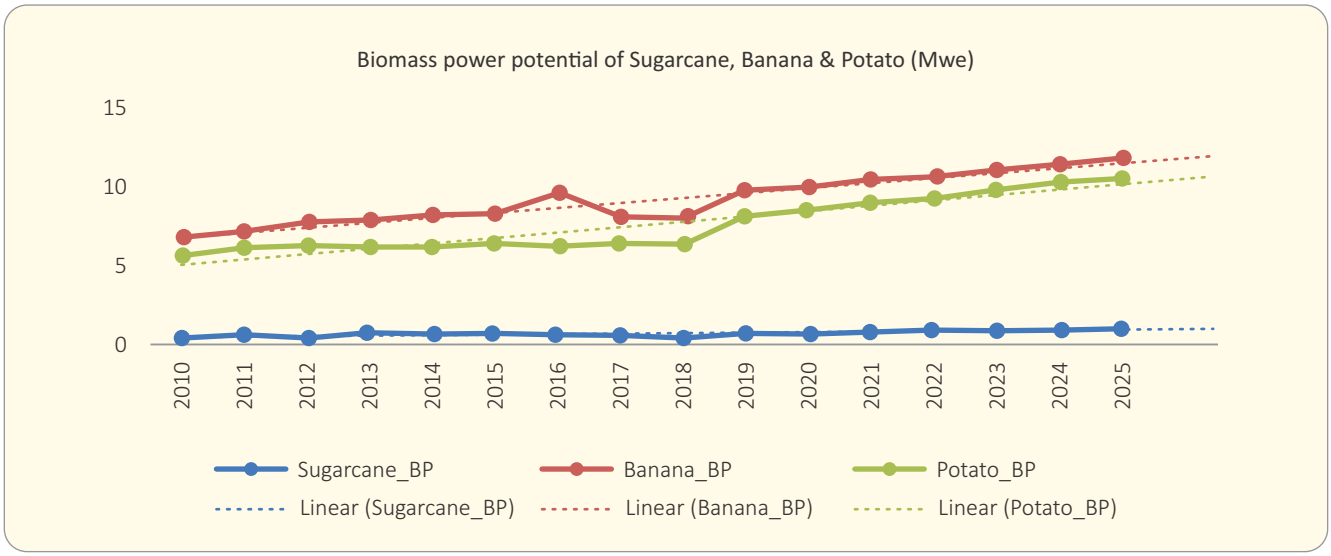


Figure 110: Biomass Power Potential for Sugarcane, Banana and Potato in Manipur

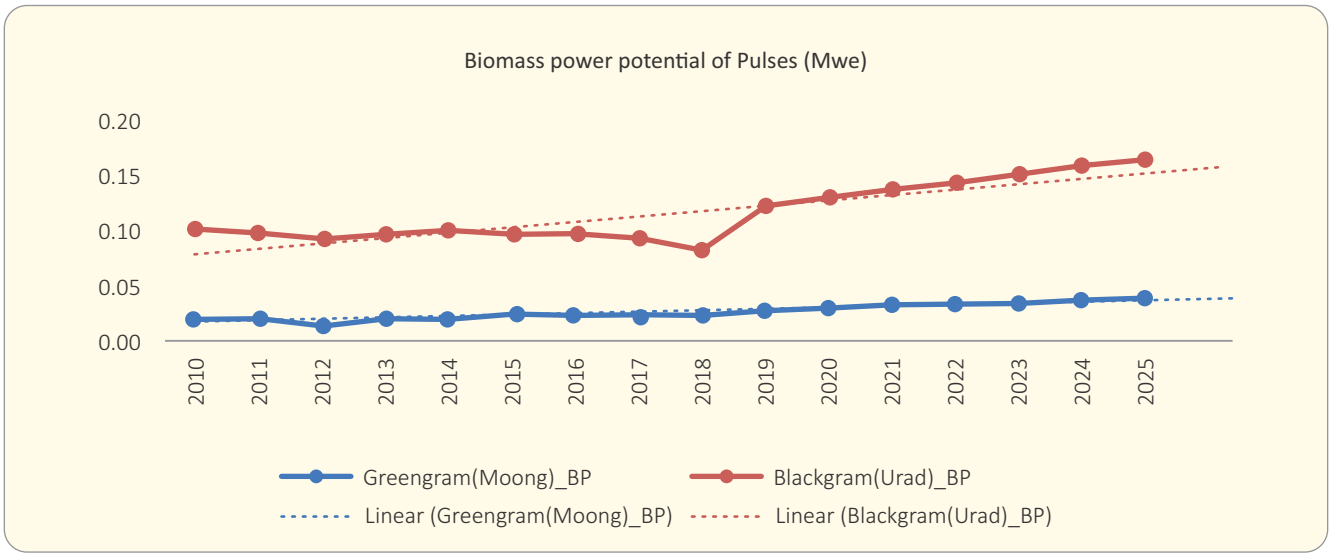


Figure 111: Biomass Power Potential for Moong and Urad in Manipur

Meghalaya

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Meghalaya collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Meghalaya was calculated, which was the input to arrive at biomass power potential in Meghalaya. Thus, the total biomass power potential for the state of Meghalaya for 2018 was 68.54 MWe, and for 2019-20 is 69.90 MWe.

Districts Selected for Primary Field Survey	05 (East Khasi Hills, East Garo Hills, North Garo Hills, West Garo Hills and West Khasi Hills)
Average Rainfall	2818 mm
Type of soil	Laterite soil, Mountainous soil, Red Sandy loam and Sandy Loam soil
Major source of irrigation	Rainfed and River
Major Rivers	Nokrek-Simsang, Tura, Umtrew, Umiam, Umkhen and Umngi
Major Crops	Arecanut, Banana, Cashewnut, Cotton (lint), Ginger, Jute, Maize, other oilseed, Rapeseed & Mustard, Paddy, Potato, Sweet potato and Tapioca

Utilization of Crop residue at farmer's level in Meghalaya:

1. **Essential Usage**: Paddy cattle feeding
2. **Specific Usage**: Arecanut husk is used for hardboard, paperboard, cushion and no woven fabrics besides various uses like decorative items, fibrous domestic fuel.
3. **Field preparation**: Residue of Arecanut, Ginger and Mustard are burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Arecanut	10000 - 20000
	Rapeseed & Mustard	4000
	Ginger	3000

Survey Images:

Sohkyll, South West Khasi Hills, Meghalaya

Alda, Rugu, East Garo Hills, Meghalaya

Marsh, South West Khasi Hills, Meghalaya

Table 79: Crop-wise change in Area, Production and Biomass Potential in Meghalaya

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	116835.7	243798	365697	21941.82	2.98408752	110924.67	303380.67	455071.00	25658.26	3.49	17.11
Wheat	566.1667	1015.5	1827.9	365.58	0.0493533	454.67	880.00	1584.00	316.80	0.04	-13.34
Maize	17068	25396	58410.8	11682.16	1.36681272	18112.00	41469.67	95380.23	19076.05	2.23	63.01
Small millets	5159.5	4368.5	5242.2	524.22	0.06605172	2924.00	2782.33	3338.80	333.88	0.04	-36.31
Gram	536.6667	332.666667	365.93333	73.18667	0.00958745	1844.00	1960.33	2156.37	431.27	0.06	487.03
Arhar/Tur	799	630.5	1765.4	1235.78	0.14952938	1168.00	1511.67	4232.67	2962.87	0.36	138.96
Masoor			0	0	0	1250.00	1380.00	2470.20	1235.10	0.13	0
Peas & Beans (Pulses)			0	0	0	2302.00	4468.67	2234.33	1117.17	0.14	0
Other Rabi Pulses	2198.667	2038	2649.4	264.94	0.03205774	0.00	0.00	0.00	0.00	0.00	-100.00
Cowpea	0	0	0	0	0	1655.67	2509.33	2760.27	552.05	0.07	0
Rapeseed & Mustard	7236.667	4838.66667	8709.6	4354.8	0.5704788	9835.67	9296.33	16733.40	8366.70	1.10	92.13
Linseed	84.66667	40.3333333	59.693333	11.93867	0.00120581	92.00	54.00	79.92	15.98	0.00	33.88
Castor Seed	63	38.5	157.85	94.71	0.01183875	72.00	65.00	266.50	159.90	0.02	69.10
Sesamum	3263	1760	4400	1760	0.21648	2323.33	2188.00	5470.00	2188.00	0.27	24.32
Soyabean	1053.5	1097	1864.9	317.033	0.03962913	1814.00	3488.33	5930.17	1008.13	0.13	217.99
Turmeric	3871	24495	7348.5	4409.1	0.5864103	2619.33	16402.33	24603.50	14762.10	1.96	234.81
Arecanut	24713	33961	101307.8	95229.33	12.6655012	17788.00	24906.00	73288.80	68891.47	9.16	-27.66
Ginger	9461	53782	2689.1	887.403	0.11270018	9928.00	66076.57	3303.83	1101.28	0.14	24.20
Black Pepper	884	462	231	25.41	0.00312543	1012.33	754.67	377.33	42.76	0.01	67.75
Dry Chillies	3745	2798	4197	3357.6	0.436488	2306.33	2266.33	679.90	543.92	0.07	-83.84
Coriander			0	0	0	481.00	1878.00	2159.70	1079.85	0.14	0
Mesta	4332	3555.66	7289.103	3644.552	0.4883699	4467.67	4735.02	9706.79	4853.40	0.65	33.17
Banana	12944	146681	440043	96809.46	12.8756582	7205.33	92535.67	277607.00	61073.54	8.10	-37.06
Onion			0	0	0	541.00	4824.33	241.22	53.07	0.01	0

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Tobacco	1389	918	918	918	0.122094	795.33	785.33	785.33	785.33	0.10	-14.45
Sweet Potato	9842	32315	3236.5571	1941.934	0.17671602	4642.67	15902.00	1592.69	955.61	0.09	-50.79
Tapioca	8180	42643	31982.25	27184.91	2.93597055	5404.67	34746.33	26059.75	22150.79	2.39	-18.52
Cotton	14354	2348.04	59710.888	47768.71	5.78001396	7268.33	1497.47	30914.11	24731.29	2.99	-48.27
Sugarcane	90.33333	247	12.35	3.0875	0.0004199	119.67	359.33	17.97	4.49	0.00	45.48
Potato	35863	349340	282965.4	282965.4	26.3157822	18789.67	185916.00	150591.96	150591.96	14.02	-46.72
Jute	7933.5	70036.5	140073	112058.4	15.0158256	6665.67	68370.33	136740.67	109392.53	14.66	-2.38
Cashewnut	0	0	0	0	0	10138.33	16036.33	36883.57	36883.57	5.98	0
Total	**292466.3**	**1048935.87**	**1533154.6**			**254945.33**	**913426.39**	**1373261.96**	**561319.12**	**68.54**	**-17.43**

Table 80: Crop-wise Area, Production, Biomass Production, Surplus Biomass and Biomass Power Potential for Meghalaya in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	107615.8	305833.5	458750.2	27525.0	3.7
2	Wheat	462.0	892.0	1605.6	321.1	0.0
3	Maize	18310.5	42997.7	98894.7	19778.9	2.3
4	Gram	1995.3	2103.1	2313.5	462.7	0.1
5	Arhar/Tur	1187.4	1600.5	4481.4	3137.0	0.4
6	Soyabean	1880.8	3706.1	6300.4	1071.1	0.1
7	Rapeseed & Mustard	10101.4	9786.3	17615.3	8807.7	1.2
8	Cotton	7162.4	1424.9	30351.8	24281.4	2.9
9	Jute	6827.2	71853.5	143707.0	114965.6	15.4
10	Mesta	4368.6	4678.6	9591.1	4795.6	0.6
11	Sugarcane	117.3	353.8	17.7	10.6	0.0
12	Tobacco	779.5	791.8	791.8	791.8	0.1
13	Arecanut	18925.6	27297.3	78614.8	73897.9	9.8
14	Banana	7662.3	97244.3	291732.8	64181.2	8.5
15	Ginger	10016.6	69031.9	3451.6	1139.0	0.1
16	Caster Seed	74.7	65.8	269.6	161.8	0.0
17	Sesamum	2416.3	2310.5	5776.4	2310.5	0.3
18	Tapioca	5533.8	35392.9	26544.7	22563.0	2.4
19	Potato	18655.3	190344.4	154178.9	154178.9	14.4
20	Cashewnut	11470.6	19780.9	45496.0	45496.0	7.4
	Total	**235563.5**	**887489.8**	**1380485.2**	**569876.8**	**69.9**

Major contributing crops in biomass power potential in Meghalaya (2019-20) is Jute with 15.4 MWe followed by Potato (14.4 MWe), Arecanut (9.8 MWe), Banana (8.5 MWe) and Cashewnut (7.5 MWe)

Trend Analysis for Biomass power potential for the state of Maharashtra – Crop-wise

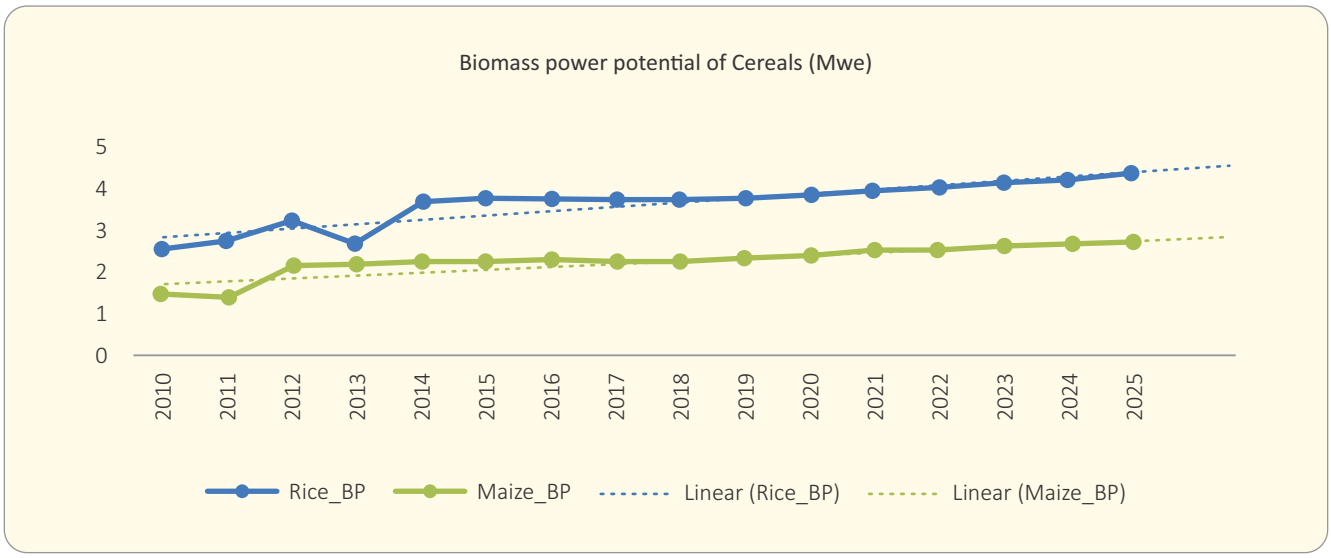


Figure 112: Biomass Power Potential for Rice and Maize in Meghalaya

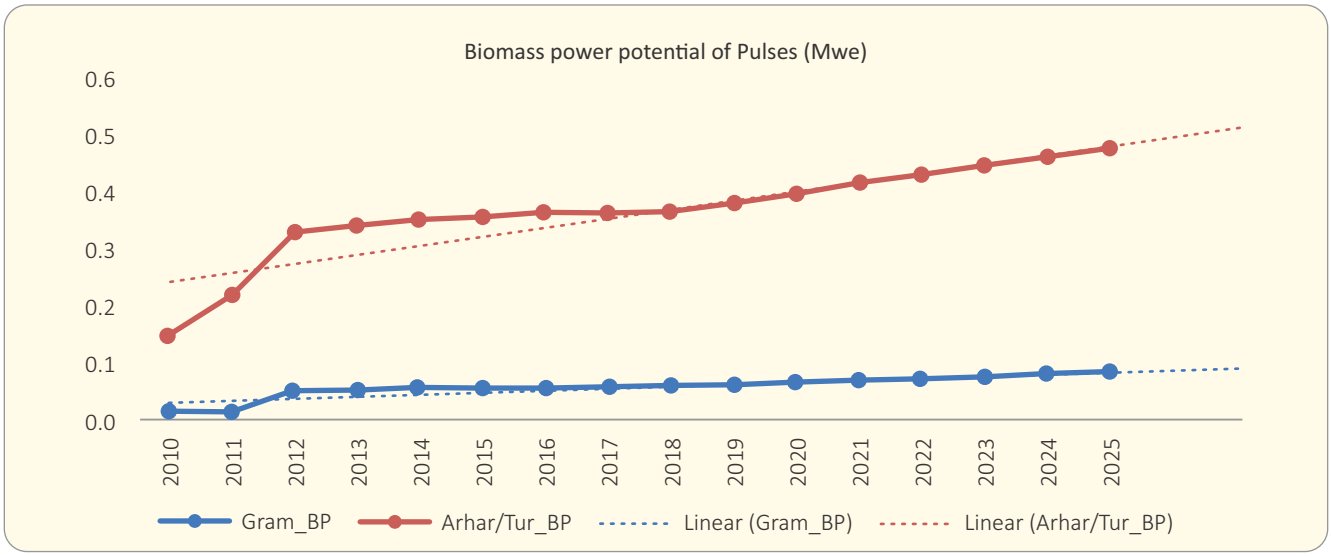


Figure 113: Biomass Power Potential for Gram and Arhar in Meghalaya

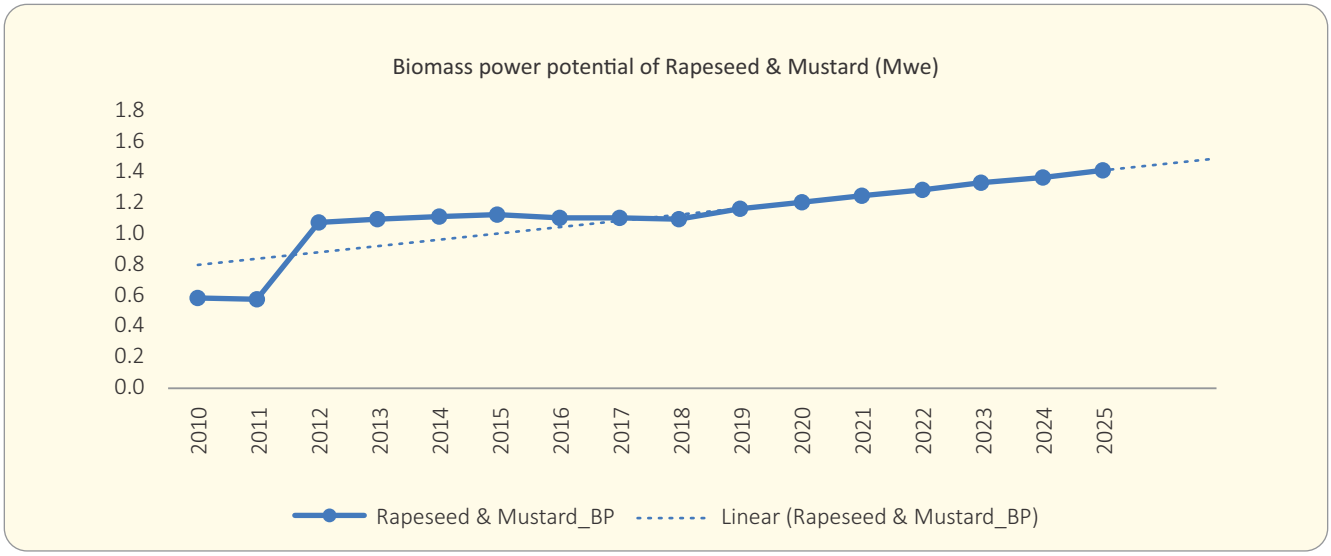


Figure 114: Biomass Power Potential for Rapeseed & Mustard in Meghalaya

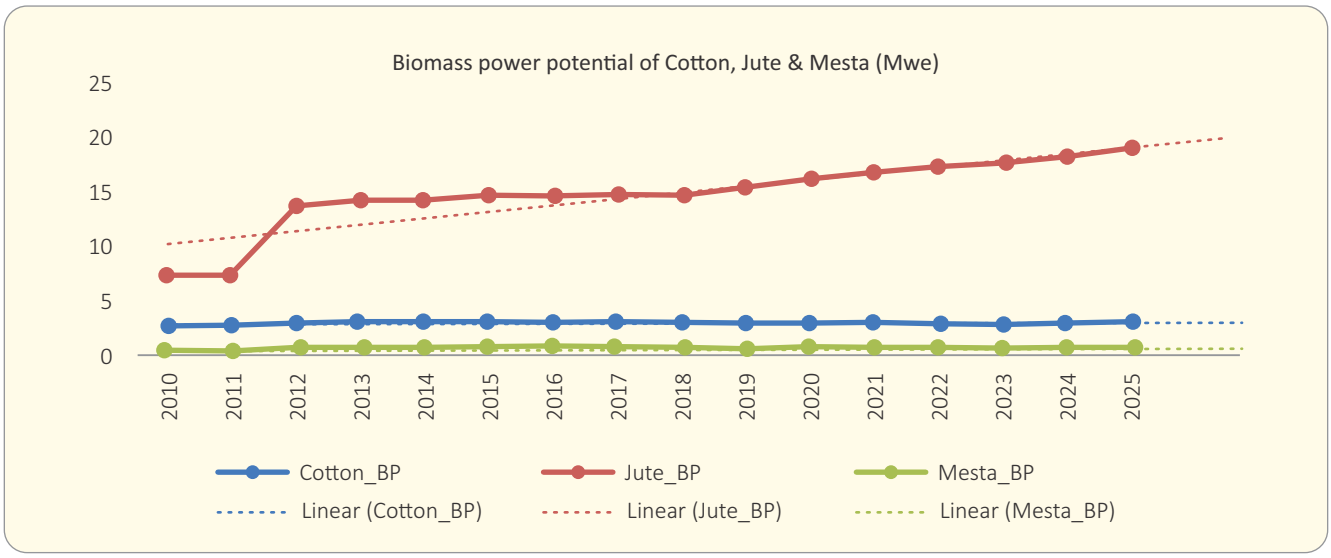


Figure 115: Biomass Power Potential for Cotton, Jute and Mesta in Meghalaya

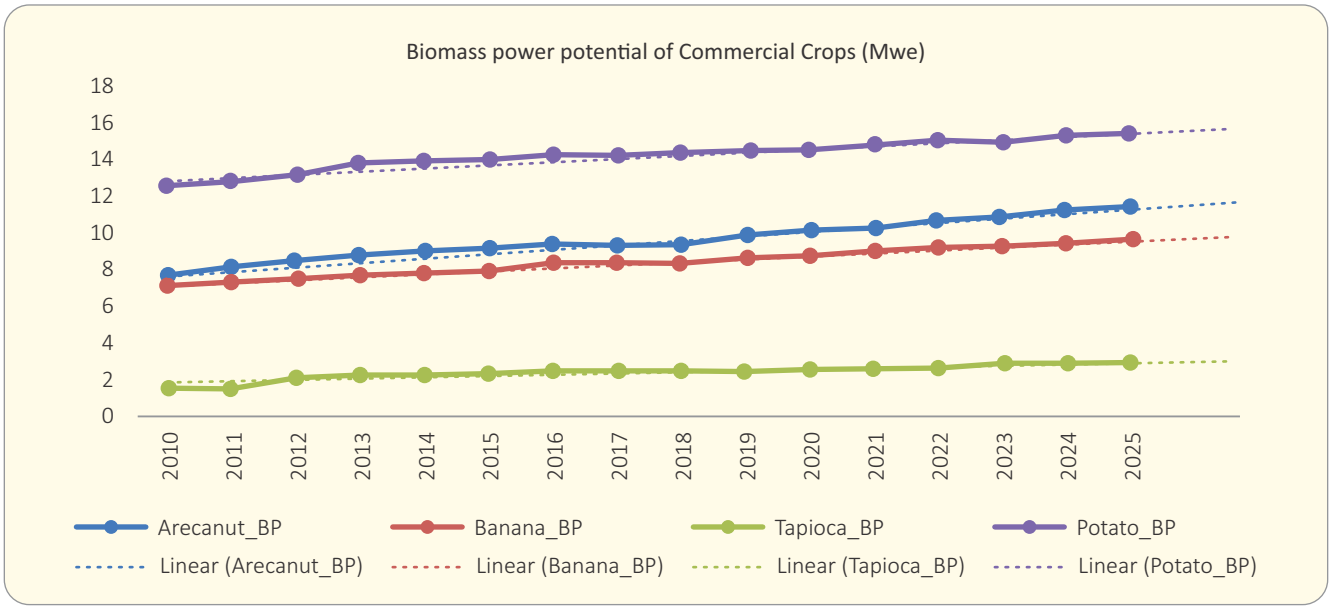


Figure 116: Biomass Power Potential for Arecanut, Banana, Tapioca and Potato in Meghalaya

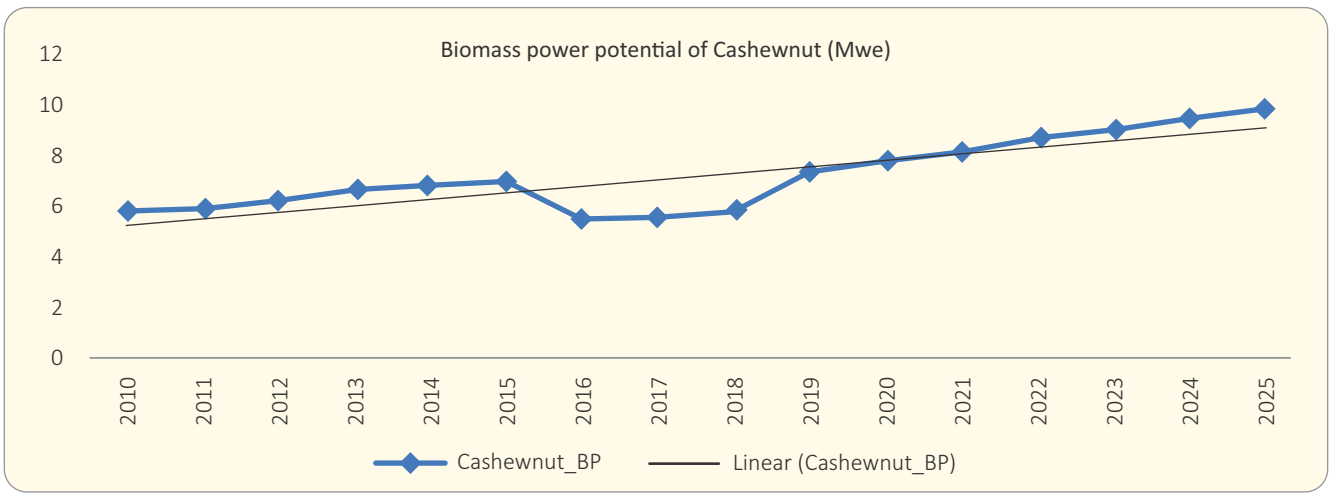


Figure 117: Biomass Power Potential for Cashewnut in Meghalaya

Mizoram

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Mizoram collected information and samples from all three (03) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Mizoram was calculated, which was the input to arrive at biomass power potential in Mizoram. Thus, the total biomass power potential for the state of Mizoram for 2018 was 2.90 MWe and for 2019-20 is 1.70 MWe.

Districts Selected for Primary Field Survey	03 (Aizwal, Kolasib and Serchhip)
Average Rainfall	1881 mm
Type of soil	Sandy Loam and Clay Loam
Major source of irrigation	Rainfed and Tube well
Major Rivers	Tlawng, Tuikum
Major Crops	Arecanut, Maize, Sugarcane, Other Rabi pulses, Cowpea, Banana, Pineapple, Mandarin Orange, Passion Fruit, Chillies, Cabbages and Paddy

Utilization of Crop residue at farmer's level in Mizoram:

1. **Essential Usage**: The Residue of Maize, cowpea, banana, cabbage and Paddy are extensively utilized for cattle feeding.
2. **Field preparation**: Stubble of Mustard and Paddy are widely burnt in an open field in order to prepare a seedbed for early sowing.
3. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Arecanut	10000 - 20000
	Rapeseed & Mustard	6000
	Paddy	8000

Survey Images:

Bhualpui, Kolasib, Mizoram

Tlungvel, Serchip, Mizoram

Sihphir Venghulan, Aizwal, Mizoram

Table 81: Crop-wise change in Area, Production and Biomass Potential for Mizoram

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	53505.83	38646.83	57970.25	6956.43	0.95	37030.07	61761.73	92642.60	11305.54	1.54	62.09
Maize	9234.00	10346.00	23795.80	4759.16	0.56	5916.40	9607.95	22098.29	4419.66	0.52	-7.82
Cowpea	0.00	0.00		0.00	0.00	1269.90	1862.10	2048.31	409.66	0.05	0
Arhar/Tur	0.00	0.00		0.00	0.00	322.93	311.52	872.25	610.57	0.07	0
Other Kharif Pulses	3175.33	2018.00	2623.40	524.68	0.06	945.93	1261.67	1640.17	328.03	0.04	-33.85
Other Rabi Pulses	1557.50	2099.83	2729.78	272.98	0.03	1234.27	1919.13	2494.87	249.49	0.03	0.63
Soyabean	0.00	0.00		0.00	0.00	1025.10	1584.93	2694.39	458.05	0.06	0
Sesamum	0.00	0.00		0.00	0.00	827.77	568.33	1420.83	568.33	0.07	0
Rapeseed & Mustard	0.00	0.00		0.00	0.00	643.67	590.60	1063.08	398.66	0.05	0
Other Oilseeds	3804.83	2497.33	5244.40	5244.40	0.50	0.00	0.00	0.00	0.00	0.00	-100.00
Tapioca	89.50	310.50	232.88	197.94	0.02	181.33	1936.30	1452.23	1234.39	0.13	566.57
Cotton	241.17	20.29	929.63	743.71	0.09	126.73	8.52	500.32	400.26	0.05	-46.23
Sugarcane	1196.83	8909.67	445.48	111.37	0.02	1562.93	48879.03	2443.95	610.99	0.08	315.47
Potato	492.33	1661.83	1346.09	888.42	0.08	450.67	2762.23	2237.41	1476.69	0.14	71.85
Tobacco	554.17	329.17	329.17	329.17	0.04	626.00	442.50	442.50	442.50	0.06	47.13
Onion	0.00	0.00	0.00	0.00	0.00	96.00	504.30	25.22	5.55	0.00	0
Total	**73851.50**	**66839.45**	**95646.88**			**52259.70**	**134000.85**	**134076.41**	**22918.36**	**2.90**	**23.22**

Table 82: Crop-wise Area, Production, Biomass, Surplus biomass and Biomass Power Potential for Mizoram in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	31943.6	41143.1	61714.7	7405.8	1.0
2	Maize	5707.4	6629.9	15248.9	3049.8	0.4
3	Cotton	43.0	4.1	172.4	137.9	0.0
4	Sugarcane	1553.7	39076.9	1953.8	488.5	0.1
5	Tobacco	217.1	201.9	201.9	201.9	0.0
6	Tapioca	184.6	1599.5	1199.6	1019.7	0.1
7	Potato	210.2	1717.2	1390.9	918.0	0.1
	Total	**39859.8**	**90372.6**	**81882.2**	**13221.5**	**1.7**

Major contributing crops in biomass power potential in Mizoram (2019-20) is Rice with 01 MWe followed by Maize (0.4 MWe), Tapioca (0.1 MWe), Potato (0.1 MWe) and Sugarcane (0.1 MWe)

Trend Analysis for Biomass power potential for the state of Mizoram – Crop-wise

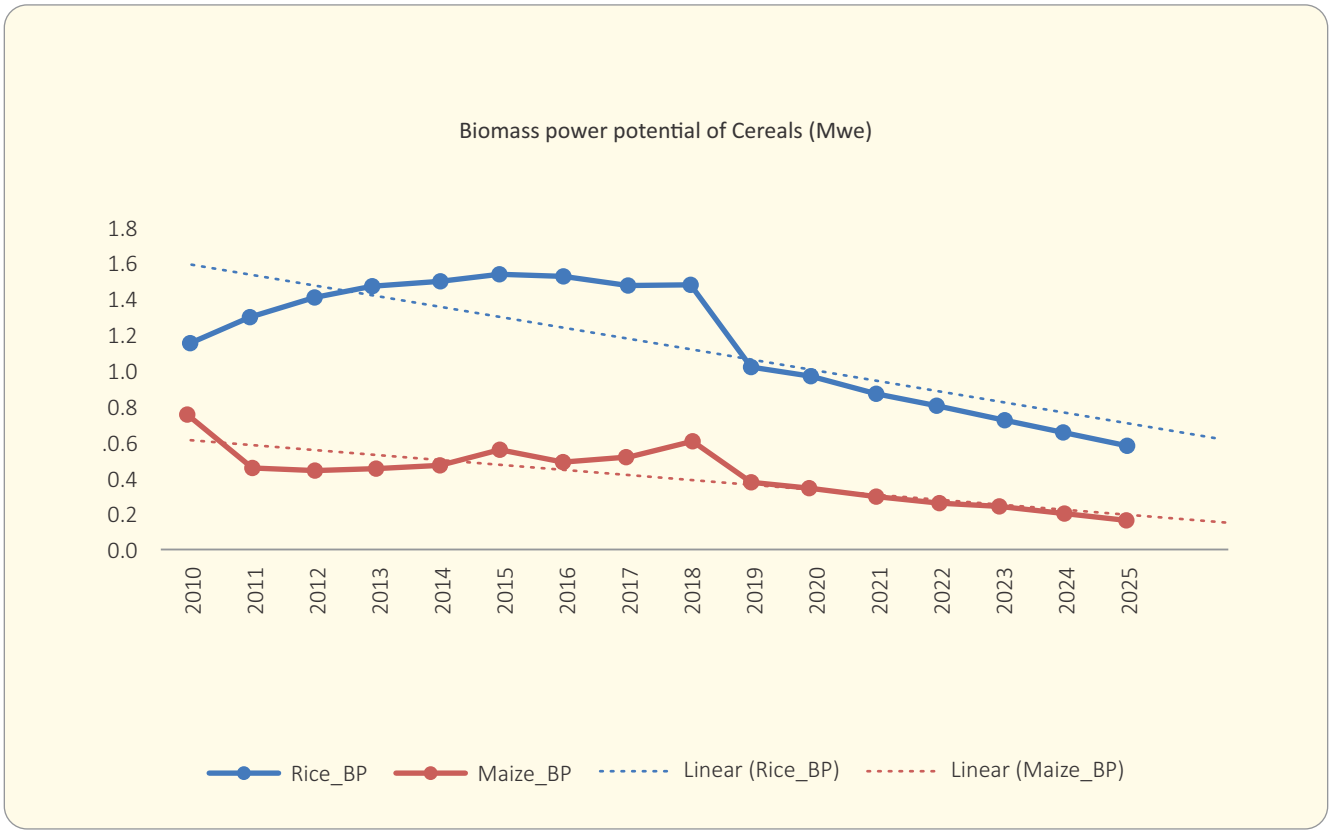


Figure 118: Biomass Power Potential for Rice and Maize in Mizoram

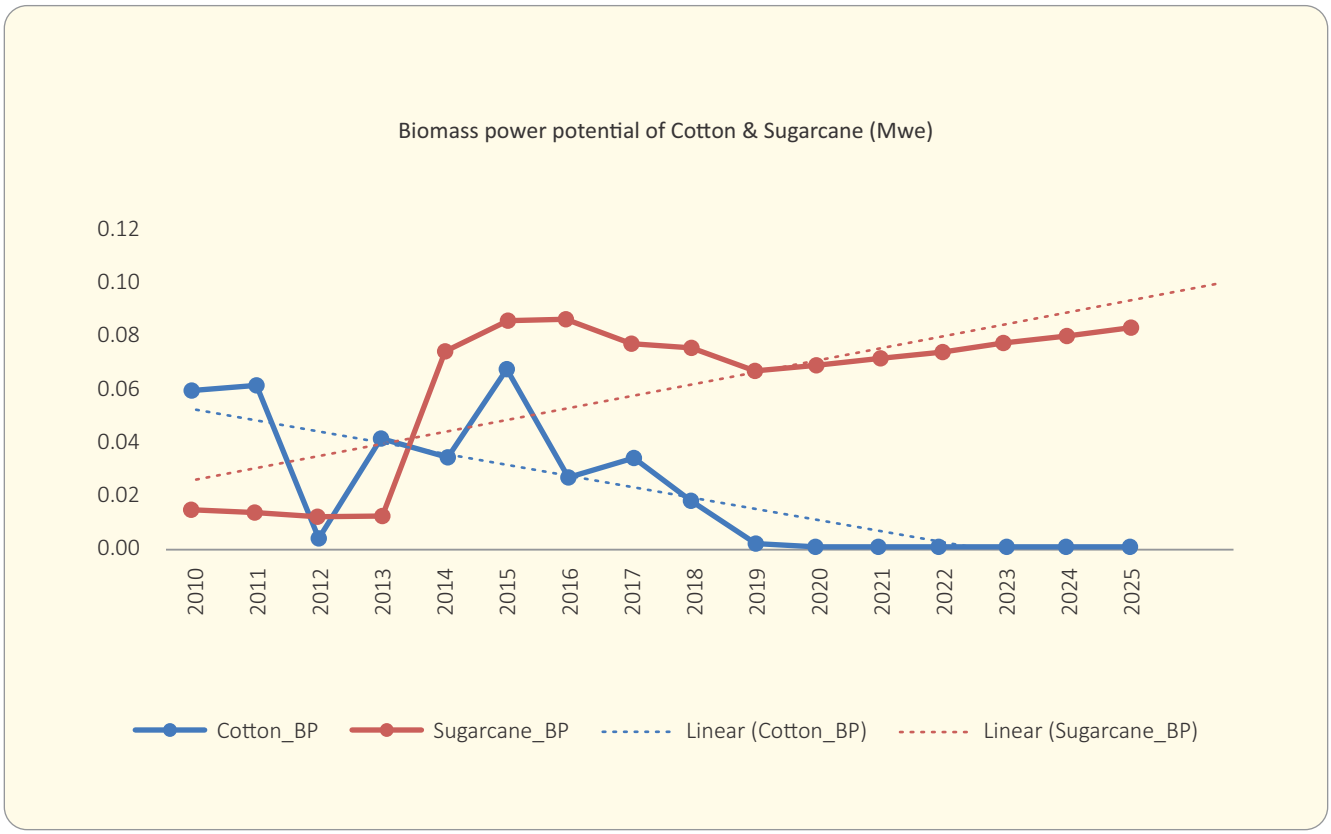


Figure 119: Biomass Power Potential for Cotton and Sugarcane in Mizoram

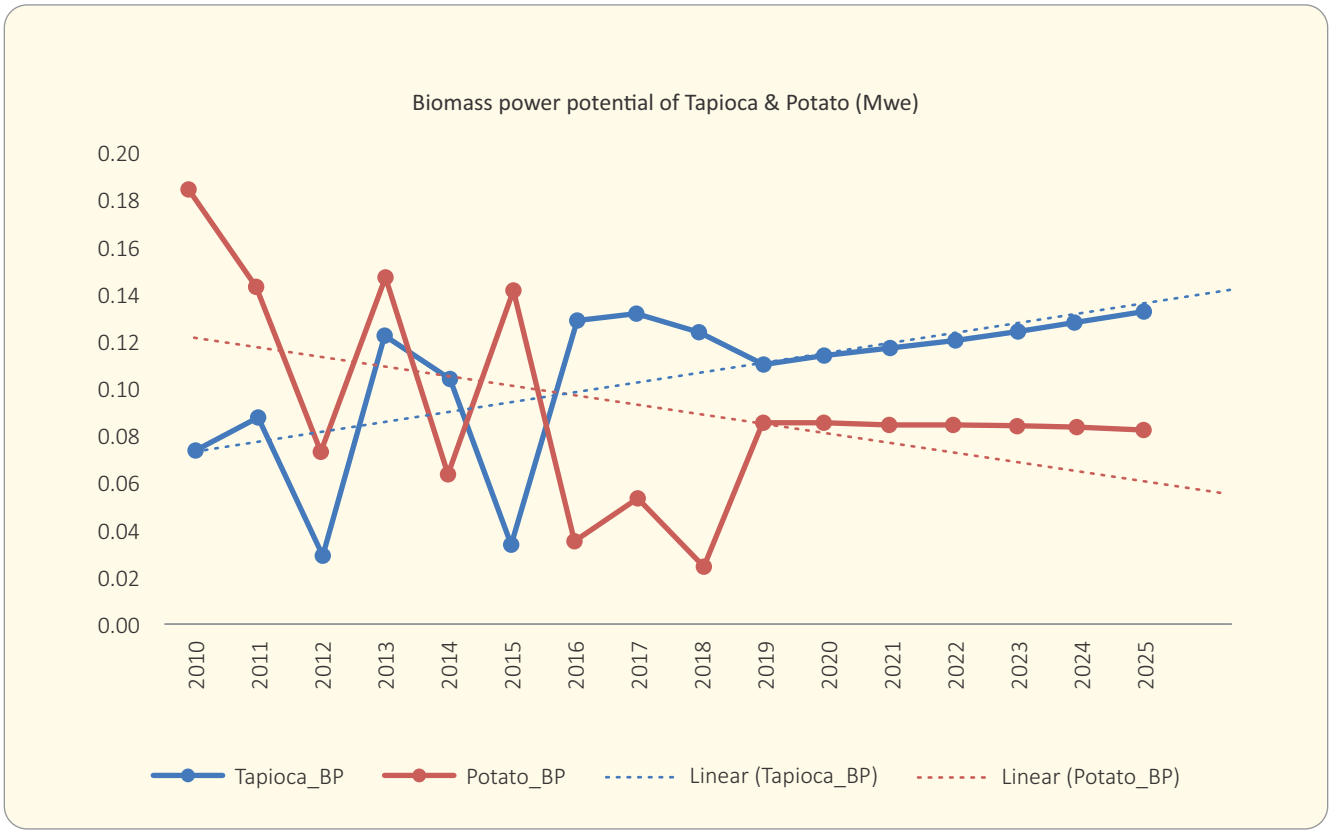


Figure 120: Biomass Power Potential for Tapioca and Potato in Mizoram

Nagaland

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Nagaland collected information and samples from all four (04) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Nagaland was calculated, which was the input to arrive at biomass power potential in Nagaland. Thus, the total biomass power potential for the state of Nagaland for 2018 was 53.90 MWe, and for 2019-20 is 56.70 MWe.

Districts Selected for Primary Field Survey	04 (Dimapur, Kohima, Peren and Wokha)
Average Rainfall	1881 mm
Type of soil	Sandy, Loamy, Black Cotton, Mountain Soil
Major source of irrigation	Canal, Rainfed, River
Major Rivers	Dhansiri, Dikhu, Doyang, Mbeiki, Ntanki, Tepuiki and Zungki
Major Crops	Rice, Maize, Rapeseed & Mustard, Potato, Small millets, Other Kharif pulses, Sugarcane, Soyabean, Linseed, Oilseeds

Utilization of Crop residue at farmer's level in Nagaland:

1. **Essential Usage**: Residue of Maize and Rice are extensively used for cattle feeding. The residue of Maize, Seasame and Mustard are primarily utilized for compost fertilizer.
2. **Field preparation**: Residue of Maize, Rice and Seasame are burnt in the open field.
3. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Maize	4000
	Paddy	10000
	Sesamum	7000
	Mustard	5000
	Other Oilseeds	10000 -20000

Survey Images:

Sodzulhou, Dimapur, Nagaland

Guju, Kohima, Nagaland

Old Ralan, Wokha, Nagaland

Table 83: Crop-wise change in Area, Production and Biomass Potential in Nagaland

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	184575.00	356760.00	535140.00	159187.22	21.68	201013.33	456180.00	684270.00	203548.67	27.72	27.88
Wheat	1325.00	2025.00	3645.00	729.00	0.10	2975.00	5082.50	9148.50	1829.70	0.25	147.01
Maize	71525.00	129235.00	297240.50	59448.10	6.94	72550.83	138818.33	319282.17	63856.43	7.46	7.47
Sugarcane	5010.00	239595.00	11979.75	2994.94	0.41	9196.67	425630.00	21281.50	5320.38	0.72	76.48
Moong (Green Gram)	470.00	415.00	518.75	155.63	0.02	590.00	668.33	835.42	250.63	0.03	60.02
Potato	5615.00	71790.00	58149.90	38378.93	3.57	10930.00	105753.33	85660.20	56535.73	5.26	47.44
Masoor	1260.00	880.00	1575.20	787.60	0.08	2370.83	2225.83	3984.24	1992.12	0.21	156.98
Jute	2675.00	748.80	1497.60	748.80	0.10	3171.67	1578.00	3156.00	1578.00	0.21	-100.00
Rapeseed &Mustard	29360.00	25560.00	46008.00	23004.00	3.01	28638.33	27190.00	48942.00	24471.00	3.21	6.50
Gram	250.00	200.00	220.00	44.00	0.01	721.67	646.67	711.33	142.27	0.02	85.66
Arhar/Tur	3420.00	3670.00	10276.00	7193.20	0.87	4595.83	4774.17	13367.67	9357.37	1.13	29.71
Peas & beans (Pulses)	8860.00	12095.00	6047.50	3023.75	0.37	10063.33	11799.17	5899.58	2949.79	0.37	-1.14
Mesta			0.00	0.00	0.00	1876.67	374.40	752.54	376.27	0.05	0
Urad	260.00	180.00	234.00	117.00	0.01	825.00	736.67	957.67	478.83	0.04	67.78
Linseed	8095.00	6190.00	9161.20	1832.24	0.19	6810.83	5170.83	7652.83	1530.57	0.15	-18.64
Barley			0.00	0.00	0.00	540.00	556.67	723.67	72.37	0.01	0
Sunflower	1930.00	1620.00	3240.00	2916.00	0.32	2834.17	1925.00	3850.00	3465.00	0.38	19.11
Horse-gram			0.00	0.00	0.00	503.33	540.00	702.00	70.20	0.01	0
Ragi			0.00	0.00	0.00	333.33	323.33	420.33	42.03	0.01	0
Small millets	13900.00	13290.00	15948.00	1594.80	0.20	15724.17	13546.67	16256.00	1625.60	0.20	2.41
Bajra			0.00	0.00	0.00	693.33	703.33	1849.77	350.13	0.04	0
Turmeric	660.00	2980.00	894.00	536.40	0.07			0.00	0.00	0.00	-100.00
Other Kharif pulses	4915.00	4805.00	6246.50	1249.30	0.15	10730.00	13066.67	16986.67	3397.33	0.41	174.05
Other Rabi pulses	4960.00	5415.00	7039.50	703.95	0.09	10994.17	13705.00	17816.50	1781.65	0.22	139.53

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Sesamum	6185.00	3725.00	9312.50	9312.50	1.15	4238.33	2626.67	6566.67	6566.67	0.81	-29.77
Jowar	575.00	730.00	1752.00	175.20	0.02	767.50	637.50	1530.00	153.00	0.02	-4.99
Groundnut	1135.00	1205.00	2771.50	554.30	0.07	971.67	999.17	2298.08	459.62	0.06	-19.96
Ginger	4580.00	38740.00	1937.00	639.21	0.08	3701.67	33627.50	1681.38	554.85	0.07	-11.85
Castor seed			0.00	0.00	0.00	340.00	230.00	943.00	565.80	0.07	0
Cowpea			0.00	0.00	0.00	530.00	776.67	854.33	170.87	0.02	0
Dry chillies	1800.00	2260.00	3390.00	2712.00	0.35			0.00	0.00	0.00	-100.00
other oilseeds			0.00	0.00	0.00	2423.33	1456.67	2913.33	2913.33	0.28	0
Sweet potato			0.00	0.00	0.00	1736.67	14780.00	1478.00	886.80	0.08	0
Tapioca	1240.00	28590.00	21442.50	18226.13	1.97	2383.33	48233.33	36175.00	30748.75	3.32	68.57
Cardamom	610.00	150.00	390.40	156.16	0.02	900.00	1440.00	576.00	230.40	0.03	74.18
Cotton	130.00	8.50	512.70	410.16	0.05	147.50	11.90	586.68	469.34	0.06	13.49
Niger seed			0.00	0.00	0.00	810.00	560.00	593.60	59.36	0.01	0
Other Cereals			0.00	0.00	0.00	1700.00	1740.00	2262.00	226.20	0.03	0
Soyabean	27075.00	36510.00	62067.00	10551.39	1.32	25895.83	32168.33	54686.17	9296.65	1.16	-11.96
Total	**392395.00**	**989372.30**	**1118637.00**	**347381.90**	**43.22**	**445228.33**	**1370282.63**	**1377650.82**	**438323.71**	**54.12**	**24.71**

Table 84: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Nagaland in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	210876.14	533699.85	800549.77	240164.93	32.66
2	Wheat	1872.81	2950.70	5311.26	1062.25	0.14
3	Jowar	280.00	270.00	648.00	64.80	0.01
4	Maize	78596.84	154001.75	354204.04	70840.81	8.28
5	Green Gram (Moong)	480.00	500.00	625.00	187.50	0.02
6	Peas & Beans	9219.30	11319.65	5659.82	2829.91	0.35
7	Gram	499.12	364.56	401.02	80.20	0.01
8	Tur (Arhar)	2351.16	2096.88	5871.26	4109.88	0.50
9	Lentil (Masur)	2579.30	2133.51	3840.32	1920.16	0.20
10	Groundnut	240.18	45.79	105.32	21.06	0.00
11	Soyabean	26335.09	32052.46	54489.18	9263.16	1.16
12	Sesamum	3067.89	1385.61	3464.04	3464.04	0.43
13	Rapeseed & Mustard	32726.74	33053.96	59497.14	29748.57	3.90
14	Sunflower	2164.91	771.23	1542.46	1388.21	0.15
15	Cotton	130.00	13.60	523.92	419.14	0.05
16	Jute	3573.68	1073.21	2146.42	1717.14	0.23
17	Mesta	2421.05	516.54	1058.90	529.45	0.07
18	Sugarcane	4852.28	206770.70	10338.54	2584.63	0.35
19	Tapioca	3043.51	61363.68	46022.76	39119.35	4.22
20	Potato	993.63	79693.86	64552.03	42604.34	3.97
	Total	**386303.63**	**1124077.54**	**1420851.17**	**452119.52**	**56.70**

Major contributing crops in biomass power potential in Nagaland (2019-20) is Rice with 32.66 MWe followed by Maize (8.23 MWe), Tapioca (4.22 MWe), Potato (3.97 MWe) and Rapeseed & Mustard (3.9 MWe)

Trend Analysis for Biomass power potential for the state of Nagaland – Crop-wise

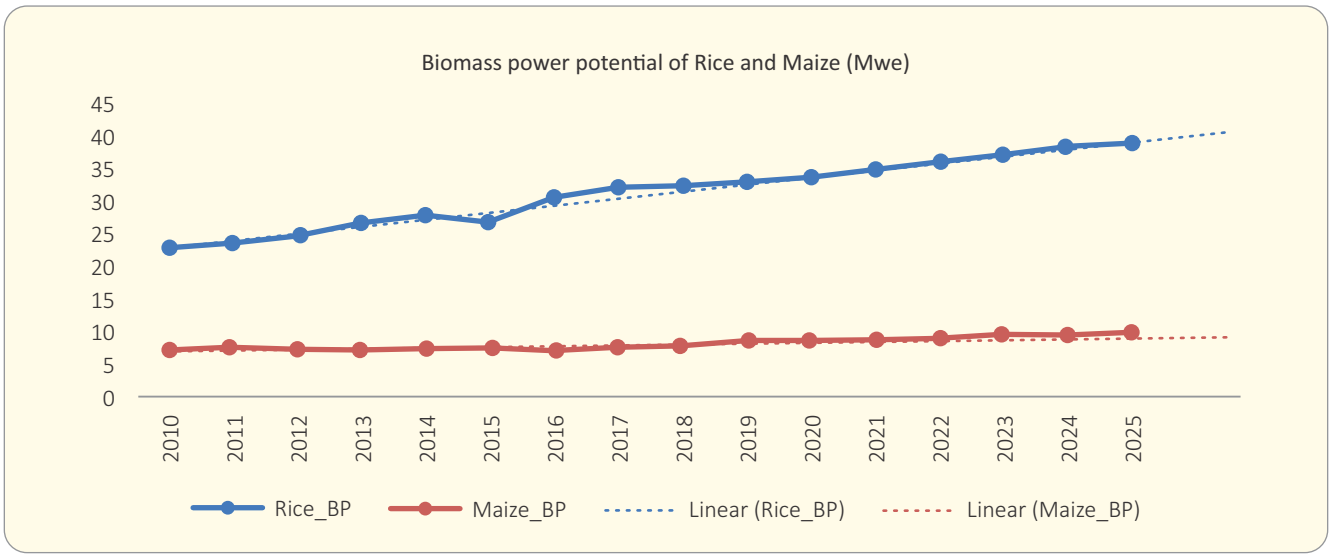


Figure 121: Biomass Power Potential for Rice and Maize in Nagaland

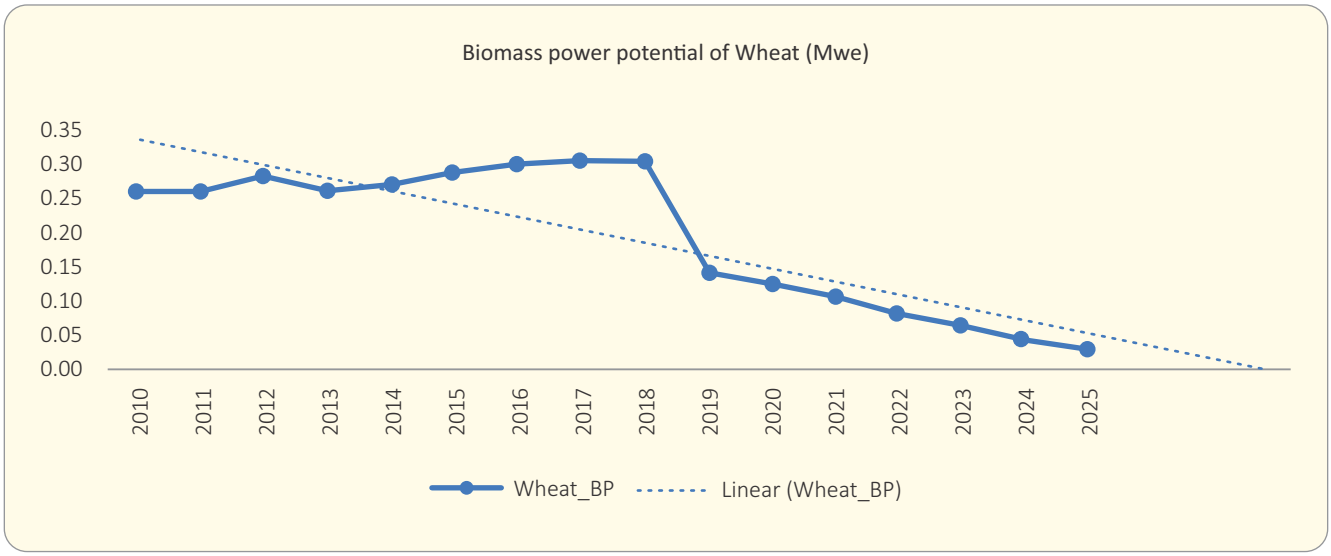


Figure 122: Biomass Power Potential for Wheat in Nagaland

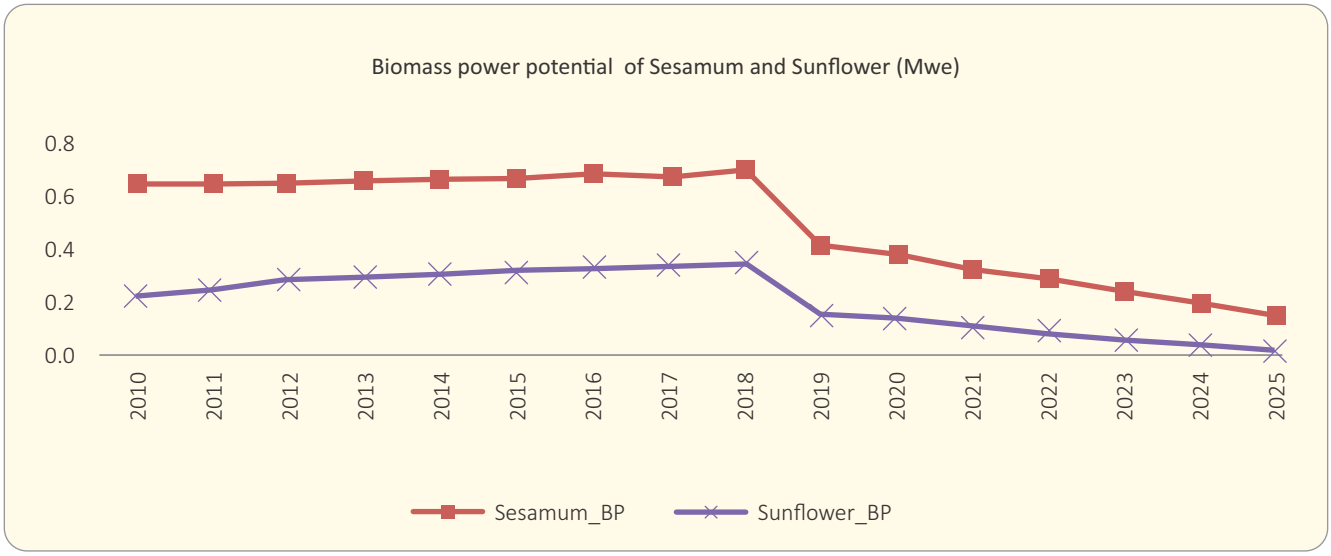


Figure 123: Biomass Power Potential for Sesamum and Sunflower in Nagaland

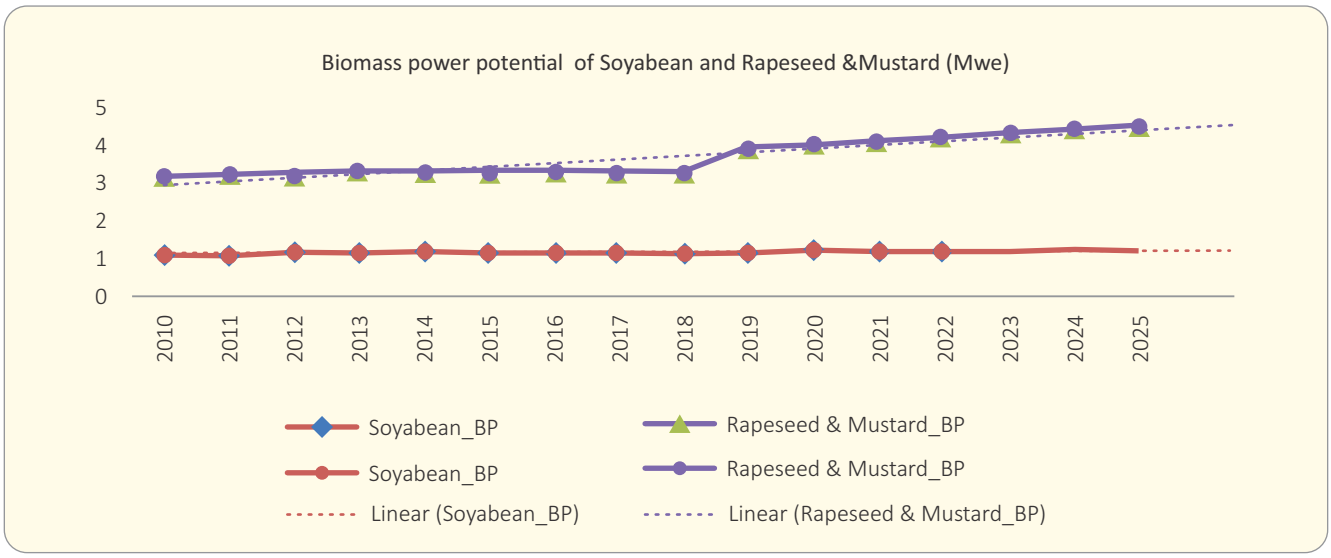


Figure 124: Biomass Power Potential for Soyabean and Rapeseed & Mustard in Nagaland

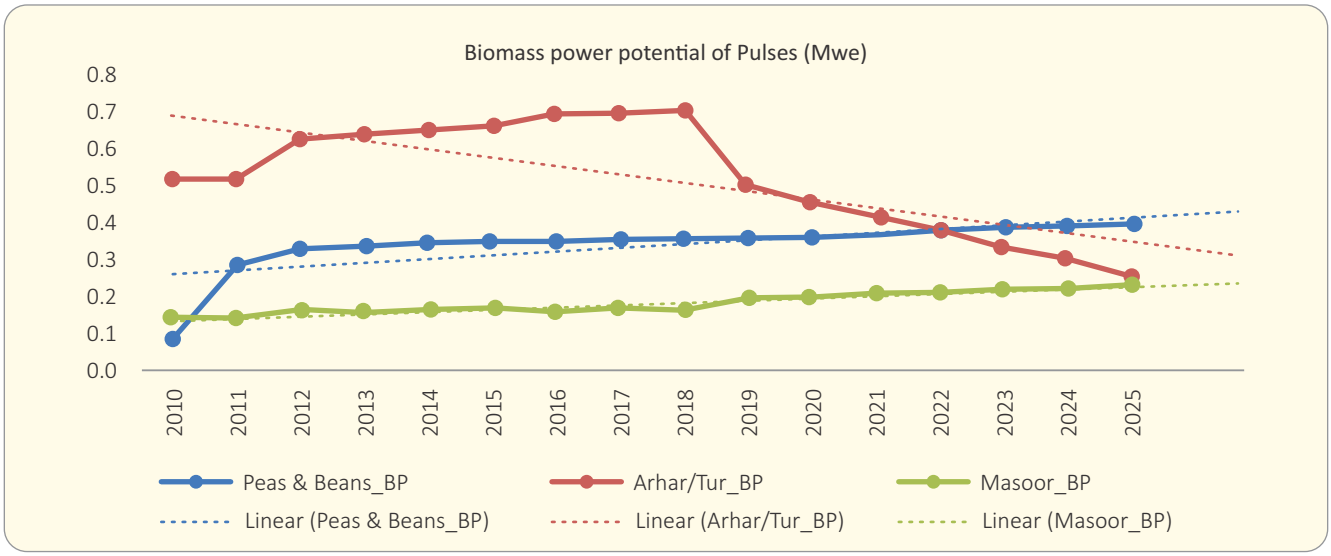


Figure 125: Biomass Power Potential for Pulses in Nagaland

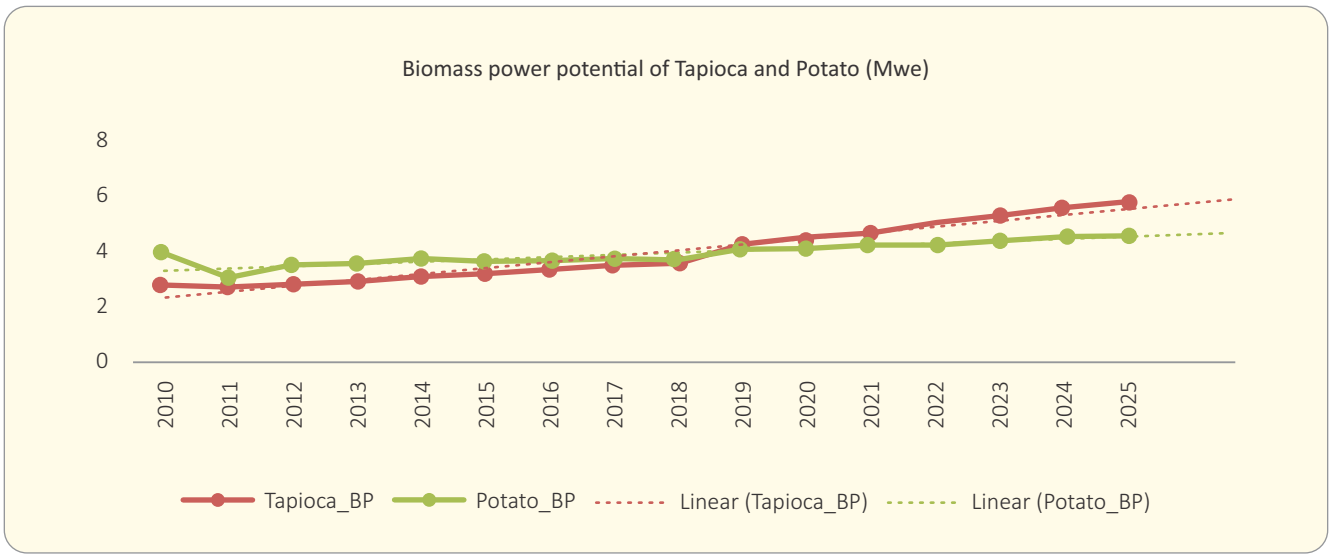
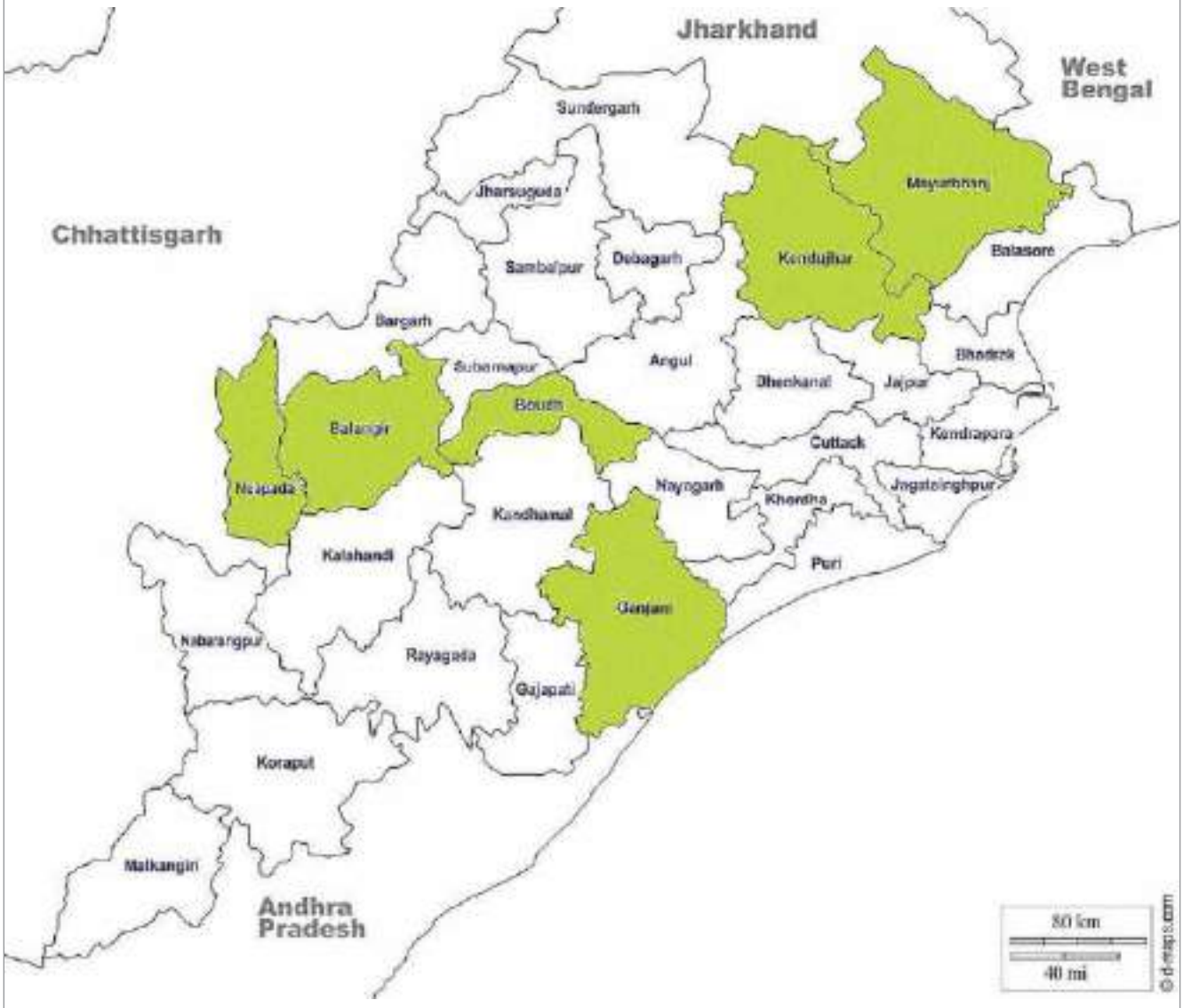


Figure 126: Biomass Power Potential for Pulses in Nagaland

Odisha



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Odisha collected information and samples from all six (06) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Odisha was calculated, which was the input to arrive at biomass power potential in Odisha. Thus, the total biomass power potential for the state of Odisha for 2018 was 298.72 MWe and for 2019-20 is 355.70 MWe.

Districts Selected for Primary Field Survey	06 (Balangir, Boudh, Ganjam, Kendujhar (Keonjhar), Mayurbhanj and Nuapada)
Average Rainfall	1489 mm
Type of soil	Brown Forest, Laterite, Red Soil
Major source of irrigation	Canals, Tube well
Major Rivers	Maize, Moong, Rice, pulses, oilseeds, jute, coconut and turmeric

Utilization of Crop residue at farmer's level in Odisha:

1. **Essential Usage**: The residue of Rice and Moong are generally used for cattle feeding. The residue of Rice, Moong, and oilseed are utilized for compost fertilizer
2. **Specific Usage**: Straw of Bagasse, Rice and Wheat, cotton stalk, groundnut shell, coir fibre are utilized for making particleboard wall panels, printing paper & corrugating medium roofing sheet fuel, polymer composites.
3. **Fuel Usage**: Residue of Coconut, Rice and Pulses are primarily utilized for domestic cooking.
4. **Field preparation**: The Residue of Moong and Rice are burnt in an open field.
5. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Coconut	10000 - 20000
	Paddy	5000 -10000
	Pulses	4000 - 7000
	Moong	3000 - 5000

Survey Images:

Baunshapani, Mayurbhanja, Odisha

Pochalundi, Ganjam, Odisha

Mahimud, Balangiri, Odisha

Table 85: Crop-wise change in Area, Production and Biomass Potential in Odisha

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	4182333.33	6616500.00	9924750.00	1786455.00	242.96	3890390.00	7406893.00	11110339.50	2007268.00	273.39	12.52
Wheat	4915.33	7312.15	13161.87	2632.37	0.36	165.67	244.43	439.97	87.99	0.01	-96.70
Ragi	66125.67	43649.47	56744.31	5674.43	0.70	45082.00	31370.47	40781.61	4078.16	0.51	-27.64
Maize	67506.67	128313.83	295121.82	59024.36	6.91	58306.00	144530.50	332420.15	66484.03	7.77	12.38
Moong (Green Gram)	242301.00	60335.83	75419.79	37709.90	4.83	283988.00	103450.50	129313.13	64560.06	8.24	70.69
Urad	134789.00	40100.68	52130.89	26065.44	2.37	86744.33	34162.37	44411.08	22205.54	2.02	-14.64
Groundnut	82303.00	95704.25	220119.78	44023.96	5.37	43153.33	49722.80	114362.44	22872.49	2.79	-48.08
Rapeseed &											
Mustard	14936.67	2779.00	5002.20	2501.10	0.33	8552.00	2555.23	4599.41	2299.71	0.30	-8.71
Sesamum	45537.67	9369.10	23422.75	9369.10	1.15	16945.33	4390.33	10975.83	4390.33	0.54	-53.04
Jute	4370.33	39198.33	78396.67	62717.33	8.40	968.00	374.46	748.92	599.14	0.08	-99.04
Sugarcane	16893.00	996638.70	49831.94	12457.98	1.69	6056.00	38723.27	1936.16	484.04	0.07	-96.10
Potato	8004.33	83066.77	67284.08	44407.49	4.13	5372.00	60401.10	48924.89	32290.43	3.01	-27.21
Total	**4870016.00**	**8122968.12**	**10861386.08**	**2093038.47**	**279.20**	**4445722.66**	**7876818.46**	**11839253.10**	**2227619.92**	**298.72**	**6.99**

Table 86: Crop-wise Area, Production, Biomass Production, Surplus biomass, Biomass Power Potential for Odisha in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	4963228.7	8774093.5	13161140.3	2369005.3	322.2
2	Wheat	73.0	157.9	284.2	56.8	0.0
3	Ragi	40939.7	33850.2	44005.3	4400.5	0.5
4	Maize	88249.3	238626.6	548841.2	109768.2	12.8
5	Green Gram (Moong)	309934.3	114953.7	143692.1	71846.1	9.2
6	Black Gram (Urad)	84354.6	33405.6	43427.3	21713.6	2.0
7	Groundnut	47728.4	65524.8	150707.1	30141.4	3.7
8	Rapeseed & Mustard	9582.5	3147.1	5664.7	2832.3	0.4
9	Sesamum	14031.1	4519.2	11298.0	4519.2	0.6
10	Jute	947.0	424.9	849.7	679.8	0.1
11	Sugarcane	7523.0	532876.6	26643.8	6661.0	0.9
12	Potato	5396.0	67428.1	54616.8	36047.1	3.4
	Total	**5571987.5**	**9869008.2**	**14191170.5**	**2657671.3**	**355.7**

Major contributing crops in biomass power potential in Odisha (2019-20) is Rice with 332.2 MWe followed by Maize (12.8 MWe), Moong (9.2 MWe), Groundnut (3.7 MWe) and Potato (3.4 MWe)

Trend Analysis for Biomass power potential for the state of Odisha – Crop-wise

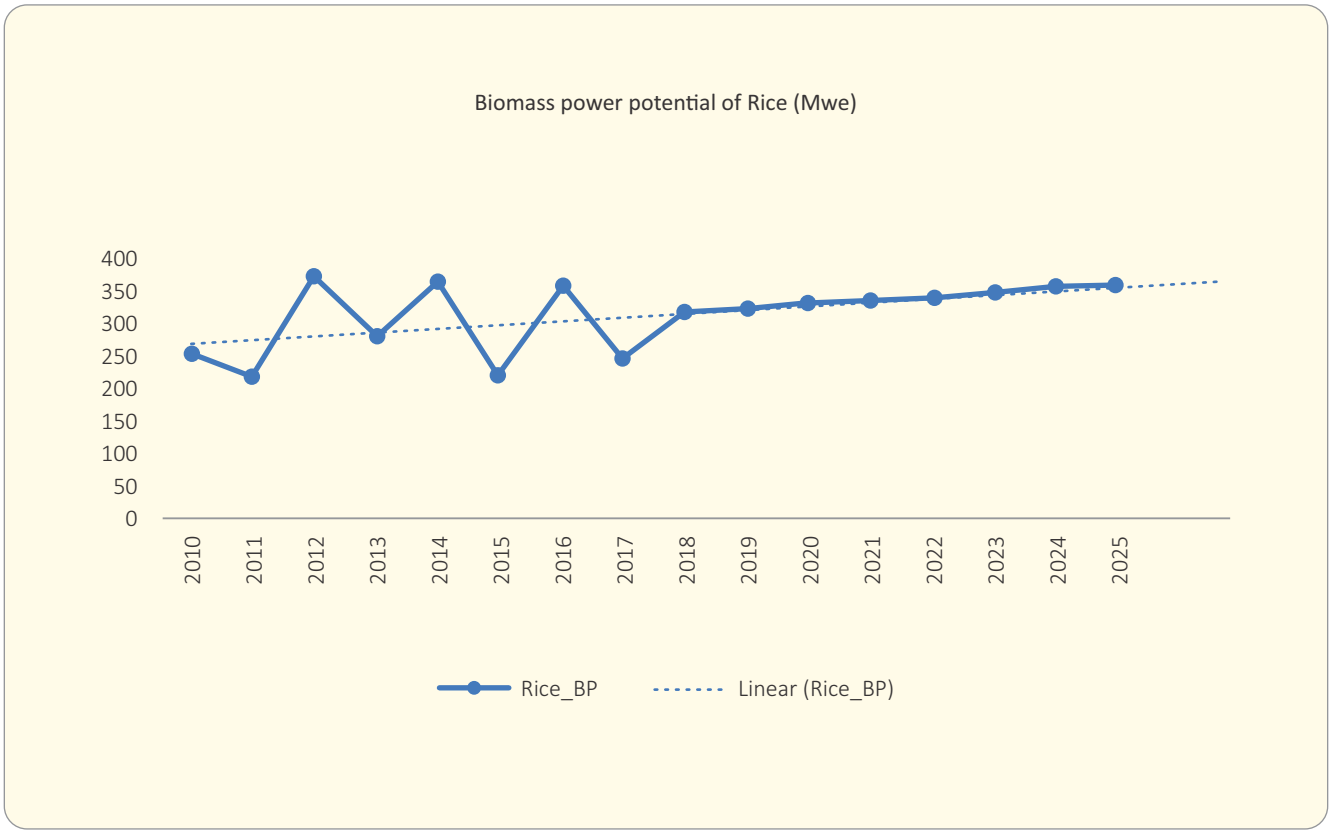


Figure 127: Biomass Power Potential for Rice in Odisha

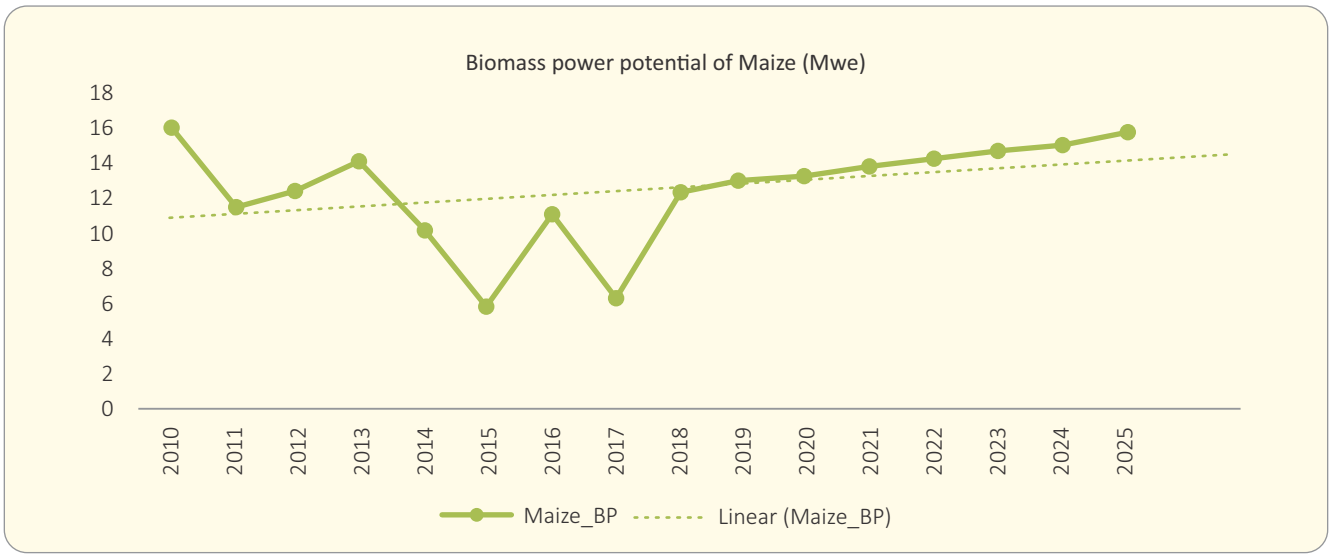


Figure 128: Biomass Power Potential for Maize in Odisha

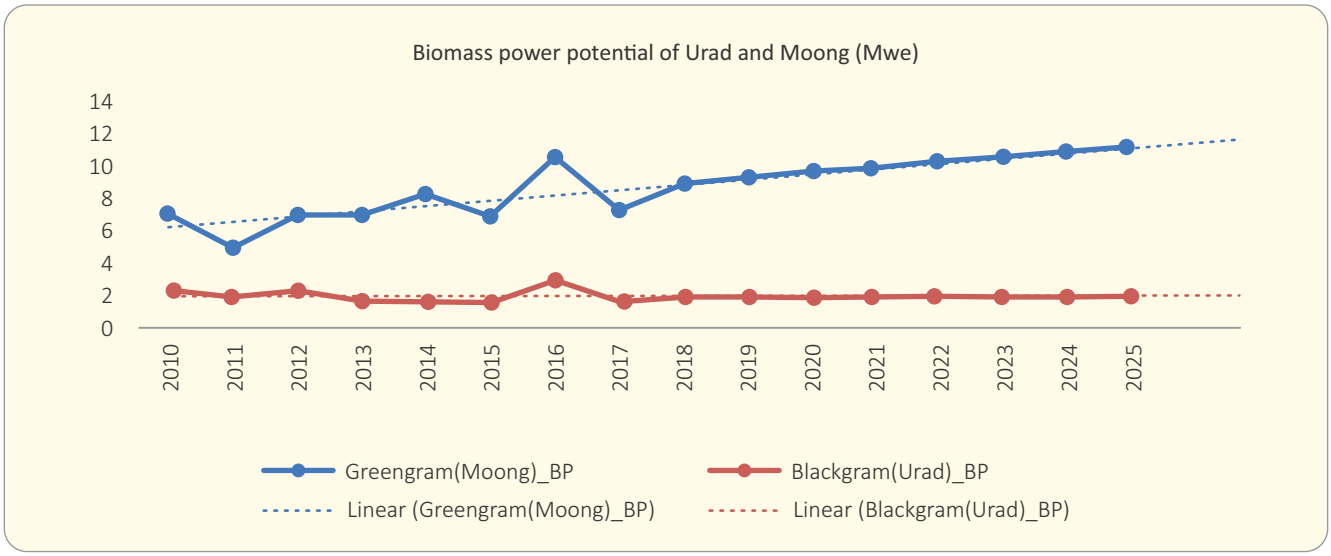


Figure 129: Biomass Power Potential for Urad and Moong in Odisha

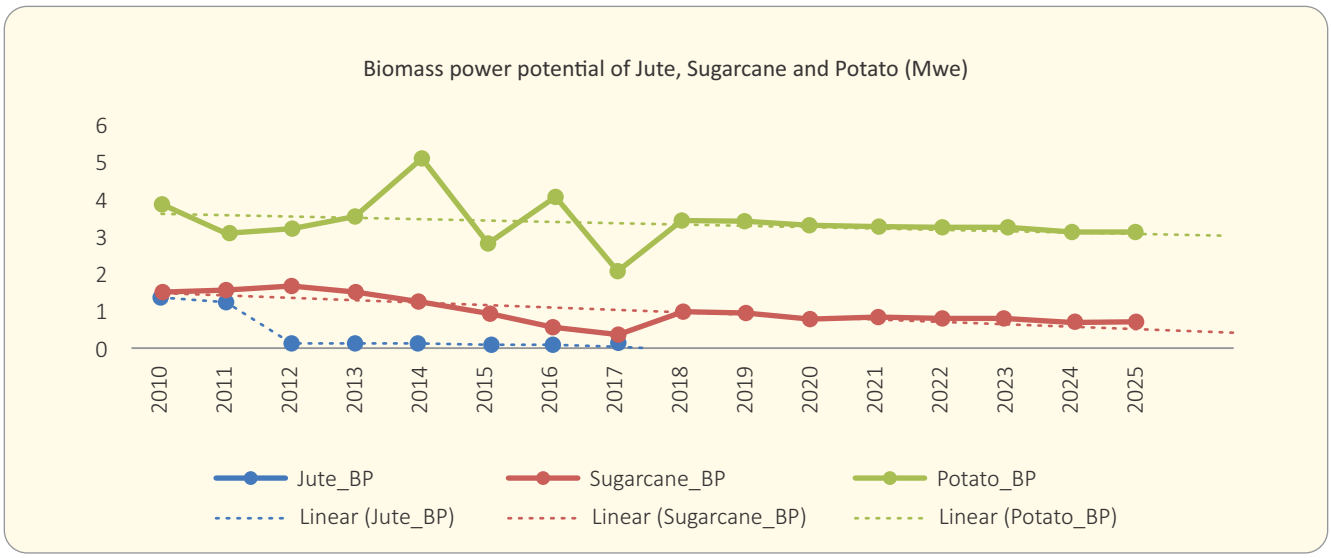


Figure 130: Biomass Power Potential for Jute, Sugarcane and Potato in Odisha

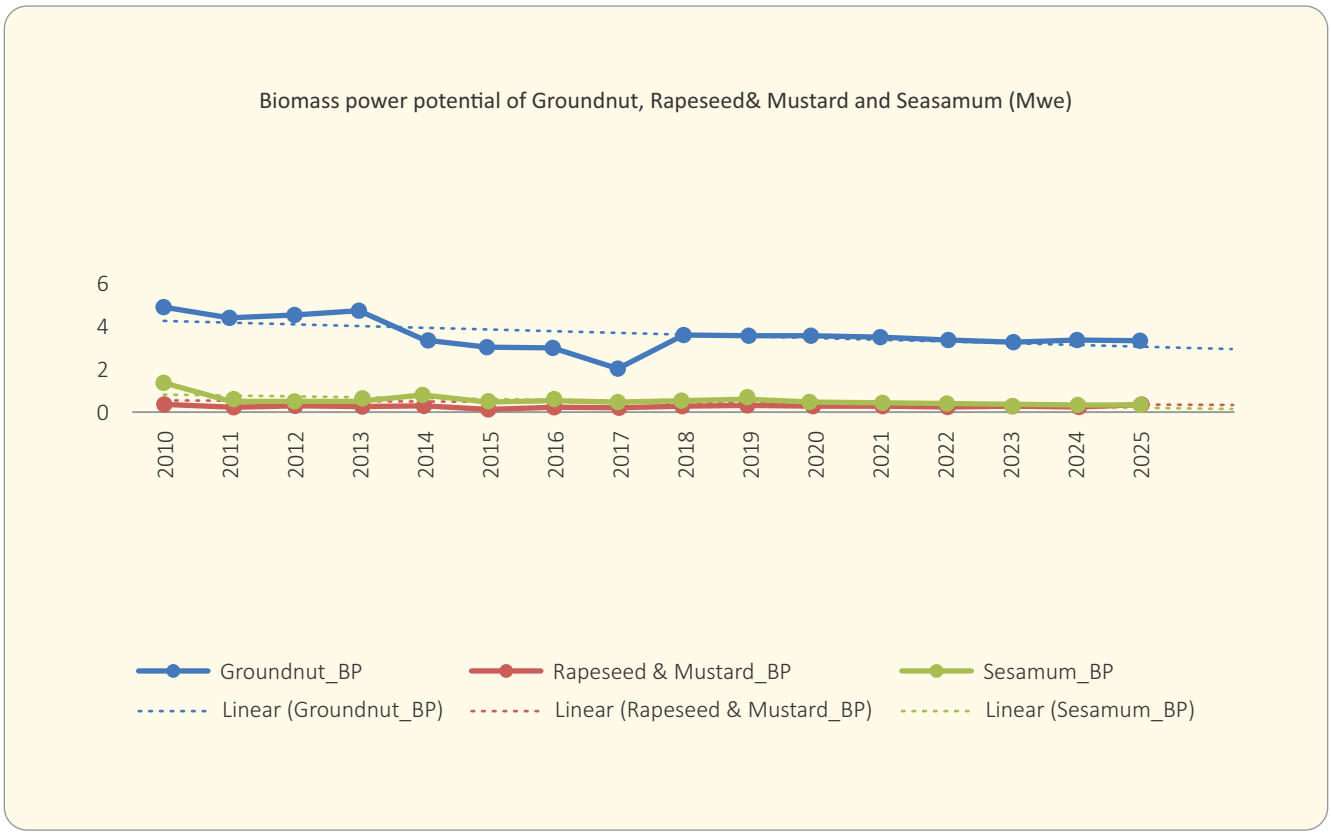


Figure 131: Biomass Power Potential for Groundnut, Rapeseed & Mustard and Sesamum in Odisha

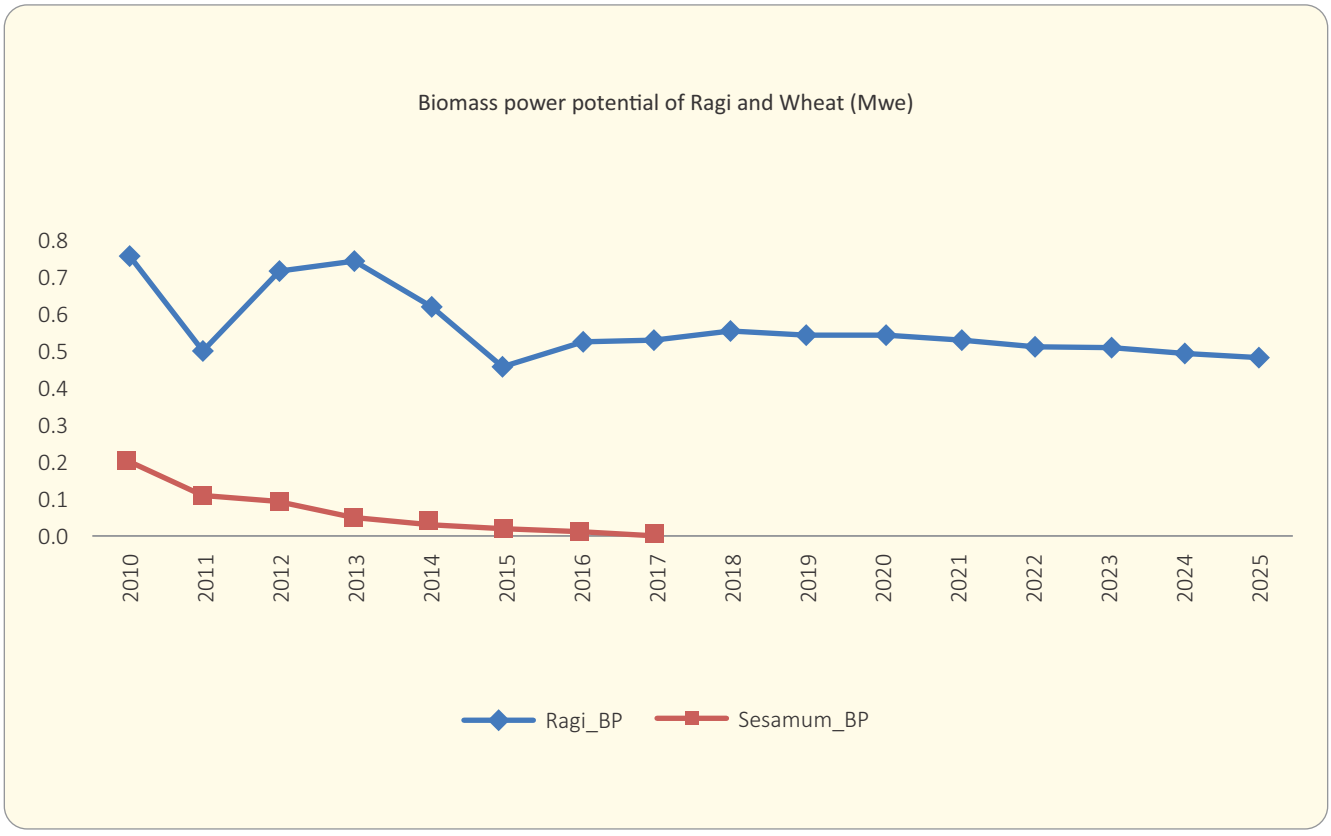


Figure 132: Biomass Power Potential for Ragi and Wheat in Odisha

Punjab

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Punjab collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Punjab was calculated, which was the input to arrive at biomass power potential in Punjab. Thus, the total biomass power potential for the state of Punjab for 2018 was 3022.11 MWe and for 2019-20 is 3100.70 MWe.

Districts Selected for Primary Field Survey	07 (Amritsar, Bhathinda, Faridkot, Fazika, Mansa, Sangrur and Tarn Taran)
Average Rainfall	649 mm
Type of soil	Loamy soil, Sandy Soils
Major source of irrigation	Canals, Tube well
Major Rivers	Manas, Satlaj and Sunam
Major Crops	Cotton, Rice and Wheat

Utilization of Crop residue at farmer's level in Punjab:

1. **Essential Usage**: Residue of Rice and wheat are utilized as cattle feed.
2. **Fuel Usage**: Some parts of Paddy and wheat residue are utilized for domestic cooking.
3. **Field preparation** Farmer burns some part of the crop in the field openly due to non-availability of nearby residue plant and to take next crop.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	4000
Expected Cost against the sale of crop residue in Future	Cotton	4000 - 5000
	Paddy	6000
	Wheat	5000 - 7000

Survey Images:

Jertuke, Bhatinda, Punjab

Tapiala, Amritsar, Punjab

Ransinghwara, Paridkot, Punjab

Table 87: Crop-wise change in Area, Production and Biomass Potential in Punjab

Crops	2006-08						2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	CRR	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	2688833	10700833	1.5	16051250	15936598	2170.565	3028666.67	12614333.33	18921500.00	18786346.43	2558.70	17.88
Wheat	3511333	15531167	1.8	27956100	2795610	377.4074	3505000.00	17181000.00	30925800.00	3092580.00	417.50	10.62
Maize	153000	506333.3	2.3	1164567	232913.3	27.20428	117666.67	440500.00	1013150.00	202630.00	23.67	-13.00
Barley	17666.67	60666.67	1.3	78866.67	7886.667	0.914853	8783.33	33116.67	43051.67	4305.17	0.50	-45.41
Bajra	9333.333	9333.333	2.63	24546.67	4646.333	0.564994	0.00	0.00	0.00	0.00	0.00	-100.00
Jowar	100	100	2.4	240	48	0.005962	0.00	0.00	0.00	0.00	0.00	-100.00
Moong (Green Gram)	11250	9300	1.25	11625	3487.5	0.445354	23083.33	19405.00	24256.25	7276.88	0.93	108.66
Masoor	1566.667	750	1.79	1342.5	671.25	0.069273	750.00	456.67	817.43	408.72	0.04	-39.11
Gram	3233.333	3433.333	1.1	3776.667	755.3333	0.098571	1850.00	2360.00	2596.00	519.20	0.07	-31.26
Arhar/Tur	6550	6116.667	2.8	17126.67	11988.67	1.445833	4583.33	4310.00	12068.00	8447.60	1.02	-29.54
Peas & beans (Pulses)	2750	3150	0.5	1575	787.5	0.09765	3566.67	4883.33	2441.67	1220.83	0.15	55.03
Urad	3300	1466.667	1.3	1906.667	953.3333	0.086849	3066.67	1545.00	2008.50	1004.25	0.09	5.34
Moth	100	100	1.8	180	54	0.006291	0.00	0.00	0.00	0.00	0.00	-100.00
Rapeseed & Mustard	34666.67	40166.67	1.8	72300	36150	4.73565	31950.00	45250.00	81450.00	40725.00	5.33	12.66
Sesamum	8733.333	2900	2.5	7250	2900	0.3567	3733.33	1220.00	3050.00	1220.00	0.15	-57.93
Groundnut	3716.667	3250	2.3	7475	1495	0.182241	1266.67	2433.33	5596.67	1119.33	0.14	-25.13
Linseed	200	100	1.48	148	29.6	0.00299	6300.00	11100.00	16428.00	3285.60	0.33	10998.52
Sugarcane	0	0	0.05	0	0	0	92000.00	7324333.33	366216.67	91554.17	12.45	0
Cotton	582666.7	418596.7	6	3135046	0	0	305666.67	166996.67	1528926.00	0.00	0.00	0
Guar seed	23466.67	18800	2	37600	5790.4	0.715114	35483.33	27285.00	54570.00	8403.78	1.04	45.13
Total	**7062467**	**29360300**		**48572922**	**19042765**	**2584.905**	**7173416.67**	**37880528.33**	**53003926.85**	**22251046.95**	**3022.11**	**16.91**

Table 88: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Punjab in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	3075420.7	12916474.0	19374711.0	19180963.9	2608.6
2	Wheat	3547901.6	17605366.0	31689658.8	3168965.9	427.8
3	Bajra	619.6	665.4	1749.9	332.5	0.0
4	Maize	108497.4	479847.6	1103649.5	220729.9	25.8
5	Gram	129.4	938.1	1031.9	206.4	0.0
6	Tur (Arhar)	1100.3	1319.3	3694.1	2585.9	0.3
7	Masoor	800.0	500.0	900.0	450.0	0.0
8	Groundnut	605.2	2327.7	5353.8	1070.8	0.1
9	Rapeseed & Mustard	31662.3	46681.6	84026.9	42013.4	5.5
10	Cotton	349027.2	230050.1	1832413.5	183241.4	22.2
11	Sugarcane	56502.6	4933523.2	246676.2	61669.0	8.4
12	Guarseed	35288.6	28680.2	57360.4	8604.1	1.1
13	Green Gram (Moong)	2323.6	3832.0	4790.0	1437.0	0.2
14	Sesamum	2700.0	900.0	2250.0	900.0	0.1
15	Black Gram (Urad)	2375.7	1245.6	1619.3	809.6	0.1
16	Barley	3736.9	17792.8	23130.7	2313.1	0.3
17	Peas & Beans	3177.6	4101.8	2050.9	1025.4	0.1
	Total	**7221868.7**	**36274245.5**	**54435066.8**	**22877318.2**	**3100.7**

Major contributing crops in biomass power potential in Punjab (2019-20) is Rice with 2608.6 MWe followed by Wheat (427.8 MWe), Maize (25.8 MWe), Cotton (22.2 MWe) and Sugarcane (8.4 MWe)

Trend Analysis for Biomass power potential for the state of Punjab – Crop-wise

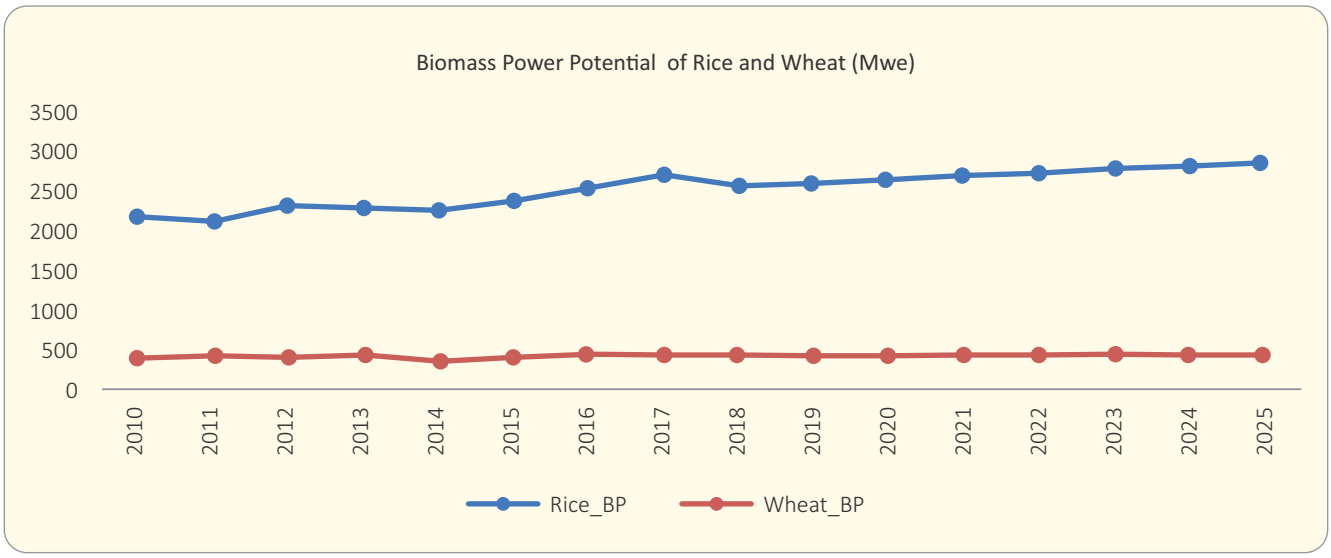


Figure 133: Biomass Power potential for Rice and Wheat in Punjab

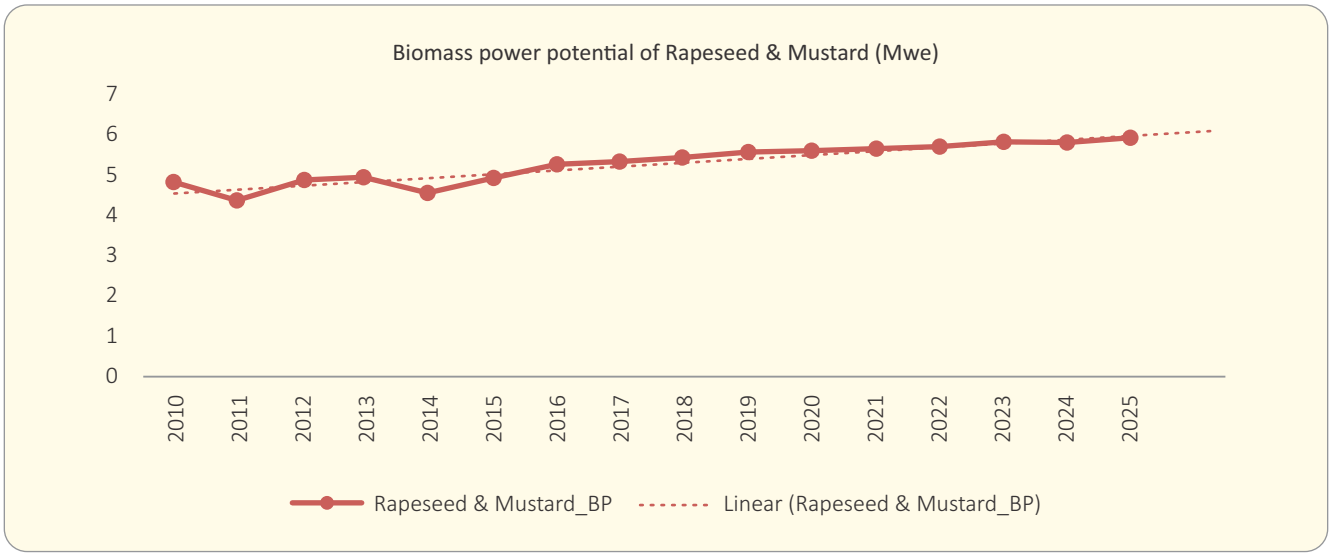


Figure 134: Biomass Power Potential for Rapeseed & Mustard in Punjab

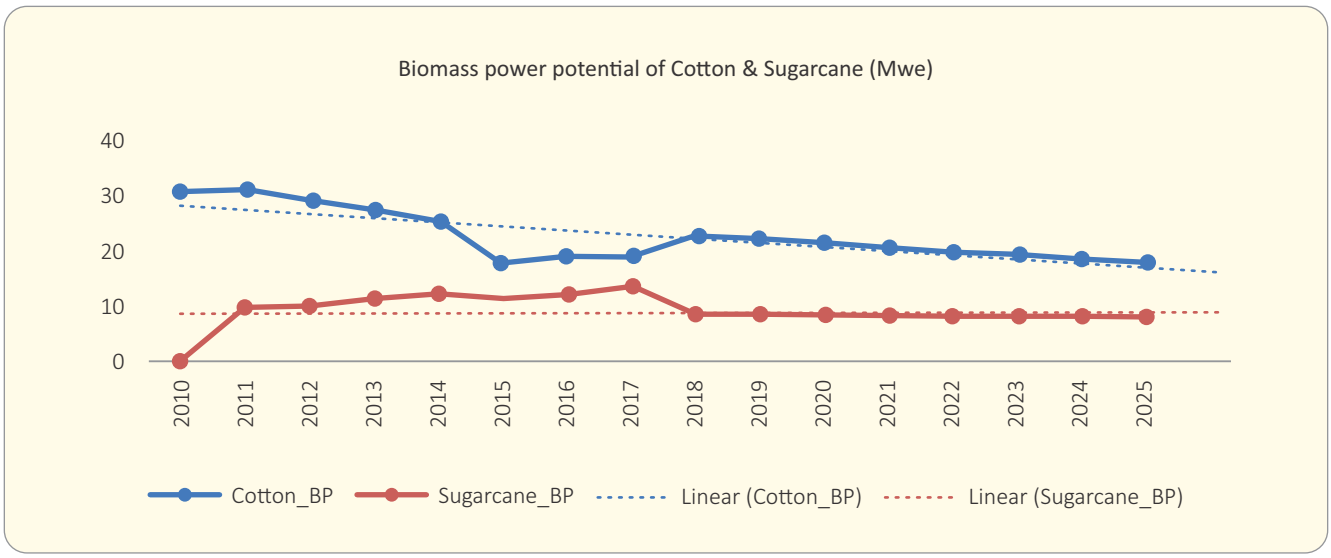


Figure 135: Biomass Power Potential for Cotton and Sugarcane in Punjab

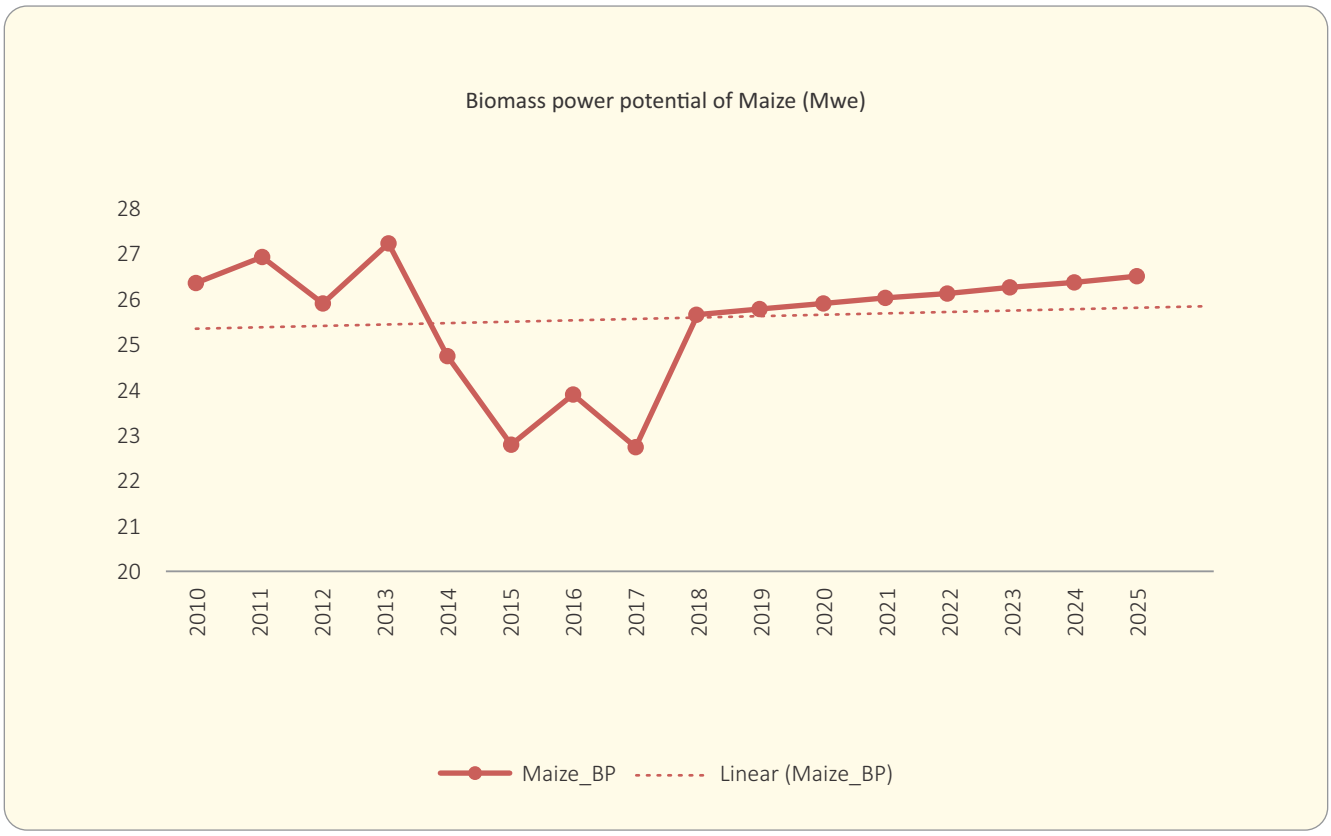


Figure 136: Biomass Power potential for Maize in Punjab

Rajasthan

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Rajasthan collected information and samples from all twelve (12) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Rajasthan was calculated, which was the input to arrive at biomass power potential in Rajasthan. Thus, the total biomass power potential for the state of Rajasthan for 2018 was 1299.55 MWe and for 2019-20 is 1817.20 MWe.

Districts Selected for Primary Field Survey	12 (Ajmer, Bikaner, Bhilwara, Bundi, Churu, Hanumangarh, Jaipur, Jodhapur, Jhalawar, Kota, Sikar, Tonk)
Average Rainfall	675 mm
Type of soil	Alluvial, Black soil, Red soil with iron content, sandy
Major source of irrigation	Canals, Tube wells, open well
Major Rivers	Ahu, Banas, Bandi, Khari, Luni, Gudha Dam, Parwan
Major Crops	Bajra, Cotton (lint), Guar seed, Gram, Moth, Groundnut, Rapeseed & Mustard, Moong (Green Gram), Wheat

Utilization of Crop residue at farmer's level in Rajasthan:

1. **Essential Usage**: Residue of Bajra, Gram, Guar seed, Groundnut, Jowar, Maize, Moth and Urad are extensively used for cattle feeding. Some parts of the residue of cotton, Bajra, Gram, Guar seed, Groundnut, Jowar, Maize, Moth and Urad are utilized for the preparation of compost manure.
2. **Fuel Usage**: Residue of Cotton is used for domestic fuel.
3. **Field preparation**: Residue of garlic and stalks of Cotton, Rapeseed & Mustard, Rice and Wheat are mostly burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Garlic	2000
	Cotton	5000 - 10000
	Rapeseed & Mustard	4000 - 5000
	Rice	5000 -7000
	Wheat	5000 - 7000

Survey Images:

Gumanpura Kata, Bundi, Rajasthan

Luni, Jodhpur, Rajasthan

Nagalkala, Jaipur, Rajasthan

Table 89: Crop-wise change in Area, Production and Biomass Potential in Rajasthan

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	124022.33	225364.00	338046.00	57467.82	7.83	190429.00	424475.17	636712.75	108241.17	14.74	88.28
Wheat	2513702.00	7467418.33	13441353.00	2688270.60	362.92	6279319.00	11449542.00	20609175.60	4121835.12	556.45	53.33
Maize	1084216.67	1719419.83	3954665.62	30188.29	3.53	896161.67	1441470.00	3315381.00	25308.25	2.96	-16.26
Small Millets	16664.00	5951.83	7142.20	714.22	0.09	13608.83	8635.33	10362.40	1036.24	0.13	45.07
Bajra	5075070.33	3991746.67	10498293.73	1837201.40	223.40	4172810.67	3713867.67	9767471.96	1709307.59	207.85	-6.96
Jowar	622025.67	365309.67	876743.20	175348.64	21.78	575515.67	331555.00	795732.00	159146.40	19.77	-9.25
Barley	257624.00	672280.00	873964.00	87396.40	10.14	265985.50	838037.00	1089448.10	108944.81	12.64	24.63
Moong (Green Gram)	901923.00	353765.67	442207.08	153811.16	19.64	1974779.33	872527.00	1090658.75	379359.57	48.44	146.66
Masoor	18632.33	15558.17	27849.12	13924.56	1.44	106427.00	69925.00	125165.75	62582.88	6.46	348.51
Gram	1187246.00	826445.33	909089.87	181817.97	23.73	2817509.00	1124864.00	1237350.40	247470.08	32.29	36.09
Arhar/Tur	19615.50	14379.83	40263.53	18789.65	2.27	14187.33	12940.17	36232.47	16908.48	2.04	-10.17
Peas & Beans (Pulses)	11600.33	23018.00	11509.00	5754.50	0.71	16038.50	40373.00	20186.50	10093.25	1.25	76.28
Urad	133177.83	49948.17	64932.62	0.00	0.00	538301.17	314593.67	408971.77	0.00	0.00	0
Moth	1208039.33	302928.50	545271.30	7789.59	0.91	1173155.83	352034.83	633662.70	9052.32	1.05	15.76
Cowpea	0.00	0.00	0.00	0.00	0.00	88592.00	64801.00	71281.10	14256.22	1.91	0
Other Kharif Pulses	121150.67	53037.17	68948.32	13789.66	1.67	63427.17	30045.17	39058.72	7811.74	0.95	-43.40
Other Rabi Pulses	14984.67	14113.83	18347.98	1834.80	0.22	7295.50	6242.00	8114.60	811.46	0.10	-55.37
Sunhamp	1135.50	696.00	1753.92	350.78	0.04	663.50	378.67	954.24	190.85	0.02	-40.84
Linseed	1655.17	1826.17	2702.73	540.55	0.05	23414.00	20447.00	30261.56	6052.31	0.61	1122.57
Guar Seed	3011383.33	1054582.67	2110069.78	324950.75	40.13	3916450.00	1631163.33	3263725.61	502613.74	62.07	54.68
Sunflower	272.00	241.00	482.00	433.80	0.05	0.00	0.00	0.00	0.00	0.00	-100.00
Rapeseed & Mustard	2808078.00	3214754.00	5786557.20	0.00	0.00	4700853.00	3533007.50	6359413.50	0.00	0.00	0
Groundnut	303840.33	474448.67	1091231.93	98210.87	11.97	576022.00	1154915.67	2656306.03	239067.54	29.14	143.46
Sesamum	370347.33	122829.67	307074.17	122829.67	15.11	295236.00	91979.67	229949.17	91979.67	11.31	-25.13

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Castor Seed	121835.00	160374.67	657536.13	394521.68	49.39	158810.83	153525.00	629452.50	377671.50	47.28	-4.26
Soyabean	821582.17	962832.67	1636815.53	0.00	0.00	2016723.00	2037800.50	3464260.85	0.00	0.00	0
Other Oilseeds	71204.00	23502.00	47004.00	47004.00	4.45	139519.50	57989.00	115978.00	115978.00	10.97	146.55
Turmeric	118.83	470.83	141.25	84.75	0.01	290.33	553.17	165.95	99.57	0.01	32.43
Coriander	196495.83	198377.17	228133.74	114066.87	14.46	197288.00	217156.50	249729.98	124864.99	15.83	9.49
Garlic	27673.33	147965.50	44389.65	44389.65	6.02	96676.83	368393.33	110518.00	110518.00	14.99	148.94
Ginger	157.67	290.00	14.50	4.79	0.00	122.33	280.50	14.03	4.63	0.00	0
Dry Chillies	19239.00	23000.33	34500.50	27600.40	3.58	10544.00	16831.00	25246.50	20197.20	2.62	-26.83
Banana	15.33	68.00	204.00	44.88	0.01	41.83	237.83	713.50	156.97	0.02	108.30
Sweet Potato	1794.50	3888.17	388.82	233.29	0.02	1742.50	8888.00	888.80	533.28	0.05	143.02
Cotton	342167.50	132560.45	795362.73	537816.70	65.02	501022.17	157204.89	2249734.98	1521249.37	183.92	182.87
Onion	41511.83	387054.83	19352.74	4257.60	0.58	70357.67	859221.33	42961.07	9451.43	1.29	121.62
Tapioca	0.00	0.00	0.00	0.00	0.00	37.00	109.00	81.75	69.49	0.01	0
Sugarcane	9282.00	537379.00	26868.95	6717.24	0.91	11441.00	510074.00	25503.70	6375.93	0.87	-4.71
Potato	8867.67	95850.17	77638.64	51241.50	4.77	14745.17	189299.50	153332.60	101199.51	9.42	97.52
Tobacco	573.67	687.33	687.33	687.33	0.09	467.33	625.00	625.00	625.00	0.08	-7.64
Total	**21468924.67**	**23644364.29**	**44987536.81**	**7050086.36**	**896.94**	**31926011.17**	**32106008.39**	**59504074.07**	**10211055.24**	**1299.55**	**44.89**

Table 90: Crop-wise Area, Production, Biomass Production, Surplus Biomass (tonnes), Biomass Power Potential for Rajasthan in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	181470.1	438982.7	658474.0	111940.6	15.2
2	Wheat	3503093.1	12776437.0	22997586.7	4599517.3	620.9
3	Jowar	600455.1	436762.5	1048229.9	209646.0	26.0
4	Bajra	5417586.7	5526360.8	14534328.9	2616179.2	317.9
5	Maize	924888.0	1697351.5	3903908.5	39039.1	4.6
6	Gram	1672292.1	1552872.3	1708159.5	341631.9	44.4
7	Tur (Arhar)	12919.2	13152.7	36827.6	17309.0	2.1
8	Lentil (Masur)	58335.9	53701.7	96663.0	48331.5	5.0
9	Groundnut	608380.2	1247688.5	2869683.6	258271.5	31.3
10	Soyabean	1163372.9	1289788.8	2192641.0	372749.0	46.6
11	Rapeseed & Mustard	2726555.3	4024710.8	7244479.4	0.0	0.0
12	Cotton	488003.6	310295.7	2537064.2	1725203.7	208.7
13	Sugarcane	4352.3	425768.4	21288.4	5322.1	0.7
14	Tobacco	417.2	620.1	620.1	620.1	0.1
15	Guarseed	4732888.4	2490196.8	4980393.7	2490196.8	307.5
16	Ginger	96.5	52.3	2.6	0.9	0.0
17	Caster Seed	232557.0	342347.1	1403623.1	842173.9	105.3
18	Green Gram (Moong)	1764925.5	829081.4	1036351.7	362723.1	46.1
19	Sesamum	406186.0	133607.2	334018.0	133607.2	16.4
20	Black Gram (Urad)	434318.8	263891.0	343058.3	0.0	0.0
21	Potato	16222.7	266381.0	215768.6	142407.3	1.3
22	Barley	330144.0	1076824.2	1399871.5	139987.2	16.2
23	Peas & Beans	10510.8	26564.9	13282.5	6641.2	0.8
	Total	**25289971.7**	**35223439.5**	**69576324.8**	**14463498.4**	**1817.2**

Major contributing crops in biomass power potential in Rajasthan (2019-20) is Wheat with 620.9 MWe followed by Bajra (317.9 MWe), Guar seed (307.5 MWe), Cotton (208.7 MWe) and Caster seed (105.3 MWe)

Trend Analysis for Biomass power potential for the state of Rajasthan – Crop-wise

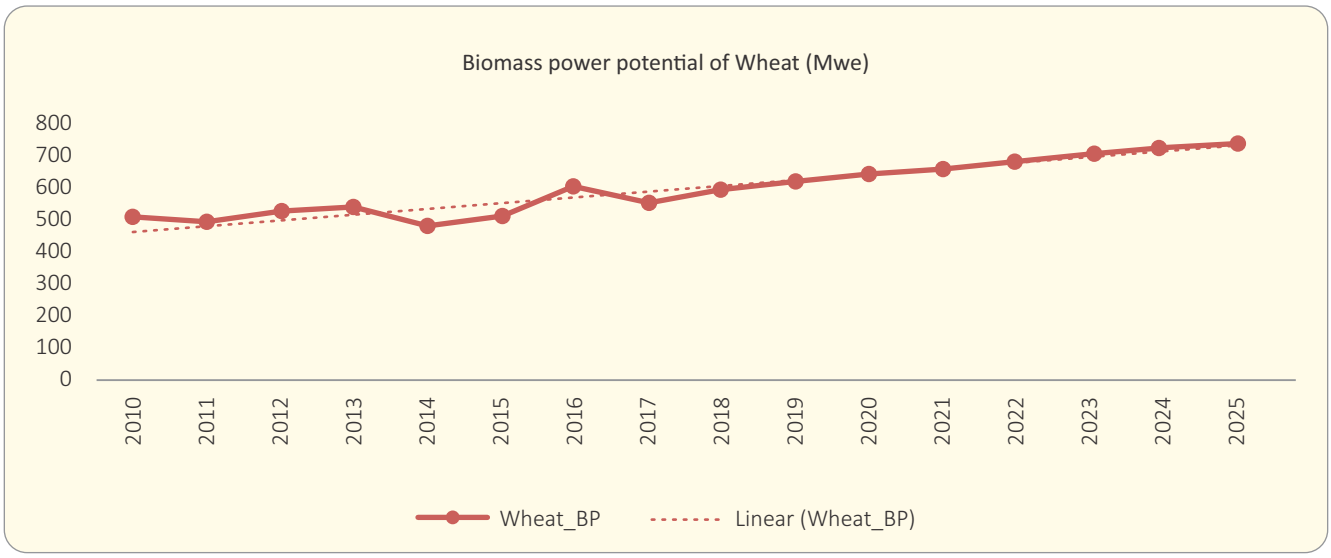


Figure 137: Biomass Power Potential for Wheat in Rajasthan

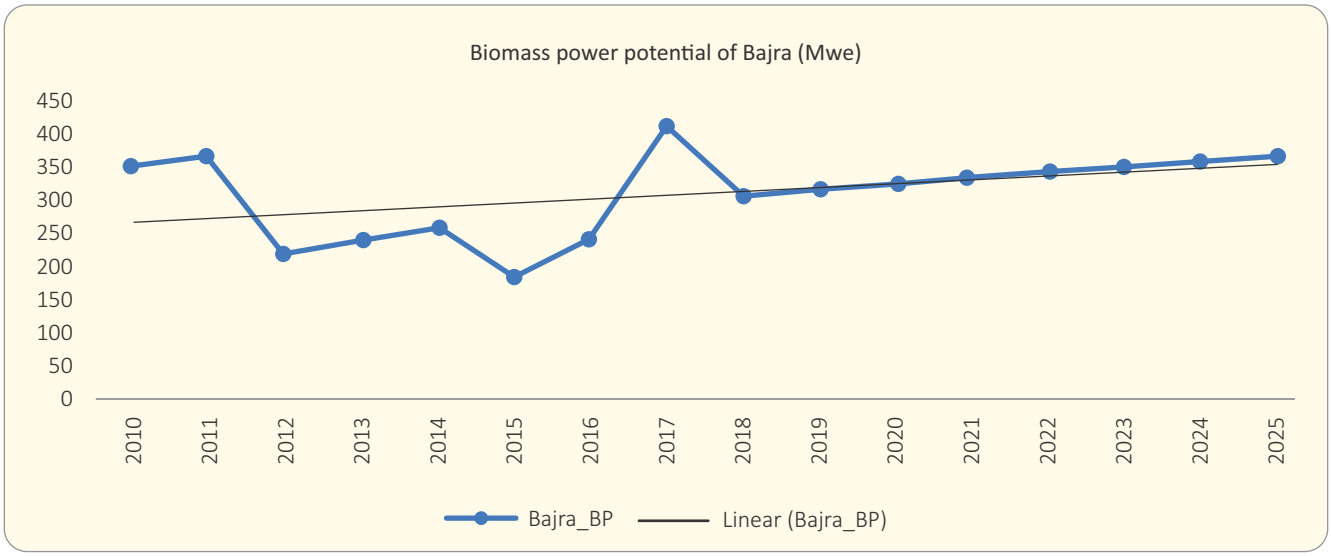


Figure 138: Biomass Power Potential for Bajra in Rajasthan

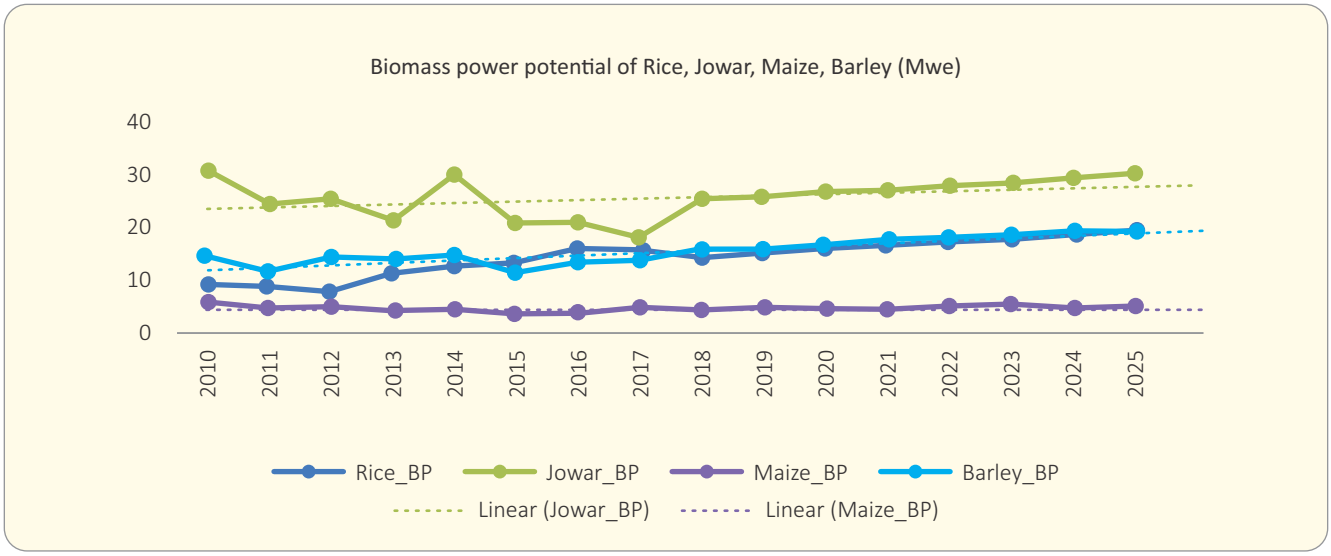


Figure 139: Biomass Power Potential for Rice, Jowar, Maize and Barley in Rajasthan

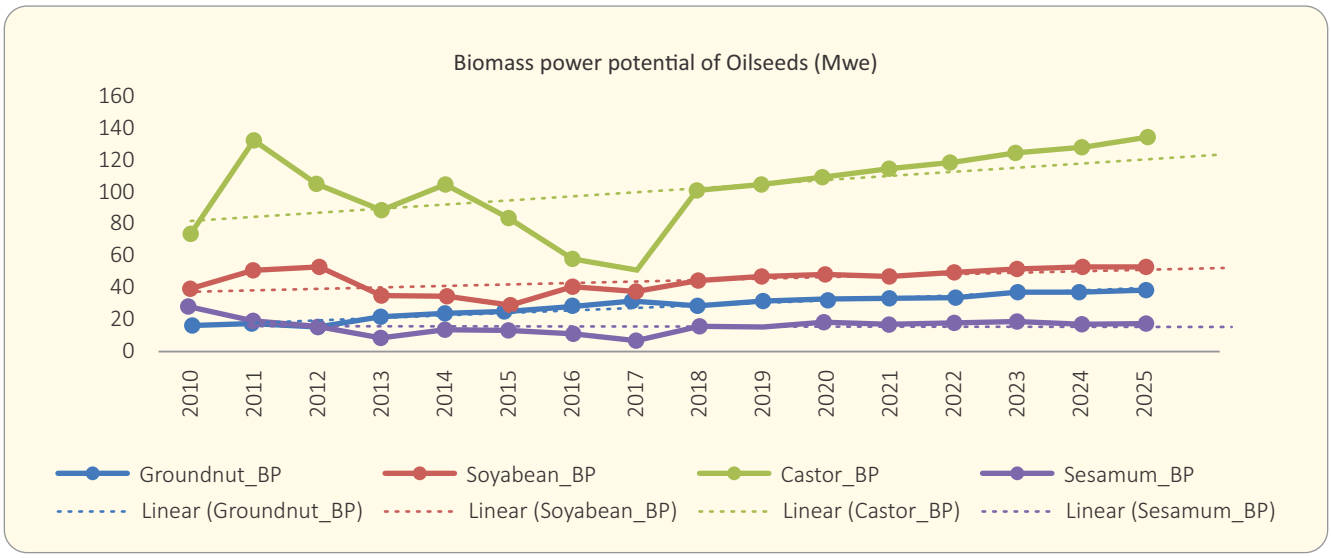


Figure 140: Biomass Power Potential for Oilseeds in Rajasthan

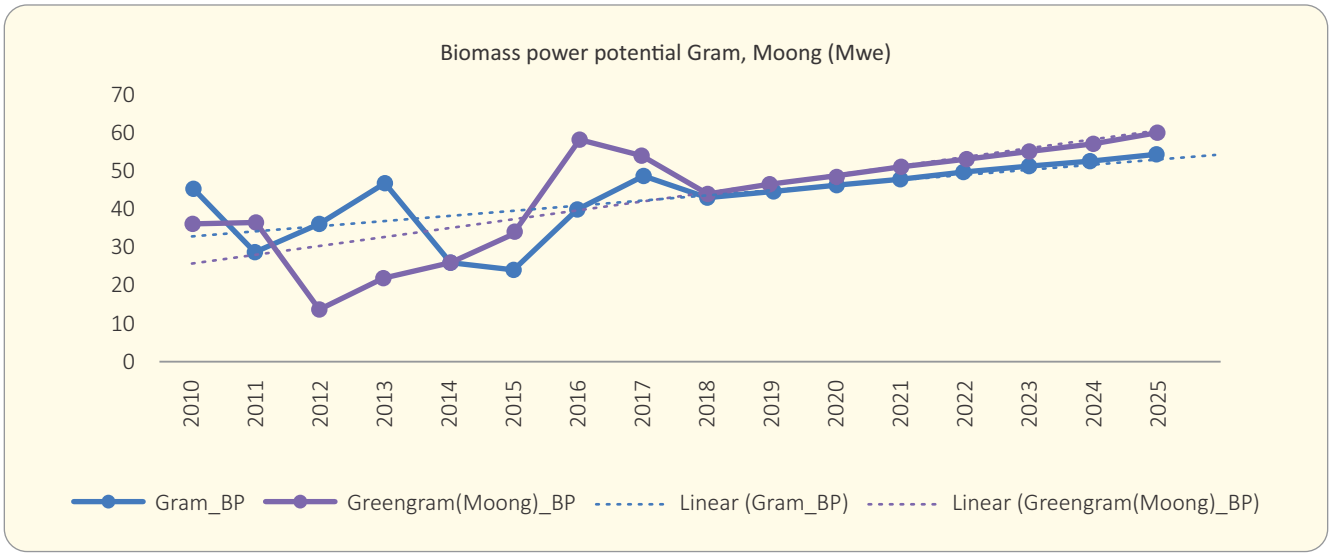


Figure 141: Biomass Power Potential for Gram and Moong in Rajasthan

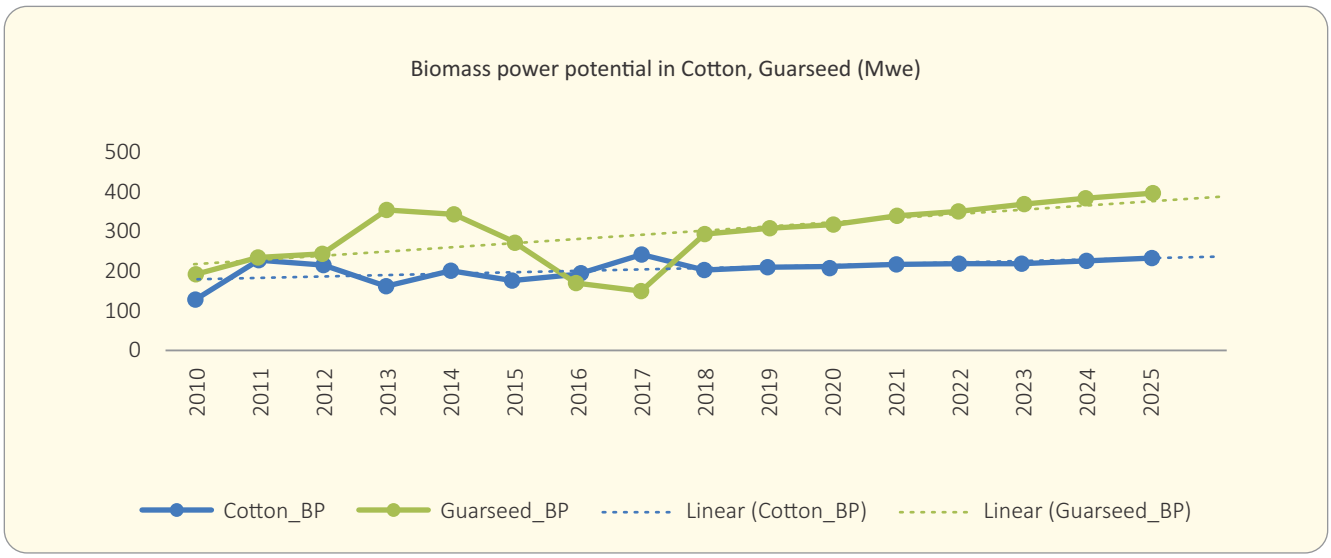


Figure 142: Biomass Power Potential for Cotton and Guarseed in Rajasthan

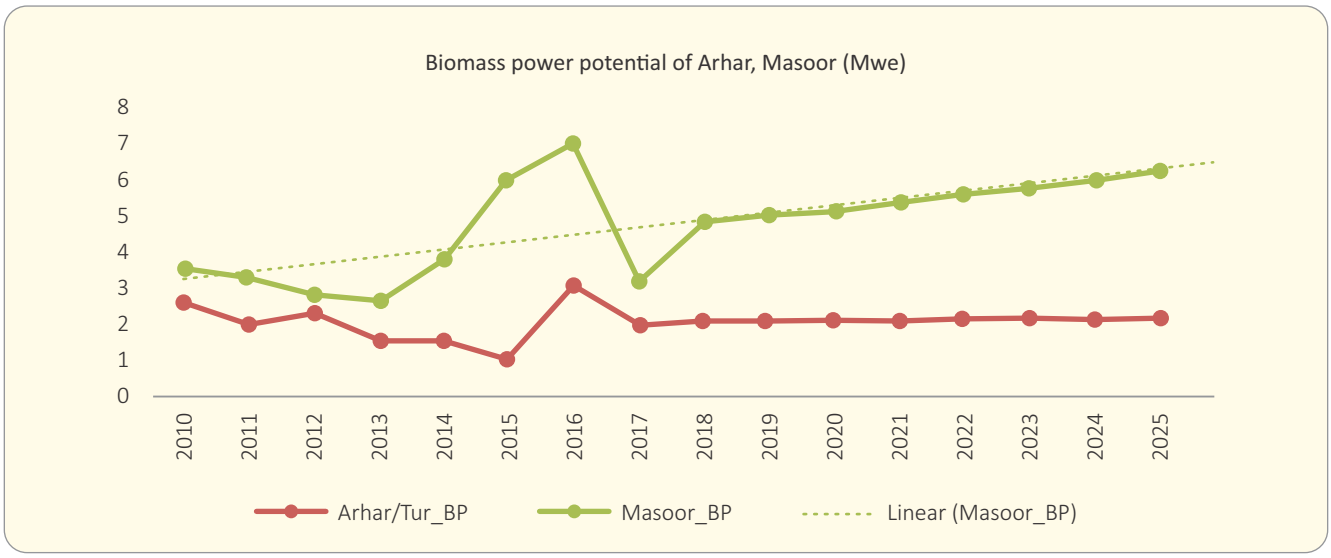


Figure 143: Biomass Power Potential for Arhar and Masoor in Rajasthan

Sikkim

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Sikkim collected information and samples from all two (02) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Sikkim was calculated, which was the input to arrive at biomass power potential in Sikkim. Thus, the total biomass power potential for the state of Sikkim for 2018 was 4.73 MWe and for 2019-20 is 4.46 MWe.

Districts Selected for Primary Field Survey	02 (East Sikkim, North Sikkim)
Average Rainfall	2739mm
Type of soil	Brown Clay Soil, Red Sandy Loam
Major source of irrigation	Rainfed, Streams and Rivers
Major Rivers	Lachen, Lachung, Lhonak, Tista, Rangit
Major Crops	Cardamom, Gingers, Maize, Rice, Other Cereals, Rapeseed & Mustard, Soyabean, Urad

Utilization of Crop residue at farmer's level in Sikkim:

1. **Essential Usage**: Cardamom, Ginger, oilseed and Rice are utilized for compost fertilizer.
2. **Fuel Usage**: for domestic cooking, farmers are using the residue of paddy, Rapeseed & mustard Soyabean and Wheat.
3. **Field preparation**: Residue of Paddy & Wheat are burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy	6000
	Rapeseed & Mustard	4000
	Wheat	5000

Survey Images:

GPU Pakshep, North Sikkim, Sikkim

GPU Pakshep, North Sikkim, Sikkim

Nimthang, East Sikkim, Sikkim

Table 91: wise change in Area, Production and Biomass Potential in Sikkim

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	11353.33	21053.33	31580.00	263.17	0.04	10730.00	19736.67	29605.00	246.71	0.03	-16.00
Wheat	4913.33	6106.67	10992.00	2198.40	0.30	336.00	360.83	649.50	129.90	0.02	-94.15
Maize	39940.00	63250.00	145475.00	29095.00	3.40	39111.00	68397.33	157313.87	31462.77	3.67	8.08
Barley	786.67	800.00	1040.00	104.00	0.01	461.67	484.00	629.20	62.92	0.01	-27.01
Small Millets	3876.67	3135.33	3762.40	376.24	0.05	8423.00	8573.00	10287.60	1028.76	0.13	159.25
Other Cereals	2946.67	2700.00	3510.00	351.00	0.04	3566.00	3476.00	4518.80	451.88	0.05	33.30
Urad	2956.67	2482.00	3226.60	645.32	0.06	2952.00	2707.33	3519.53	703.91	0.06	6.88
Other Kharif Pulses	3233.33	2719.33	3535.13	707.03	0.09	8506.00	8241.00	10713.30	2142.66	0.26	188.07
Rapeseed & Mustard	4616.67	3596.67	6474.00	3237.00	0.42	3690.33	3147.67	5665.80	2832.90	0.37	-11.64
Soyabean	3063.33	2913.33	4952.67	841.95	0.11	3504.33	3379.00	5744.30	976.53	0.12	10.97
Total	**77686.67**	**108756.67**	**214547.80**	**37819.11**	**4.51**	**81280.33**	**118502.83**	**228646.90**	**40038.94**	**4.73**	**4.94**

Table 92: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Sikkim in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	9488.11	18718.72	28078.08	280.78	0.04
2	Wheat	163.00	176.00	316.80	63.36	0.01
3	Maize	39502.12	71927.14	165432.42	33086.48	3.87
4	Soyabean	3305.21	3359.25	5710.72	970.82	0.12
5	Rapeseed & Mustard	3327.60	3063.61	5514.51	2757.25	0.36
6	Black Gram (Urad)	2786.81	2630.28	3419.36	683.87	0.06
	Total	**58572.84**	**99875.00**	**208471.89**	**37842.57**	**4.46**

Major contributing crops in biomass power potential in Sikkim (2019-20) is Maize with 3.87 MWe followed by Rapeseed & Mustard (0.36 MWe), Soyabean (0.12 MWe), Urad (0.06 MWe) and Rice (0.04 MWe)

Trend Analysis for Biomass power potential for the state of Sikkim – Crop-wise

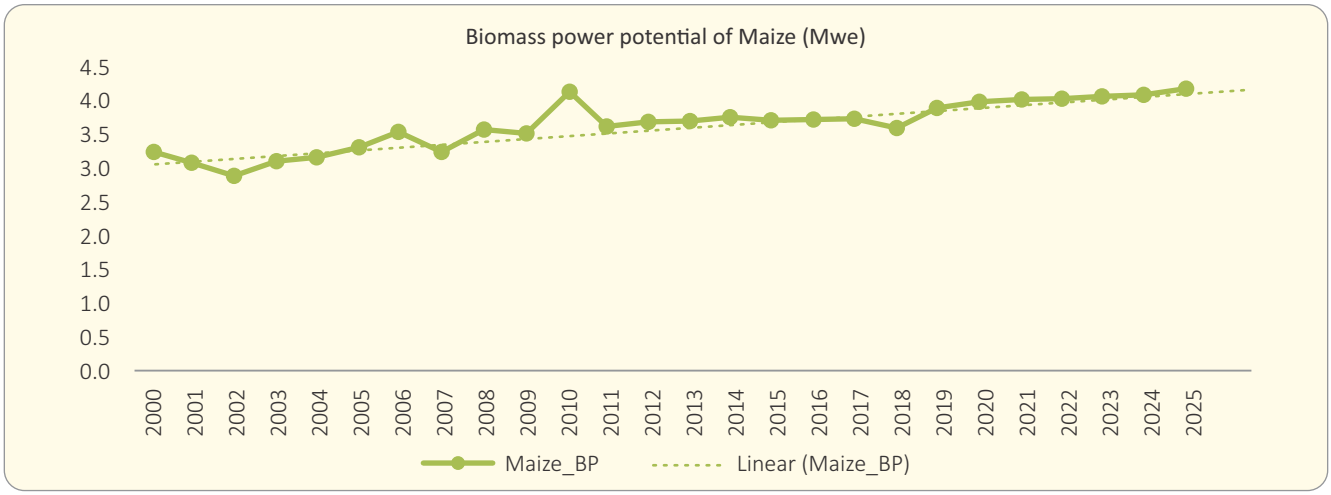


Figure 144: Biomass Power Potential for Maize in Sikkim

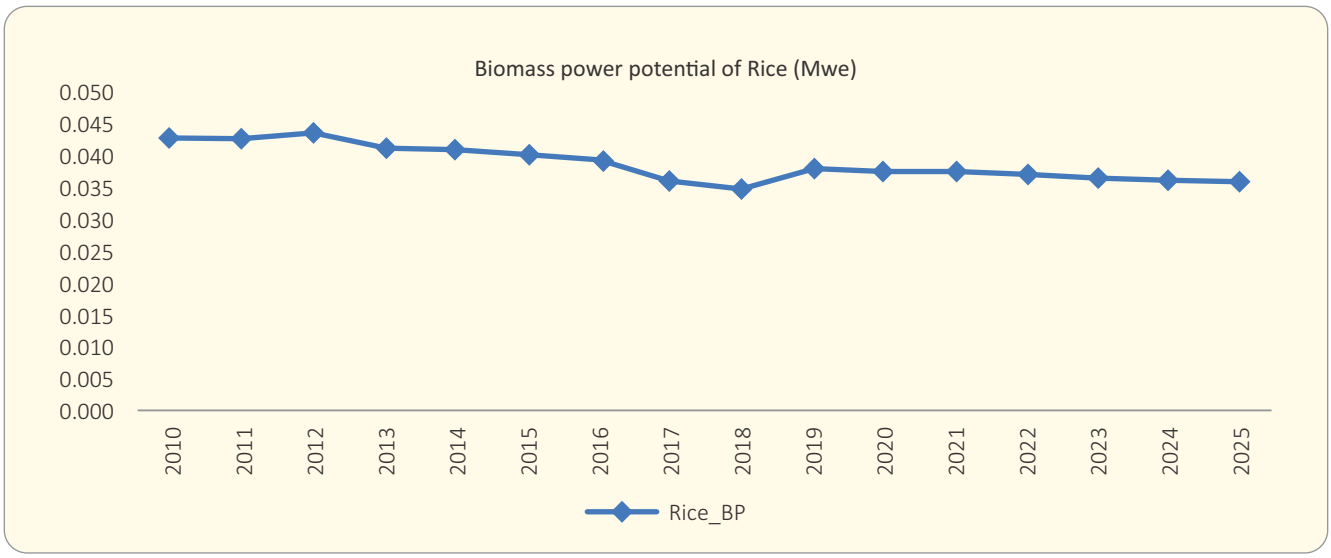


Figure 145: Biomass Power Potential for Rice in Sikkim

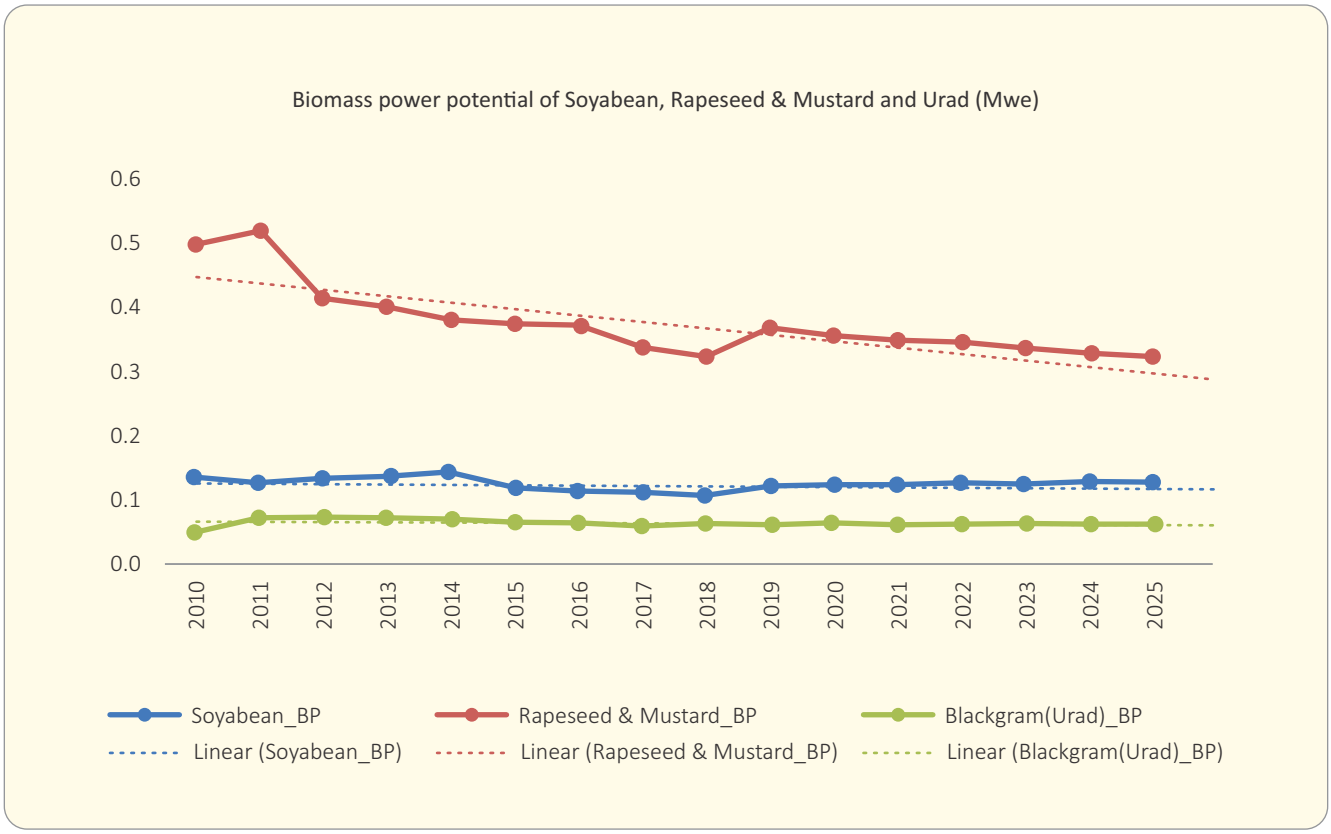
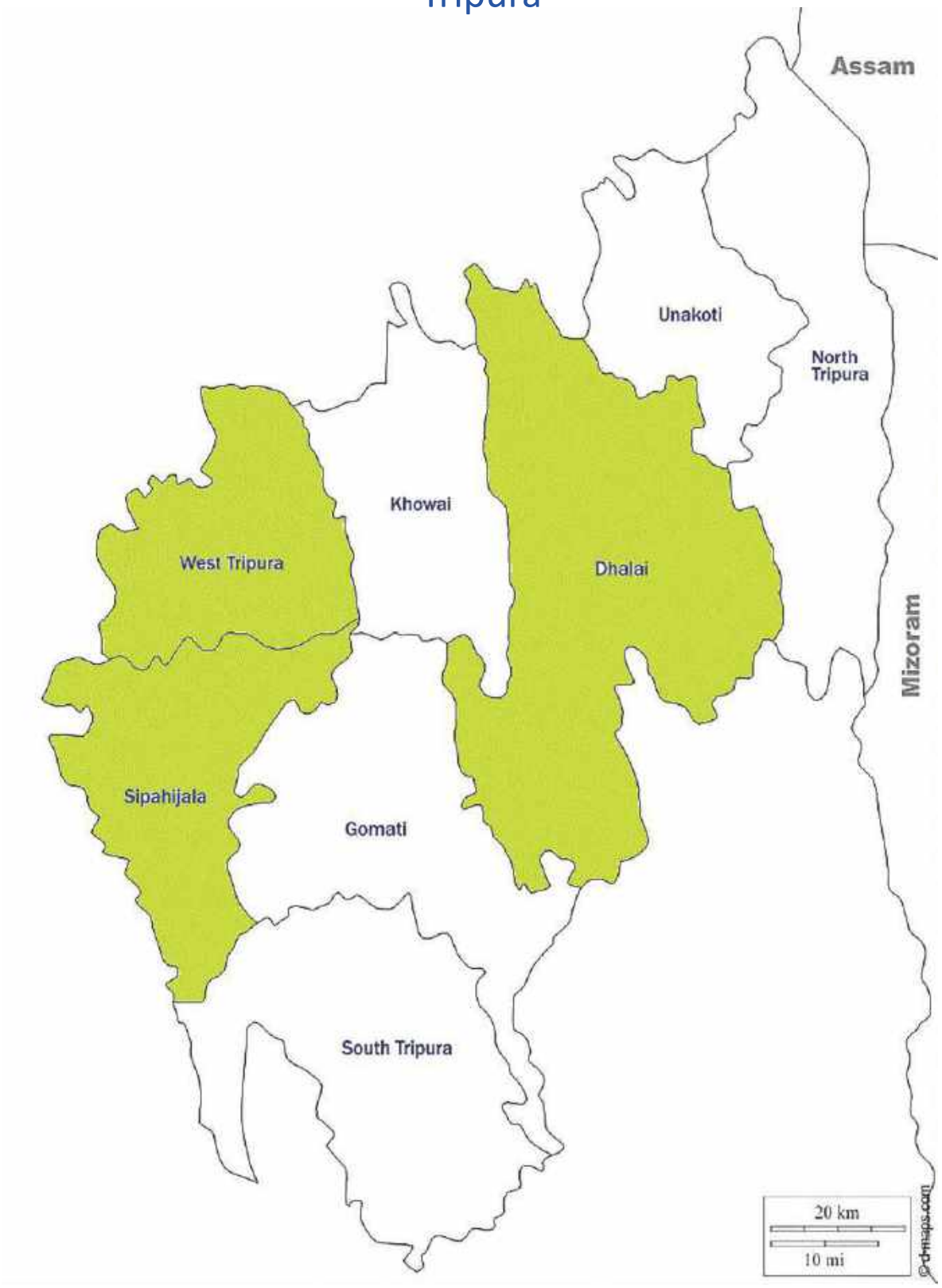


Figure 146: Biomass Power Potential for Soyabean, Rapeseed & Mustard and Urad in Sikkim

Tripura



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Tripura collected information and samples from all three (03) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Tripura was calculated, which was the input to arrive at biomass power potential in Tripura. Thus, the total biomass power potential for the state of Tripura for 2018 was 34.35 MWe and for 2019-20 is 33.0 MWe.

Districts Selected for Primary Field Survey	03 (Agartala, Dhalai and Sepahijala)
Average Rainfall	in mm (2004- 2010)
Type of soil	Laterite Soil
Major source of irrigation	Canals, Tube well
Major Rivers	Bijoy, Dhala, Gomati and Haora
Major Crops	Cowpea, Rice, Maize, Rapeseed & Mustard

Utilization of Crop residue at farmer's level in Tripura:

1. **Essential Usage** Residue of Cowpea, Maize and Paddy are extensively used for cattle feeding. Some parts of the residue of Cowpea and Maize are utilized for the preparation of compost manure.
2. **Fuel Usage**: for domestic cooking, farmers are using the residue of paddy, Rapeseed &Mustard and Wheat
3. **Field preparation**: Mostly, residues of Paddy & Wheat are burnt in an open field.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy	5000 - 6000
	Rapeseed & Mustard	4000 - 5000
	Wheat	6000

Survey Images:

Madhya Champamura, West Tripura, Tripura

Kulai G P, Dhalai, Tripura

Sepahijala, Gokulnagar, Tripura

Table 93: Crop-wise change in Area, Production and Biomass Potential in Tripura

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	248934.00	631933.00	947899.50	161142.92	21.92	307090.00	897225.67	1345838.50	228792.55	31.16	42.16
Wheat	876.00	1643.00	2957.40	591.48	0.08	157.67	341.17	614.10	122.82	0.02	-79.27
Maize	2222.00	2197.00	5053.10	1010.62	0.12	6879.33	9365.67	21541.03	4308.21	0.50	319.33
Urad	1383.67	834.67	1085.07	542.53	0.05	2214.00	1404.83	1826.28	913.14	0.08	66.37
Moong (Green Gram)	769.33	411.00	513.75	154.13	0.02	1773.67	954.00	1192.50	357.75	0.05	128.42
Masoor	345.00	238.67	427.21	213.61	0.02	2510.67	1742.00	3118.18	1559.09	0.16	704.49
Arhar /Tur	1134.00	816.67	2286.67	1600.67	0.19	3525.67	2487.67	6965.47	4875.83	0.59	209.49
Cowpea	0.00	0.00	0.00	0.00	0.00	4315.00	3356.00	3691.60	738.32	0.10	0
Peas & Beans	690.33	523.33	261.67	130.83	0.02	2010.67	1725.67	862.83	431.42	0.05	167.48
Gram	108.00	85.33	93.87	18.77	0.00	239.83	189.17	208.08	41.62	0.01	0
Other Kharif Pulses	1404.67	908.00	1180.40	236.08	0.03	1276.50	839.33	1091.13	218.23	0.03	-11.98
Other Rabi Pulses	982.33	798.00	1037.40	103.74	0.01	1107.83	987.00	1283.10	128.31	0.02	55.26
Rapeseed & Mustard	1594.33	1204.33	2167.80	1083.90	0.14	4989.67	4083.33	7350.00	3675.00	0.48	243.88
Sesamum	1748.33	908.00	2270.00	908.00	0.11	3063.33	1836.67	4591.67	1836.67	0.23	105.37
Groundnut	588.00	615.67	1416.03	283.21	0.03	907.67	1037.67	2386.63	477.33	0.06	93.95
Soyabean	0.00	0.00	0.00	0.00	0.00	268.00	234.00	397.80	67.63	0.01	0
Sugarcane	933.33	46915.33	2345.77	586.44	0.08	850.00	43866.67	2193.33	548.33	0.07	-6.78
Jute	458.00	681.96	1363.92	1091.14	0.15	647.67	980.10	1960.20	1568.16	0.21	40.09
Cotton	1075.67	256.47	4651.77	3721.42	0.45	919.00	232.73	4004.21	3203.36	0.39	-13.94
Mesta	883.33	1178.04	2414.98	1207.49	0.16	702.67	1056.72	2166.28	1083.14	0.15	-9.29
Total	**266130.33**	**701874.00**	**979426.31**	**174626.97**	**23.58**	**345448.83**	**973946.05**	**1413282.93**	**254946.89**	**34.35**	**45.67**

Table 94: Crop-wise Area (ha), Production, Biomass Production, Surplus Biomass, Biomass Power Potential for Tripura in the year 2019 - 2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	270624.8	823086.4	1234629.5	209887.0	28.5
2	Wheat	157.0	331.9	597.5	119.5	0.0
3	Maize	11967.9	16917.8	38911.0	7782.2	0.9
4	Gram	257.5	188.6	207.5	41.5	0.0
5	Arhar/Tur	5093.5	3727.4	10436.6	7305.6	0.9
6	Masoor	2957.3	2076.7	3738.0	0.0	0.0
7	Groundnut	1802.8	2309.9	5312.7	1062.5	0.1
8	Rapeseed & Mustard	7233.3	5943.6	10698.4	5349.2	0.7
9	Cotton	798.6	1298.1	5890.3	4712.2	0.6
10	Jute	781.3	1221.7	2443.5	1954.8	0.3
11	Mesta	796.1	1204.2	2420.3	1210.2	0.2
12	Sugarcane	740.5	39505.2	1975.3	493.8	0.1
13	Green Gram (Moong)	3354.7	1952.3	2440.4	732.1	0.1
14	Sesamum	5725.6	3426.4	8566.1	3426.4	0.4
15	Black Gram (Urad)	4109.6	2625.1	3412.6	1706.3	0.2
16	Peas & Beans	3089.8	2645.7	1322.9	661.4	0.1
	Total	**319490.2**	**908460.9**	**1333002.5**	**246444.8**	**33.0**

Major contributing crops in biomass power potential in Tripura (2019-20) is Rice with 28.5 MWe followed by Maize (0.9 MWe), Arhar/Tur (0.9 MWe), Rapeseed & Mustard (0.7 MWe) and Cotton (0.5 MWe)

Trend Analysis for Biomass power potential for the state of Tripura – Crop-wise

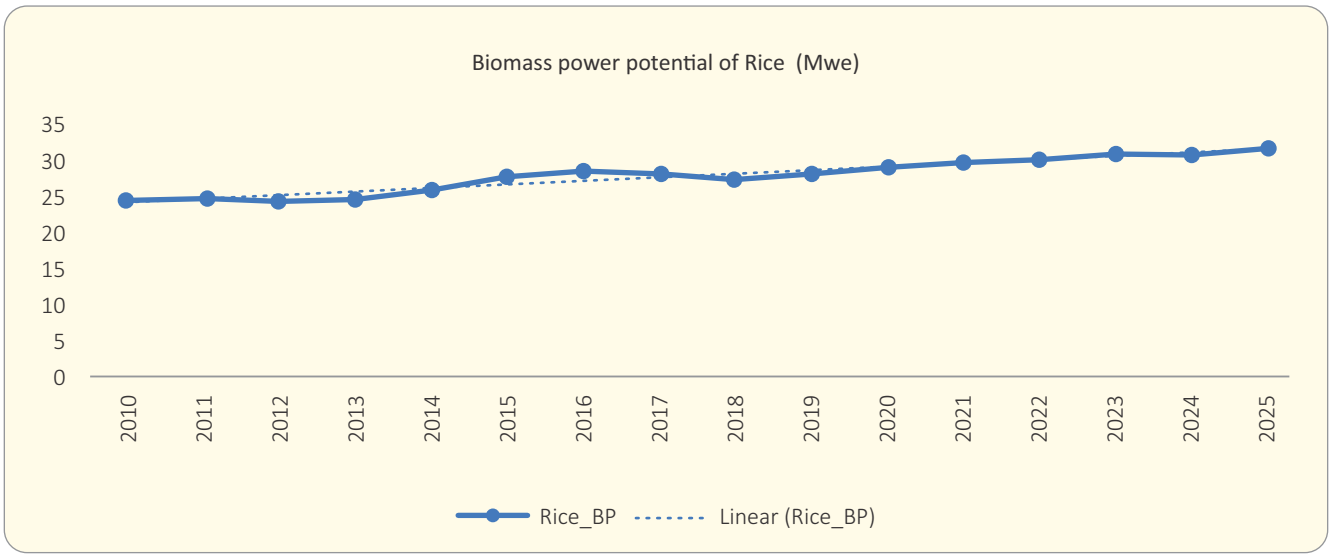


Figure 147: Biomass power Potential for Rice in Tripura

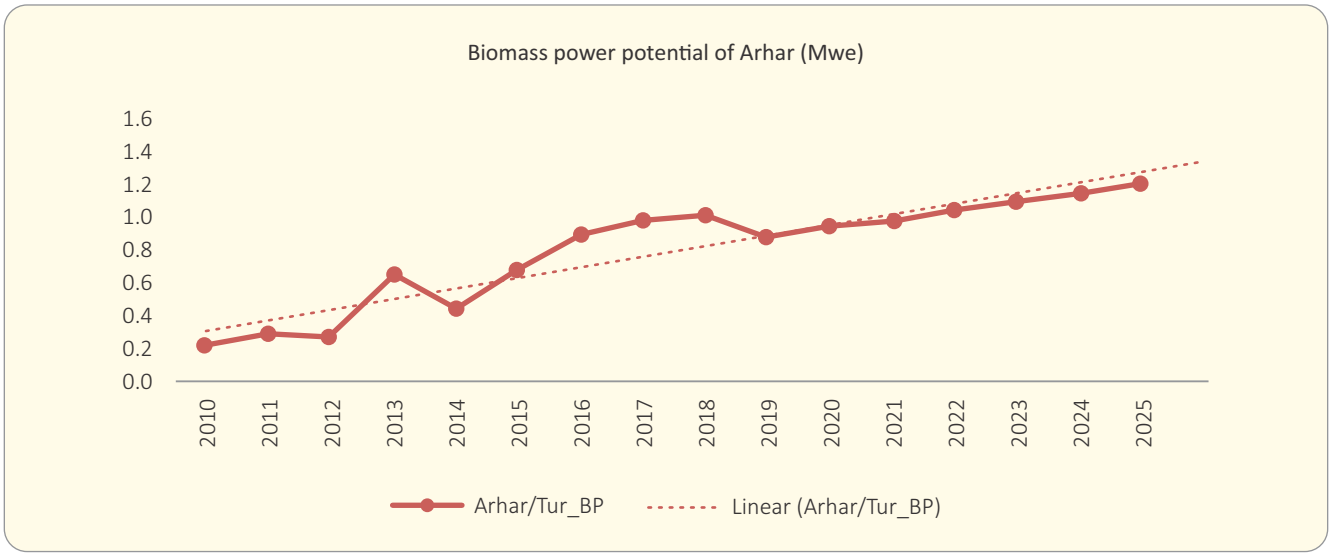


Figure 148: Biomass Power Potential for Arhar in Tripura

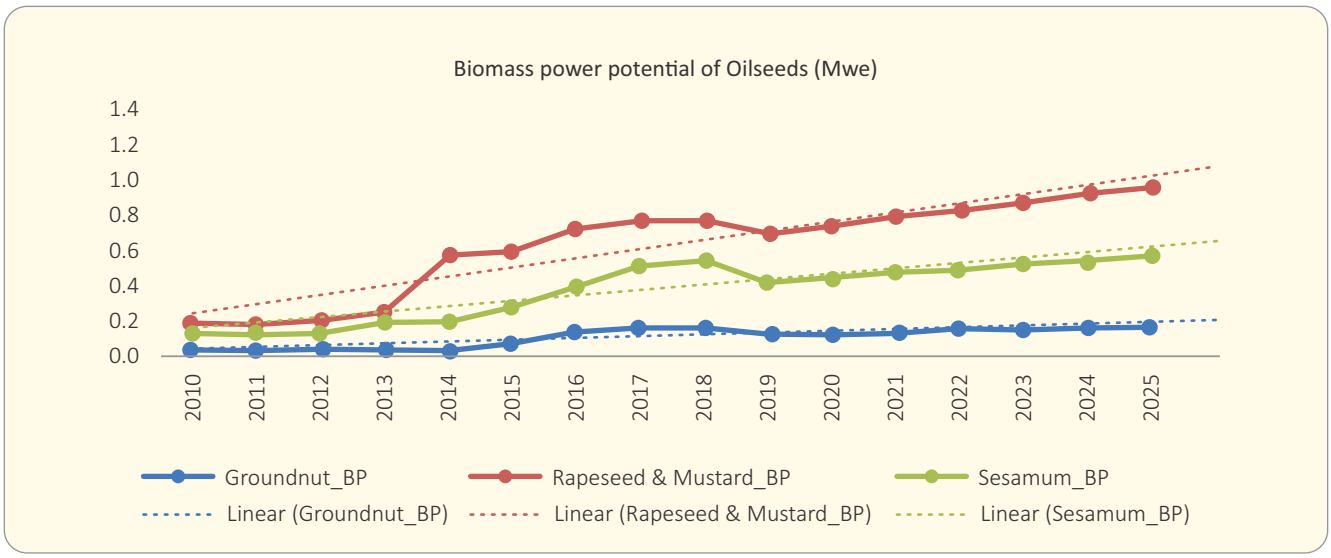


Figure 149: Biomass Power Potential for Oilseeds in Tripura

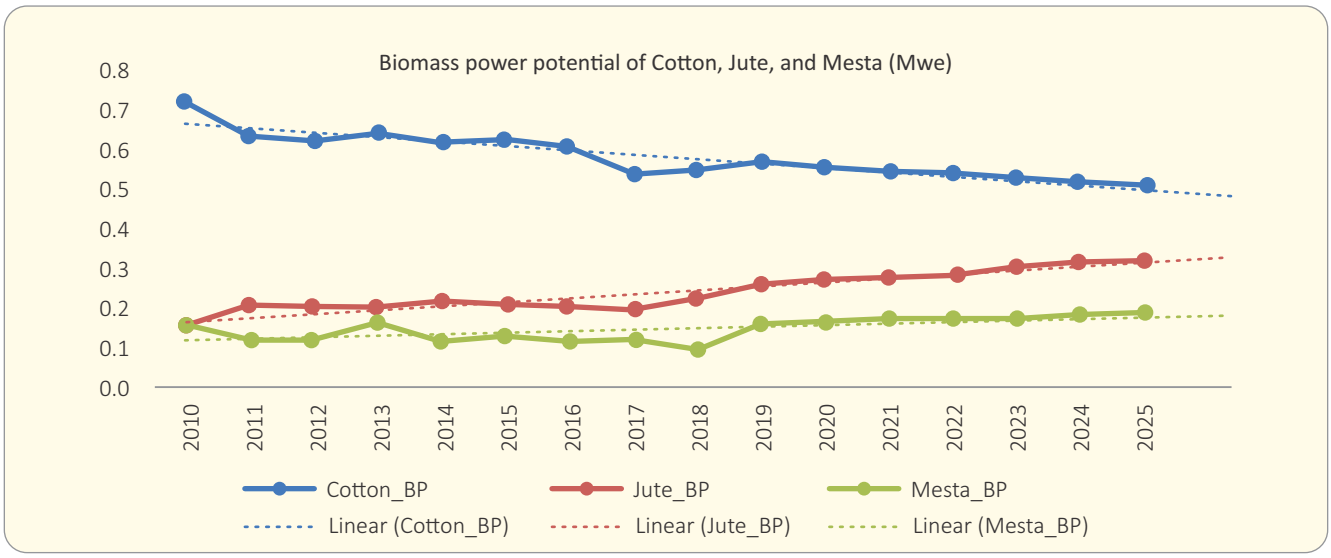


Figure 150: Biomass Power Potential for Cotton, Jute and Mesta in Tripura

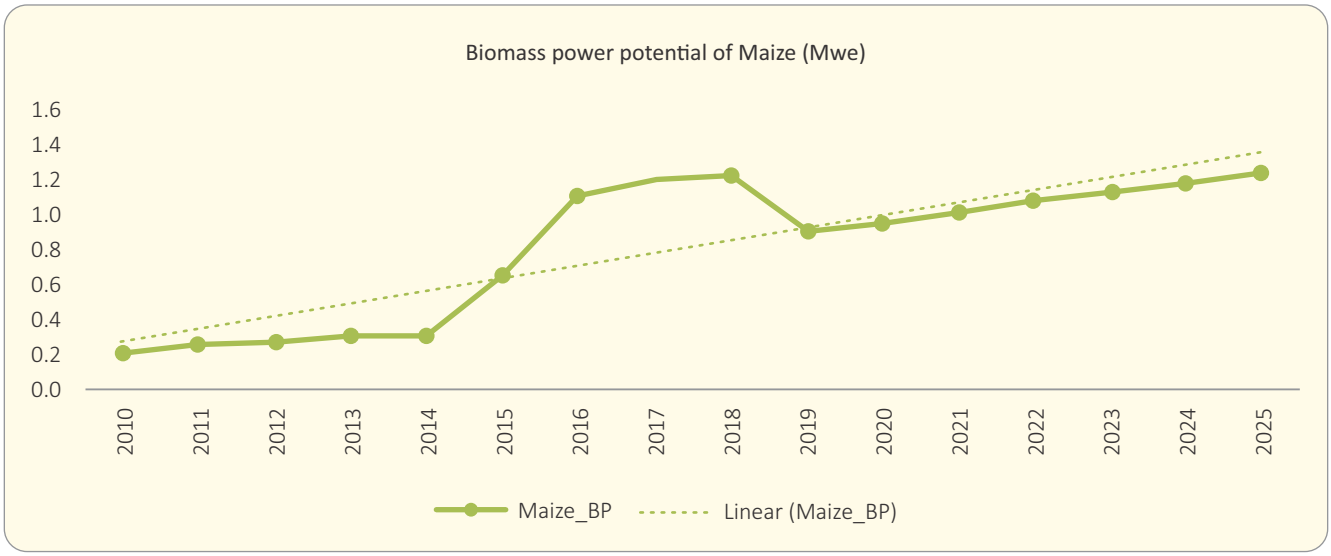


Figure 151: Biomass Power Potential for Maize in Tripura

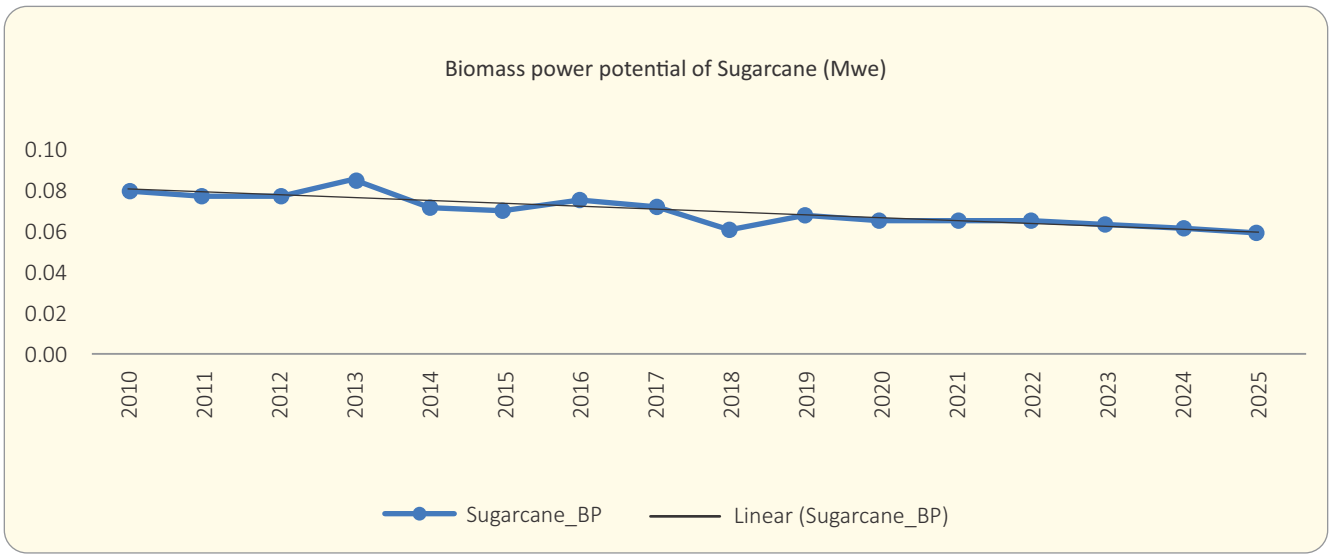


Figure 152: Biomass Power Potential for Sugarcane in Tripura

Tamil Nadu

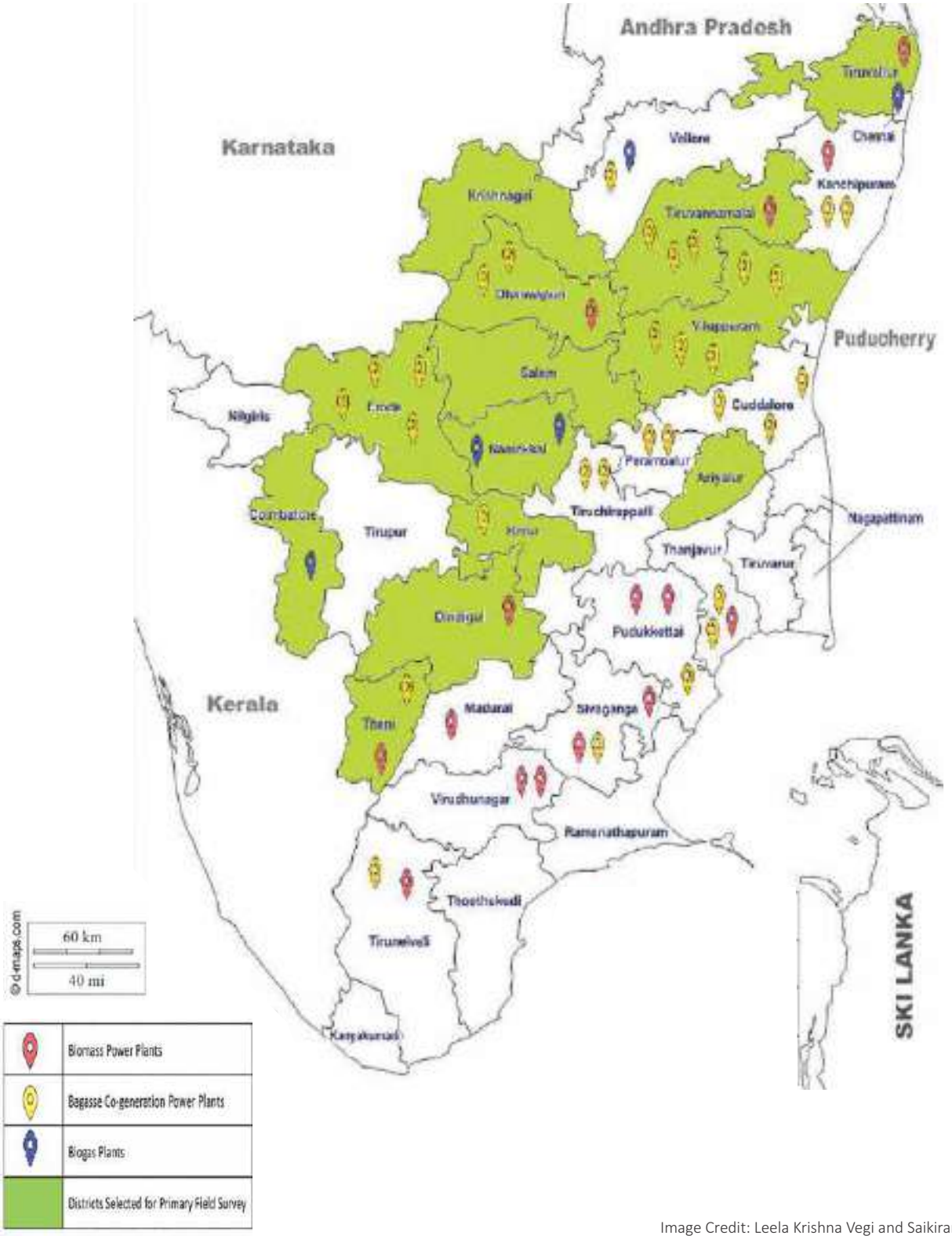


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter-02, based on secondary data, the survey teams in Tamil Nadu collected information and samples from all thirteen (13) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Tamil Nadu was calculated, which was the input to arrive at biomass power potential in Tamil Nadu. Thus, the total biomass power potential for the state of Tamil Nadu for 2018 was 1560.08 MWe and for 2019-20 is 1228.70 MWe.

Districts Selected for Primary Field Survey	13 (Erode, Coimbatore, Thiruvarur, Tiruvannamalai, Ariyalur, Villupuram, Namakkal, Salem, Krishnagiri, Theni, Karur, Krishnagiri, Dindigul)
Average Rainfall	998mm
Type of soil	Canals, Tube well
Major source of irrigation	-
Major Rivers	-
Major Crops	Arhar, Banana, Coconut, Cotton, Groundnut, Maize, Moong (Green Gram), Sugarcane, Tapioca, Ragi Rice, Urad

Utilization of Crop residue at farmer's level in Tamil Nadu:

1. **Essential Usage**: The residue of Rice and Moong are generally used for cattle feeding. The residue of Rice, Moong, and oilseed are utilized for compost fertilizer
2. **Specific Usage**: Arhar stalk is also used for the construction of small huts. The residue of Soyabean is also used for fuel for making bricks in a brick kiln. Sugarcane top leaves are used for cattle feeding, and bagasse's are used for energy generation in the sugar mills. The residue of Banana is utilized for Organic Mushroom production.
3. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	2000 - 3000
Expected Cost against the sale of crop residue in Future	Paddy	5000 - 6000
	Rapeseed & Mustard	4000 - 5000
	Wheat	6000

Survey Images:

Agram, Dindigul, Tamil Nadu

Killapaliyur, Ariyalur, Tamil Nadu

Pollachi, Coimbatore, Tamil Nadu

Table 95: Crop-wise change in Area, Production and Biomass Potential in Tamil Nadu

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	1907812.67	5691665.33	8537498.00	1451374.66	197.39	3550429.50	12102847.00	18154270.50	3086225.99	420.34	112.95
Wheat	140.00	700.00	1260.00	252.00	0.03	0.00	0.00	0.00	0.00	0.00	-100.00
Maize	261487.83	966324.00	2222545.20	444509.04	52.01	656072.50	4617495.67	10620240.03	2124048.01	248.09	377.00
Ragi	93096.67	164718.67	214134.27	21413.43	2.66	165816.67	560664.17	728863.42	72886.34	9.05	240.32
Small Millets	41490.00	41421.33	49705.60	4970.56	0.63	23767.50	27481.00	32977.20	3297.72	0.42	-34.05
Bajra	61189.17	90882.67	239021.41	45414.07	5.54	117823.83	270325.83	710956.94	134573.99	16.36	195.38
Jowar	301084.00	260352.67	624846.40	12496.93	1.55	716823.00	772159.83	1853183.60	37063.67	4.60	196.99
Moong (Green Gram)	146218.00	51679.00	64598.75	12919.75	1.65	375745.83	167806.00	209757.50	41951.50	5.36	224.68
Gram	9058.83	4274.50	4701.95	940.39	0.12	10300.50	8131.00	8944.10	1788.82	0.23	94.53
Arhar/Tur	29133.67	19881.33	55667.73	38967.41	4.72	105785.00	90839.00	254349.20	178044.44	21.47	354.92
Urad	276048.00	102435.33	133165.93	14648.25	1.33	844560.50	556814.33	723858.63	79624.45	7.25	445.40
Horse Gram	53514.00	24980.00	32474.00	3247.40	0.41	121199.50	83769.67	108900.57	10890.06	1.38	237.33
Masoor	0.00	0.00	0.00	0.00	0.00	59007.00	59968.00	107342.72	53671.36	5.54	0
Other Kharif Pulses	0.00	0.00	0.00	0.00	0.00	113836.00	66594.00	86572.20	17314.44	2.10	0
Sesamum	63564.33	30590.33	76475.83	30590.33	3.76	38705.17	21132.50	52831.25	21132.50	2.60	-30.87
Sunflower	33335.33	51079.00	102158.00	91942.20	10.11	14512.17	6198.50	12397.00	11157.30	1.23	-87.86
Rapeseed & Mustard	307.00	72.00	129.60	64.80	0.01	574.00	133.50	240.30	120.15	0.02	57.40
Groundnut	527161.00	1037609.67	2386502.23	238650.22	29.12	646282.83	829810.33	1908563.77	0.00	0.00	-100.00
Castor Seed	5507.33	1683.50	6902.35	1380.47	0.17	9478.00	3034.50	12441.45	7464.87	0.93	449.77
Turmeric	30103.50	164688.67	49406.60	29643.96	3.94	27921.00	106029.67	31808.90	19085.34	2.54	-35.57
Coriander	15770.50	5400.00	6210.00	3105.00	0.39	9440.00	4061.83	4671.11	2335.55	0.30	-24.06
Garlic	507.33	3002.00	900.60	900.60	0.12	711.67	4090.00	1227.00	1227.00	0.17	38.65
Ginger	729.00	14043.33	702.17	231.72	0.03	391.00	6448.00	322.40	106.39	0.01	-54.93
Arecanut	5596.17	11577.00	26050.10	24487.09	3.26	6901.67	13156.00	31229.80	29356.01	3.90	19.77

STATE-WISE BIOMASS POWER POTENTIAL

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Black pepper	3320.50	759.33	379.67	41.76	0.01	4845.50	1066.67	533.33	60.44	0.01	-25.90
Dry Chillies	66656.17	37299.17	55948.75	44759.00	5.82	45167.67	20821.33	31232.00	24985.60	3.24	-44.32
Cardamom	4302.00	392.00	250.88	100.35	0.02	3927.67	345.67	2513.71	1005.48	0.15	660.14
Banana	114020.33	5397310.00	16191930.00	3562224.60	473.78	87896.33	3227721.33	9683164.00	2130296.08	282.69	-40.33
Cashewnut	122389.00	62243.67	143160.43	143160.43	23.19	86863.00	12424.33	28575.97	28575.97	4.63	-80.04
Coconut	412211.00	1083066.67	2461144.00	2215029.60	303.46	435506.67	989693.33	2484296.67	2235867.00	306.98	1.16
Sweet potato	966.50	14301.67	1432.40	859.44	0.08	401.50	6866.33	687.71	412.62	0.04	-53.06
Tapioca	135708.33	5369257.33	4026943.00	3422901.55	369.67	80666.67	2364861.67	1773646.25	1507599.31	162.82	-55.96
Tobacco	5657.83	8336.17	8336.17	8336.17	1.11	4603.67	6971.17	6971.17	6971.17	0.93	-16.47
Potato	4652.17	77061.50	62419.82	41197.08	3.83	4263.67	89554.33	72539.01	47875.75	4.46	16.38
Cotton	107398.83	42173.46	500897.18	15026.92	1.82	340957.67	29958.90	1361548.72	40846.46	4.94	171.34
Onion	31937.00	277603.33	13880.17	3053.64	0.42	29944.67	242574.50	12128.73	2668.32	0.36	-13.60
Sugarcane	361331.67	39714231.33	1985711.57	496427.89	67.51	214130.00	20550660.67	1027533.03	256883.26	34.94	-48.25
Total	**5233405.67**	**60823095.96**	**40287490.76**	**12425268.72**	**1569.66**	**8955259.50**	**47922510.57**	**52141319.87**	**12217413.37**	**1560.08**	**-0.61**

Table 96: Crop-wise Area, Production, Biomass Production, Surplus Biomass and Biomass Power Potential for Tamil Nadu in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1718937.6	6431722.3	9647583.4	1640089.2	223.1
2	Jowar	274070.3	421979.4	1012750.7	20255.0	2.5
3	Bajra	93375.6	116245.3	305725.0	58087.8	7.1
4	Maize	393707.1	2595166.0	5968881.7	1193776.3	139.6
5	Gram	6695.7	4676.5	5144.1	1028.8	0.1
6	Tur (Arhar)	22672.5	24660.9	69050.6	48335.4	6.1
7	Groundnut	205761.7	768973.7	1768639.5	0.0	0.0
8	Sunflower	9629.7	11417.9	22835.9	20552.3	2.3
9	Cotton	153292.0	51629.8	696095.0	20882.8	2.5
10	Sugarcane	260027.0	26376023.4	1318801.2	329700.3	44.8
11	Arecanut	7111.3	14265.2	32746.1	30781.3	4.1
12	Banana	87697.7	3559670.7	10679012.1	2349382.7	310.1
13	Cashewnut	78027.7	16816.4	38677.8	38677.8	6.3
14	Coconut	450257.9	1105714.8	2630317.8	2367286.0	324.3
15	Ginger	418.1	5525.6	276.3	91.2	0.0
16	Castor Seed	4374.0	1417.1	5810.0	3486.0	0.4
17	Green Gram (Moong)	198087.9	108280.3	135350.4	27070.1	3.4
18	Sesamum	20119.4	14090.1	35225.2	14090.1	1.7
19	Tapioca	68751.7	2066007.2	1549505.4	1317079.6	142.2
20	Black Gram (Urad)	383507.8	272493.5	354241.5	38966.6	3.5
21	Potato	3992.9	90104.4	72984.6	48169.8	4.5
	Total	**4440515.5**	**44056880.4**	**36349654.3**	**9567789.1**	**1228.7**

Major contributing crops in biomass power potential in Tamil Nadu (2019-20) is Coconut with 324.3 MWe followed by Banana (310.1 MWe), Rice (223.1 MWe), Tapioca (142.2 MWe) and Maize (139.6 MWe)

Trend Analysis for Biomass power potential for the state of Tamil Nadu – Crop-wise

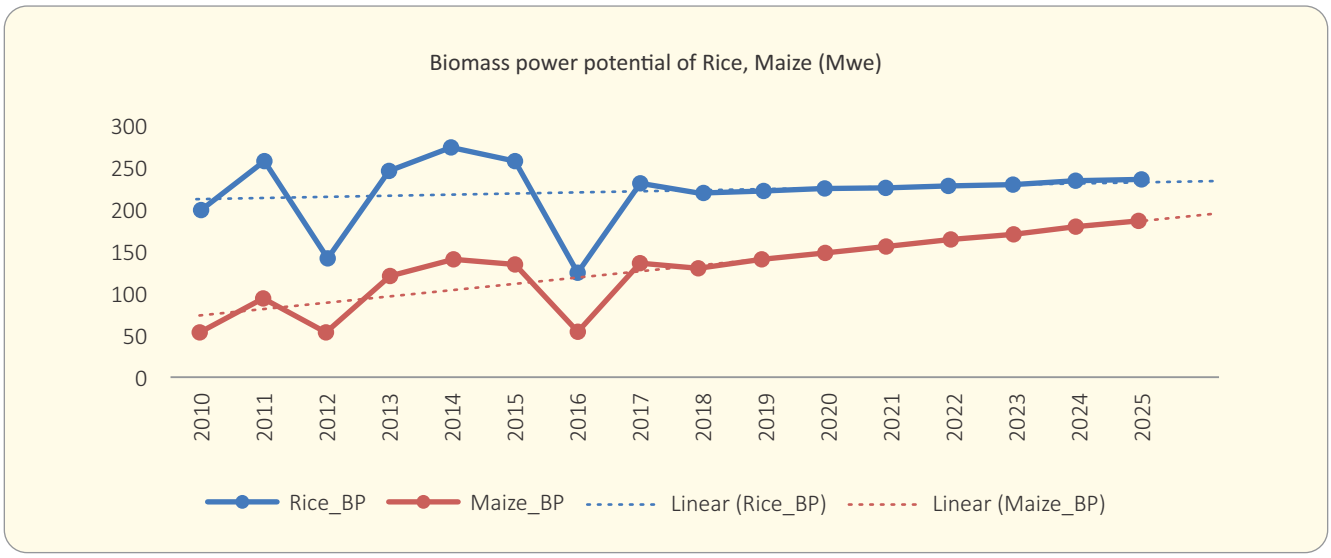


Figure 153: Biomass Power Potential for Rice and Maize in Tamil Nadu

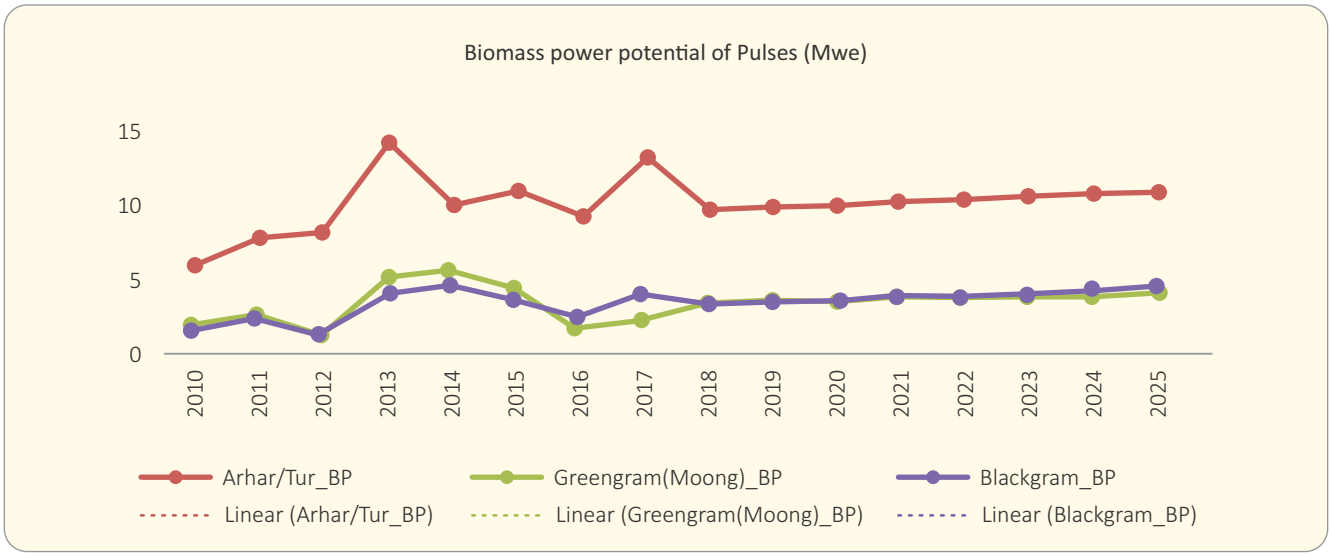


Figure 154: Biomass Power Potential for Pulses in Tamil Nadu

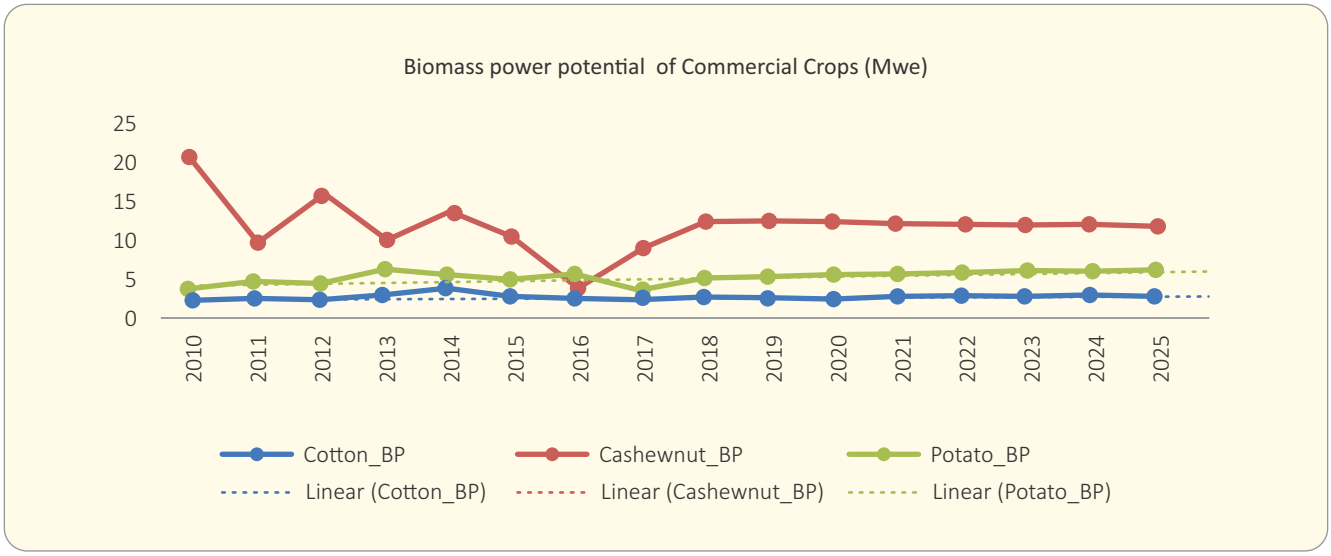


Figure 155: Biomass Power Potential for Commercial Crops in Tamil Nadu

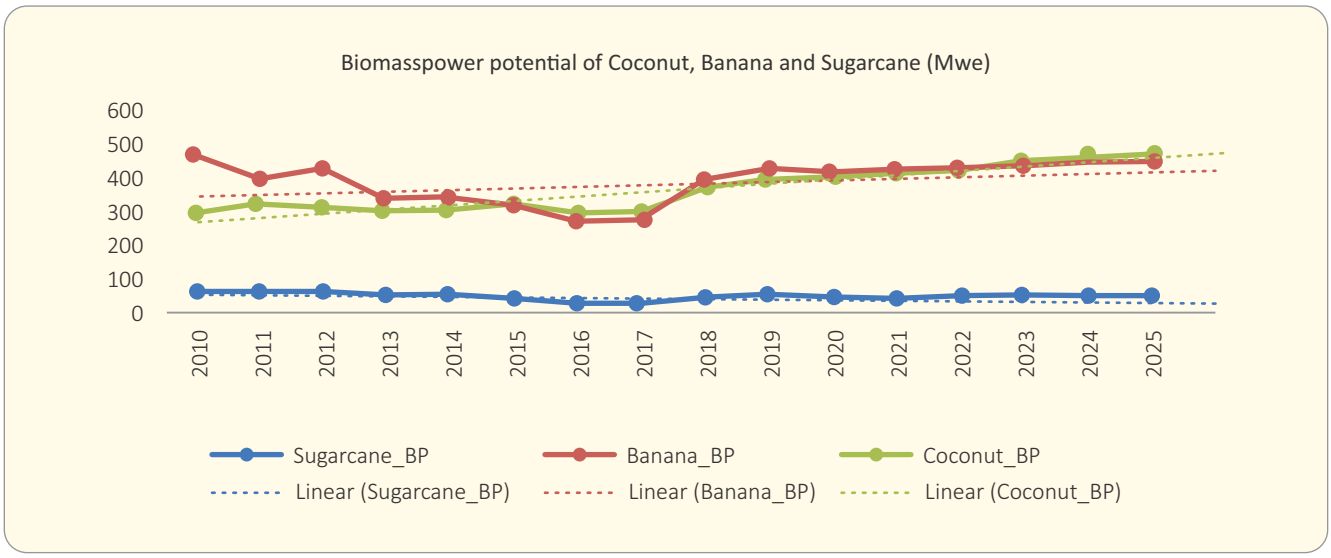


Figure 156: Biomass Power Potential for Coconut, Banana and Sugarcane in Tamil Nadu

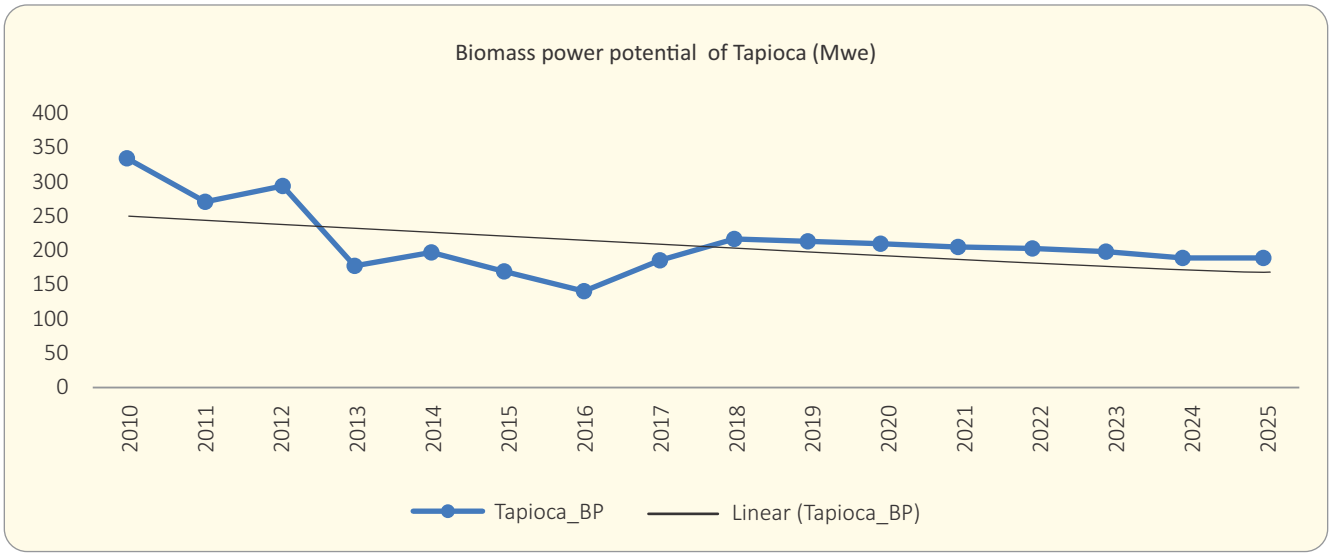


Figure 157: Biomass Power Potential for Tapioca in Tamil Nadu

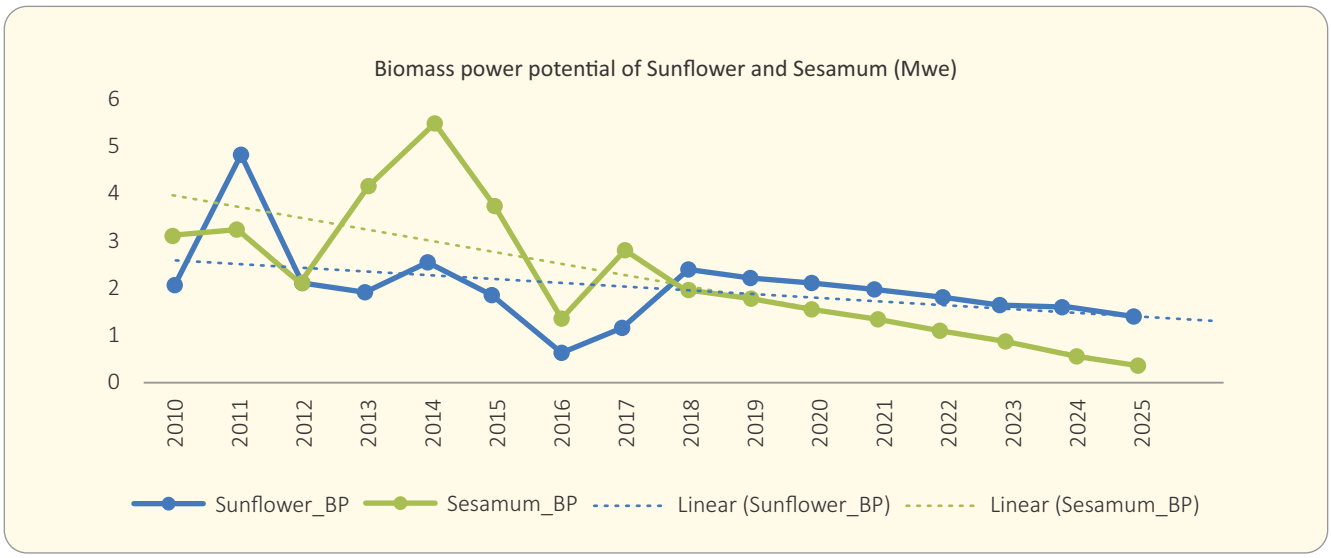


Figure 158: Biomass Power Potential for Sunflower and Sesamum in Tamil Nadu

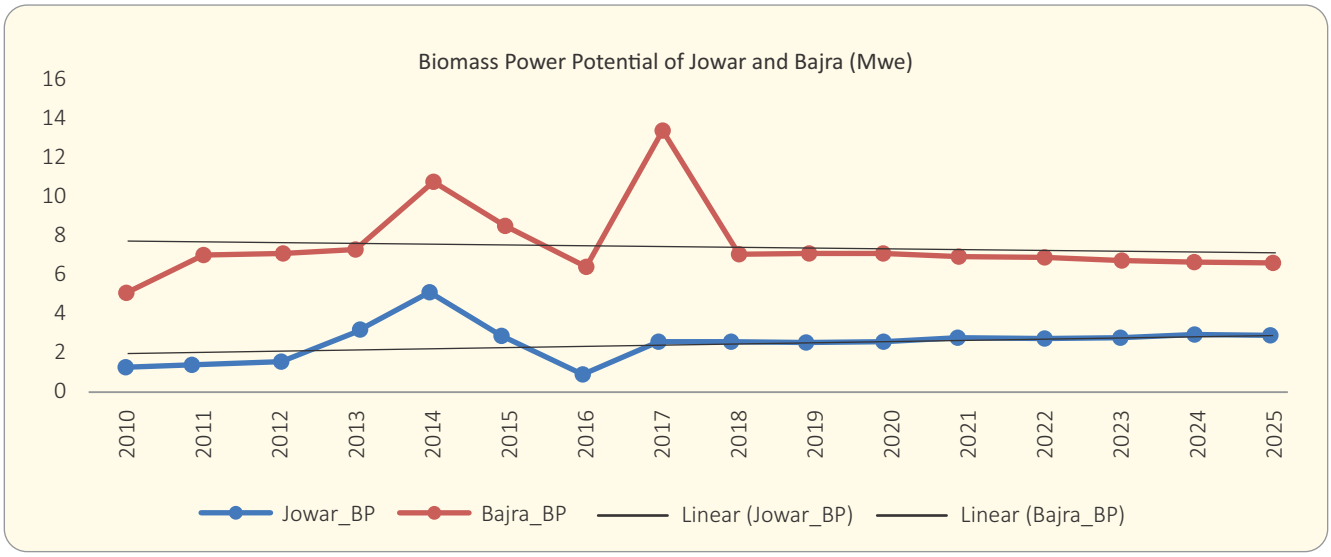


Figure 159: Biomass Power Potential for Jowar and Bajra in Tamil Nadu

Telangana

Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Telangana collected information and samples from all eleven (11) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Andhra Pradesh. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 1678.36 MWe and for 2019-20 is 1342.80 MWe.

Districts Selected for Primary Field Survey	11 (Sangareddy, Vikarabad, Nalgonda, Mahabubnagar, Jangaon, Nizamabad, Jayashankar Bhupalapally, Mahabubabad, Nagarkurnool, Kamareddy and Wanaparthy)
Average Rainfall	961 mm
Type of soil	Red and Black Soil, Loamy Soil, Medium Black, Sandy Loamy Soil, Red Sandy and Clay Loamy
Major source of irrigation	Canals, Tube wells and River
Major Rivers	Akeru, Palleru, Krishna,Manjira, Halla, Munsi, Nagarjuna Sagar, Nizam Sagar, Godavari
Major Crops	Arhar, Cotton, Dry chillies, Groundnut, Maize, Moong (Green Gram), Rice and Soyabean

Utilization of Crop residue at farmer's level in Telangana:

1. **Essential Usage** Residue of Arhar, Gram, Groundnut, Maize, Moth and Urad are extensively used for cattle feeding. Some parts of the residue of cotton, Gram, Groundnut, and Maize are utilized for the preparation of compost manure.
2. **Fuel Usage**: for domestic cooking, farmers are using the residue of paddy, Rapeseed & mustard Soyabean and Wheat
3. **Field preparation**: Residue of Paddy & Wheat are burnt in an open field.
4. **Commercial** Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	-	-
Expected Cost against the sale of crop residue in Future	Paddy	5000
	Rapeseed & Mustard	4000
	Wheat	6000

Survey Images:

Kohi, Nagireddypally, Sangareddy, Telangana

Bhiknur, Kamareddy, Telangana

Sonpeth, Nizamabad, Telangana

Table 97: Crop-wise change in Area, Production and Biomass Potential in Telangana

Crops	2014-16				
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
Rice	2132533.33	7223828.00	10835742.00	1368725.31	186.42
Wheat	7595.67	13291.33	23924.40	4784.88	0.65
Maize	1022943.33	3406373.67	7834659.43	2350397.83	274.53
Ragi	1427.67	1459.17	1896.92	189.69	0.02
Small Millets	1608.50	1392.00	1670.40	167.04	0.02
Bajra	21637.67	19477.17	51224.95	9696.15	1.18
Jowar	116302.67	117395.00	281748.00	28174.80	3.50
Moong (Green Gram)	181959.00	108643.50	135804.38	40741.31	5.20
Gram	125179.00	146328.00	160960.80	34491.60	4.50
Arhar/Tur	432144.33	262366.50	734626.20	202022.21	24.36
Masoor	50.00	18.50	33.12	16.56	0.00
Urad	66804.83	49572.00	64443.60	32221.80	2.94
Cowpea	11430.67	14362.67	15798.93	3159.79	0.42
Horse Gram	2537.17	999.83	1299.78	129.98	0.02
Other Kharif Pulses	123.00	56.00	72.80	14.56	0.00
Other Rabi Pulses	101.50	123.00	159.90	15.99	0.00
Sunflower	14873.50	21241.67	42483.33	38235.00	4.21
Linseed	26.00	10.50	15.54	3.11	0.00
Rapeseed & Mustard	1809.50	2813.50	5064.30	2532.15	0.33
Sesamum	29796.67	16063.67	40159.17	16063.67	1.98
Groundnut	231176.00	449455.50	1033747.65	103374.77	12.60
Safflower	6244.33	4132.17	12396.50	2479.30	0.27
Castor Seed	63349.17	33440.67	137106.73	82264.04	10.30
Other Oilseeds	3705.50	87789.50	175579.00	175579.00	16.61
Soyabean	367453.67	412692.33	701576.97	50864.33	6.36
Turmeric	65943.33	363859.67	109157.90	65494.74	8.71
Coriander	3914.50	1717.00	1974.55	987.28	0.13
Garlic	366.00	1106.00	331.80	331.80	0.04
Dry Chillies	144906.83	524978.33	787467.50	629974.00	81.71
Ginger	3347.83	23515.00	1175.75	1175.75	0.15
Banana	2526.67	115200.33	345601.00	76032.22	10.09
Cashewnut	4167.33	2232.33	5134.37	5134.37	0.83
Coconut	439.00	1853.02	3145.76	2831.19	0.39
Sweet Potato	146.50	1485.83	148.58	89.15	0.01
Cotton	2105578.67	813677.52	9791289.47	8322596.05	1006.20
Tobacco	2132533.33	28522.50	28522.50	28522.50	3.79
Mesta	177.00	225.90	463.10	231.55	0.03
Sugarcane	48648.50	3674673.83	183733.69	45933.42	6.25

Crops	2014-16				
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
Potato	4937.33	55514.50	44966.75	29678.05	2.76
Onion	22636.00	566613.17	28330.66	6232.74	0.85
Total	**9383081.50**	**18568500.77**	**33623638.17**	**13761589.65**	**1678.36**

Table 98: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Telangana in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	1931772.0	6668944.0	10003416.0	1300444.1	176.9
2	Wheat	4844.0	9093.0	16367.4	3273.5	0.4
3	Jowar	56079.0	67511.0	162026.4	16202.6	2.0
4	Bajra	7978.0	3964.0	10425.3	1980.8	0.2
5	Maize	543066.0	2082991.0	4790879.3	1437263.8	168.0
6	Green Gram (Moong)	72291.0	47608.0	59510.0	17853.0	2.3
7	Black Gram (Urad)	32072.0	30456.0	39592.8	19796.4	1.8
8	Gram	104391.0	163835.0	180218.5	37845.9	5.0
9	Arhar/Tur	296113.0	191397.0	535911.6	150055.2	18.2
10	Groundnut	126512.0	315136.0	724812.8	72481.3	8.8
11	Soyabean	148113.0	234599.0	398818.3	27917.3	3.5
12	Sunflower	2538.0	4976.0	9952.0	8956.8	1.0
13	Caster Seed	19952.0	15157.0	62143.7	37286.2	4.7
14	Sesamum	17663.0	11963.0	29907.5	11963.0	1.5
15	Cotton	1839735.0	654047.1	8429896.7	7165412.2	867.0
16	Sugarcane	39824.0	3169577.0	158478.9	39619.7	5.4
17	Tobacco	4041.0	12555.0	12555.0	12555.0	1.7
18	Banana	1518.0	93466.0	280398.0	61687.6	8.2
19	Cashewnut	1509.0	371.0	853.3	853.3	0.1
20	Dry chillies	144906.8	524978.3	787467.5	496104.5	64.3
21	Ginger	1623.0	11221.0	561.1	561.1	0.1
22	Potato	1947.0	36040.0	29192.4	19267.0	1.8
	Total	**5398487.8**	**14349885.5**	**26723384.4**	**10939380.2**	**1342.8**

Major contributing crops in biomass power potential in Telangana (2019-20) is Cotton with 867.0 MWe followed by Rice (176.9 MWe), Maize (168 MWe), Dry Chillies (64.3 MWe) and Arhar/Tur (18.2 MWe)

Trend Analysis for Biomass power potential for the state of Telangana – Crop-wise

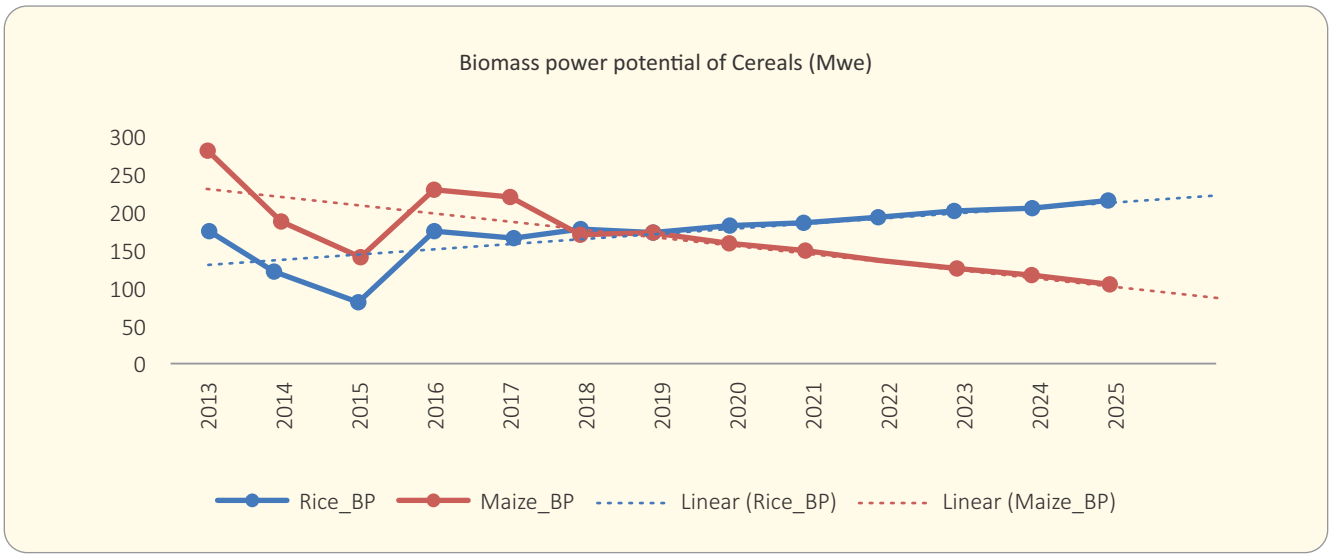


Figure 160: Biomass Power Potential for Cereals in Telangana

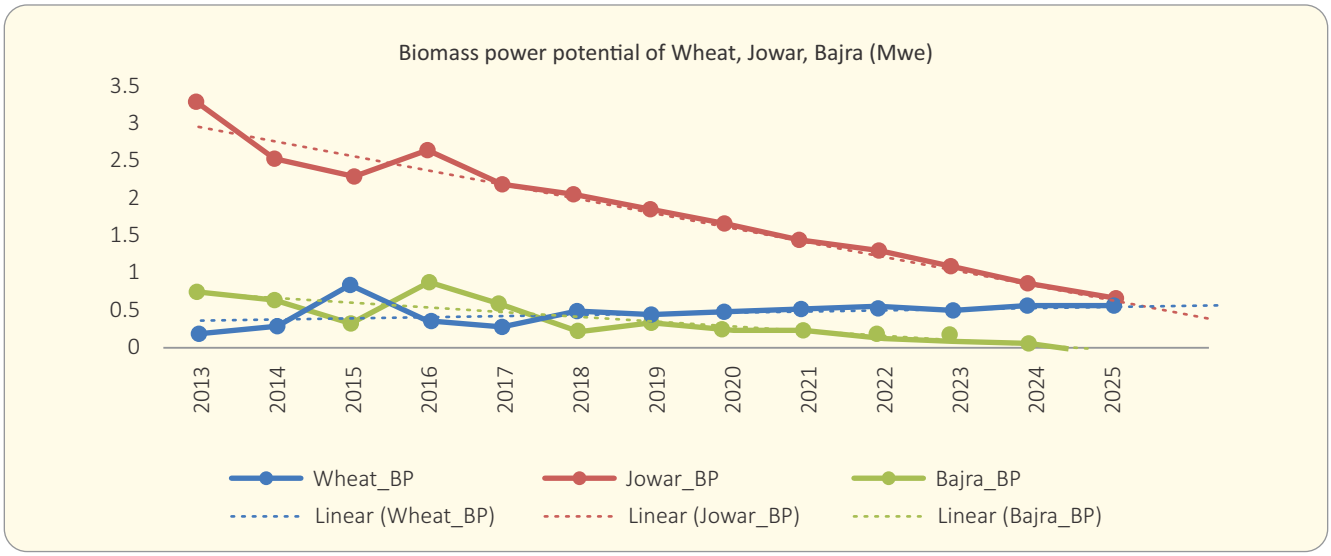


Figure 161: Biomass Power Potential for Wheat, Jowar and Bajra in Telangana

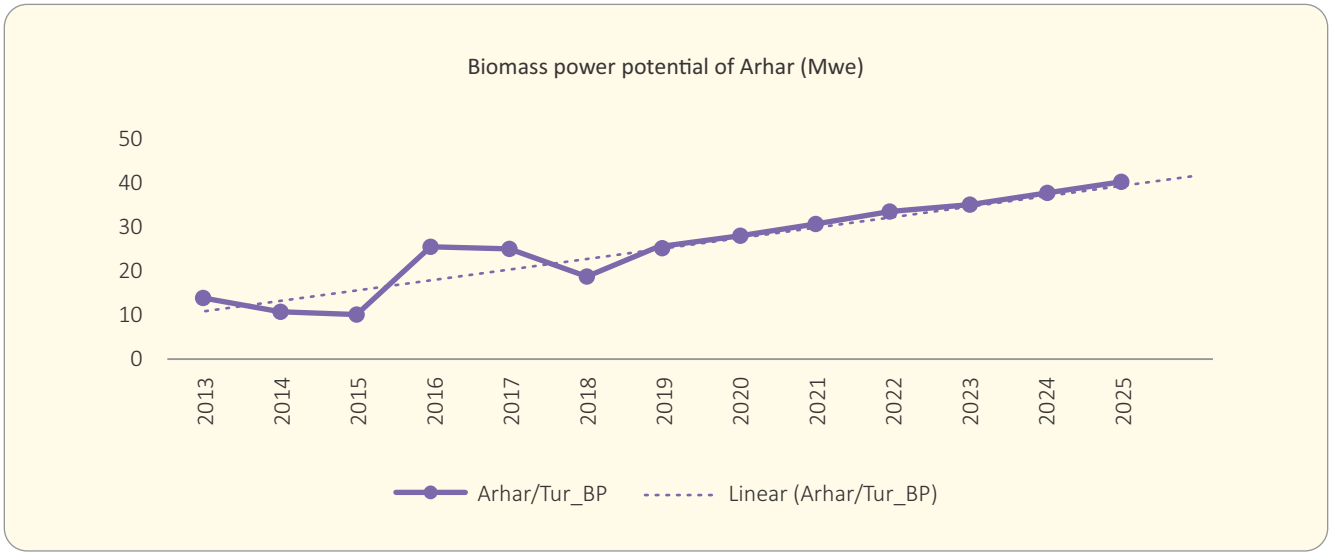


Figure 162: Biomass Power Potential for Arhar in Telangana

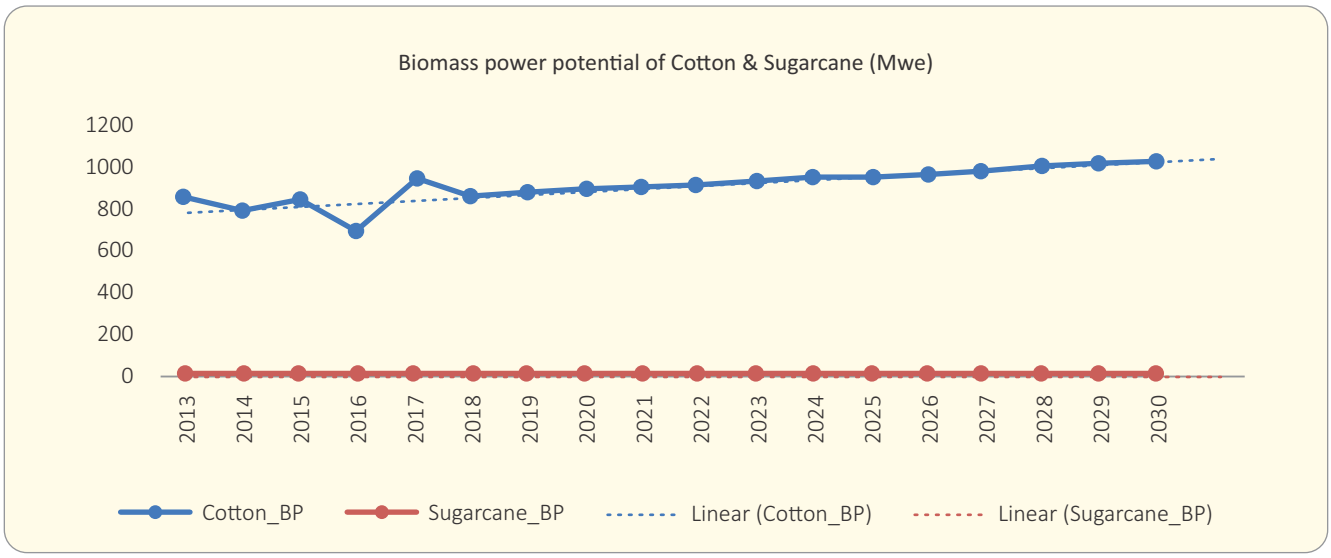


Figure 163: Biomass Power Potential for Cotton and Sugarcane in Telangana

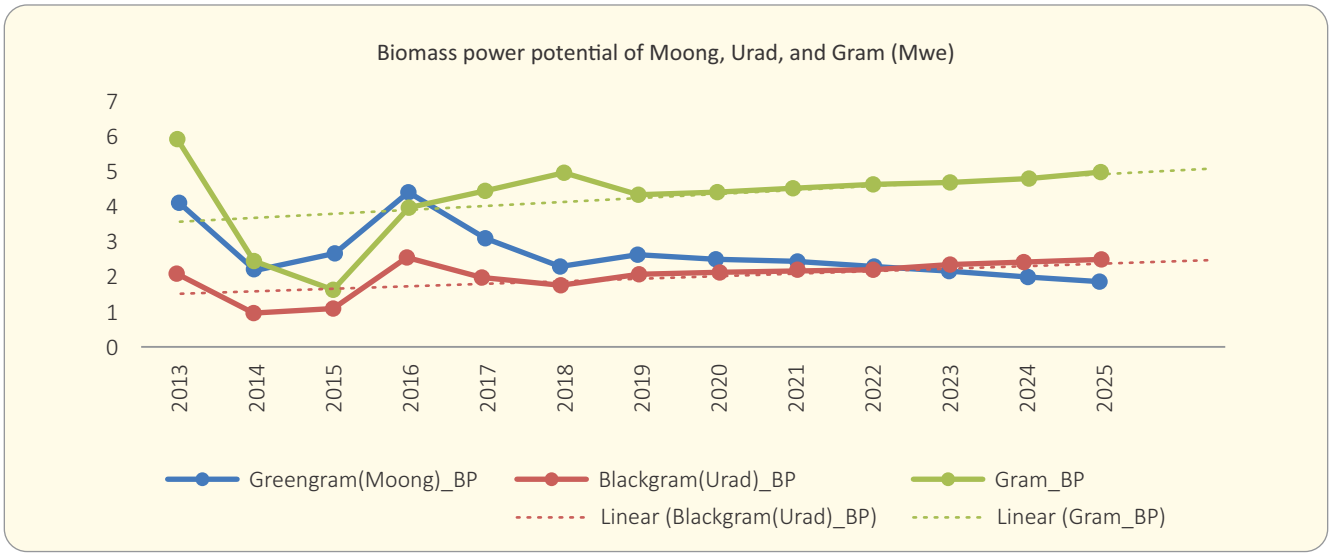


Figure 164: Biomass Power Potential for Moong, Urad and Gram in Telangana

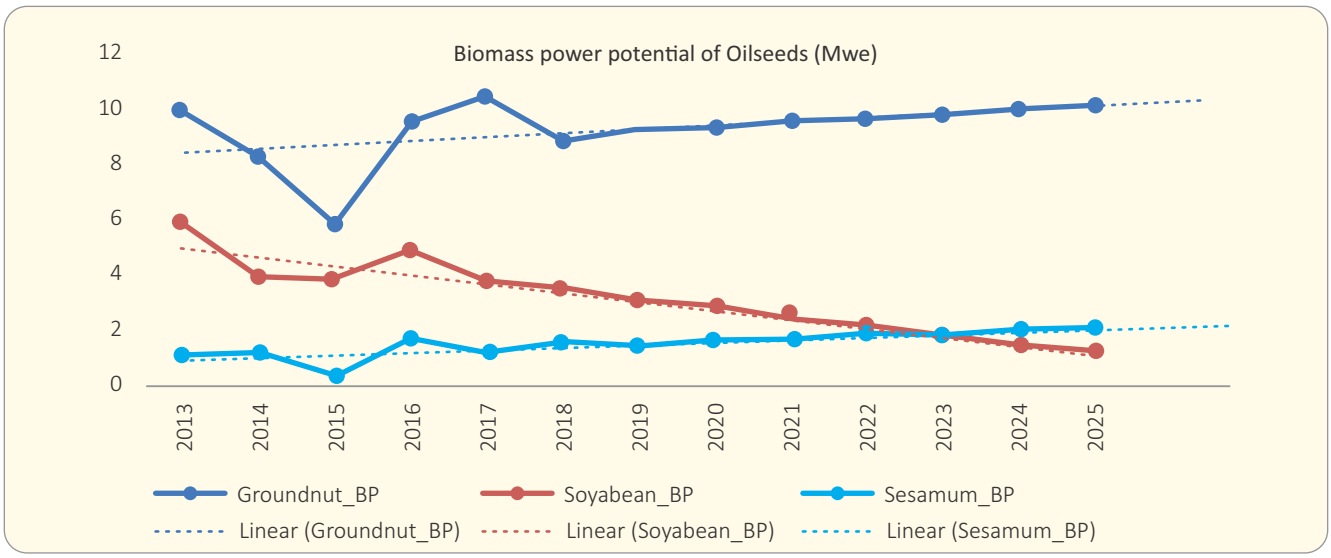


Figure 165: Biomass Power Potential for Oilseeds in Telangana

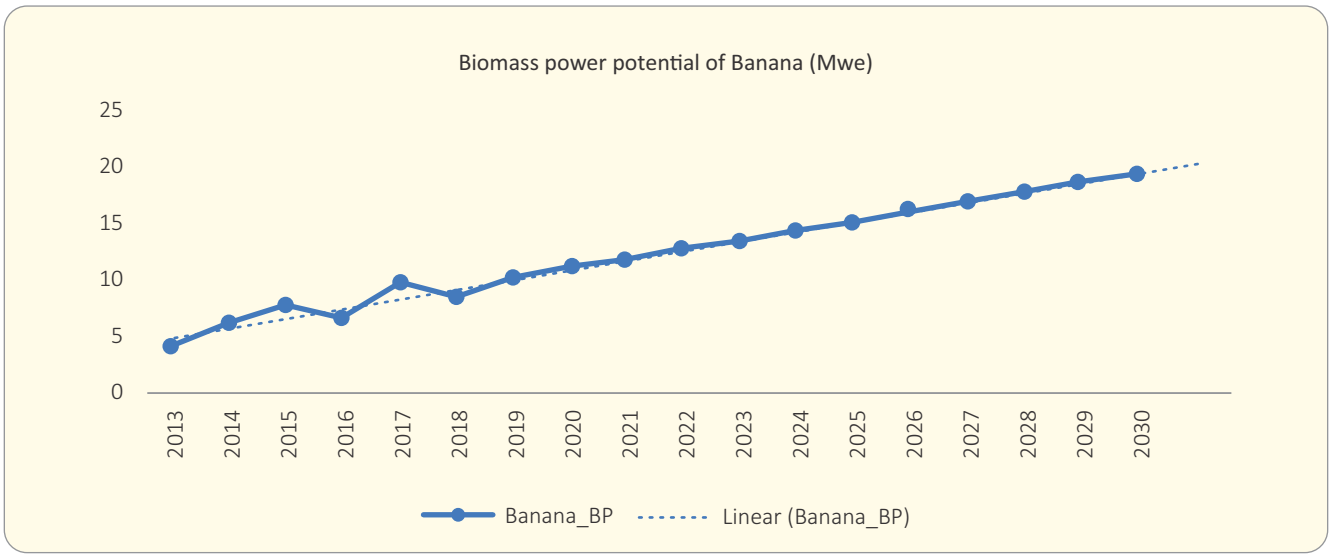


Figure 166: Biomass Power Potential for Banana in Telangana

Uttar Pradesh

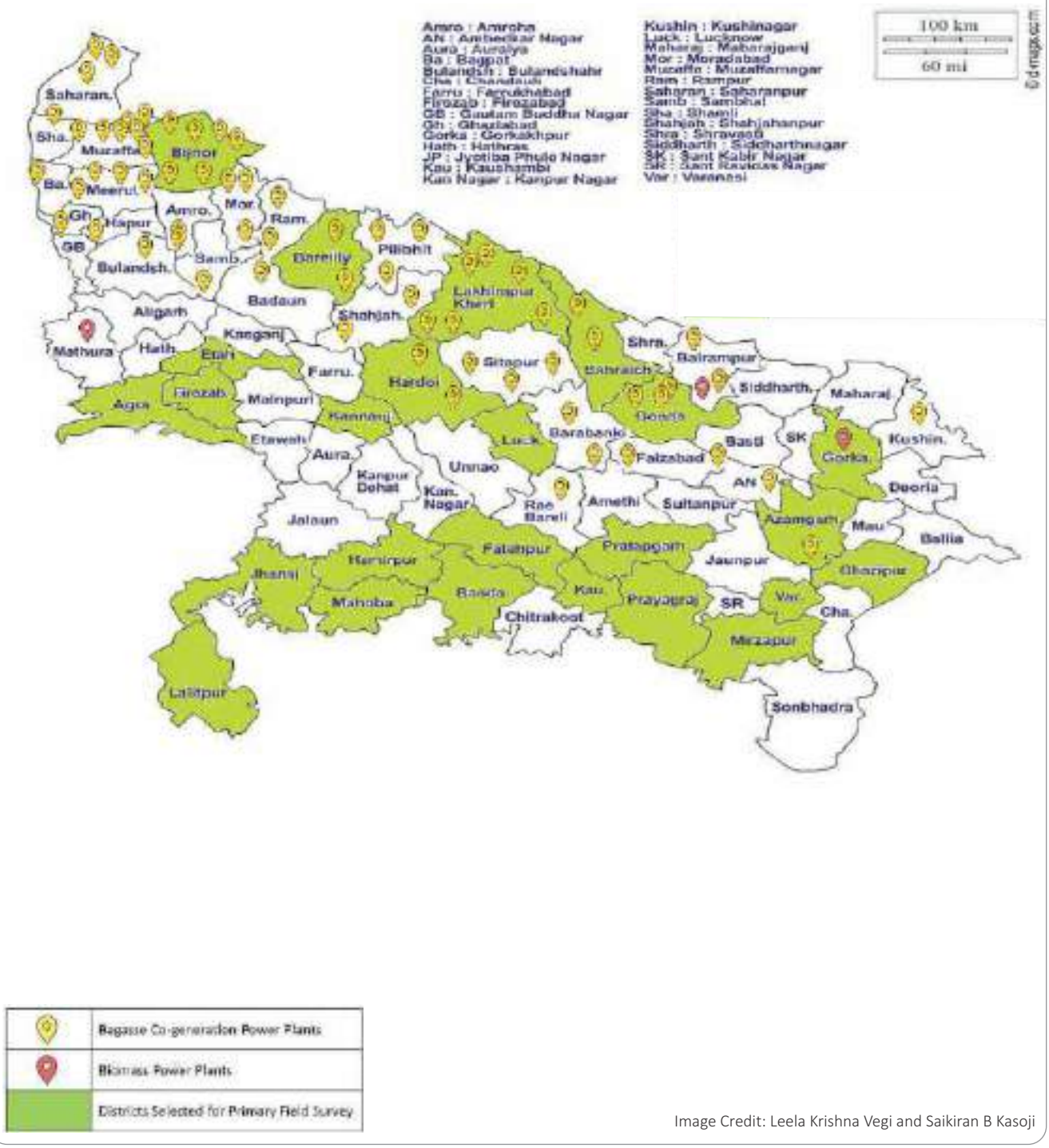


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter-02, based on secondary data, the survey teams in Uttar Pradesh collected information and samples from all twenty-five (25) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Uttar Pradesh was calculated, which was the input to arrive at biomass power potential in Uttar Pradesh. Thus, the total biomass power potential for the state of Uttar Pradesh for 2018 was 2800.31 MWe and for 2019-20 is 2636.15 MWe.

Districts Selected for Primary Field Survey	25 (Agra, Allahabad, Azamgarh, Bahraich, Banda, Bareilly, Bijnor, Etah, Fatehpur, Firozabad, Hardoi, Hamirpur, Jhansi, Ghazipur, Gonda, Gorakhpur, Kheri, Kaushambi, Lalitpur, Lucknow, Kannauj, Mahoba, Mirzapur, Pratapgarh
Average Rainfall	1025 mm
Type of soil	Alluvial Soil
Major source of irrigation	Canals, Tube well
Major Rivers	Betwa,Dhasan, Ganga, Ghagra, Gomati, Ramganga, Yamuna
Major Crops	Arhar, Bajra, Maize, Rapeseed &Mustard, Urad, Potato, Gram, Masoor, Peas & beans (Pulses), Sesamum, Jowar, Barley, Groundnut, Moong (Green Gram), Garlic, Tobacco, Onion, Rice, Wheat

Utilization of Crop residue at farmer's level in Uttar Pradesh:

1. **Essential Usage**: The residue of Rice and Moong are generally used for cattle feeding. The residue of Rice, Moong, and oilseed are utilized for compost fertilizer
2. **Specific Usage**: Arhar stalk is also used for the construction of small huts. The residue of Soyabean is also used for fuel for making bricks in a brick kiln. Sugarcane top leaves are used for cattle feeding, and bagasse's are used for energy generation in the sugar mills. The residue of Banana is utilized for Organic Mushroom production
3. **Fuel Usage**: Stalk of Arhar, Cotton and Mustard are used for domestic cooking.
4. **Field preparation**: Residue of garlic and stalks of Cotton, Rapeseed & Mustard, Rice and Wheat are mostly burnt in an open field.
5. **Commercial** Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	2000 - 3000
Expected Cost against the sale of crop residue in Future	Paddy	5000 - 6000
	Rapeseed & Mustard	5000 - 6000
	Wheat	6000 - 10000

Survey Images:

Bahaurgarh, Etah, Uttar Pradesh

Mahammadpur, Firozabad, Uttar Pradesh

Paliya, Azamgarh, Uttar Pradesh

Table 99: Crop-wise change in Area, Production and Biomass Potential in Uttar Pradesh

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	5888054.00	12000695.50	18001043.25	900052.16	122.41	5946702.00	15336758.50	23005137.75	1035231.20	141.00	15.19
Wheat	9275187.00	26558898.33	47806017.00	9561203.40	1290.76	9831251.33	36218923.67	65194062.60	13038812.52	1760.24	36.37
Maize	836674.33	1193372.00	2744755.60	27447.56	3.21	755766.33	1552755.33	3571337.27	35713.37	4.17	29.95
Barley	173477.33	363418.67	472444.27	47244.43	5.48	154960.67	439541.67	571404.17	57140.42	6.63	20.95
Small Millets	14807.50	9073.33	10888.00	1088.80	0.14	8245.33	5464.00	6556.80	655.68	0.08	-40.99
Bajra	857038.00	1308628.33	3441692.52	344169.25	41.99	903372.17	1770585.00	4656638.55	465663.86	56.62	34.85
Jowar	212561.00	202796.33	486711.20	97342.24	12.07	169417.83	196980.83	472754.00	94550.80	11.74	-2.71
Moong (Green Gram)	63580.00	31425.50	39281.88	11784.56	1.51	90534.67	51376.83	64221.04	19266.31	2.46	62.93
Urad	405195.00	203858.00	265015.40	212012.32	19.29	608639.83	331175.83	430528.58	344422.87	31.38	62.66
Masoor	547898.00	420410.67	752535.09	376267.55	38.76	483016.67	486001.17	869942.09	434971.04	44.89	15.81
Gram	578031.67	479449.00	527393.90	158218.17	20.73	545346.50	644745.00	709219.50	212765.85	27.77	33.94
Arhar/Tur	363226.17	306710.33	858788.93	738558.48	89.37	290848.50	322718.17	903610.87	778699.95	93.91	5.08
Peas & Beans (Pulses)	351030.00	423753.00	211876.50	105938.25	13.14	342059.67	507901.33	253950.67	126975.33	15.74	19.82
Soyabean	7776.33	6670.50	11339.85	1927.77	0.24	15836.67	12882.00	21899.40	3722.90	0.47	93.90
Rapeseed & Mustard	627655.00	691903.00	1245425.40	622712.70	81.58	707069.33	973256.67	1751862.00	875931.00	114.75	40.66
Linseed	31740.00	11167.33	16527.65	3305.53	0.33	28859.33	16962.83	25104.99	5021.00	0.51	53.67
Groundnut	101580.67	68918.17	158511.78	31702.36	3.87	94492.00	91687.33	210880.87	42176.17	5.14	32.85
Sunflower	13704.67	22232.50	44465.00	40018.50	4.40	2923.33	3765.00	7530.00	6777.00	0.75	-83.06
Sesamum	161948.67	26293.67	65734.17	1972.03	0.24	292262.50	71450.33	178625.83	5656.48	0.70	189.89
Sannhamp	3190.00	886.33	2233.56	446.71	0.06	2155.67	452.00	1139.04	227.81	0.03	-52.92
Garlic	32726.00	168913.00	50673.90	50673.90	6.89	35196.00	206136.50	61840.95	61840.95	8.39	21.71
Ginger	927.50	2475.00	123.75	40.84	0.01	901.00	3980.00	199.00	65.67	0.01	-16.53
Dry Chillies	15292.50	14987.50	22481.25	17985.00	2.34	13415.50	12374.50	18561.75	14849.40	1.93	-17.69
Turmeric	1520.50	4942.00	1482.60	889.56	0.12	1320.50	1735.00	520.50	312.30	0.04	-65.39

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Coriander	5654.50	3326.50	3825.48	1912.74	0.24	6898.00	3597.50	4137.13	2068.56	0.26	9.29
Tobacco	24294.83	134826.83	134826.83	134826.83	17.93	26062.33	95311.67	95311.67	95311.67	12.68	-29.30
Potato	500502.00	10717568.67	8681230.62	1041747.67	96.88	573288.67	15340572.67	12425863.86	1475571.33	137.38	41.80
Onion	21669.17	290023.50	14501.18	3190.26	0.43	25612.67	357463.00	17873.15	3932.09	0.53	24.36
Sugarcane	2169895.33	122554112.33	6127705.62	1593203.46	216.68	2205976.00	171234413.00	8561720.65	2211777.83	300.80	38.82
Sweet potato	18589.17	244196.50	24419.65	14651.79	1.33	16004.50	178702.00	17870.20	10722.12	0.98	-26.64
Cotton	4473.50	178.22	17391.38	13913.10	1.68	5199.33	314.25	20448.81	16359.04	1.98	17.73
Guar Seed	2540.50	2132.50	4265.00	639.75	0.08	1966.00	1408.00	2816.00	433.66	0.05	-33.05
Banana	1991.00	75867.00	227601.00	50072.22	6.66	3376.00	186413.00	559239.00	123032.58	16.33	145.14
Total	**23314431.83**	**178544110.05**	**92473209.20**	**16207159.89**	**2100.84**	**24188976.83**	**246657804.58**	**124692808.67**	**21600658.78**	**2800.31**	**33.29**

Table 100: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Uttar Pradesh in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	5917933.2	15108395.5	22662593.3	1133129.7	154.1
2	Wheat	9947269.2	33875189.3	60975340.8	12195068.2	1647.6
3	Jowar	122469.4	143562.6	344550.2	68910.0	8.5
4	Bajra	1119378.9	2197757.2	5780101.6	578010.2	70.3
5	Barley	119985.5	337650.9	438946.1	43894.6	5.1
6	Maize	699498.6	1437767.7	3306865.8	33068.7	3.9
7	Green Gram (Moong)	97975.8	57437.9	71797.3	21539.2	2.7
8	Black Gram (Urad)	649950.0	361508.6	469961.1	375968.9	34.2
9	Peas & Beans	343922.2	442918.4	221459.2	110729.6	13.7
10	Gram	422848.6	404141.5	444555.7	133366.7	17.3
11	Tur (Arhar)	307565.4	268458.8	751684.7	646448.8	77.6
12	Lentil (Masur)	457701.3	413346.9	744024.4	372012.2	38.4
13	Groundnut	94320.4	88978.6	204650.7	40930.1	5.0
14	Soyabean	26489.7	19279.6	32775.3	5571.8	0.7
15	Rapeseed & Mustard	700622.5	885373.6	1593672.5	796836.3	104.4
16	Sesamum	417405.4	96637.6	241593.9	7247.8	0.9
17	Sunflower	1796.3	2573.4	5146.7	4632.1	0.5
18	Cotton	5583.0	171.2	21592.2	17273.8	2.1
19	Sugarcane	2241639.9	164297819.5	8214891.0	2135871.7	290.5
20	Tobacco	30582.4	122581.4	122581.4	122581.4	16.3
21	Guarseed	2774.0	2159.8	4319.7	648.0	0.1
22	Potato	627866.1	15723925.0	12736379.2	1528365.5	142.3
	Total	**24355577.7**	**236287634.9**	**119389482.7**	**20372105.03**	**2636.15**

Major contributing crops in biomass power potential in Uttar Pradesh (2019-20) is Wheat with 1647.6 MWe followed by Sugarcane (290.5 MWe), Rice (154.1 MWe), Potato (142.3 MWe) and Rapeseed & Mustard (104.4 MWe)

Trend Analysis for Biomass power potential for the state of Uttar Pradesh – Crop-wise

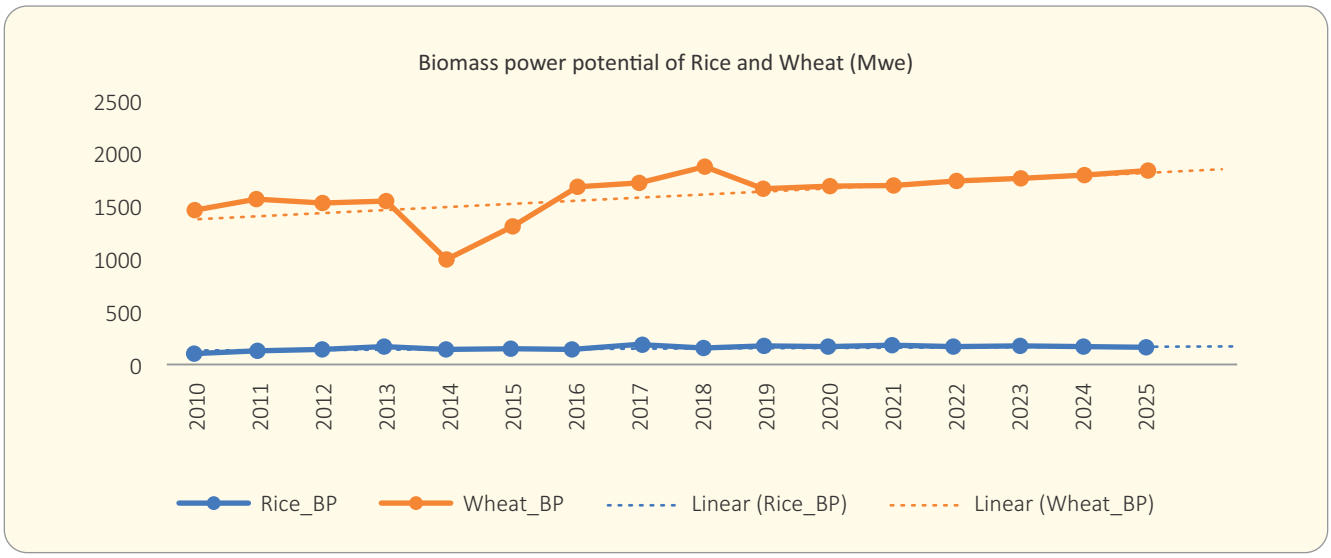


Figure 167: Biomass Power Potential for Rice and Wheat in Uttar Pradesh

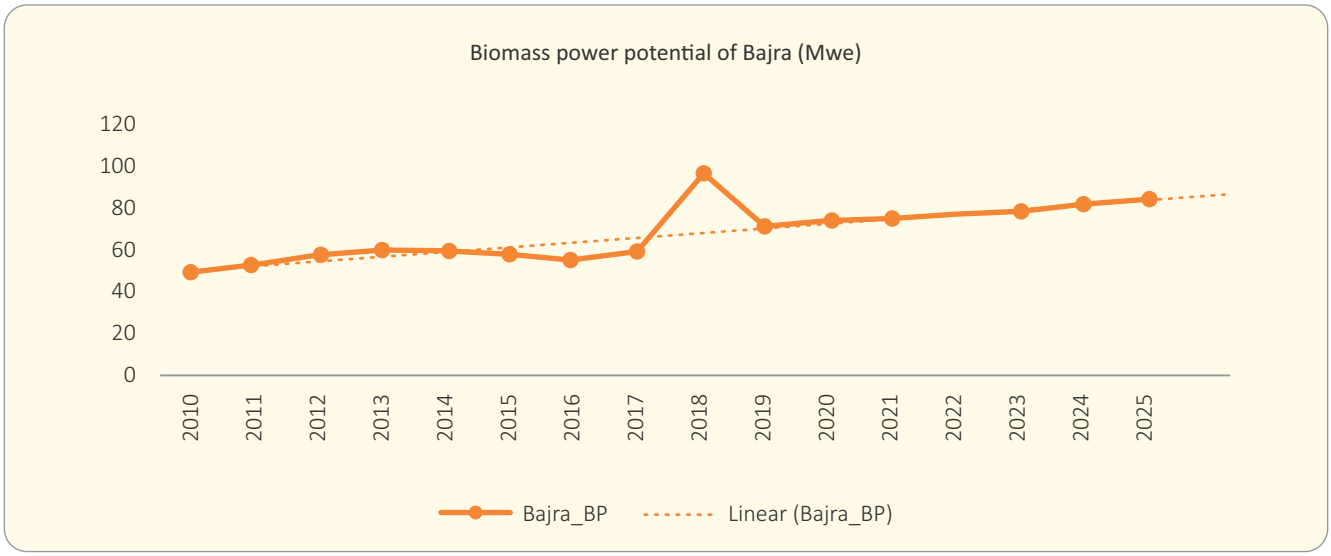


Figure 168: Biomass Power Potential for Bajra in Uttar Pradesh

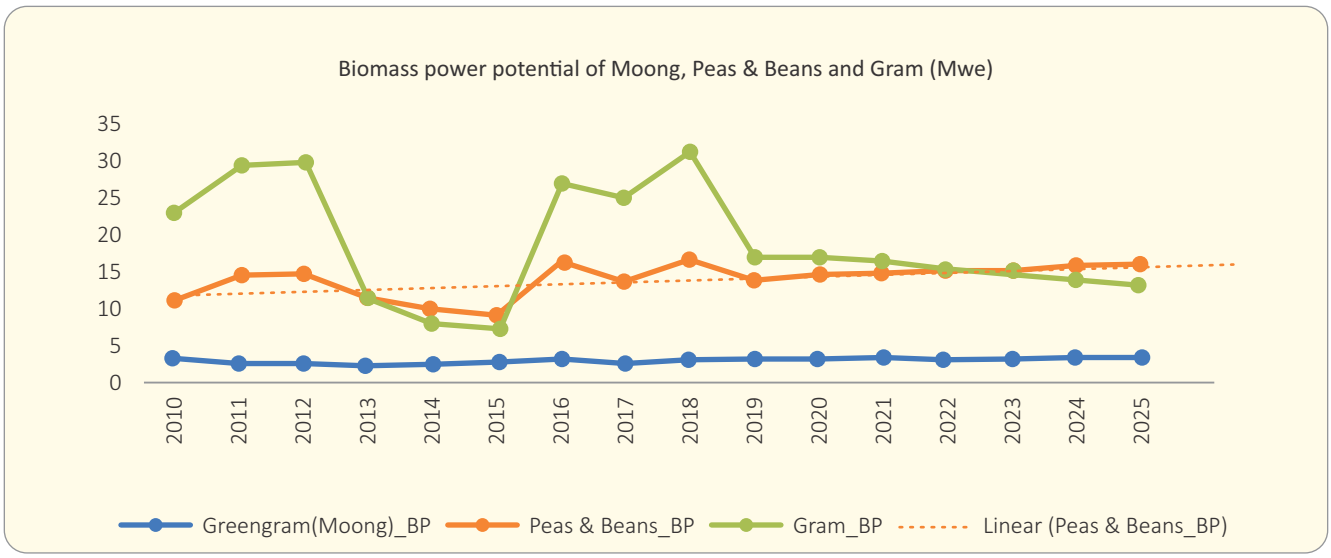


Figure 169: Biomass Power Potential for Moong, Peas & Beans and Gram in Uttar Pradesh

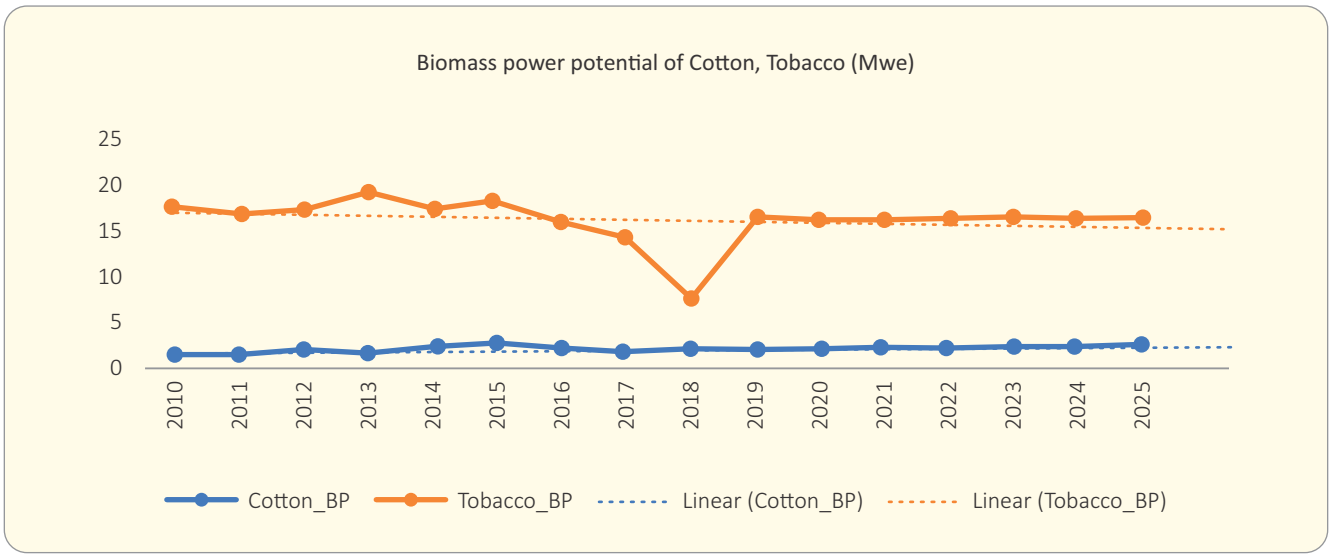


Figure 170: Biomass Power Potential for Cotton and Tobacco in Uttar Pradesh

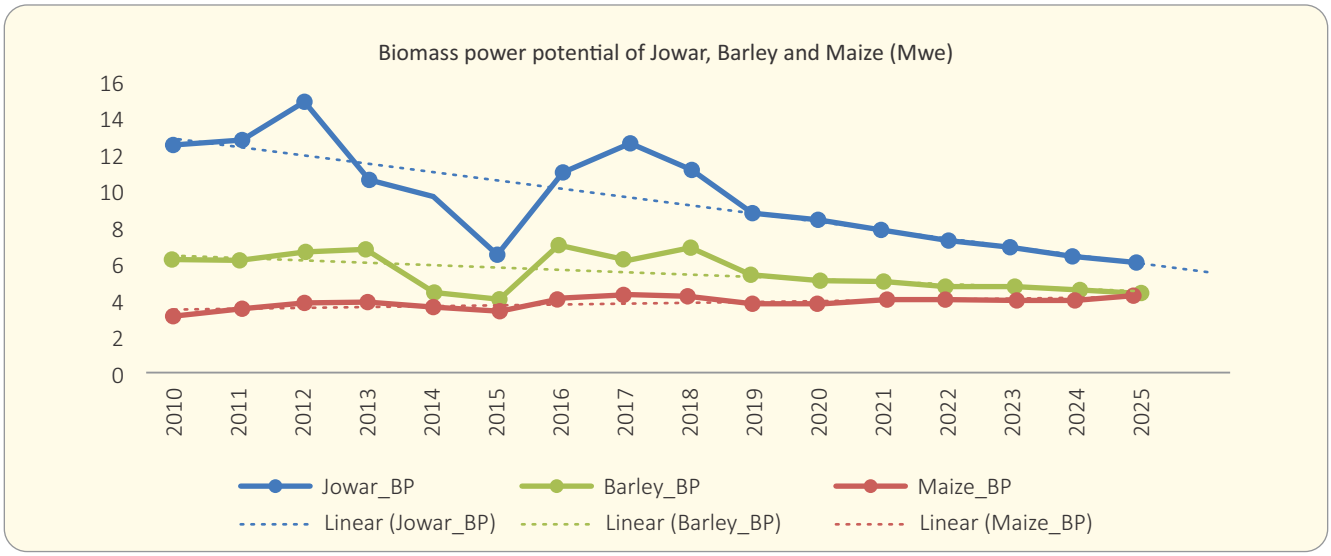


Figure 171: Biomass Power Potential for Jowar, Barley and Maize in Uttar Pradesh

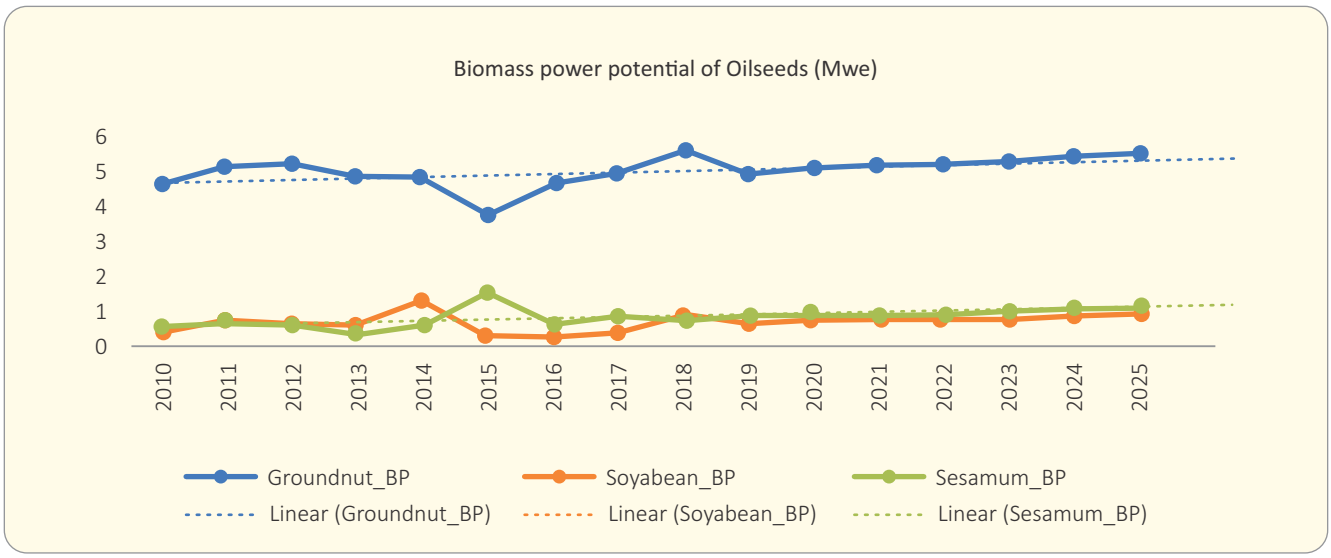


Figure 172: Biomass Power Potential for Oilseeds in Uttar Pradesh

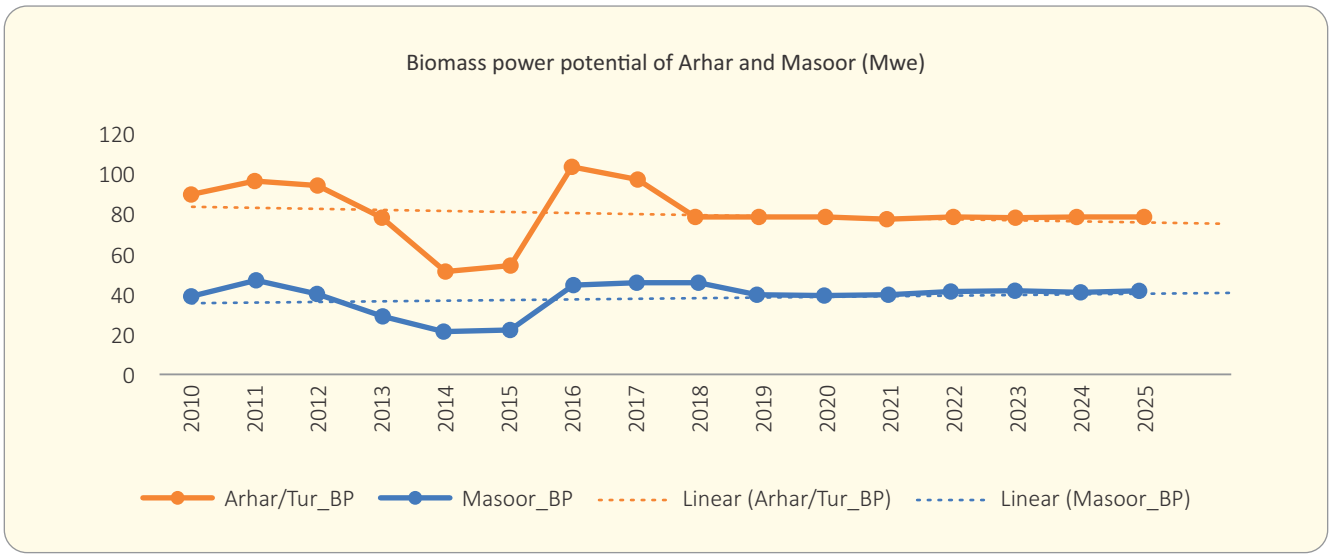


Figure 173: Biomass Power Potential for Arhar and Masoor in Uttar Pradesh

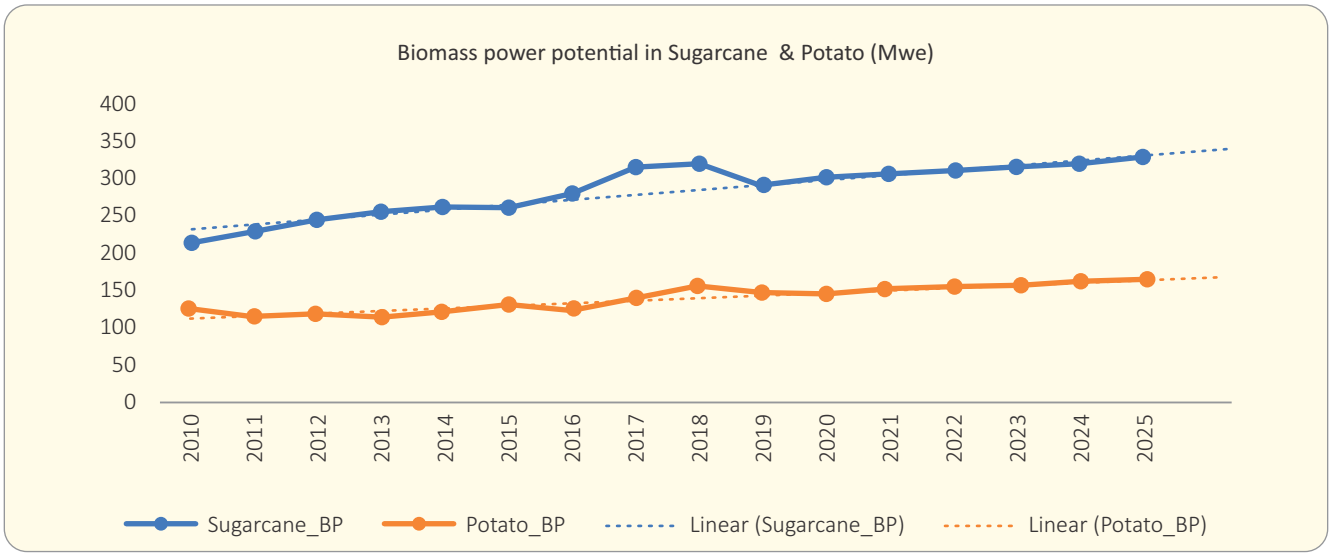


Figure 174: Biomass Power Potential for Sugarcane and Potato in Uttar Pradesh

Uttarakhand

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in Uttarakhand collected information and samples from all five (05) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Uttarakhand. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 93.34 MWe, and for 2019-20 is 89.23 MWe.

Districts Selected for Primary Field Survey	05 (Dehradun, Haridwar, Pauri Garhwal, Tehri Garhwal and Udham Singh Nagar)
Average Rainfall	Loamy Soil
Type of soil	Canals, Tube well
Major source of irrigation **Major Rivers**	Ganga, Ramganga
Major Crops	Rapeseed & Mustard, Rice, Sugarcane, Wheat

Utilization of Crop residue at farmer's level in Uttarakhand:

1. **Essential Usage**: The residue of Rice and Moong are generally used for cattle feeding. The residue of Rice, Moong, and oilseed are utilized for compost fertilizer
2. **Fuel Usage**: The residue of Rice, Soyabean, rapeseed and mustard and Wheat are also used for domestic cooking
3. **Field preparation**: In order to prepare the land for future sowing in a short duration and with less effort, the residue of crops like Rice, Wheat and Soyabean are burnt in an open field
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	2000 - 3000
Expected Cost against the sale of crop residue in Future	Paddy	5000 - 6000
	Rapeseed & Mustard	5000 - 6000
	Wheat	5000 - 6000

Survey Images:

Jakhlagga, Tehri Garhwal, Uttarkhand

Jalalpur, Haridwar, Uttarkhand

Chillarkhal, Kotdwar, Pauri, Uttarkhand

Table 101: Crop-wise change in Area, Production and Biomass Potential in Uttarakhand

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	292158.00	602656.83	903985.25	144637.64	19.67	263346.50	651584.50	977376.75	158307.50	21.56	9.62
Wheat	376623.33	788571.67	1419429.00	283885.80	38.32	334986.50	910792.00	1639425.60	327885.12	44.26	15.51
Maize	27537.33	38963.67	89616.43	17923.29	2.10	21327.00	39720.50	91357.15	18271.43	2.13	1.62
Barley	23793.33	24302.00	31592.60	3159.26	0.37	19525.00	25051.00	32566.30	3256.63	0.38	2.10
Ragi	122948.33	172321.67	224018.17	22401.82	2.78	103934.50	148119.00	192554.70	19255.47	2.39	-13.97
Small Millets	71050.00	84239.00	101086.80	10108.68	1.27	55313.50	74431.00	89317.20	8931.72	1.13	-11.39
Bajra	73.00	72.00	189.36	47.34	0.01	0.00	0.00	0.00	0.00	0.00	-100.00
Other Cereals	55384.50	63323.00	94984.50	9498.45	1.12	1917.50	1224.50	1591.85	159.19	0.02	-98.32
Moong (Green Gram)	69.17	30.33	37.92	11.38	0.00	31.50	17.00	21.25	6.38	0.00	0
Urad	12086.17	8580.83	11155.08	5577.54	0.51	12777.00	10075.50	13098.15	6549.08	0.60	16.98
Masoor	11512.33	4929.33	8823.51	4411.75	0.45	9895.50	7124.50	12752.86	6376.43	0.66	46.23
Horse Gram	9351.67	7056.33	9173.23	917.32	0.12	12245.00	10045.50	13059.15	1305.92	0.17	38.21
Gram	775.33	510.33	561.37	112.27	0.01	658.00	534.50	587.95	117.59	0.02	53.45
Moth	307.67	107.33	193.20	57.96	0.01	8.50	4.50	8.10	2.43	0.00	-97.17
Arhar/Tur	2389.33	1648.33	4615.33	3230.73	0.39	2999.50	2802.50	7847.00	5492.90	0.66	69.86
Peas & Beans (Pulses)	4140.67	3308.00	1654.00	827.00	0.10	4296.50	4126.50	2063.25	1031.63	0.13	27.92
Other Kharif Pulses	11973.00	8504.33	11055.63	2211.13	0.27	11988.50	11976.50	15569.45	3113.89	0.38	39.55
Other Rabi Pulses	171.17	133.50	173.55	17.36	0.00	28.00	22.50	29.25	2.93	0.00	0
Other Summer Pulses	1.00	1.00	1.30	0.26	0.00	12.00	7.00	9.10	1.82	0.00	0
Soyabean	9174.67	11900.67	20231.13	4046.23	0.51	10984.00	13185.50	22415.35	0.00	0.00	-100.00
Rapeseed & Mustard	12519.00	7730.67	13915.20	6957.60	0.91	13547.50	11330.00	20394.00	10197.00	1.34	46.79
Linseed	40.00	15.00	22.20	4.44	0.00	25.00	10.00	14.80	2.96	0.00	0
Groundnut	1576.83	1689.17	3885.08	777.02	0.09	872.00	1164.00	2677.20	535.44	0.07	-27.48
Sunflower	48.33	51.67	103.33	93.00	0.01	7.00	4.00	8.00	7.20	0.00	-92.08

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Sesamum	1998.33	452.00	1130.00	226.00	0.03	1876.00	553.50	1383.75	0.00	0.00	-100.00
Other Oilseeds	1560.50	808.83	1617.67	1617.67	0.15	446.50	266.00	532.00	532.00	0.05	-66.45
Garlic	817.33	1177.00	353.10	353.10	0.05	1827.00	3196.50	958.95	958.95	0.13	160.07
Ginger	1796.83	19170.00	958.50	316.31	0.04	2188.50	23146.50	1157.33	381.92	0.05	21.35
Dry Chillies	5671.00	2000.00	3000.00	2400.00	0.31	0.00	0.00	0.00	0.00	0.00	-100.00
Turmeric	219.67	448.00	134.40	80.64	0.01	844.00	1810.50	543.15	325.89	0.04	333.43
Tobacco	25.50	87.50	87.50	87.50	0.01	7.50	14.50	14.50	14.50	0.00	-80.72
Potato	14531.33	142624.67	115525.98	76247.15	7.09	13136.50	141843.00	114892.83	75829.27	7.06	-0.43
Onion	1987.00	9968.00	498.40	109.65	0.01	3528.50	43022.00	2151.10	473.24	0.06	543.61
Sugarcane	118197.83	6848620.83	342431.04	85607.76	11.64	91806.50	5915578.50	295778.93	73944.73	10.06	-13.60
Total	**1192509.50**	**8856003.50**	**3416239.77**	**687961.03**	**88.38**	**996387.00**	**8052783.50**	**3552156.94**	**723271.13**	**93.34**	**5.61**

Table 102: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Uttarakhand in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	259348.0	626533.0	939799.5	150367.9	20.5
2	Wheat	307452.0	927657.0	1669782.6	333956.5	45.1
3	Maize	21384.0	40273.0	92627.9	18525.6	2.2
4	Barley	18926.0	27023.0	35129.9	3513.0	0.4
5	Black Gram (Urad)	12540.0	10759.0	13986.7	6993.4	0.6
6	Peas & Beans	5552.0	5551.0	2775.5	1387.8	0.2
7	Gram	795.0	646.0	710.6	142.1	0.0
8	Tur (Arhar)	3199.0	2571.0	7198.8	5039.2	0.6
9	Lentil (Masur)	8981.0	7891.0	14203.8	7101.9	0.7
10	Sesamum	1848.0	550.0	1375.0	0.0	0.0
11	Groundnut	709.0	735.0	1690.5	338.1	0.0
12	Soyabean	9054.0	9681.0	16457.7	0.0	0.0
13	Rapeseed & Mustard	13144.0	12258.0	22064.4	11032.2	1.4
14	Sugarcane	92863.0	6459016.0	322950.8	80737.7	11.0
15	Ginger	2540.0	28133.0	1406.7	464.2	0.1
16	Potato	11925.0	129198.0	104650.4	69069.3	6.4
	Total	**770260.00**	**8288475.00**	**3246810.73**	**688668.74**	**89.23**

Major contributing crops in biomass power potential in Uttarakhand (2019-20) is Wheat with 45.1 MWe followed by Rice (20.5 MWe), Sugarcane (11.0 MWe), Potato (6.4 MWe) and Maize (2.2 MWe)

Trend Analysis for Biomass power potential for the state of Uttarakhand – Crop-wise

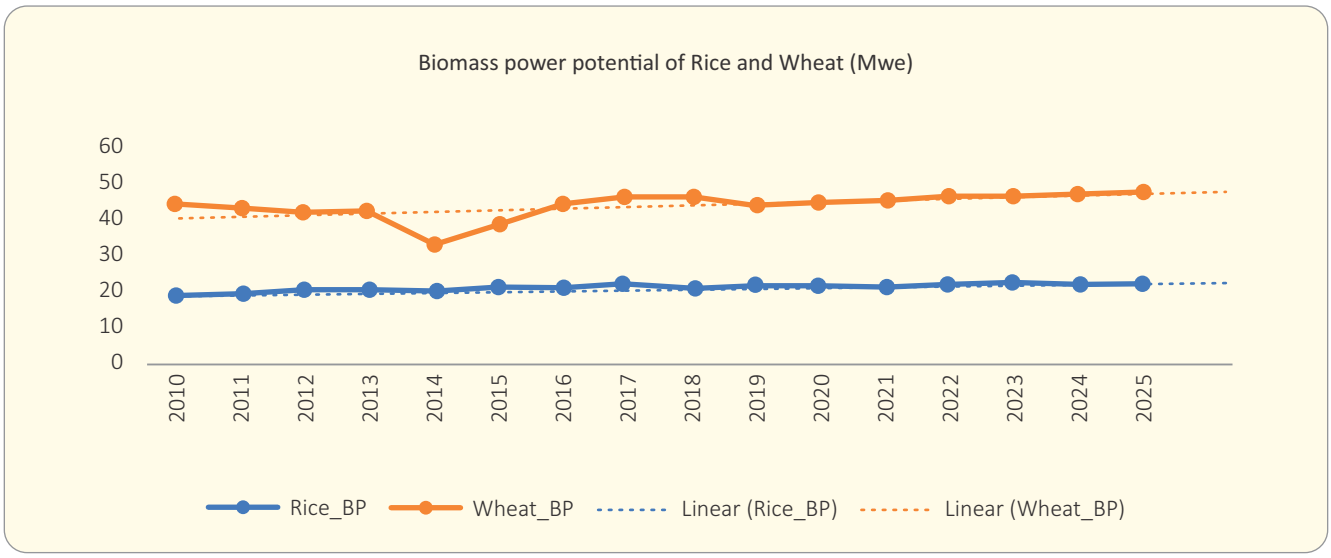


Figure 175: Biomass Power Potential for Rice and Wheat in Uttarakhand

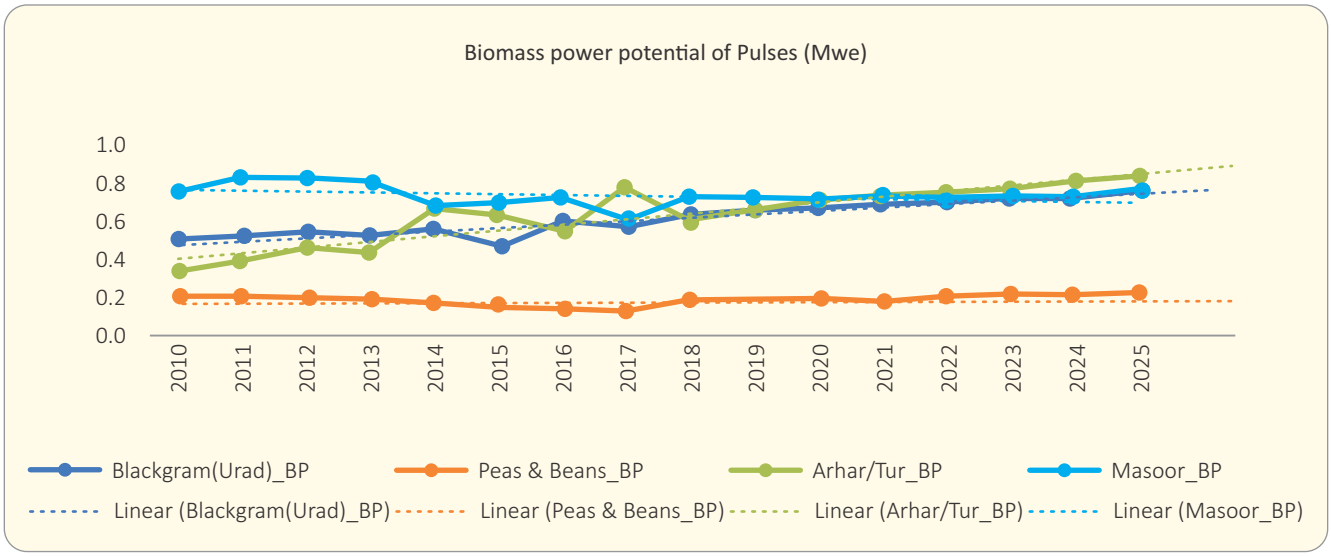


Figure 176: Biomass Power Potential for Pulses in Uttarakhand

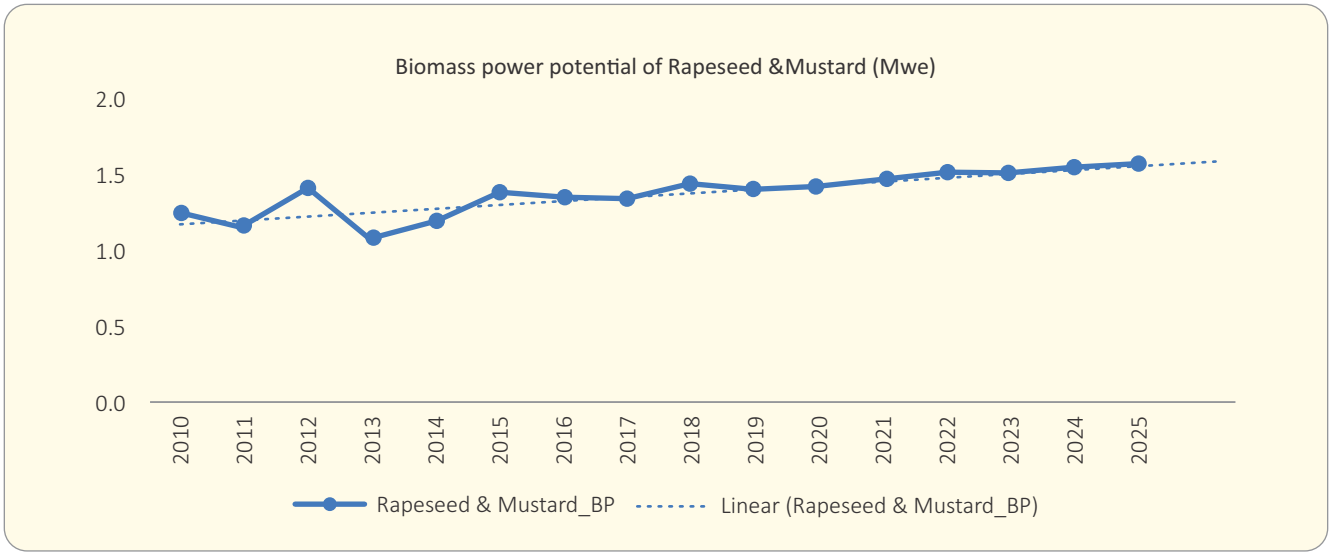


Figure 177: Biomass Power Potential for Rapeseed & Mustard in Uttarakhand

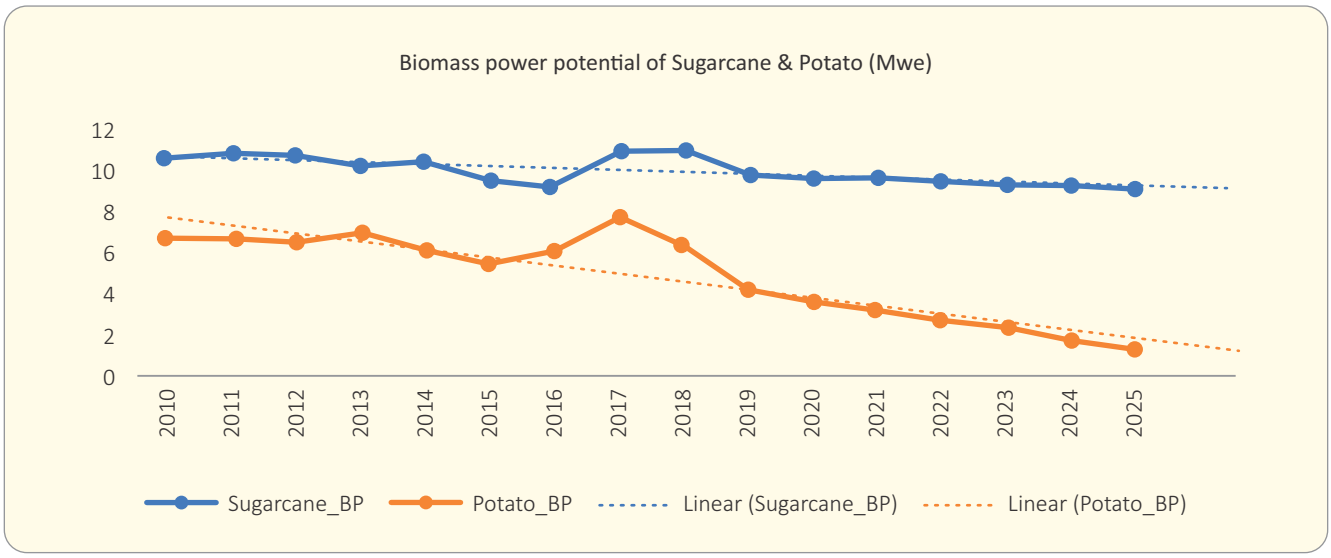


Figure 178: Biomass Power Potential for Sugarcane and Potato in Uttarakhand

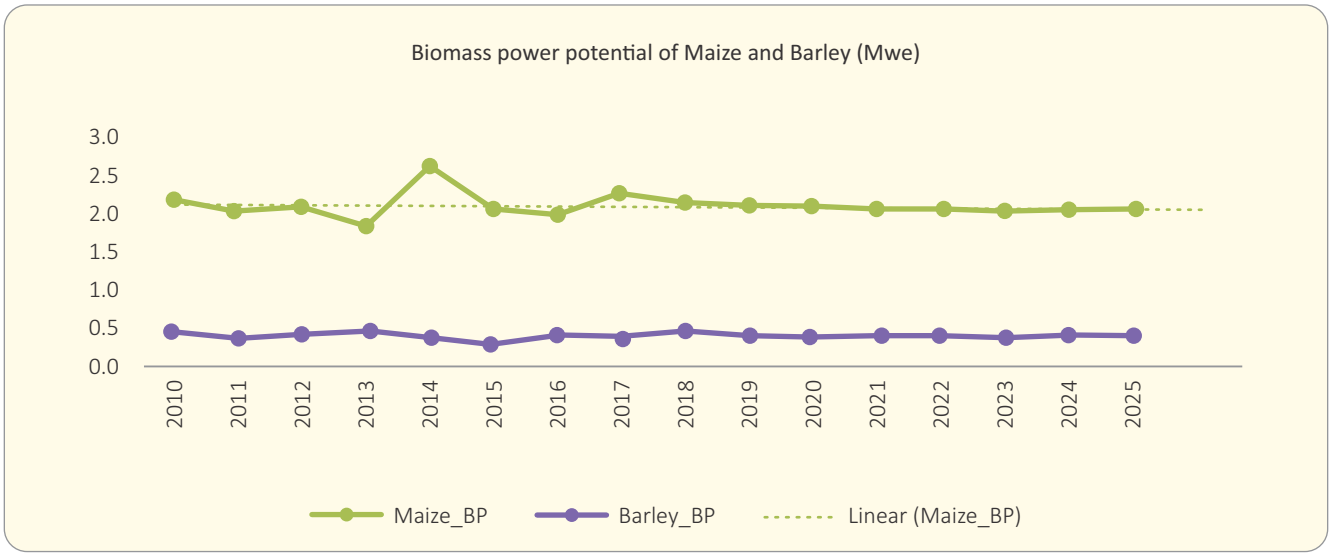
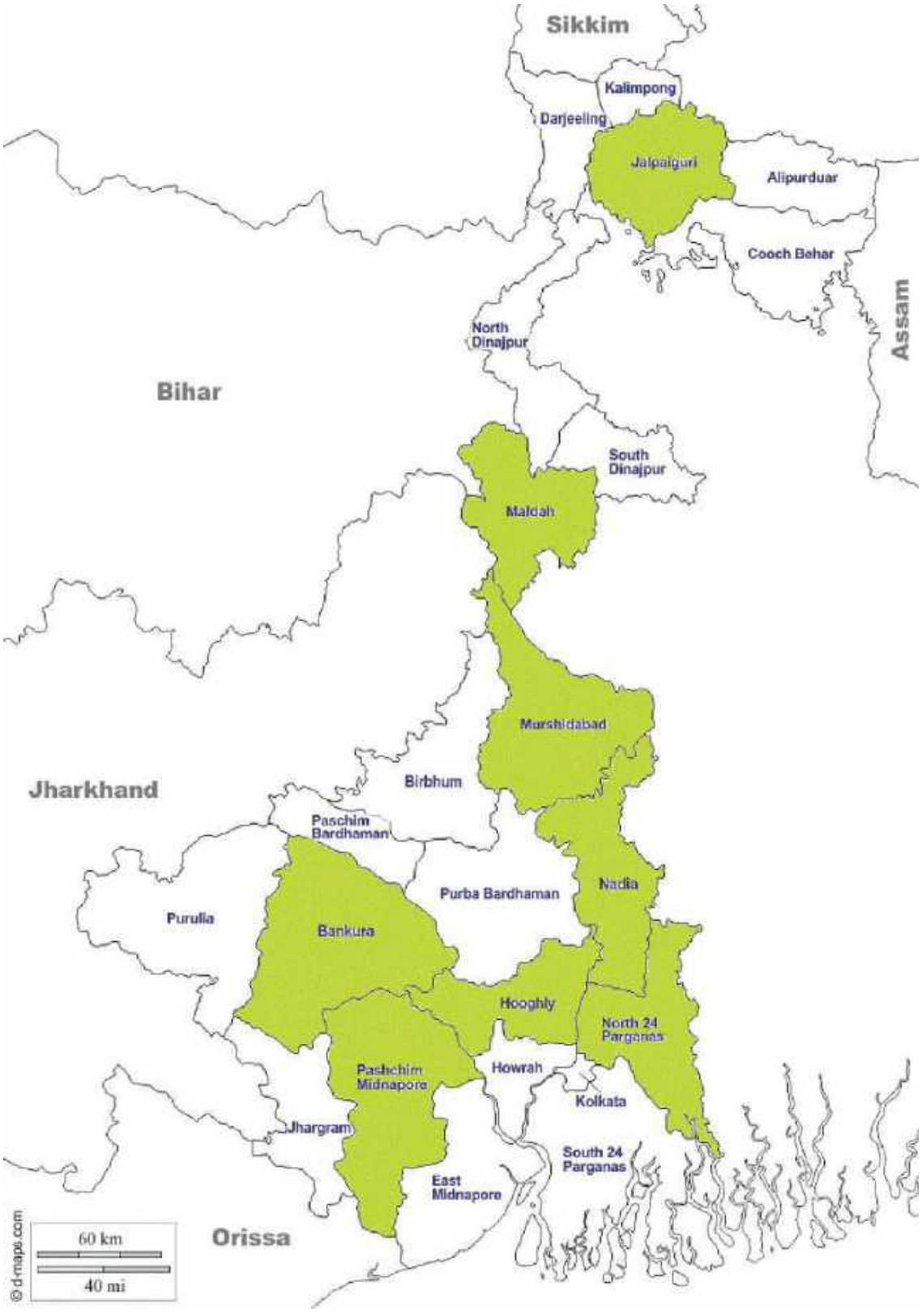


Figure 179: Biomass Power Potential for Maize and Barley in Uttarakhand

West Bengal



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

As explained in chapter 02, based on secondary data, the survey teams in West Bengal collected information and samples from all seven (07) districts to calculate surplus factor against the availability of surplus biomass for power generation and GCV.

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Andhra Pradesh. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 1741.74 MWe and for 2019-20 is 1590.60 MWe.

Districts Selected for Primary Field Survey	07 (Medinipur West, Bankura, Murshidabad, Hooghly, Nadia, Paraganas North, Jalpaiguri)
Average Rainfall	in mm (2004- 2010)
Type of soil	Red Laterite Soil, Old Alluvial Soil
Major source of irrigation **Major Rivers**	Canals, Tube well
Major Crops	Jute, Moong, Sugarcane, Wheat

Utilization of Crop residue at farmer's level in West Bengal:

1. **Essential Usage**
2. **Field preparation**: In order to prepare the land for future sowing in a short duration and with less effort, the residue of crops like Rice, Wheat and Soyabean are burnt in an open field.
3. **Fuel Usage**: Jute, Mesta, and Sunflower are used as domestic fuel.
4. **Commercial**: Present revenue earning by farmers by selling crop residues to briquetting or biomass plant and expected cost of crop residue

Particulars	Name of the crop	Cost of the residue (Rs./Ton)
The existing cost of the crop residue being sold in the state	Paddy	3000 - 4000
Expected Cost against the sale of crop residue in Future	Paddy	5000 - 6000
	Rapeseed & Mustard	5000 - 6000
	Wheat	6000 - 10000

Survey Images:

Boylaso, Mednipur, West Bengal

Nalahati, Murshidabad, West Bengal

Jurabandha, Sadar, Jalpaiguri, West Bengal

Table 103: Crop-wise change in Area, Production and Biomass Potential in West Bengal

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	6054798.00	15478631.00	23217946.50	1160897.33	157.88	5531655.00	16092761.50	24139142.25	1225244.34	166.88	5.70
Wheat	370777.67	913944.33	1645099.80	329019.96	44.42	268600.50	749276.50	1348697.70	269739.54	36.41	-18.02
Maize	173397.50	613610.00	1411303.00	282260.60	33.02	288774.00	1643561.50	3780191.45	756038.29	88.31	167.43
Barley	2659.17	3319.50	4315.35	431.54	0.05	1867.00	2660.00	3458.00	345.80	0.04	-19.77
Ragi	28284.50	31693.50	41201.55	4120.16	0.51	13375.00	14445.00	18778.50	1877.85	0.23	-54.27
Small Millets	4203.33	3903.33	4684.00	4684.00	0.59	3283.00	1938.50	2326.20	232.62	0.03	-95.03
Jowar	1396.67	593.33	1424.00	284.80	0.04	0.00	0.00	0.00	0.00	0.00	-100.00
Bajra	148.50	55.50	145.97	27.73	0.00	155.50	45.00	118.35	22.40	0.00	0
Moong (Green Gram)	16201.67	9663.17	12078.96	3623.69	0.46	58395.50	43986.00	54982.50	16494.75	2.11	357.91
Urad	58691.67	41351.67	53757.17	26878.58	2.45	80256.00	57722.00	75038.60	37519.30	3.42	39.51
Masoor	58344.17	40269.33	72082.11	36041.05	3.71	120856.50	113179.00	202590.41	101295.21	10.45	181.77
Horse Gram	2369.83	1145.83	1489.58	148.96	0.02	1882.50	1042.50	1355.25	135.53	0.02	-13.94
Gram	26502.67	24110.67	26521.73	5304.35	0.69	28987.50	35633.00	39196.30	7839.26	1.02	48.26
Arhar/Tur	1334.33	1008.83	2824.73	1977.31	0.24	2827.00	4144.00	11603.20	8122.24	0.98	308.14
Peas & Beans (Pulses)	10403.00	7453.33	3726.67	1863.33	0.23	17033.00	19263.50	9631.75	4815.88	0.60	159.64
Other Kharif Pulses	1921.50	1279.33	1663.13	332.63	0.04	5118.00	3950.00	5135.00	1027.00	0.12	210.67
Other Rabi Pulses	185.00	64.00	83.20	16.64	0.00	527.00	315.50	410.15	41.02	0.00	0
Soyabean	534.67	320.33	544.57	92.58	0.01	589.50	514.00	873.80	148.55	0.02	85.68
Rapeseed & Mustard	449791.67	360646.00	649162.80	324581.40	42.52	599331.50	685026.00	1233046.80	616523.40	80.76	89.94
Linseed	6032.83	1543.50	2284.38	456.88	0.05	6688.00	1970.00	2915.60	583.12	0.06	17.79
Groundnut	126654.00	224466.00	516271.80	103254.36	12.60	77904.00	192837.50	443526.25	88705.25	10.81	-14.18
Sunflower	13305.67	16183.83	32367.67	29130.90	3.20	7221.00	9124.00	18248.00	16423.20	1.81	-43.55
Sesamum	405429.00	346822.00	867055.00	346822.00	42.66	235592.50	223634.00	559085.00	223634.00	27.51	-35.52
Sannhamp	2345.00	13096.50	33003.18	6600.64	0.82	839.50	3800.00	9576.00	1915.20	0.24	-71.04

STATE-WISE BIOMASS POWER POTENTIAL

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Niger Seed	5088.50	3295.33	3493.05	349.31	0.04	3786.00	2563.00	2716.78	271.68	0.03	-18.70
Safflower	699.83	775.00	2325.00	465.00	0.05	477.50	421.00	1263.00	252.60	0.03	-44.93
Castor Seed	118.00	86.00	352.60	211.56	0.03	62.00	39.00	159.90	95.94	0.01	-59.96
Coconut	27710.33	5713.29	115126.30	103613.67	14.20	30314.00	74286.08	176970.56	159273.50	21.87	54.00
Cotton	5920.00	2030.03	26962.06	21569.65	2.61	225.50	26.59	915.40	732.32	0.09	-96.61
Sugarcane	17332.50	1593963.50	79698.18	19924.54	2.71	19827.50	1630360.50	81518.03	20379.51	2.77	2.27
Tobacco	12132.00	17024.67	17024.67	17024.67	2.26	15093.00	22511.50	22511.50	22511.50	2.99	32.48
Khesari	31431.17	25164.83	26674.72	8002.42	0.99	65803.00	69339.50	73499.87	22049.96	2.73	176.18
Mesta	10891.50	23005.47	47161.22	23580.61	3.16	13384.50	26573.31	54475.29	27237.64	3.65	15.50
Jute	646171.33	1579573.02	3159146.04	2527316.83	338.66	556203.50	1503695.07	3007390.14	2405912.11	322.39	-4.80
Potato	406854.33	6532531.67	5291350.65	4444734.55	413.36	432894.50	14969236.00	12125081.16	10239880.19	953.33	130.63
Total	**8980061.50**	**27918337.64**	**37370351.32**	**9835644.19**	**1124.29**	**8489830.00**	**38199880.55**	**47506428.68**	**16277320.68**	**1741.74**	**54.92**

Table 104: Crop-wise Area, Production, Biomass Production, Surplus biomass and Biomass Power Potential for West Bengal in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	5425108.5	16266862.2	24400293.3	1220014.7	165.9
2	Wheat	207136.0	629529.0	1133152.3	226630.5	30.6
3	Jowar	64.0	30.0	72.0	14.4	0.0
4	Bajra	71.0	29.0	76.3	14.5	0.0
5	Barley	1463.7	2585.8	3361.6	336.2	0.0
6	Maize	217203.9	1147810.9	2639965.1	527993.0	61.7
7	Black Gram (Urad)	71640.3	52448.2	68182.7	34091.4	3.1
8	Gram	20354.8	27117.4	29829.1	5965.8	0.8
9	Arhar/Tur	1632.8	3137.1	8783.8	6148.7	0.7
10	Green Gram (Moong)	53975.9	36161.1	45201.3	13560.4	1.7
11	Peas & Beans	15726.5	17974.8	8987.4	4493.7	0.6
12	Masoor	108628.8	98336.9	177006.5	88503.3	9.1
13	Sesamum	257817.9	243176.7	607941.8	243176.7	29.9
14	Groundnut	80353.8	199585.9	459047.6	91809.5	11.2
15	Soyabean	554.2	443.1	753.3	128.1	0.0
16	Rapeseed & Mustard	513026.3	603654.1	1086577.3	543288.6	71.2
17	Sunflower	9137.6	11212.6	22425.3	20182.7	2.2
18	Cotton	295.3	172.7	1501.9	1201.6	0.1
19	Jute	523252.3	1422606.5	2845212.9	2276170.3	304.6
20	Mesta	9088.2	21575.5	44229.8	22114.9	3.0
21	Sugarcane	17398.4	1723178.8	86158.9	21539.7	2.9
22	Tobacco	15752.8	28071.7	28071.7	28071.7	3.7
23	Coconut	30358.6	78275.1	180140.6	162126.5	22.2
24	Potato	462647.2	13658664.9	11063518.6	9293355.6	865.2
	Total	**8042688.8**	**36272640.2**	**44940491.3**	**14830932.5**	**1590.6**

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Potato with 865.2 MWe followed by Jute (304.6 MWe), Rice (165.9 MWe), Rapeseed & Mustard (71.2 MWe) and Maize (61 .7 MWe)

Trend Analysis for Biomass power potential for the state of West Bengal – Crop-wise

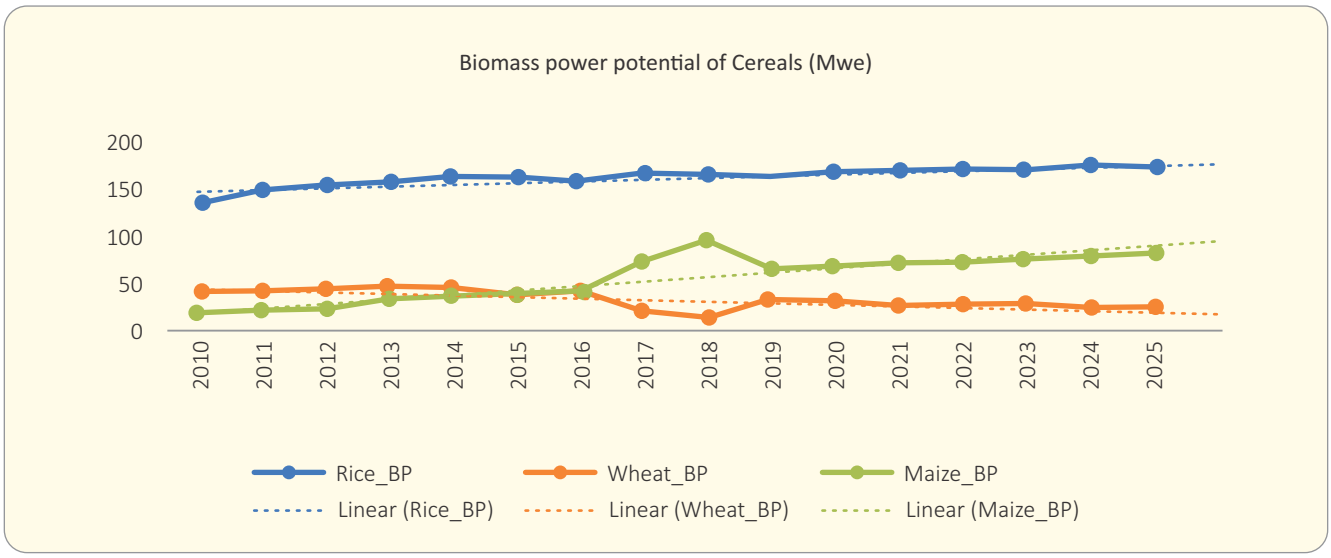


Figure 180: Biomass Power Potential for Cereals in West Bengal

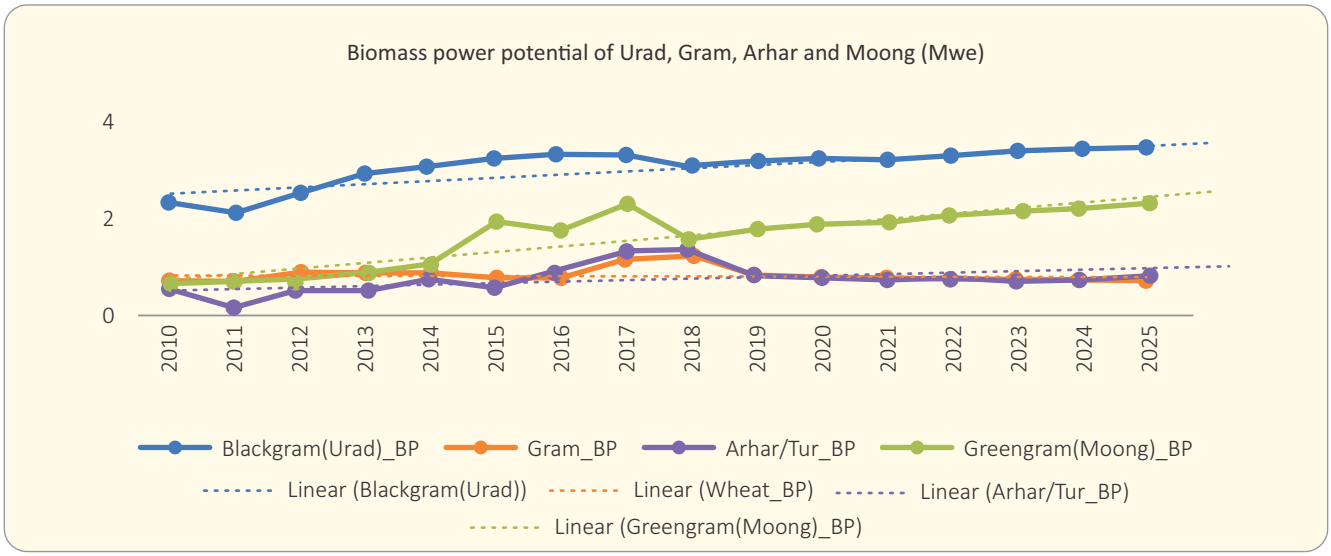


Figure 181: Biomass Power Potential for Urad, Gram, Arhar and Moong in West Bengal

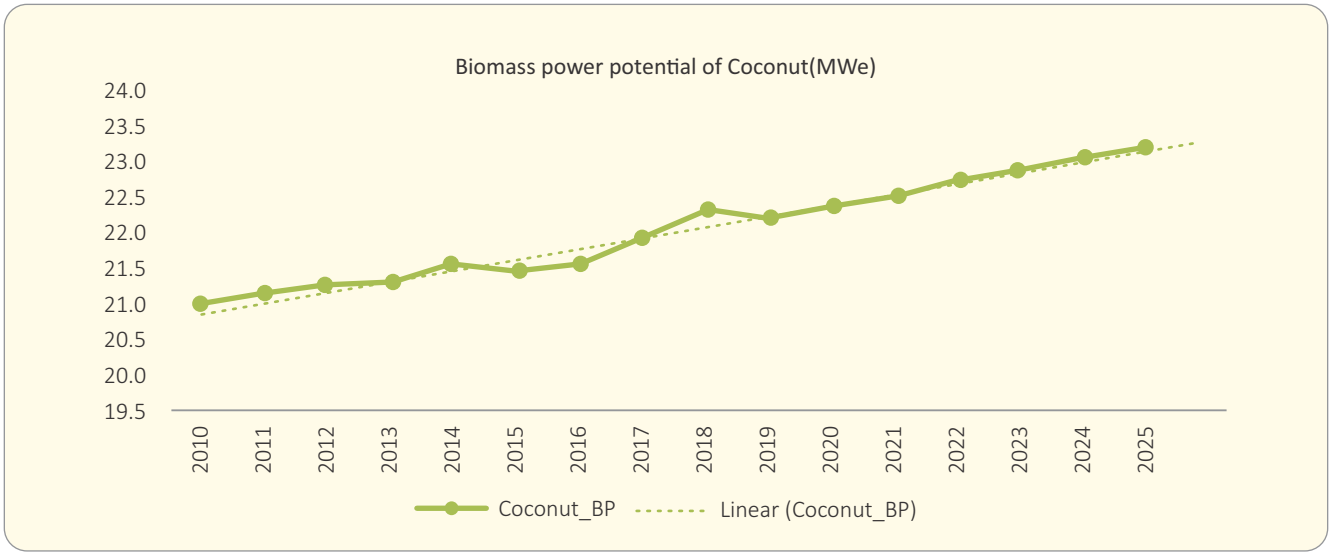


Figure 182: Biomass Power Potential for Coconut in West Bengal

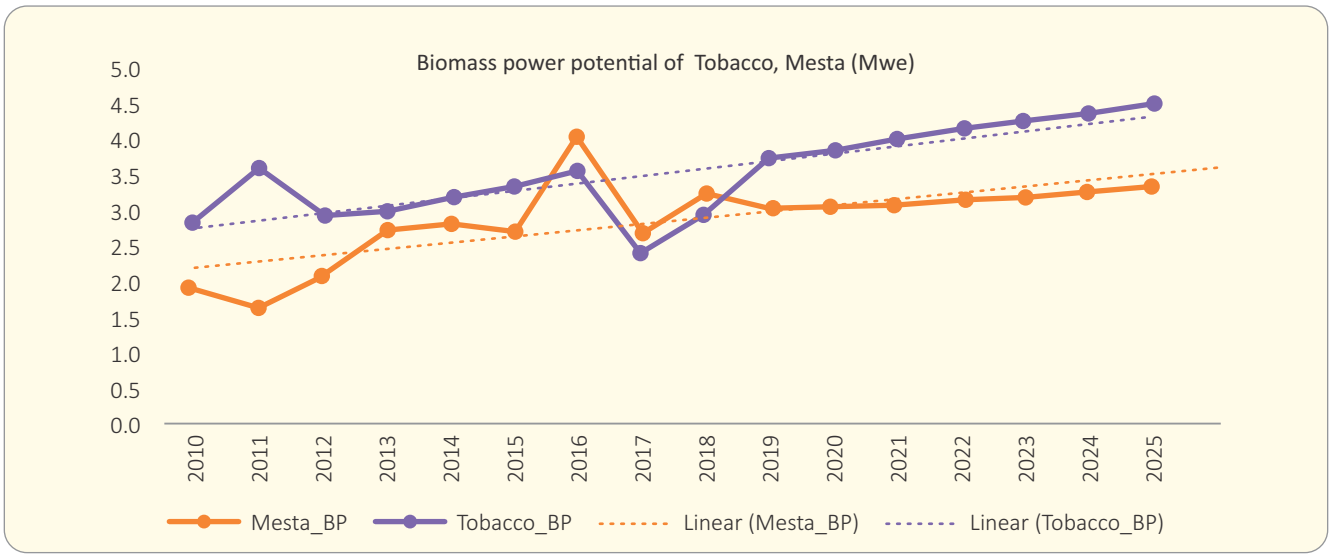


Figure 183: Biomass Power Potential for Tobacco and Mesta in West Bengal

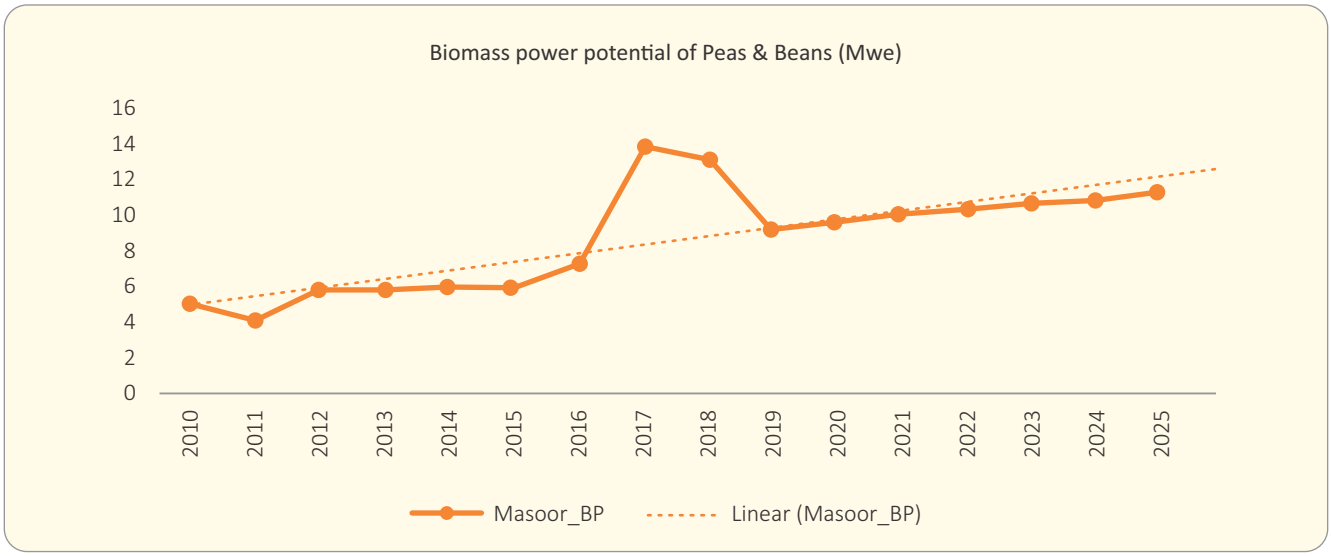


Figure 184: Biomass Power Potential for Peas and Beans in West Bengal

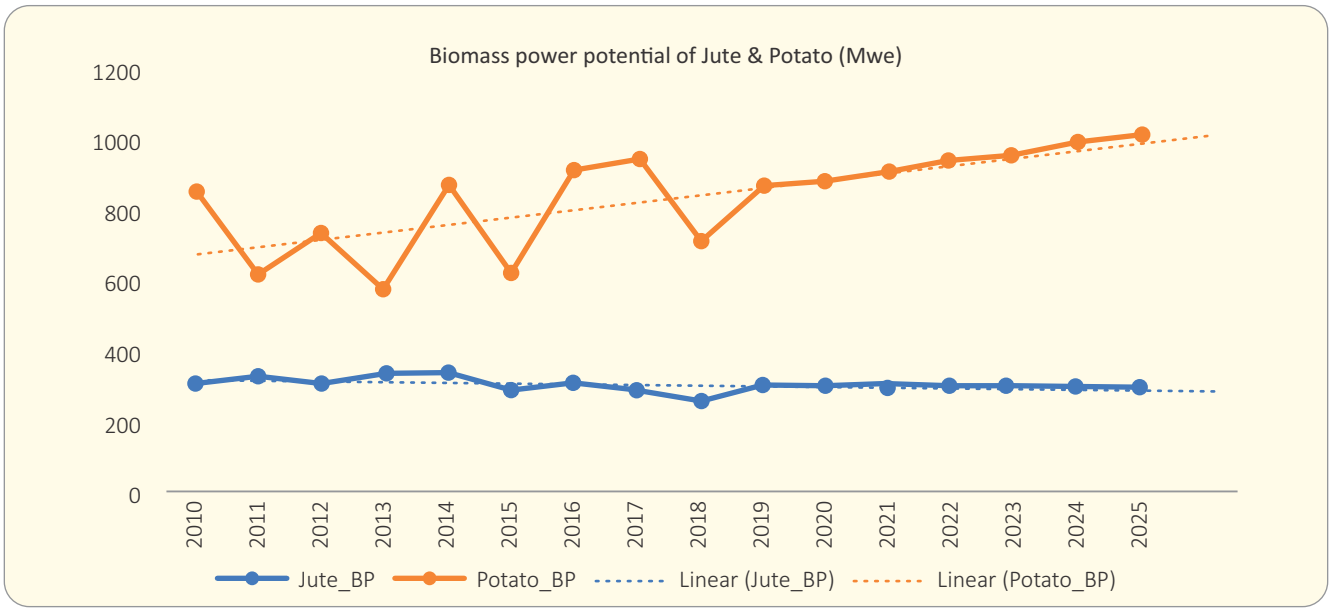


Figure 185: Biomass Power Potential for Jute and Potato in West Bengal

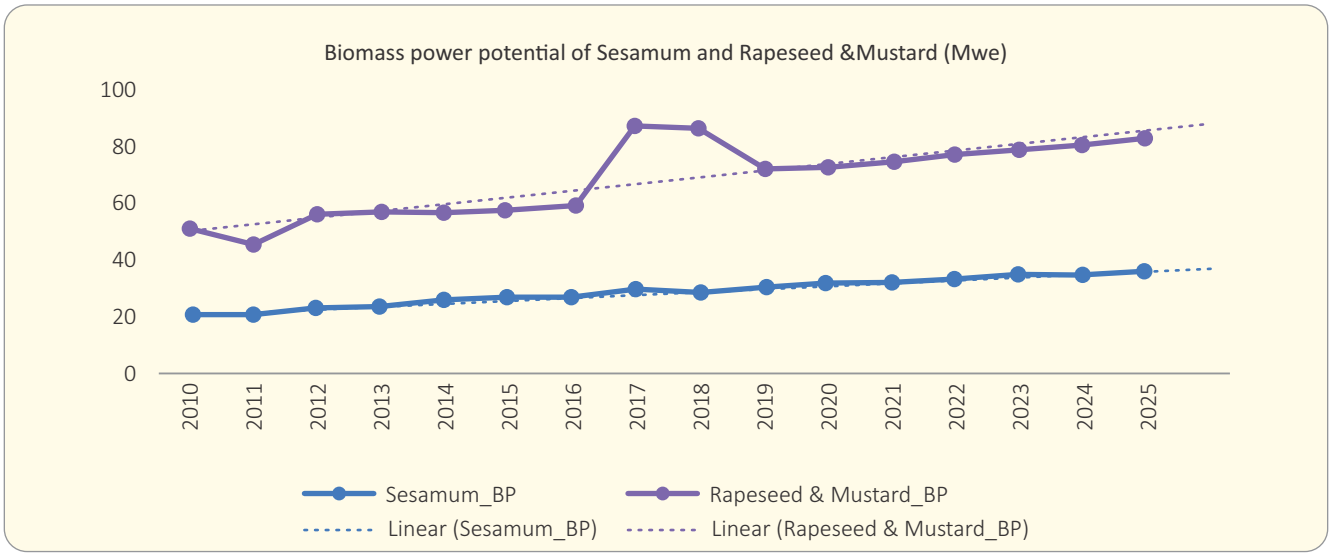


Figure 186: Biomass Power Potential for Sesamum and Rapeseed & Mustard in West Bengal

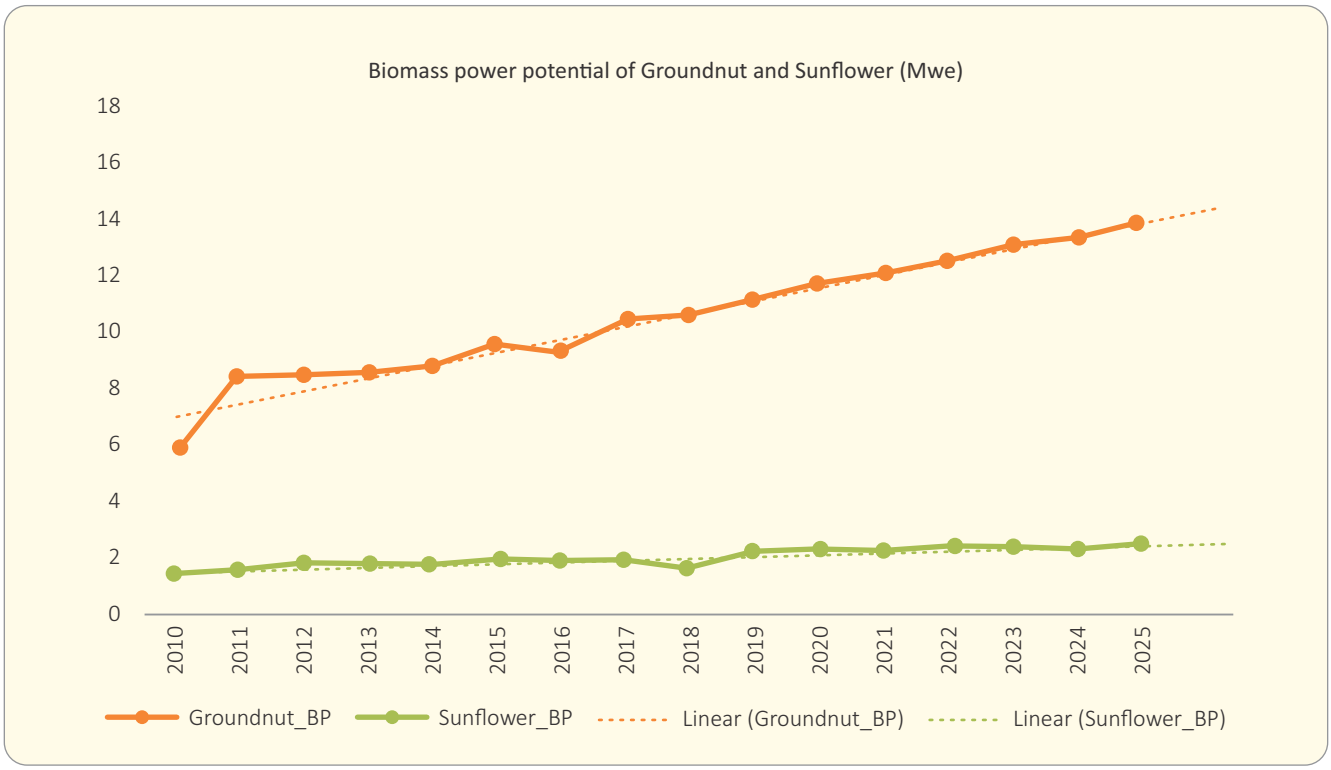
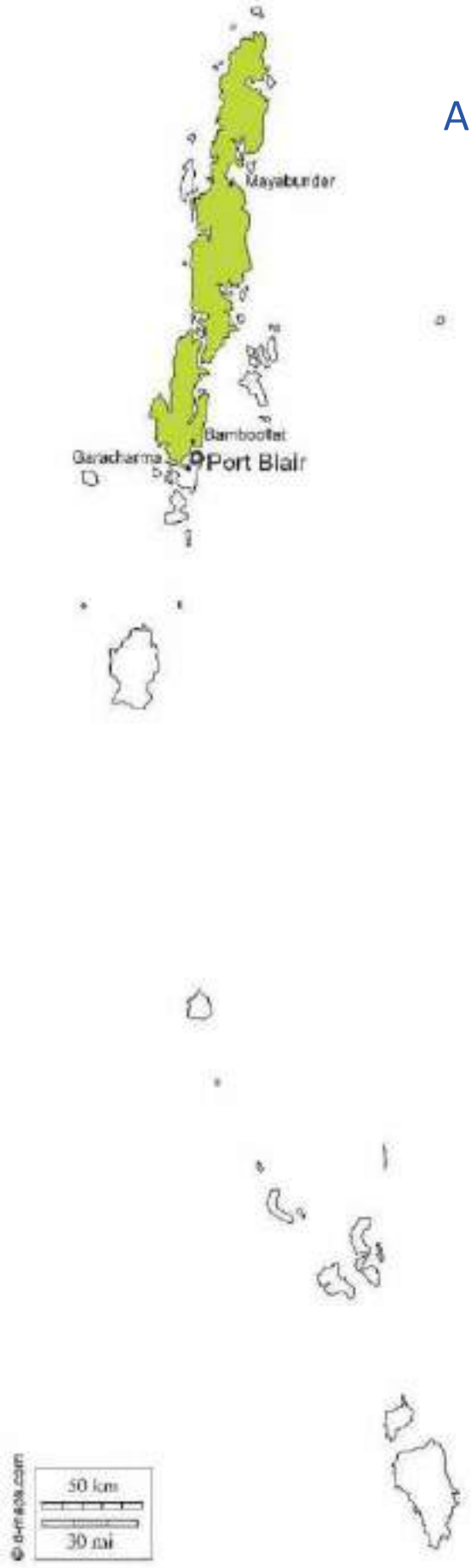


Figure 187: Biomass Power Potential for Groundnut and Sunflower in West Bengal

Andaman and Nicobar Islands



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 105: Crop-wise change in Area, Production and Biomass Potential in Andaman & Nicobar

Crops	2006-08					2016-18					Growth Rate (%)
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	
Rice	15109.92	43399.66	65099.49	11066.91	1.51	5803.69	13130.34	19695.51	3348.24	0.46	-69.75
Maize	469.81	1520.36	3496.83	699.37	0.08	130.55	391.44	900.31	180.06	0.02	-74.25
Cowpea	0.00	0.00	0.00	0.00	0.00	533.98	2687.97	2956.76	591.35	0.08	100.00
Moong (Green Gram)	1553.93	871.91	1089.89	326.97	0.04	856.13	407.78	509.73	152.92	0.02	-53.23
Arhar / Tur	155.00	220.50	617.40	432.18	0.05	7.72	5.10	14.28	10.00	0.00	-97.69
Urad	2502.41	1428.93	1857.61	928.80	0.08	612.62	315.32	409.92	204.96	0.02	-77.93
Other Oilseeds	59.62	36.38	72.76	72.76	0.01	36.00	15.00	30.00	30.00	0.00	-58.77
Rapeseed & Mustard	30.00	14.57	26.23	13.11	0.00	6.10	2.42	4.36	2.18	0.00	-83.39
Sunflower	15.83	16.66	33.32	29.99	0.00	0.50	0.30	0.60	0.54	0.00	-98.20
Sesamum	81.60	61.91	154.78	61.91	0.01	33.00	8.05	20.13	8.05	0.00	-87.00
Groundnut	62.50	44.12	101.48	20.30	0.00	3.10	2.18	5.00	1.00	0.00	-95.07
Ginger	205.56	1850.00	92.50	30.53	0.00	159.59	1702.10	85.11	28.08	0.00	-7.99
Arecanut	16416.00	17251.70	63049.36	59266.40	7.88	4637.50	10094.50	21988.10	20668.81	2.75	-65.13
Dry Chillies	1108.64	2110.84	3166.26	2533.01	0.33	227.56	1160.14	1740.22	1392.17	0.18	-45.04
Turmeric	243.00	1324.18	397.25	238.35	0.03	114.87	1081.22	324.37	194.62	0.03	-18.35
Black Pepper	2446.52	283.00	141.50	15.57	0.00	401.27	63.77	31.89	3.61	0.00	-77.47
Cashewnut	570.00	155.13	356.80	356.80	0.06	878.33	218.98	503.65	503.65	0.08	41.16
Coconut	53924.09	25534.50	234847.24	211362.51	28.96	21968.00	19720.00	102662.00	92395.80	12.69	-56.29
Banana	4751.11	42674.90	128024.70	28165.43	3.75	1997.37	15652.10	46956.30	10330.39	1.37	-63.32
Sweet Potato	371.53	2245.73	224.57	134.74	0.01	99.83	1425.00	142.50	85.50	0.01	-36.55
Tapioca	793.98	5489.78	4117.34	3499.73	0.38	150.93	2468.00	1851.00	1573.35	0.17	-55.04
Sugarcane	458.43	9068.00	453.40	113.35	0.02	140.21	2616.21	130.81	32.70	0.00	-71.15
Tobacco	0.00	0.00	0.00	0.00	0.00	150.93	2468.00	1851.00	1851.00	0.25	-
Total	**101329.48**	**155602.76**	**507420.69**	**319368.72**	**43.20**	**38798.85**	**73167.92**	**200962.52**	**131737.98**	**18.13**	**-60.40**

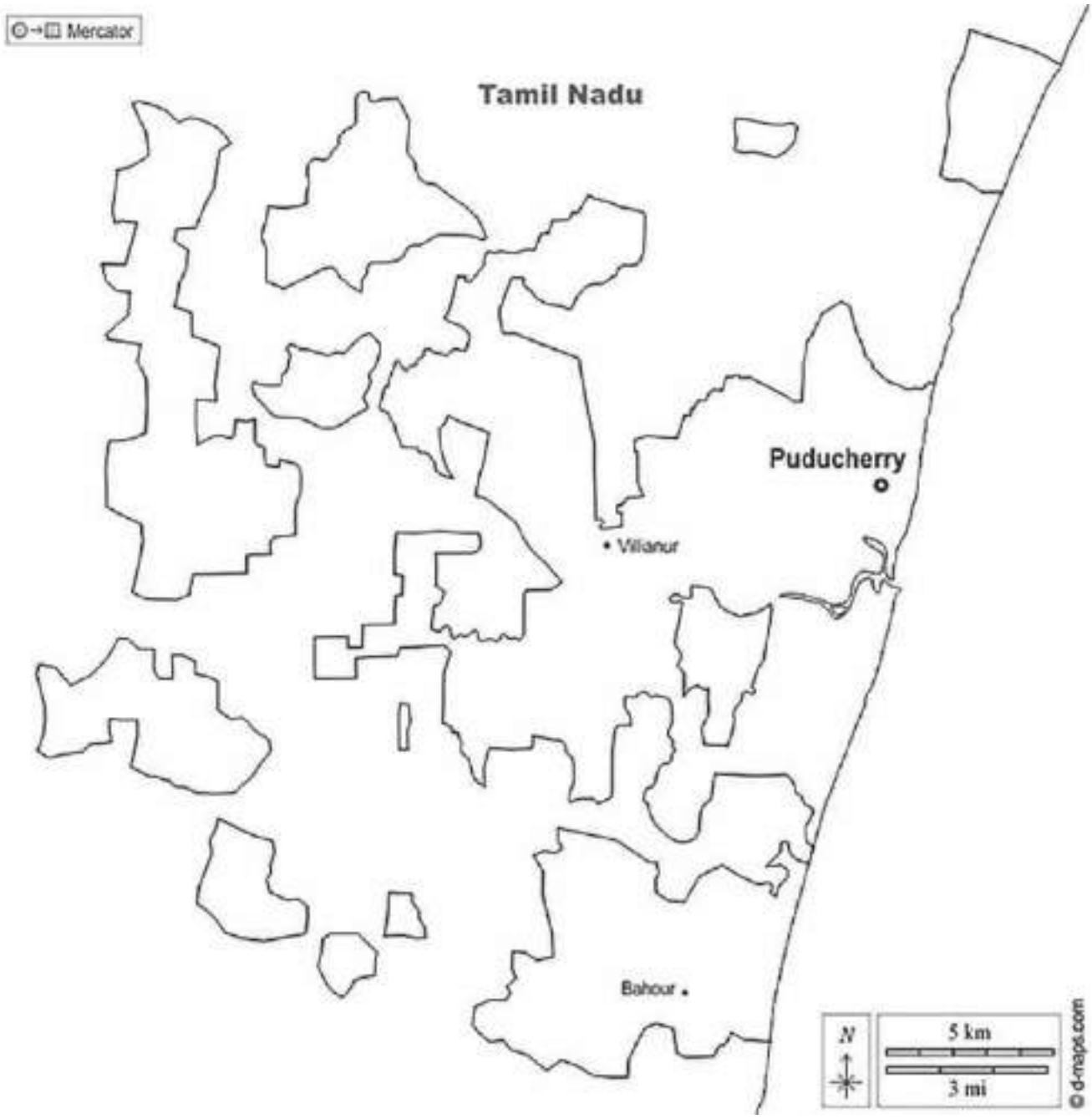
Table 106: Crop-wise Area, Production, Biomass Production, Surplus Biomass, Biomass Power Potential for Andaman & Nicobar in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Arecanut	4558.5647	11229.0472	22658.9320	21299.3960	2.8384
2	Arhar	72.2965	31.1860	87.3207	0.1036	0.0000
3	Banana	2033.4364	17832.2572	53496.7716	11769.2897	1.5614
4	Black Gram	776.5177	370.3132	481.4071	240.7036	0.0219
5	Cashewnut	583.7828	174.3763	401.0655	401.0655	0.0652
6	Coconut	20759.4793	16544.4096	95446.2244	85901.6020	11.7926
7	Ginger	59.0905	1460.5428	73.0271	24.0990	0.0031
8	Green Gram	835.0426	405.5804	506.9754	152.0926	0.0194
9	Groundnut	10.2053	8.2249	18.9173	0.0021	0.0000
10	Maize	150.7623	369.1937	849.1455	17.8737	0.0021
11	Other Oilseed	29.4930	13.3949	26.7898	0.0985	0.0000
12	Rapeseed & Mustard	10.1791	4.1339	7.4409	0.0019	0.0000
13	Rice	4976.5018	8003.5266	12005.2899	2040.8993	0.2776
14	Sugarcane	139.0191	1669.5298	83.4765	20.8691	0.0028
15	Sunflower	0.9707	0.9168	2.7505	0.0002	0.0000
16	Tapioca	211.8967	2707.4102	2030.5576	1725.9740	0.1868
	Total	**35207.2385**	**60824.0434**	**188176.0919**	**123594.0708**	**16.7713**

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Andaman & Nicobar. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 18.13 MWe, and for 2019-20 is 16.77 MWe.

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Coconut with 11.79 MWe followed by Arecanut (2.83 MWe), Banana (1.56 MWe), Rice (0.277 MWe) and Tapioca (0.186 MWe).

Puducherry



Surveyed Districts

Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

Table 107: Crop-wise change in Area, Production and Biomass Potential in Puducherry

Crops	2006-08					2015-17				
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
Rice	20971.33	54973.50	82460.25	14018.24	1.91	16613.00	50679.00	76018.50	12923.15	1.76
Ragi	55.00	135.00	175.50	17.55	0.00	51.17	111.33	144.73	14.47	0.00
Small millets	1.50	1.00	1.20	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Bajra	70.00	137.50	361.63	68.71	0.01	13.67	29.67	78.02	14.77	0.00
Jowar	6.50	11.00	26.40	2.64	0.00	7.00	14.50	34.80	3.48	0.00
Arhar	0.00	0.00	0.00	0.00	0.00	541.00	373.00	1044.40	731.08	0.09
Urad	1809.00	331.00	430.30	215.15	0.02	834.00	493.50	641.55	320.78	0.03
Moong (Green Gram)	1706.50	255.50	319.38	95.81	0.01	819.00	199.00	248.75	74.63	0.01
Other Kharif pulses	1.00	1.00	1.30	0.26	0.00	3.50	8.50	11.05	2.21	0.00
Other Rabi pulses	32.00	29.50	38.35	7.67	0.00	61.00	111.00	144.30	14.43	0.00
Other Summer Pulses	0.00	0.00	0.00	0.00	0.00	12.50	25.00	32.50	6.50	0.00
Groundnut	772.33	1588.83	3654.32	730.86	0.09	275.00	822.20	1891.06	378.21	0.05
Sunflower	4.50	3.00	6.00	5.40	0.00	0.00	0.00	0.00	0.00	0.00
Sesamum	207.67	186.17	465.42	186.17	0.02	96.83	90.83	227.08	90.83	0.01
Black pepper	12.00	7.33	3.67	0.40	0.00	10.00	18.00	9.00	1.02	0.00
Cashewnut	174.00	173.00	397.90	397.90	0.06	146.00	46.00	105.80	105.80	0.02
Arecanut	62.00	80.25	304.95	286.65	0.04	53.33	84.67	227.73	214.07	0.03
Dry chillies	6.00	9.83	14.75	11.80	0.00	7.33	62.67	94.00	75.20	0.01
Turmeric	3.50	5.50	1.65	0.99	0.00	5.33	15.33	4.60	2.76	0.00
Coconut	2124.00	5733.60	27234.60	24511.14	3.36	1927.00	3359.33	10227.49	9204.75	1.26
Sweet potato	1.00	1.00	0.10	0.06	0.00	8.00	77.00	7.70	4.62	0.00
Tapioca	333.50	12267.67	9200.75	7820.64	0.84	249.33	5226.17	3919.63	3331.68	0.36
Cotton(lint)	57.00	6.63	39.78	31.82	0.00	189.33	55.19	840.89	672.71	0.08
Sugarcane	2256.00	258148.33	12907.42	3226.85	0.44	1647.67	201406.00	10070.30	2517.58	0.34

Crops	2006-08					2015-17				
	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)	Area (Ha)	Crop Production (Tonnes)	Biomass Generation (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
Onion	4.00	24.50	1.23	0.27	0.00	3.00	15.33	0.77	0.17	0.00
Banana	302.67	10290.33	30871.00	6791.62	0.90	249.00	4077.67	12233.00	2691.26	0.36
Tobacco	0.00	0.00	0.00	0.00	0.00	209.00	4388.00	4388.00	4388.00	0.58
Total	**30973.00**	**344400.98**	**168917.82**	**58428.74**	**7.72**	**24032.00**	**271788.89**	**122645.66**	**37784.15**	**5.00**

Table 108: Crop-wise Area, Production, Biomass, Surplus biomass, Biomass Power Potential for Puducherry in the year 2019-2020

Sr. No	Crop Name	Area (Ha)	Crop Production (Tonnes)	Biomass Production (Tonnes)	Surplus Biomass (Tonnes)	Biomass Power Potential (Mwe)
1	Rice	11291.1	39316.5	58974.8	1.0	1.4
2	Bajra	213.8	458.7	1206.3	229.2	0.0
3	Groundnut	120.9	585.9	1347.5	269.5	0.0
4	Cotton	154.0	27.9	646.5	517.2	0.1
5	Sugarcane	1654.7	273471.8	13673.6	3418.4	0.5
6	Banana	252.7	5010.7	15032.2	3307.1	0.4
7	Cashewnut	128.9	28.5	65.4	65.4	0.0
8	Coconut	1666.6	4353.9	9932.0	8938.8	1.3
9	Green Gram (Moong)	484.2	9.4	11.8	3.5	0.0
10	Tapioca	131.9	2000.1	1500.1	1275.1	0.1
11	Black Gram (Urad)	91.5	4.8	6.2	3.1	0.0
	Total	**16190.3**	**325268.2**	**102396.4**	**18028.4**	**3.8**

Based on the secondary data such as area, yield, crop residue ratio, the surplus biomass potential against each crop in Andhra Pradesh was calculated, which was the input to arrive at biomass power potential in Andhra Pradesh. Thus, the total biomass power potential for the state of Andhra Pradesh for 2018 was 5.00 MWe and for 2019-20 is 3.80 MWe.

Major contributing crops in biomass power potential in Andhra Pradesh (2019-20) is Rice with 1.4 MWe followed by Coconut (1.3 MWe), Sugarcane (0.5 MWe), Banana (0.4 MWe) and Tapioca (0.1 MWe).

Trend Analysis for Biomass power potential for the state of Puducherry – Crop-wise

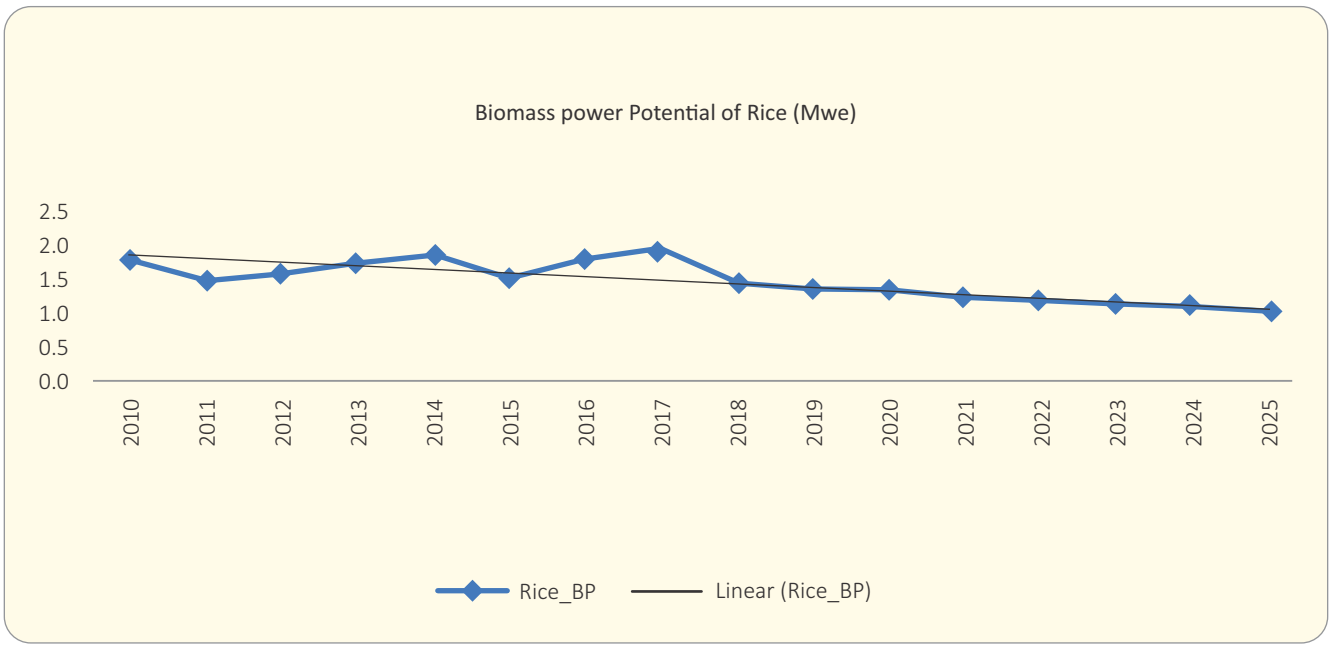


Figure 188: Biomass Power Potential for Rice in Puducherry

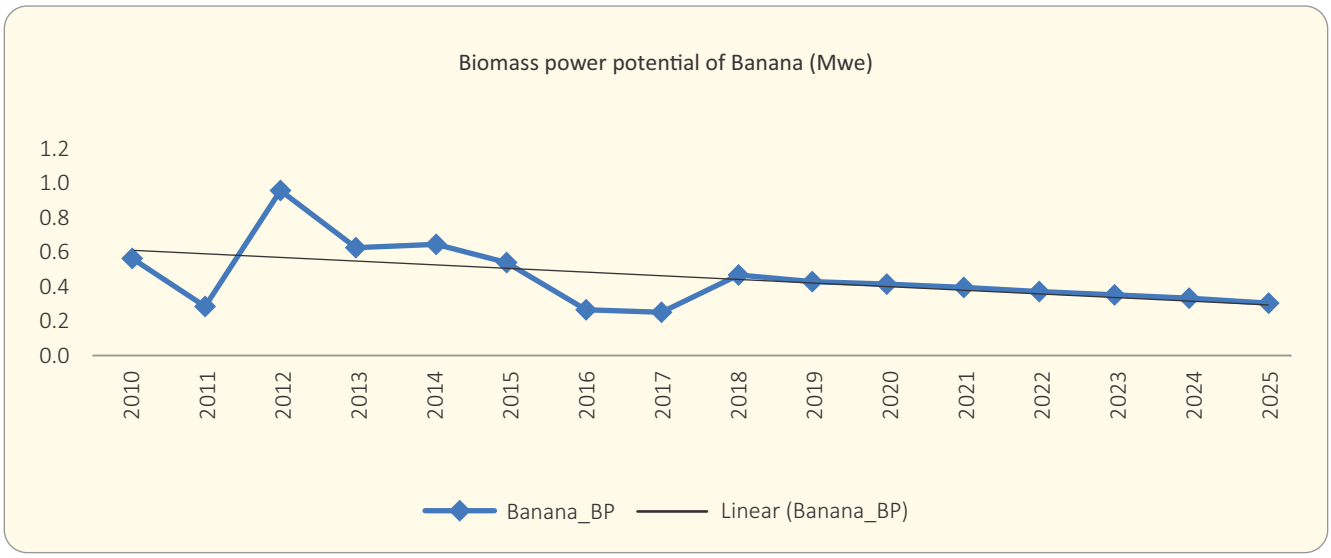


Figure 189: Biomass Power Potential for Banana in Puducherry

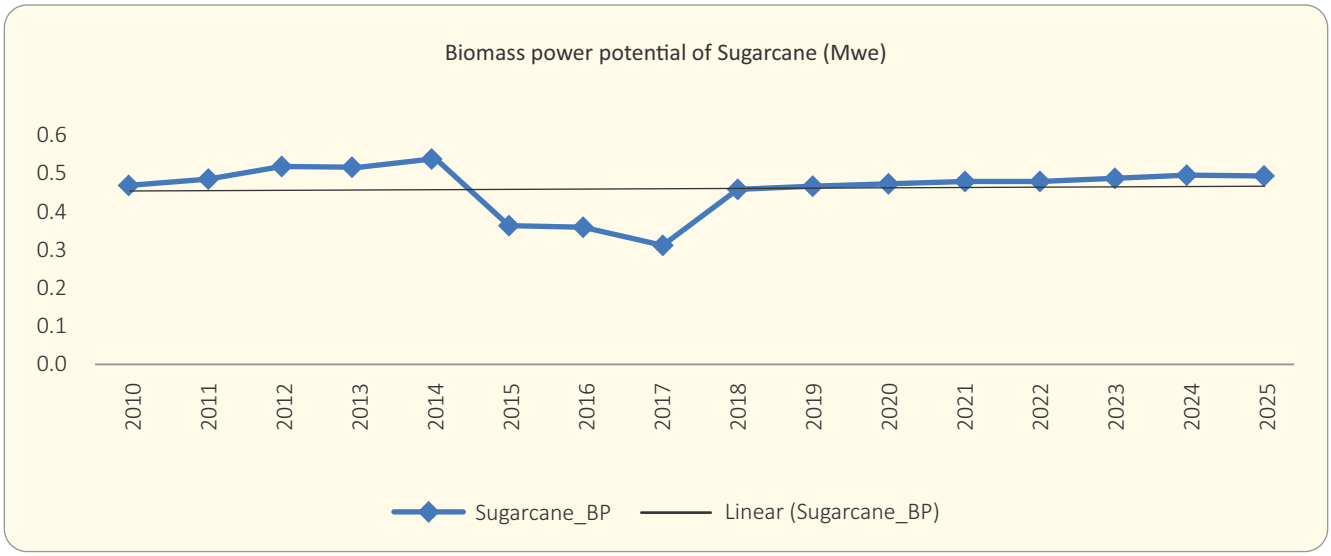


Figure 190: Biomass Power Potential for Sugarcane in Puducherry

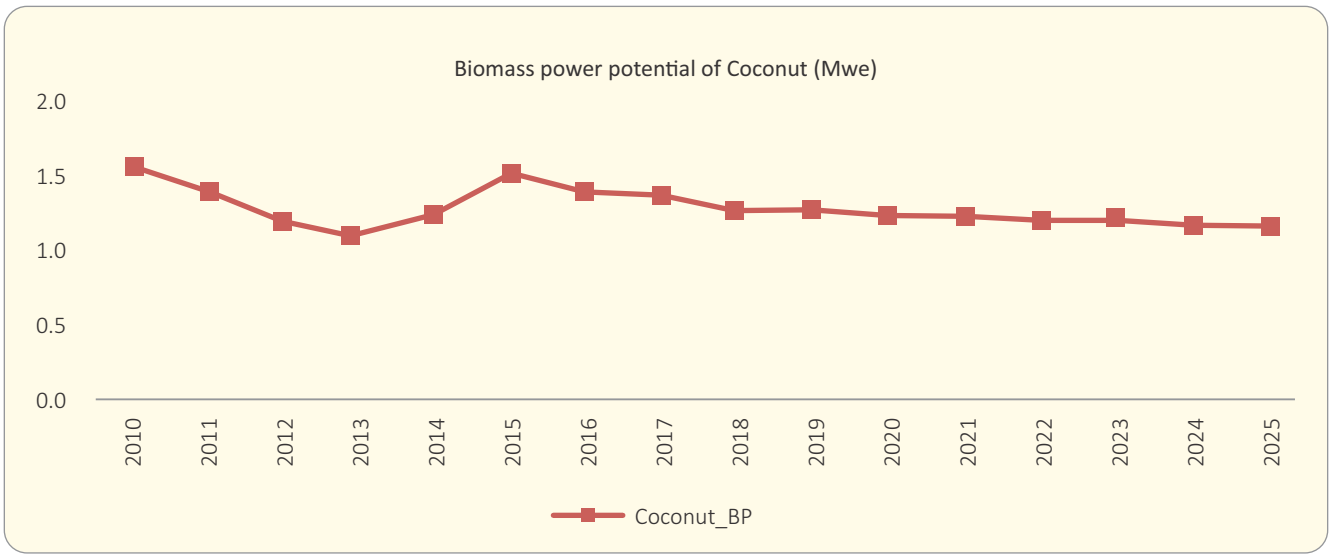


Figure 191: Biomass Power Potential for Coconut in Puducherry

06
CHAPTER

Bagasse Co-generation Power Potential

INTRODUCTION

Sugarcane is an important commercial crop in India. India is one of the leading producers of sugarcane in the world, next to Brazil. Sugarcane is cultivated in more than a hundred countries in the world, but only a few countries account for maximum sugarcane production in the world. As per FAO (Food and Agriculture Organization), India constitutes 22.8% of the area under sugarcane cultivation among significant sugarcane producing countries (depicted in the graph below) in the world and 24.8% of sugarcane production among major sugarcane producing countries in the world for the year 2018.

Sugarcane produces two different crop residues, i.e. top leaves and bagasse. Sugar and Jaggery are the final products of sugarcane. In the process of making sugar and jaggery, the un-utilized crop residue has multiple uses at different levels like bagasse, molasses, and ash.

Bagasse mainly consists of cellulose, hemicellulose, pentosans, lignin, sugar, wax, and minerals. The quantity obtained varies from 22 to 36% of sugarcane which depends upon the quality of sugarcane and harvesting practices. The bagasse is utilized in Power Generation, Plastic Industry, Paper Industry, Poultry, Ethanol and Sprit Production, Yeast Making, Vinegar Production and Feedstock for cattle.

As of FY 2017-18, at a glance, 47.32 Lakh Hectares of the area under production for sugarcane has a yield of 79.6 tonnes per hectare. At all India level, 524 sugar mills are in operation with a recovery rate of 10.73% by producing 323.28 Lakh MTs of sugar.[20]

Table 109: Sugarcane Statistics at a Glance

S.No.	Particulars	Units	Sugar Season				
			2013-14	2014-15	2015-16	2016-17	2017-18
1	Area under sugarcane cultivation	Lakh Hectares	49.93	50.67	49.27	44.36	47.32
2	Yield of cane per hectare	Tonnes	70.50	71.50	70.70	69.00	79.60
3	Factories in operation	Numbers	513	538	526	489	525
4	Sugar Recovery	%	10.23	10.37	10.62	10.48	10.73
5	Opening Stock	LMTs	92.00	75.28	91.20	77.25	39.41
6	Total Sugar produced	LMTs	243.60	283.13	251.25	202.62	323.28
7	Import	LMTs	11.77	12.36	0.00	4.48	2.24
8	Consumption	LMTs	244.27	256.55	248.50	244.48	254.50
9	Exports	LMTs	27.82	23.02	16.70	0.46	6.32
10	Closing stock of Sugar	LMTs	75.28	91.20	77.25	39.41	104.11
11	Molasses Production	LMTs	108.50	124.79	108.85	90.02	139.80
12	Molasses Recovery	%	4.56	4.57	4.60	4.65	4.64

Source: National Federation of Cooperative Sugar Factories Ltd., Sugar statistics at a glance 2013-18

20. Directorate of Sugar, Price Policy of Sugarcane 2019-20, Page. No. 1

Bagasse Co-generation

Bagasse Cogeneration, also known as Combined Heat and Power (CHP), is the simultaneous production of electricity, heating and/ or cooling, from a single fuel input (Bagasse), with an overall efficiency usually exceeding 70%. The bagasse co-generation is usually adopted in sugar mills to support their auxiliary power consumption as well as heating requirement.

The Bagasse generated in sugar mills by crushing sugarcane is mainly being utilized to meet the self-requirement of sugar mills, i.e. as a fuel in boilers. Apart from conventional sugar mills, there are cogeneration Bagasse plants installed in various states across the nation. These cogeneration plants not only provide process steam (at different parameters for various process requirements in sugar mills) but also generate electricity from Bagasse in an efficient manner. The electricity so generated is supplied to the grid after meeting its auxiliary power consumption.

Table 110: State-wise Biomass and Bagasse co-generation installed capacity

State/UTs	Biomass IPP (In MW)	Bagasse Cogeneration (In MW)	Non-Bagasse Cogeneration (In MW)	Cumulative Installed Capacity (as of 31.12.2019)
Andhra Pradesh	171.20	206.90	105.57	483.67
Bihar	12	100.50	12.20	124.70
Chhattisgarh	222.40	20	2.50	244.90
Gujarat	44.50	20.80	12	77.30
Haryana	19.40	102	89.26	210.66
Karnataka	137.30	1729.80	20.20	1887.30
Madhya Pradesh	92.50	0	14.84	107.34
Maharashtra	217	2351	16.40	2584.40
Punjab	138.50	161	173.95	473.45
Rajasthan	114.30	4.95	2	121.25
Tamil Nadu	218.70	750.40	43.55	1012.65
Telangana	60.10	98	2	160.10
Uttarakhand	0.12	72.60	57.50	130.22
Uttar Pradesh	28	1929.50	159.76	2117.26
West Bengal	300	-	19.92	319.92
Odisha	50.40	-	8.82	59.22
Himachal Pradesh	-	-	9.20	9.20
Kerala	-	-	2.27	2.27
Meghalaya	-	-	13.80	13.80
Jharkhand	-	-	4.30	4.30
Assam	-	-	2	2
Manipur	-	-	-	0
Nagaland	-	-	-	0
Arunachal Pradesh	-	-	-	0
Tripura	-	-	-	0
Sikkim	-	-	-	0
Mizoram	-	-	-	0
Goa	-	-	-	0
Jammu& Kashmir	-	-	-	0
Total	**1826.42**	**7547.45**	**772.04**	**10145.91**

In order to elicit detailed information regarding the design and operation of Bagasse based cogeneration plants, a comprehensive questionnaire was designed (Refer to Annexure A). A total of 35 responses have been received from different states. Based on the data provided in our survey, analysis has been carried out to understand the philosophy of operation of these plants viz a viz Sugarcane availability by calculating Plant Load Factor (PLF), Plant Availability Factor, Plant Loading Factor, Auxiliary Consumption etc.

The detailed information on the status of sugar mills was collected through structured questionnaire administered in 36 sugar mills across India covering almost all states. the information on plant capacity, crop residue management, residue collection from surrounding areas, residue to electricity generation, bagasse generation, purchasing cost, year-wise procurement of sugarcane, plant running hours, amount of electricity consumed, amount of electricity exported to grid was collected.

State-wise and sector wise number of sugar mills installed

From secondary data it is been observed that there are total 732 sugar mills in India and their distribution is shown as below:

Table 111: State-wise sugar mills installed (2017-18)

Sr. No	States	Private	Public	Co-operative	Total
1	**Punjab**	08	-	16	24
2	**Haryana**	03	-	16	24
3	**Rajasthan**	01	01	01	03
4	**Uttar Pradesh**	116	14	28	158
5	**Uttarakhand**	04	02	04	10
6	**Madhya Pradesh**	18	02	05	25
7	**Chhattisgarh**	-	-	03	03
8	**Gujarat**	05*	-	23	28*
9	**Maharashtra**	77	-	169	246
10	**Bihar**	13	15	-	28
11	**Assam**	01	-	02	03
12	**Orissa**	04	-	04	08
13	**West Bengal**	2*	01	-	03*
14	**Andhra Pradesh**	19	01	13	33
15	**Telangana**	10	-	01	11
16	**Karnataka**	52	03	25	80
17	**Tamil Nadu**	27	03	16	46
18	**Pondicherry**	01	-	01	02
19	**Kerala**	01	-	01	02
20	**Goa**	-	-	01	01
21	**Nagaland**	-	01	-	01
22	**Dadar & Nagar Haveli**	-	-	01	01
	All India	**362**	**43**	**328**	**732**
Closed Mills		**71**	**33**	**104**	**208**
Operational Mills[21]		**291**	**10**	**224**	**524**
		19.61%	**77.27%**	**31.60%**	**100%**

* Includes Refineries in West Bengal And Gujarat.
Source: Directorate of Sugar, Price Policy of Sugarcane 2019-20, Page. No. 1

21. https://www.chinimandi.com/state-wise-number-of-factories-in-operation/

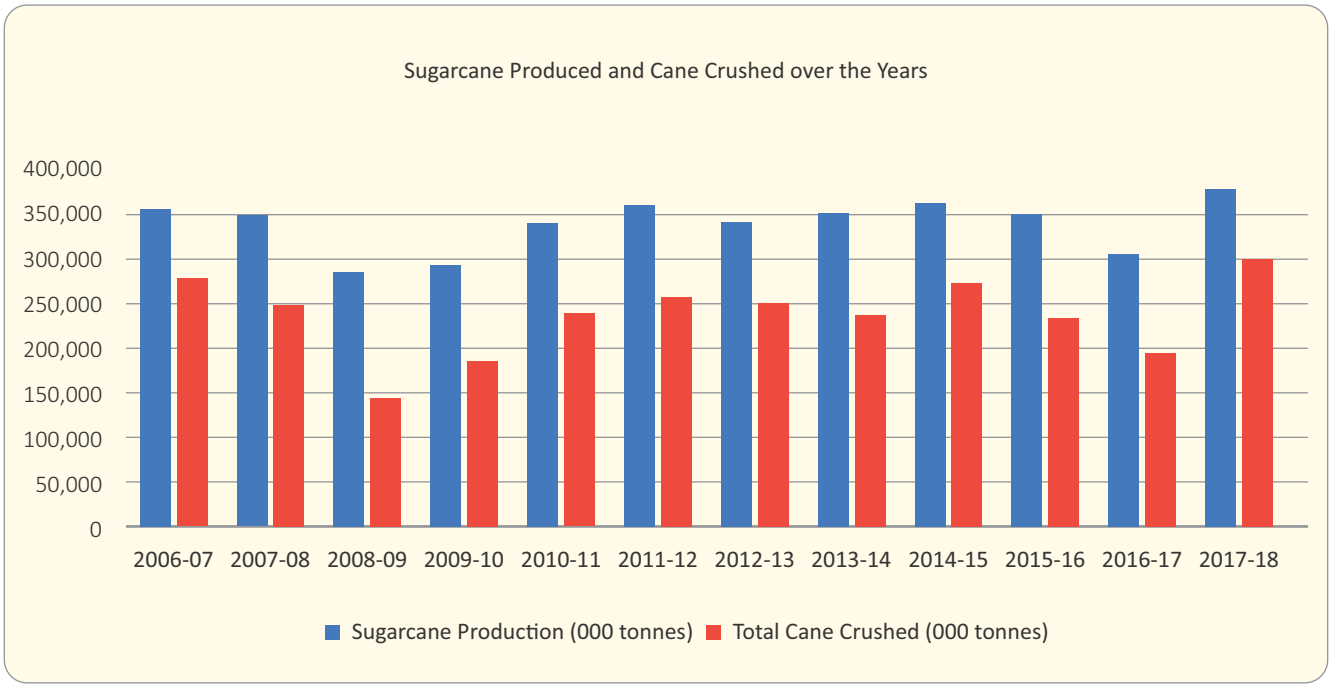
Email Based Survey

The email survey was also administered to get more information on the utilization of bagasse in sugar mills and cogeneration plants. The information sort from state nodal agencies revealed that 654 biomass and bagasse power plants are in working condition in India.

Table 112: Status of Biomass and Bagasse Co-generation Power Plants (as of 09.12.2020)

S.no.	Contacted SNAs	Total no of Biomass Plant	Total no of Bagasse Plants	Total No of Plants in the State/country
1	(Andhra Pradesh) NREDCAP	57	16	73
2	(Telangana)TSREDCO	6	12	18
3	(Tamil Nadu) TEDA	20	31	51
4	(Uttar Pradesh) UPNEDA	6	66	72
5	(Kerala) ANERT	1	0	1
6	(Bihar) BREDA	2	11	13
7	(Chhattisgarh) CREDA	24	4	28
8	(Gujarat) GEDA	6	8	14
9	Daman & Diu	0	0	0
10	(Maharashtra) MEDA	6	139	145
11	(Punjab) PEDA	11	55	66
12	(Rajasthan) RRECL	13	0	13
13	(Sikkim) SREDA	0	0	0
14	(Haryana) HAREDA	4	29	33
15	(Madhya Pradesh) MP URJA	0	34	34
16	(Tripura) TREDA	0	0	0
17	(Odisha) OREDA	3	0	3
18	(Assam) AEDA	1	0	1
19	(West Bengal) WBREDA	12	0	12
20	Karnataka (KREDL)	15	49	64
21	Arunachal Pradesh (APEDA)	0	0	0
22	(Goa) GEDA	0	0	0
23	(Himachal) HIMURJA	0	0	0
24	(Jammu & Kashmir) JAKEDA	0	0	0
25	(Jharkhand) JREDA	0	0	0
26	Mizoram (ZEDA)	0	0	0
27	Nagaland (NREDA)	0	0	0
28	Puducherry (REDAP)	0	0	0
29	Meghalaya (MNREDA)	0	0	0
30	Delhi	0	0	0
31	(Uttarakhand) UREDA	12	1	13
	Total	**199**	**455**	**654**

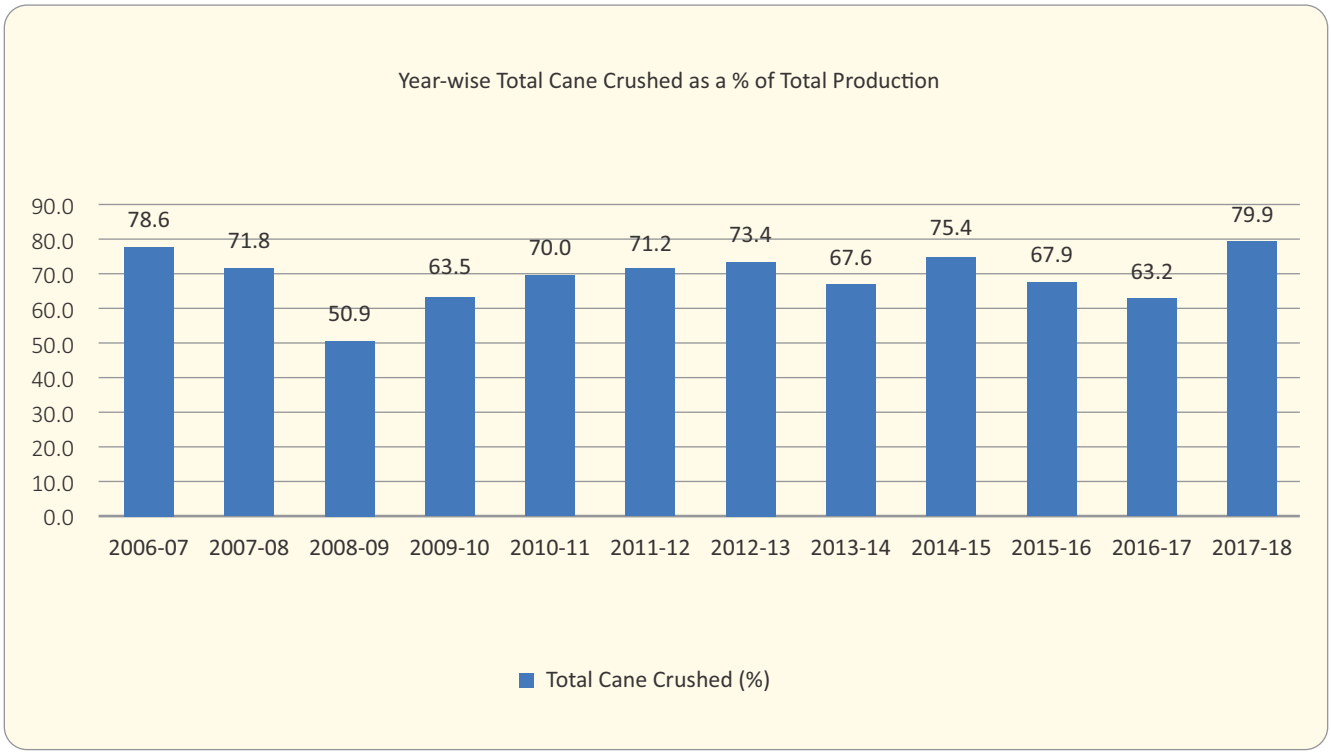
The data collected through a primary survey and secondary data sources were collated to note the utilization pattern of sugarcane and its residue depending on obtained values, bagasse availability was determined. In the sugar industry, the majority of sugarcane is crushed for sugar production. The following graph shows the cane crushed vis sugarcane produced in the last 12 years.



Source: Co-operative Sugar Vol. 51

Figure 192: Year-wise Sugarcane Production and Cane Crushed (in tonnes)

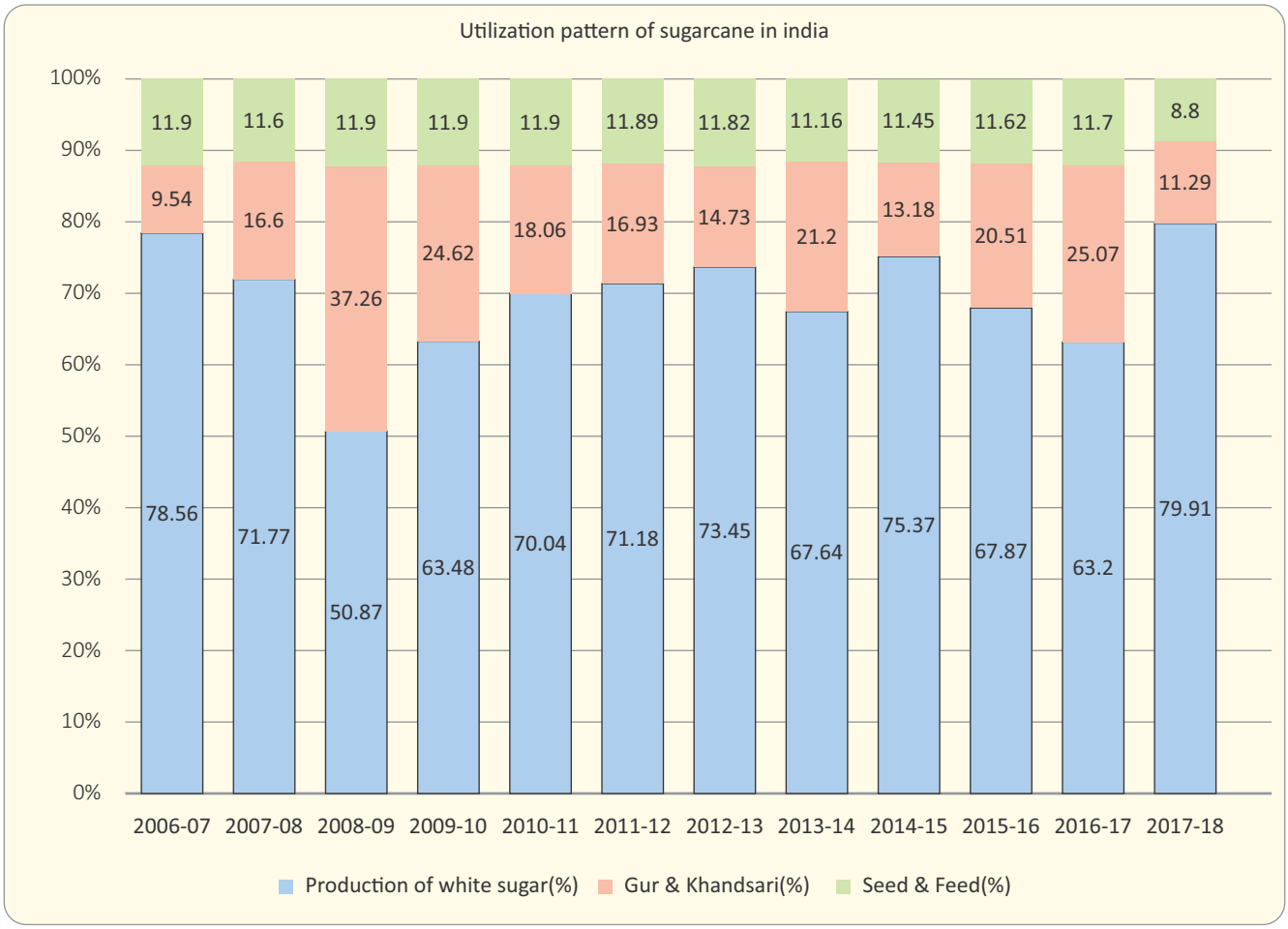
It is also being observed that the average cane crushed in the last decade is 69.45% of the total sugarcane produced in India and is represented as below:



Source: Co-operative Sugar Vol. 51

Figure 193: Percentage of total cane crushed (%) from 2006-18

Sugarcane produced in India has also got various other usages, apart from sugar production in sugar mills like Gur & Khandsari, Seed and Feed production. The utilization of sugarcane over the last 12 years for various purposes is depicted in the graph below.



Source: India Council of Agriculture Research, ICAR

Figure 194: Utilization Pattern of Sugarcane in India

It can be inferred from the above graph that the use of Sugarcane as Seed & Feed is nearly constant throughout the years. In contrast, there are fluctuations in the Sugarcane utilization for Sugar and Gur & Khandsari Production.

As per the Members of the Khandsari Association, there are approximately 50 Khandsari Sugar manufacturing units in India[22]. However, Gur manufacturing units' data is not available with the association as the manufacturing units are unorganized and non-registered.

Bagasse produced in both Khandsari and Gur manufacturing units is burnt in the furnace to provide heat for boiling the sugarcane juice. An effort has to make to modernize the manufacturing process to enable the availability of Bagasse from this unorganized sector to utilize the same for power generation.

State-wise Bagasse Availability (2015-18)

The state-wise information on the area of sugarcane cultivation (Ha), Yield (tonnes/Ha), Production (tonnes), sugar production (tonnes), sugar recovery (%), cane crushed in sugar mills (tonnes), bagasse availability (tonnes) to assess the surplus power potential from bagasse availability is collated and presented as below:

The table below represents the sugarcane, sugar and Bagasse statistics for the previous years.

22. A Status Report on Khandsari Sugar/Jaggery (Gur), MSME, Govt. of India

Table 113: Sugarcane, Sugar and Bagasse Statistics from the year 2015-16 to 2017-18

States / Uts	Area (000 hectare)			Yield (t/ha)			Production (000 tonnes)			Sugar Production (000 tonnes)			Sugar Recovery (%)			Cane Crushed in Sugar Mills (000 tonnes)			Bagasse Availability (000 tonnes)		
	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18
Andhra Pradesh	122	103	99	76.7	76	78.7	9353	7830	7790	550	390	460	9.31	9.34	9.43	5907.6	4175.6	4878.0	1949.52	1377.94	1609.76
Bihar	244	239.6	233.8	51.8	54.4	59.1	12649	13036	13825	500	530	720	9.69	9.08	9.54	5160.0	5837.0	7547.2	1702.79	1926.21	2490.57
Gujarat	157	169	182	70.8	44.8	66.3	11120	11950	12072	1120	880	1110	10.37	10.56	10.51	10800.4	8333.3	10561.4	3564.13	2750.00	3485.25
Haryana	93	102	114	72	80.6	84.5	6692	8223	9633	540	670	730	9.39	10.19	10.46	5750.8	6575.1	6979.0	1897.76	2169.77	2303.06
Karnataka	450	397	370.3	84.1	69	84.1	37834	27378	31135	4050	2140	3690	10.59	10.28	10.57	38243.6	20817.1	34910.1	12620.40	6869.65	11520.34
Maharashtra	987	633.3	902	74.7	82.5	92	73680	52262	82984	8470	4200	10710	11.19	11.19	11.09	75692.6	37533.5	96573.5	24978.55	12386.06	31869.25
Punjab	90	88	96	73.4	81.3	83.6	6607	7152	8024	670	660	820	10.01	9.34	9.74	6693.3	7066.4	8418.9	2208.79	2331.91	2778.23
Tamil Nadu	252.3	218.3	171.9	101.1	87	99.8	25494	18988	17154	1370	1050	550	8.47	9.08	8.5	16174.7	11563.9	6470.6	5337.66	3816.08	2135.29
Telangana	35	29	35	68.7	71.1	74.4	2405	2061	2604	280	120	270	10.83	10.32	10.84	2585.4	1162.8	2490.8	853.19	383.72	821.96
Uttar Pradesh	2169	2160	2234	67	64.9	79.2	145385	140169	177033	6850	8770	12050	10.51	10.26	10.73	65176.0	85477.6	112302.0	21508.09	28207.60	37059.65
Uttarakhand	96.9	93	90	60.8	69.6	69.7	5886	6477	6271	270	350	450	9.52	8.2	10.18	2836.1	4268.3	4420.4	935.92	1408.54	1458.74
Others	231	203.6	209.2	49.1	51.8	54.4	11344	10543	11379	460	480	650	10.47	10.25	10.64	4393.51	4682.93	6109.02	1449.86	1545.37	2015.98
All-India	**4927.2**	**4435.8**	**4737.2**	**70.7**	**69**	**80.2**	**348449**	**306069**	**379904.0**	**25130.0**	**20240.0**	**32210.0**	**10.5**	**10.3**	**10.6**	**239414.1**	**197493.5**	**301660.8**	**79006.7**	**65172.8**	**99548.1**

In order to assess the surplus power potential, it was necessary to understand the apportionment of surplus bagasse from sugar production towards power generation and heat requirement. The detailed focus group discussion revealed that there is a scope to utilize surplus bagasse in existing co-generation plants. It was also noted that the bagasse availability for Co-generation plants might be increased by collecting the same from other sugar mills, which do not have the co-generation facility. The structured survey and Focus Group Discussion (FGDs) reveal the following observations to calculate the surplus bagasse available for power production, which leads to power potential calculation.

1. Crop Residue Ratio (CRR) of Bagasse as 0.33;
2. Gross Calorific Value (GCV) of Bagasse as 4350 Kcal/Kg;
3. Percentage Consumption of Bagasse by Power Block for Generating Electricity as 55%;
4. Efficiency of Cogeneration Plants is considered as 67% (45% heat block + 22% power block);
5. Average Plant running days as 150 days;
6. The maximum loading factor is 90-95%

Field Survey in various locations – visiting Biomass and Bagasse Co-generation Plants across the Country

Based on the above observations, the state-wise bagasse availability, apportionment of power generation and final surplus power potential is calculated and presented as below:

Table 114: State-wise Bagasse Co-generation Power Potential in India for 2015-18

States	Area (000 hectare)	Yield (tonnes/ha)	Sugarcane Production (000 tonnes)	Sugar Production (000 tonnes)	Sugar Recovery (%)	Cane Crushed (000 tonnes)	Bagasse Availability (000 tonnes)	Bagasse Apportioned for Power Block (55%) (000 Tonnes)	Available Bagasse Power Generating Potential in Sugar Mills (in MW)	Bagasse Cogeneration Installed Capacity (MW), as per MNRE (30.10.2020)	Surplus Bagasse Power Potential at Sugar Mills (in MW)
Andhra Pradesh	108	77.1	8324.3	466.7	9.4	4985	1645.3	904.9	279.6	206.9	72.7
Bihar	239	55.1	13170.0	583.3	9.4	6181	2039.9	1122.0	346.6	100.5	246.1
Gujarat	169	60.6	11714.0	1036.7	10.5	9891	3264.3	1795.4	554.7	20.8	533.9
Haryana	103	79.0	8182.7	646.7	10.0	6458	2131.2	1172.1	362.1	102	260.1
Karnataka	405	79.1	32115.7	3293.3	10.5	31424	10370.2	5703.6	1762.1	1729.8	32.3
Maharashtra	840	83.1	69642.0	7793.3	11.2	69853	23051.7	12678.4	3917.0	2351	1566.0
Punjab	91	79.4	7261.0	716.7	9.7	7390	2439.0	1341.4	414.4	161	253.4
Tamil Nadu	214	96.0	20545	990.0	8.7	11401	3762.4	2069.3	639.3	750.4	0.0
Telangana	33	71.4	2356	223.3	10.7	2094	691.2	380.1	117.4	98	19.4
Uttar Pradesh	2187	70.4	154195	9223.3	10.5	87841	28987.6	15943.2	4925.7	1929.5	2996.2
Uttara-khand	93	66.7	6211	356.7	9.3	3835	1265.6	696.1	215.1	72.6	142.5
Others	214	51.8	11088	530.0	10.5	5071	1673.7	920.5	284.4	24.95	259.4
All-India	**4700**	**73.3**	**344807**	**25850.0**	**10.5**	**247289**	**81605.5**	**44883.1**	**13866.7**	**7547.45**	**6382.1**

Source: Calculated Values
Installed Bagasse Potential in Others is 20 MW in Chhattisgarh and 4.95 MW in Rajasthan.

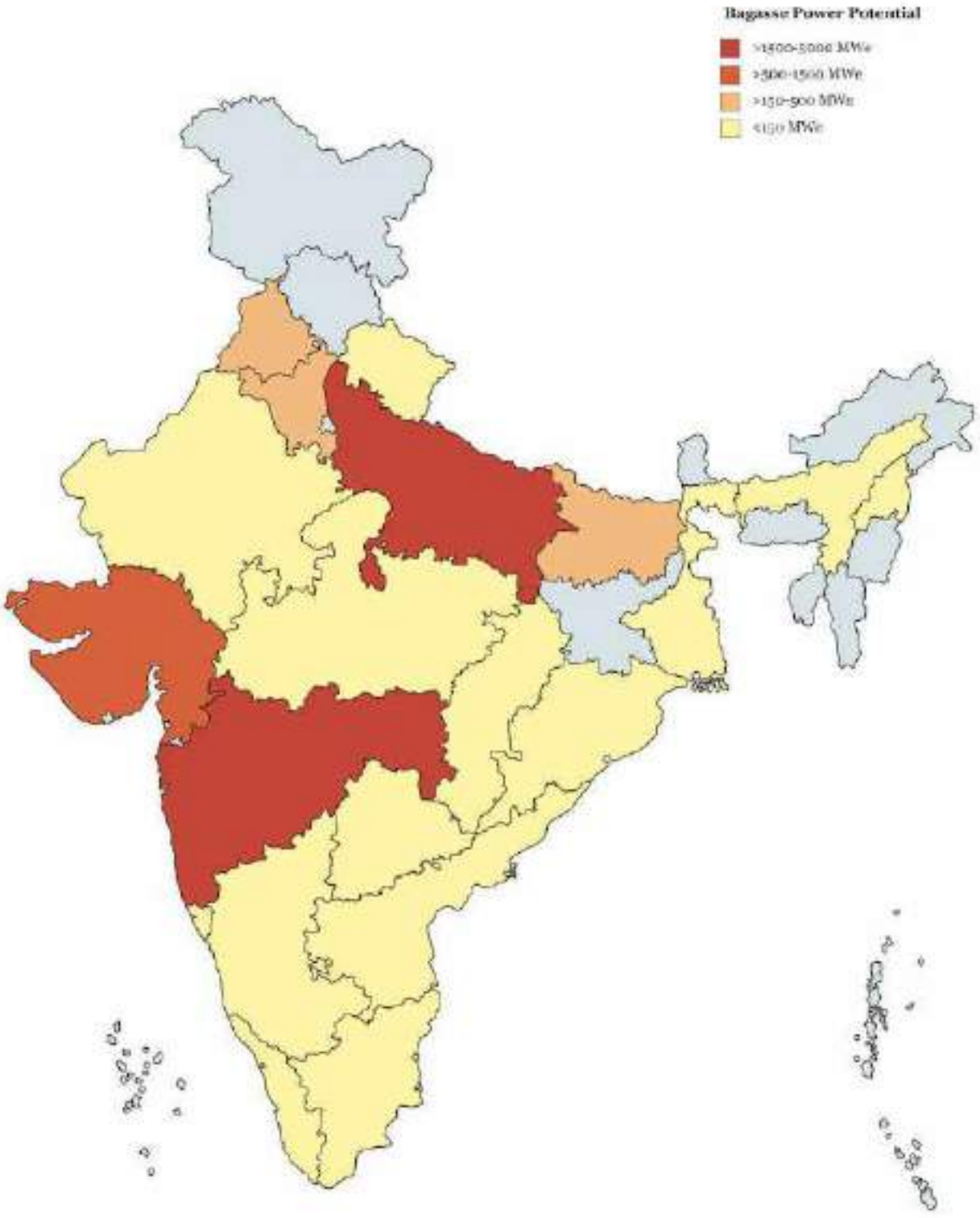


Image Credit: Leela Krishna Vegi and Saikiran B Kasoji

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07
CHAPTER

Observations

OBSERVATIONS

The critical observations of the study are as follows:

- The total gross cropped area (selected crops list of 54) (TE-2015-2018) brought under selected crops in India was around 198.11 million hectares at all India level.
- Total production produced from these 54 selected crops at all India level for the selected period was around 774.38 million tonnes.
- The calculated total available biomass potential at all India level was derived as around 754.50 million tonnes.
- Around 2/3rd portion of total biomass produced, i.e., 525.98 million tonnes, is utilized for domestic purpose and other purposes like cattle feeding, compost fertilizer, etc.
- The remaining 1/3rd portion, 228.52 million tonnes, has resulted in surplus biomass.
- The estimated gross biomass power potential for 2015-18 from the selected crops is around 28445.52 MWe at all India level.
- The estimated gross biomass power potential (based on trends) for 2019-20 from the selected crops is around 30319.00 MWe at all India level.
- The estimated gross bagasse co-generation power potential for 2015-18 is 6382.1 MWe at all India level.
- To the total biomass power potential for 2015-18, the lions share is contributed by Punjab (10.6%), Uttar Pradesh (9.8%), followed by Gujarat (9.3%), Maharashtra (9.2%), Madhya Pradesh (8.8%), Andhra Pradesh (7.0%), Karnataka (6.3%), West Bengal (6.1%), Telangana (5.9%), Tamil Nadu (5.5%) and Haryana (4.8%) contributing to 83.4% of all India Biomass Power Potential.
- For the year 2019-20, the lions share is contributed by Madhya Pradesh (10.9%), followed by Punjab (10.2%), Maharashtra (10.1%), Gujarat (10%), Uttar Pradesh (8.7%), Andhra Pradesh (7.6%), Karnataka (6.9%), Rajasthan (6%), West Bengal (5.2%), Telangana (4.4%), Haryana (4.4%), contributing to 84.4% of all India Biomass Power Potential.
- For 2015-18, the highest biomass power generating potential crops are rice (19.98%) followed by Cotton (19.65%), Wheat (15.84%), Maize (6.24%), Potato (5.68%), Coconut (4.11%), Banana (3.39%), Sugarcane (3.05%), Other Oilseeds (2.39%), Arhar/Tur (2.08%) and Castor (1.88%) contributing to 84.29% of all India Biomass Power Potential.
- For the year 2019-20, the highest biomass power generating potential crops are Cotton (20.34%), followed by Rice (19.10%), Wheat (15.99%), Maize (6.12%), Potato (4.95%), Coconut (4.44%), Banana (3.94%), Sugarcane (3.15%), Arhar/Tur (2.73%), Castor (2.18%) and Bajra (2.15%) contributing to 85.09% of all India Biomass Power Potential.
- The high potential states in biomass power generation with reference to Rice crop are Punjab, Tamil Nadu, Haryana, Andhra Pradesh, Chhattisgarh, Odisha, Madhya Pradesh, Telangana, and West Bengal.
- On average, the surplus factor for rice crop at all India level is around 0.21, i.e., 41.72 million tonnes is availability as surplus biomass from rice crop residue. The biomass power potential derived from the rice crop residue is about 5682.46 MWe during the period of TE 2015-18.
- On average, the surplus factor for a wheat crop at all India level is around 0.19, i.e., 33.37 million tonnes is available as surplus biomass from wheat crop residue. The biomass power potential derived from the wheat crop residue is about 4505.30 MWe during the period of TE 2015-2018.
- Total Maize biomass production and surplus biomass are at 69.92 million tones, and 15.21 million tonnes, respectively, from which biomass power potential derived was about 1776.35 MWe.
- From the Cereals group, total biomass production is 488.90 million tonnes, and 96.68 million tonnes are surplus biomass from which biomass power potential was derived as about 12744.43 MWe.
- In total, the Pulses group contributes about 4.59%, i.e., 1308.03 MWe biomass power of the total gross biomass power potential in India.
- The whole oilseeds group contributes about 7.07%, i.e., 2013.27 MWe biomass power potential of the total gross biomass power potential in India. Groundnut, Castor, Sunflower are the major oilseed crops contributing the most to biomass production.
- Cotton is another potential crop that contributes about 19.65%, i.e., 5590.08 MWe biomass power potential to the total gross biomass power potential at all India level.
- The high potential states in biomass power generation with reference to Cotton are Maharashtra (36.85%), Gujarat (23.29%), Telangana (18.00%), Haryana (5.33%), which contributes to 83.48% of all India Power Potential for Cotton.
- With reference to the Primary field Survey, on average, the selected respondents are holding 1.7101 hectares at all India level.
- The majority of the sample farm respondents belong to wetland 3259, whereas 1457 respondents have the dry land for cultivations.

OBSERVATIONS

- From the selected total sampled respondents, a major chunk of the respondent's belongs to the marginal category (2083), followed by the small category (1245), medium category (1334), and a small proportion is from large category (54) respondents.
- The average family size of the selected respondents is 5.89 at all India level.
- The average cattle holding by each respondent is about 8.9 number which includes cows, buffaloes and ox and etc.,
- Highest avg. Biomass production at individual farm level is seen in Punjab and Kerala state around 93-98 tonnes, followed by Karnataka 54.7 tonnes and Haryana with 32 tonnes. The remaining states have less than 10-20 tonnes.
- Avg. surplus biomass at the farm level is highest in Karnataka (20.41 t/ha), Andhra Pradesh (5.51 t/ha) and Punjab (5.04 t/ha). Andhra Pradesh, Karnataka, and Meghalaya states are utilizing more than half of the produced biomass for domestic purposes, whereas in other states such as Chandigarh, Gujarat, Maharashtra, Manipur, Punjab and Telangana state the utilization rate is about 30-40% range in total biomass production. The remaining states showed a 20 % and below level utilization rate.
- At all India level, the average area of 2.72 hectare results in avg. production of 13.71 tonnes and 20.13 tonnes of biomass. From this, 13.66 tonnes is utilized, i.e., 67% is utilized for domestic uses, and the remaining 6.47 tonnes is surplus biomass at an individual farmer level in India.
- Only 36.79 respondents are willing to supply residue for biomass power production and Bagasse co-generation out of the total sample of 4716 respondents as the biomass producing plants are absent or not near to their field.
- Hardly 2.91 % of the respondent's opined that they have contract obligation/ Commitment with Energy producers or any other industries for selling crop residues in the selected study area.
- 54.9% of the total sample opined that they are not willing to sell crop biomass residue to agencies/ suppliers supplying biomass to energy producers.
- About half of the respondents, i.e., 41.37% of the sample respondents, are willing to go for contract obligation with energy producers for supplying the crop residues from your land/fields.
- 27.8% of the respondents confirmed that they are in favour of village-level co-operative body/societies/associations which can be formed by the government to regular the supply and pricing of crop residues to energy producers.
- The majority of the farmers opined that they are not aware of these biomass power-producing plants and the supply chain of these process.
- In addition to that, they expressed a concern related to the occurrence of additional transportation cost in the transport of the biomass residue to the plant, which they are not interested.
- Rice crop has shown high deviation in shredding cost from Rs. 2000 to 7000 per acre across the states, whereas other cereals, pulses and oilseeds shredding cost ranged between Rs. 2000-3500 per acre.
- The shredding cost for jute, sugarcane and Arecanut is slightly on the higher side at Rs. 7000 to 10000 per acre.
- The annual electricity generation for the year FY 2017-18 in bagasse-based power plants is 11773 MU. As we have been observed, most of the plants are running for around 5-6 months in a year. This shows that to meet this generation with an all India installed capacity of 7547.45 MW, the average loading factor of the plant is around 45% which again reiterate the availability of spare generation capacity in the existing cogeneration plant.

From this study, it is evident that there is a considerable scope for the establishment of the biomass plant for biomass power and bagasse generation based on the supply-demand dynamics of the biomass availability at each state level for effective utilization of the produced residual biomass. There is a need for considerable efforts to be laid for bringing awareness among the farming community and the different stakeholders about the importance of the surplus biomass and effective utilization of the biomass for biomass power generation.

Biomass Power Potential of Major Crops

Major Crop	Crop Area (million Hectare)	Crop Production (million tonnes)	Biomass Generation (million tonnes)	Surplus Biomass (million tonnes)	Biomass Power Potential (Mwe)	Percent Share (%)
Rice	46.15	123.03	184.55	41.72	5682.46	18.74
Wheat	34.00	106.85	192.34	33.37	4505.30	14.86
Maize	9.75	30.40	69.92	15.21	1776.35	5.86
Potato	1.69	39.86	32.29	17.37	1617.08	5.33
Cotton	12.46	4.67	57.61	46.24	5590.08	18.44
Cereals	107.09	279.17	488.90	96.68	12744.43	42.03
Pulses	27.71	19.23	27.20	11.21	1308.03	4.31
Oilseeds	18.51	21.65	47.73	17.81	2013.37	6.64
All India	**182.17**	**801.88**	**791.78**	**242.48**	**30319.00**	**100.00**

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ANNEXURE A

Annexure - 01	Literature Review
Annexure - 02	Questionnaires
Annexure - I	Questionnaire format used for Primary Survey (English Format)
Annexure - I (a)	Questionnaire format used for Primary Survey (Hindi Format)
Annexure - II	Questionnaire format used for Biomass Plant (e-mail base survey)
Annexure - III	Questionnaire format used for Bagasse Cogeneration Plants / Sugar Mills (e-mail base survey)
Annexure - IV	GCV Crop Sample Test Results for Batch 01, 02 and 03
Annexure - 03	Contact Information of SNAs and Manufacturing Associations
Annexure - 04	State-wise Analysis on responses received from Bagasse Co-generation plants
Annexure - 05	Special Report on Assessment of Biomass Power Potential in Lakshadweep Islands

Annexure - 01 | Literature Review

[1] Ishwar Prakash Sharma, Chandra Kanta, Yogendra Singh Gusain (2018), Crop residues utilization: Wheat, paddy, cotton, sugarcane and groundnut, International Journal of Botany Studies

The study provides the use of crop residues which has been left after harvesting in the agriculture field. Traditionally after harvesting of the grains, farmers usually burn the crop residue in-situ. The open burning of crop residue has adverse environmental impacts and serious health hazards. The same crop residue can be a source of income to farmers. Since crop residue has wide range of applications which includes fodder to animals, livestock bedding, domestic fuel, as a fuel in biomass plants for power generation etc. Crop residue is a vital natural resource for conserving and sustaining soil productivity. Hence, the incorporation of residue on agriculture field can improve physical and biological conditions of the soil and prevent soil degradation. Crop residue also contains large quantities of nutrients, and thus the return of crop residues to the soil can save a considerable quantity of fertilizers. Thus, the crop residues are not the agricultural waste but are valuable resource with wide range of applications.

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[2] Technology Information Forecasting and Assessment Council –TIFAC (2018), A Report on "Estimation of Surplus Crop Residue in India for Bio-fuel Production"

Technology Information Forecasting and Assessment Council has conducted a study to estimate the surplus crop residue of eleven major producing crops viz. Rice, Wheat, Maize, Sugarcane, Cotton, Gram, Tur, Groundnut, Mustard, Soyabean and Castor. In order to find biomass usage by the farmers and selling of crop residue to industries etc. field survey was conducted in 10 states covering 43 districts and 1376 farmers. For the districts where survey could not be conducted, the data related to crop biomass usage was assessed based on literature review, discussion with personals from ICAR institutes located in the regions and expert judgment. Based on the field survey data, crop-wise and district wise surplus factor was estimated using statistical analysis. And these factors were used to estimate surplus crop biomass.

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[3] Jaswinder Singh and Amit Chauhan (2014), Assessment of Biomass Resources for Decentralized Power Generation in Punjab, International journal of Applied Engineering Research

The study assessed availability of biomass resources for power generation in state of Punjab. The surplus biomass generated by major crops, were estimated by considering residue to product ratio. The results indicated that the agricultural biomass could be used to provide continuous and sustainable fuel supply to the decentralized power plants in the state. The power plants with capacity of 1MW to 2MW can be installed in the rural areas of Punjab, to meet the local energy needs. This will provide the waste disposal system for the agricultural biomass in spite of burning in the fields, as well as it will also overcome the problems of energy deficit. A supply potential of the order of 41.89Million Metric Tonnes (MMT) was evaluated through agricultural biomass. Under the specific assumptions, a total of 5667 MW of electric power would be generated, by using all the biomass resources available on annual basis.

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[4] Moonmoon Hiloidhari, Dhiman Das and D C Baruah (2014), Bio-energy potential from crop residue biomass in India, Renewable and Sustainable Energy Reviews

The study assessed crop residue biomass and subsequent bio-energy potential in 28 states of India using crop statistics and standard procedure. Total of 39 residues from 26 crops cultivated in India were considered for the study. It was found that, India produces 686 Million Tonnes (MT)of gross crop residue biomass on annual basis, of which 234 MT (34% of gross) was estimated as surplus for bio-energy generation. At state level, Uttar Pradesh produced the highest amount of crop residue amongst all the 28 states. Amongst all the crops, sugarcane produces the highest amount of surplus residue followed by rice. The estimated annual bio-energy potential from the surplus crop residue biomass was 4.15 Exajoule (EJ), equivalent to 17% of India's total primary energy consumption. There existed the variation from 679 MJ (West Bengal) to 16840 MJ (Punjab) of per capita crop residue bio-energy power potential amongst the states of India.

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[5] Jagtar Singh, B.S. Panesar and S.K. Sharma (2011), Mathematical model for transporting the biomass to biomass-based power plant, Biomass and Bio energy

The study dealt with the mathematical model for collection and transportation of the biomass from fields to biomass-based power plants. The unit transport cost was calculated using the model. Four systems of transport were conceptualized for two transport modes (tractor with wagon and truck). Three types of agricultural biomass (loose, baled and briquetted) were considered for transport analysis. For all modes of transport, it was observed that unit cost of transport decreases with increase in distance. The transport cost was least for briquetted biomass as compared to loose and baled biomass.

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[6] T.V. Ramachandra, G. Kamakshi, B.V. Shruthi (2003), Bio-resource Status in Karnataka, Renewable and Sustainable Energy Review

The study assessed the bio-resource status of various agro-climatic

zones in Karnataka. Biomass generation from agriculture, horticulture, and forest was computed. The study has also computed consumption of the biomass for various purpose viz. Domestic fuels, Cattle Feeding, Industries etc. Secondary data was the source for the estimation of biomass availability. And the data from the primary survey, National Sample Survey Office (NSSO) and Literature were the source of the data for estimation of biomass usage. The ratio of biomass availability and biomass usage was calculated for the all the aforementioned zones. If the value was greater than 1 then it was called surplus zone and if the value was less than 1 it was called deficit zone. In this manner all the agro-climatic zones were categorized into surplus zones and deficit zones.

[7] IISc Bangalore, Biomass Resource Atlas of India

The Biomass Resource Atlas of India provides the information on taluka wise, district wise and state-wise biomass availability, biomass usage, surplus biomass and its associated power potential for the years 1998-99 and 2000-04. It provided a brief overview on procedure followed and variables that were considered to arrive at the final result i.e. biomass power potential. It also furnished information on crop residue type of each crop during their study along with residue factor of each residue type. They have categorized the crops based on season which we find helpful during our survey plan preparation.

[8] Crop residues utilization: Wheat, paddy, cotton, sugarcane and groundnut Crop residues utilization: Wheat, paddy, cotton, sugarcane and groundnut (2018) Ishwar Prakash Sharma, Chandra Kanta and Yogendra Singh Gusain. International Journal of Botany Studies, Volume 3(3): 11-15

Sharma et al, (2018) studied on Crop residues which are plants part, left in the field after harvesting. These are good source of nutrients when added to the soil. And are good natural resources, crops like Wheat, Paddy, Cotton, Sugarcane and Groundnut left large amount of residues in the ground which might be utilize by many ways like industry, nutrient and energy production etc. Residues rich in lignin and polyphenol contents experience the lowest decay. Decomposition of crop residues occurs at a rapid rate under the warm and humid conditions of the tropics. Crop residues caused marked increases in microbial populations and microbial biomass in soils. The addition of crop residues to flooded soils enhanced biological N fixation by phototrophic and heterotrophic bacteria. So they finally concluded that the crop residues are not the agricultural waste but it is most valuable for the managing system as well as for the human welfare.

[09] Utilization of Crop Residues for Livestock Feeding: A Field Experience (2018) Rakashkumar Rathod, Veeranna K C, Ramachandra B and Dattu Reddy XXVI Annual Conference of Society of Animal Physiologists of India (SAPI)World Bank funded KWDP Sujala-3 Project

As per IPCC methodology fraction of crop residues burnt in field was taken as 25 per cent for all the crops (IPCC, 2006). The data shows that, sugarcane and rice residue burning constitutes 37% and 30% of total all-India emissions due to burning. In India, approximately 6.5 million tonnes of sugarcane trash is being produced every year and most of the residues are usually burnt in the field with the opinion that its management is laborious, will reduce germination and hinders routine ratoon cultivation practices.

The options in terms of incentives or awards to the farmers in this direction and developing relevant technologies and practices is the urgent need for improving productivity and protecting the environment. Residue to crop ratio – table no 1.

One ton of rice straw on burning releases about 3 kg particulate matter, 60 kg CO, 1460 kg CO2, 199 kg ash and 2 kg SO2 (Gadi, 2003).

[10] Moonmoon Hiloidhari, Kathleen Araújo, Shilpi Kumari, D.C. Baruah, T.V. Ramachandra, Rupam Kataki, and I.S. Thakur (2018) Bioelectricity from sugarcane bagasse co-generation in India–An assessment of resource potential, policies and market mobilization opportunity for the case of Uttar Pradesh Journal of Cleaner Production IP7.1

Uttar Pradesh, the largest sugarcane-producing state in India, having potential to produce 27.05 million tonnes of usable bagasse annually. Major, sugarcane producing regions are identified within the western and northeastern agro-climatic zones. Specific to power generation, the state could produce 1.93 GW of bioelectricity from sugarcane bagasse. At the agro-climatic zone level, the bioelectricity potential varies between 2.46 MW (Vindhyan zone) and 655 MW (western plain zone).

When considered at the district level, the potential varies from 66 kW in Firozabad to an upper bound of 232 MW in Muzaffarnagar. The latter estimate indicates that some districts of Uttar Pradesh could be transitioned to 100% renewable electricity from bagasse cogeneration. In conjunction with the ongoing growth path for India and energy access considerations, we recommend more strategically-focused energy policies, like auctions and regular resource-mapping zoning that can catalyze biomass energy adoption, while mitigating the greenhouse gas footprint of India.

Annexure - 02 | Questionnaires

Annexure - I : Questionnaire format used for Primary Survey

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Ministry of New and Renewable Energy

Note: Fill all the blanks in the questionnaire, each question will have impact on data analysis

STATE:		**FORM NO.:**
District:	**Mandal/Tehsil:**	**Village:**
Name of the Surveyor		
Contact No. of Surveyor		
Survey Date (DD/MM/YYYY)		

1. GENERAL INFORMATION

(Tick ✔ the suitable box)

Name of the farmer	
Total Agriculture Land Area holding by farmer	Guntha (1000sqft)/Acres /Hectare
Type of Land	☐ Wet Land ☐ Dry Land
Type of Farmer	☐ Small ☐ Medium ☐ Large
Total no. of Family Members (No.)	Adults / Children's
Cattle Population in farmers Family (No.)	

2. CROP PATTERN

(Try to collect all the information from the farmer about his annual cropping pattern, for all mentioned seasons)

Sno.	Crops Name	Total Crop Area (in Acres)	Crop Production (in Tonnes)	Remarks (If any)
Kharif (June – Sept)				
1				
2				
3				
4				
Rabi (Oct – Jan)				
1				
2				
3				
4				
Summer (Feb – May)				
1				
2				
3				
4				
Perennial (Year-Round or Whole Year)				
1				
2				
3				
4				

3. RESIDUE UTILIZATION OF AGRICULTURE FARMERS

Sno.	Queries to Farmer						
1	Current Usage of Crop Residue — Please tick on appropriate check box: in □Tonnes / in□%)						
	Crop Name	**Open Burning**	**Cattle Feeding**	**Domestic Fuel**	**Compost Fertilizer**	**Selling to food Industry**	**Any other (.....)**

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Note: Fill all the blanks in the questionnaire, each question will have impact on data analysis

Sno.	Queries to Farmer

2 Cost of Residue if farmer is Selling /Supplying to biomass/bagasse co-gen plant or other industries*

Name of Crop(s):

(Tick ✔ the appropriate box) (Units: in Rs./Tonne)

✓	Biomass Plants		✓	Sugar Mill		✓	Any Other/Paper Mills	
✓	Brick Making		✓	Ice Factory		✓	Coal based power plant	

Mention any other in detail (if any):

3 If Farmer is not selling the crop residue, ask him, is he interested to sell?(Tick ✔ the suitable box)

✓	YES	✓	NO

If Yes, then only ask him below questions.

Do you think you could supply the crop residue from your field to biomass plant?

Name of Crop Residue	Duration of Supply	Quantity (in tonnes)	Name of Crop Residue	Duration of Supply	Quantity (in tonnes)

4 Crop Sample Collection:

S.no	Distance between two plants			No. of plants /____ area	
	Crop Name	Length	Breadth	No. of Sq.ft	No. of plants
1					
2					
3					
4					

5 Cost of Shredding / handling the crop residue by the farmer?

S.no	Crop Name	Cost of Shredding/Handling	Acre / Tonnes	Time for collection of Crop Residue(*Hrs./Days*)
1				
2				
3				
4				

6 What kind of issues you (farmer) are facing during handling and selling crop residue to biomass plants or other industries?

a.

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Note: Fill all the blanks in the questionnaire, each question will have impact on data analysis

Sno.	Queries to Farmer
	b. c. d.
8	Are you having any contract obligation/commitment with any energy producers or any other Industries for selling crop residues?(Tick ✔ the suitable box) ☐ YES ☐ NO Mention the details if "Yes" 1. No. of Years of contract..... 2. Name of Energy Producer/ Industries (Specify).....
9	Are you willing to sell crop biomass residue to agencies/suppliers supplying biomass to energy producers? (Tick ✔ the suitable box) ☐ YES ☐ NO Mention the reason if any
10	Are you willing to go for a contractual obligation with energy producers for supplying the crop residues from your land?(Tick ✔ the suitable box) ☐ YES ☐ NO If Yes ☐ Range: <1 Year; 1 – 5 — Mention appropriate value ☐ Range: 5 – 10; > 10 Years — Mention appropriate value Mention the reason, if any
11	Are you in favor of Village level cooperative body/ Societies/Associations which can be formed by the government to regulate the supply and pricing of crop residues to energy producers? (Tick ✔ the suitable box) ☐ YES ☐ NO Mention the reason, if any

**Industries – Small and medium scale industries, other processing or product manufacturing companies like brick making, pottery, etc.*

AUTHORIZATION BY LOCAL AUTHORITY

Name of the Local Authority & Contact Details *(Village Panchayat/Taluka)*	
Signature of the Local Authority with Stamp	

asci Leadership Through Learning

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Ministry of New and Renewable Energy

Note: Fill all the blanks in the questionnaire, each question will have impact on data analysis

Key Points to the Surveyor

Sno.	Rabi Crops (Winter Crops / Rabi Harvest) Harvesting Starts: April/May	Kharif Crop Harvesting Time: June to November
1	**Major Crops:** Barley, Mustard, Sesame, Peas, Gram, Oats, Wheat	**Major Crops:** Bajra, Jowar, Maize, Millet, Rice, Soybean, Sugarcane (Whole Year)
2	**Fruits:** Almond, Banana, Br, Date, Grape, Grape Fruit, Guava, Lemon, Lime, Mangoes, Orange, mulberries.	**Fruits:** Muskmelon, Sugarcane, Watermelon, Orange.
3	**Seed Plants:**Alfaalfa, Coriander, Cumin, Fenugreek, Linseed, Mustard, Isabgol, Sunflower, Bengal Gram, Red Gram (Black Pepper)	**Seed Plants:**Arhar, Black Gram, Cotton, Cowpea, Green Gram, Groundnut, Guar, Linseed, Mothbean, Mung Bean, Sesame, Urad Bean
4	**Vegetables:** Bean, Beetroot, Brinjal, Broccoli, Cabbage, Capsicum, Carrot, Cauliflower, Chickpea, Fenugreek, garlic, lady Finger, Lettuce, Pea, Onion, Potato, Radish, spinach, sweet potato, tomato, turnip	**Vegetables:** Bitter Gourd, Bottle Gourd, Brinjal, Chilli, Lady Finger, Sponge Gourd, tinda, Tomato, Turmeic, French Bean

Type of Farmers

Sno.	Type of Farmer	Range (Acers)
1	Small	0 – 1
2	Medium	1 – 5
3	Large	More than 5

Mention any if additional Information is to be included, Use the space below:

Annexure - I (a): Questionnaire format used for Primary Survey (Hindi Format)

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Ministry of New and Renewable Energy

राज्य:		प्रपत्र संख्या /तारीख:	
जिला:		मंडल/ तहसील/ गाँव:	
सर्वेक्षक का नाम मो नं			

१. सामान्य जानकारी

(उपयुक्त बॉक्स पर टिक करें)

किसान का नाम				
कुल कृषि भूमि क्षेत्र किसान द्वारा धारण	गुंठा (१००० वर्ग फुट) / एकड़ / हेक्टेर( )			
किसान का प्रकार	छोटा	मध्यम	बड़ा	
भूमि का प्रकार		सिंचित भूमी	गैर सिंचित भूमी	
परिवार के सदस्यों कुल संख्या		वयस्क		कुल बच्चे
किसान के परिवार में मवेशियों की कुल संख्या				

२. फसल स्वरूप (सभी उल्लिखित सत्रों के लिए किसान से उसकी वार्षिक फसल पद्धति के बारे में सभी जानकारी एकत्र करने का प्रयास करें)

क्रमांक	फसलों का नाम	कुल फसल क्षेत्र (एकड़ में)	फसल उत्पादन (टन में)	टिप्पणी (यदि कोई)
खरीफ (जून - सितंबर)				
१				
२				
३				
४				
रबी (अक्टूबर - जनवरी)				
१				
२				
३				
४				
ग्रीष्मकालीन (फरवरी - मई)				
१				
२				
३				
बारहमासी (वर्ष-दौर या पूरे वर्ष)				
१				
२				

३. कृषि किसानों का अवशेष उपयोग

क्रमांक	किसान को प्रश्न
१	**फसल अवशेष का वर्तमान उपयोग** कृपया उपयुक्त चेक बॉक्स पर टिक करें: in □Tonnes / in□%

फसल का नाम	खुले मे जलाना	पशुखाद्य	घरेलू ईंधन	खाद उर्वरक	खाद्य उद्योग को बेचना	अन्य उपयोग (.....)

२ यदि किसान बायोमास / बैगास को-जनरेशन प्लांट या अन्य उद्योगों को अवशेष बेच रहा / ले रहा है तो अवशेषों की लागत *

फसल का नाम:

(उचित बॉक्स पर टिक करें) (इकाइयाँ रु में / टन में)

✓	बायोमास प्लांट	✓	चीनी का खारखाना	✓	कोई अन्य / पेपर मिल्स
✓	ईंट बनाना	✓	बर्फ का कारखाना	✓	कोयला बिजली संयंत्र

किसी अन्य का विस्तार से उल्लेख करें (यदि कोई हो):

QUESTIONNAIRE FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY

Ministry of New and Renewable Energy

क्रमांक	किसान को प्रश्न

३

यदि किसान अवशेष नहीं बेच रहा है, तो क्या वह बेचने के लिए इच्छुक है? (टिक करे ✔उपयुक्त बॉक्स)) हाँ / नाही
यदि हाँ, तो उससे केवल निचे दिये गये प्रश्न पूछें।
क्या आपको लगता है कि आप अपने खेत से बायोमास प्लांट में फसल अवशेषों की आपूर्ति कर सकते हैं?

फसल अवशेष का नाम	आपूर्ति की अवधि	मात्रा (टन में)	फसल अवशेष का नाम	आपूर्ति की अवधि	मात्रा (टन में)

४

फसल नमूना संग्रह

क्रमांक	दो पौधों के बीच की दूरी			पौधों की संख्या / ___ क्षेत्र	
	फसल का नाम	लंबाई	चौड़ाई	वर्ग फुट की संख्या	पौधों की संख्या
१					
२					
३					
४					

५

किसान द्वारा फसल अवशेषों को खेती से निकालनेकी लागत?

क्रमांक	फसल का नाम	हैंडलिंग की लागत	एकर / टन	फसल अवशेष के संग्रह का समय (Hrs./Days)
१				
२				
३				
४				

६

बायोमास प्लान्ट या अन्य उद्योगों को फसल अवशेष सौंपने / बेचने के दौरान आप किस तरह के मुद्दों का सामना कर रहे हैं?
a.
b.

७

क्या आपके पास फसल अवशेषों को बेचने के लिए किसी भी ऊर्जा उत्पादकों या किसी अन्य उद्योग के साथ कोई अनुबंध दायित्व / प्रतिबद्धता है? (टिक करे ✔उपयुक्त बॉक्स) हाँ / नाही (विवरण का उल्लेख करें यदि "हाँ")
१. अनुबंध के वर्षों की संख्या .....
२. ऊर्जा उत्पादक / उद्योग का नाम (विस्तार से उल्लेख करे) .....

८

क्या आप ऊर्जा उत्पादकों को, बायोमास आपूर्ति करने वाली एजेंसियों / आपूर्तिकर्ताओं को फसल बायोमास अवशेषों को बेचने के लिए तैयार हैं? (टिक करे ✔उपयुक्त बॉक्स)) हाँ / नाही
यदि कोई कारण है तो उल्लेख करें

९

क्या आप अपने खेत से फसल के अवशेषों की आपूर्ति के लिए ऊर्जा उत्पादकों के साथ अनुबंध किए जाने को तैयार हैं? (टिक करे ✔उपयुक्त बॉक्स)) हाँ / नाही (अगर हा,)

✔	सीमा/ Range	उपयुक्त मूल्य का उल्लेख करें	✔	सीमा/ Range	उपयुक्त मूल्य का उल्लेख करें
	<१ वर्ष			५ –१०	
	१ – ५			> १० वर्ष	

कारण का उल्लेख करें, यदि कोई हो

१०

क्या आप ग्राम स्तरीय सहकारी संस्था / सोसायटी / संघों के पक्ष में हैं जो सरकार द्वारा ऊर्जा उत्पादकों को फसल अवशेषों की आपूर्ति और मूल्य निर्धारण को विनियमित करने के लिए बनाई जा सकती है? (टिक करे ✔उपयुक्त बॉक्स)

	हा		नहीं

कारण का उल्लेख करें, यदि कोई हो

स्थानीय अधिकारी द्वारा मान्यता

स्थानीय प्राधिकरण और संपर्क विवरण का नाम (ग्राम पंचायत / तालुका) स्टाम्प के साथ स्थानीय प्राधिकरण का हस्ताक्षर	

Annexure - II : Questionnaire format used for Biomass Plant (for email base survey)

EVALUATION STUDY FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE CO-GENERATION POWER POTENTIAL IN THE COUNTRY
SURVEY QUESTIONNAIRE FOR BIOMASS PLANTS

1. PLANT LOCATION

State:	District:
Mandal:	Village:

2. CONTACT DETAILS AND AUTHENTICATION

Name of the Company	
Contact Details of Company Representative	Name: Designation and Department: Mobile No.& Email ID:
Authorized Signature	

3. GENERAL PLANT INFORMATION

Type of the plant	
Capacity of the Plant (MW)	
Quantity of Biomass required (in Tonnes) at full load	
Quantity of Biomass available (in Tonnes)	
Type of Fuel available *(Ex: Rice husk, Stalks, etc.)*	
Type of Boiler Technology (Single fuel / Multi fuel / Any Others – Mention if any)	

4. CROP RESIDUE MANAGEMENT BY THE COMPANY

Type of Crop Residue	Required quantity (in Tonnes)	Available quantity (in Tonnes)	Average Cost of Residue (in Rs./Tonne)	Maximum radius considered for collecting crop residue (Kms)

5. EXTRACTION OF RESIDUE FROM THE VILLAGES

Type of Crop Residue	List the villages considered for residue extraction

6. RESIDUE TO ELECTRICITY GENERATION

Particulars / Financial Year (FY)	FY 2016 - 17	FY 2017 - 18	FY 2018 - 19
Tariff (in Rs. per kWh)			
Plant Running Hours (in a Year)			
Plant not Running Hours (in a Year)			
No. of Units Generated per annum (in MU)			

EVAULATION STUDY FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE CO-GENERATION POWER POTENTIAL IN THE COUNTRY
SURVEY QUESTIONNAIRE FOR BIOMASS PLANTS

7. MONTH-WISE AVAILABILITY OF CROP RESIDUE (Tick ✔ the appropriate box)

✔	Month	Mention Residue Types	Quantity (in tonnes)
	January		
	February		
	March		
	April		
	May		
	June		

✔	Month	Mention Residue Types	Quantity (in tonnes)
	July		
	August		
	September		
	October		
	November		
	December		

8. INCENTIVES & OTHER QUERIES *(For additional information use back side of the page)*

1	List the availing any incentives from the Government or Financial Institutions?
2	On what basis you have installed the biomass plant in this location?
3	What is the availability of Evacuation Lines for the plant?

Annexure - III : Questionnaire format used for Bagasse Cogeneration Plants / Sugar Mills (for email base survey)

EVAULATION STUDY FOR ASSESSMENT OF BIOMASS POWER AND BAGASSE COGENERATION POTENTIAL IN THE COUNTRY
SURVEY QUESTIONNAIRE FOR SUGAR MILLS

1. PLANT LOCATION

State:	District:
Mandal:	Village:

2. CONTACT DETAILS AND AUTHENTICATION

Name of the Company	
Contact Details of Company Representative	Name: Designation and Department: Mobile No.& Email ID:
Authorized Signature	

3. GENERAL PLANT INFORMATION

Type of the Plant	
Capacity of the Plant (MW)	
Quantity of Bagasse required (in Tons) at full load	
Quantity of Bagasse available (in Tons)	
Type of Fuel Usage (Ex: Rice husk, Stalks, etc.)	
Type of Boiler Technology (Single type / Multi fuel type/ Any Others – Mention if any)	

4. CROP RESIDUE MANAGEMENT

Type of Crop Residue	Required quantity (in tonnes)	Available quantity (in tonnes)	Cost of Residue (in Rs./ Tonnes)	Maximum radius considered for collecting sugarcane (Kms)

5. EXTRACTION OF RESIDUE FROM THE VILLAGES

Type of Crop Residue	List the villages considered for residue extraction

6. RESIDUE TO ELECTRICITY GENERATION

Particulars / Financial Year (FY)	FY 2016 - 17	FY 2017 - 18	FY 2018 - 19
Tariff (in Rs. per kWh)			
Plant Running Hours (in a year)			
Plant not Running Hours (in a year)			
No. of Units Generated per annum (in MU)			

7. FOR BAGASSE CO-GENERATION PLANTS

Particulars / Financial Year (FY)	FY 2016 - 17	FY 2017 - 18	FY 2018 - 19
Average Purchasing Cost of Sugarcane (in Rs./ Tonne)			
Year-wise Procurement of Sugarcane (in Tonnes)			
Amount of Bagasse Generated (in Tonnes)			
Amount of electricity consumed for captive usage (in MU)			
Amount of electricity export to grid (in MU)			

8. INCENTIVES & OTHER QUERIES

(Mention the details at the back side of the page)

1	Do you avail any incentives from the Government or Financial Institutions?
2	On what basis you have installed the biomass plant in this location?
3	What is the availability of Evacuation Lines for the plant?

GCV test results for different crop residue samples (Batch 01)

Issued to:
Senior Research Associate
Administrative Staff College of India
Bellavista, RajBhavan, Hyderabad-500 082.

LUCID Laboratories Pvt. Ltd.
Taking to the Core

Report No : LL/20-21/[illegible]
Issue Date : 20/11/2020
Customer Ref /Letter :
Ref Date : 06/11/2020

Sample Particulars: Crop & Briquette Samples

Qty : 32nos. Packing:Polythene covers Batch No:1
Test Requ: Proximate analysis & Gross Calorific Value
Dt. Of receipt of sample : 06/11/2020
Dt. Of starting of analysis : 10/11/2020
Dt. Of completion of analysis : 20/11/2020

TEST RESULTS

S.No.	Lab No	Sample Code	As Received Basis					As Dry Basis			
			Moisture (% by mass)	Ash (%bymass)	Volatile Matter (% by mass)	Fixed Carbon (% by mass)	Gross Calorific Value (K.Cal/Kg)	Ash (% bymass)	Volatile Matter (% by mass)	Fixed Carbon (% by mass)	Gross Calorific Value (K.Cal/Kg)
1	5478/1	AS/UD/MA/PU/ARECANUT/SAMPLE01/FULLCROP(Coir)	8.71	6.18	69.28	15.83	4520	6.77	75.89	17.34	4950
2	5478/2	AS/UD/MA/PU/ARECANUT/SAMPLE01/FULLCROP(Shell)	12.13	1.52	75.01	13.34	4950	1.73	85.09	15.18	5630
3	5478/3	UP/AG/ET-GA/BAJRA/SAMPLE02/STALK	10.37	9.22	67.48	12.93	4180	10.28	75.29	14.43	4660
4	5478/4	UP/AG/ET-GA/BAJRA/SAMPLE02/COBS	8.91	2.00	71.84	17.22	3720	2.20	78.90	18.90	4080
5	5478/5	UP/AG/ET-GA/BAJRA/SAMPLE06/LEAVES	9.62	12.66	68.60	9.32	4410	14.01	75.89	10.30	4880
6	5478/6	AP/VSP/A/CASHEWNUT/SAMPLE01/FULLCROP(Shell)	7.25	1.28	77.04	13.86	5580	1.38	83.08	14.94	6010
7	5478/7/1	KAR/TU/HU/VS/COCONUT/SAMPLE01/FULLCROP(Coir)	11.93	1.86	62.86	23.75	4660	2.11	70.91	26.98	5290
8	5478/7/2	KAR/TU/HU/VS/COCONUT/SAMPLE01/FULLCROP(Shell)	11.36	0.30	66.44	22.50	5100	0.34	74.76	25.30	5740
9	5478/8	RAJ/HAN/PUSTG-34/COTTON/SAMPLE01/GRAINS	7.30	6.14	76.77	9.79	4560	6.62	82.81	10.57	4920
10	5478/9	RAJ/HAN/PUSTG-34/COTTON/SAMPLE02/STALK	9.51	6.27	68.53	15.89	4260	6.93	75.71	17.56	4710
11	5478/10	RAJ/HAN/PUSTG-34/COTTON/SAMPLE06/LEAVES	11.38	19.06	58.16	11.40	3610	21.51	65.63	12.86	4070
12	5478/11	RAJ/HAN/PUSTG-34/COTTON/SAMPLE07/FLOWER	9.08	7.10	67.19	16.63	3900	7.81	73.90	18.29	4290
13	5478/13	MAH/AM/AM/NA/GRAM/SAMPLE02/STALK	9.15	6.34	72.64	12.69	4340	6.75	80.00	13.25	4780
14	5478/14/1	MAH/AM/AM/NA/GRAM/SAMPLE03/HUSK(Green shell)	9.43	27.69	57.52	5.34	4750	30.58	63.53	5.89	5250
15	5478/14/2	MAH/AM/AM/NA/GRAM/SAMPLE03/STALK	10.24	5.01	69.76	14.99	4510	5.58	77.71	16.71	4800
16	5478/15	KAR/CH/VI/TH/GROUNDNUT/SAMPLE01/GRAINS(Shell)	10.46	18.20	60.49	10.85	4290	20.33	67.56	12.11	4790
17	5478/16	KAR/CH/VI/TH/GROUNDNUT/SAMPLE02/STALK	11.66	6.74	70.51	11.09	4110	7.63	79.81	12.56	4650
18	5478/17	KAR/CH/VI/TH/GROUNDNUT/SAMPLE06/LEAVES	9.37	31.91	53.59	4.13	2910	35.37	59.83	4.80	3230
19	5478/19	KAR/BP/SH/AV/JOWAR/SAMPLE02/STALK	9.36	6.59	70.39	13.26	4300	7.27	78.10	14.63	4740
20	5478/20	KAR/BP/SH/AV/JOWAR/SAMPLE06/LEAVES	9.53	8.65	68.30	13.50	3620	9.57	75.51	14.92	4000
21	5478/22	JHA/HA/KE/PE/MAIZE/SAMPLE02/STALK	8.08	2.78	71.68	17.46	3910	3.02	77.97	19.01	4250
22	5478/23	JHA/HA/KE/PE/MAIZE/SAMPLE06/COBS	16.62	3.21	61.39	14.78	4310	3.85	80.51	17.74	5170
23	5478/24	JHA/HA/KE/PE/MAIZE/SAMPLE06/LEAVES	9.15	7.57	70.40	12.88	3680	8.34	77.50	14.17	4050
24	5478/25	WB/MU/BI/MA/PADDY/SAMPLE01/GRAINS	12.41	7.63	66.25	13.71	3870	8.71	75.64	15.65	4420
25	5478/26	WB/MU/BI/MA/PADDY/SAMPLE02/STALK	9.84	12.08	64.34	13.74	4080	13.39	71.40	14.83	4530
26	5478/27	MAH/GO/TB/KH/WHEAT/SAMPLE01/HUSK	9.26	13.76	63.42	13.57	3600	15.18	69.89	14.86	6180
27	5478/28	MAH/GO/TB/KH/WHEAT/SAMPLE02/STALK	7.84	9.38	67.70	15.08	4180	10.17	73.46	16.37	4750
28	5478/30	MAH/LAT/-/D/SOYABEAN/SAMPLE01/STALK	9.80	5.10	69.35	15.75	4250	5.65	76.88	17.47	4710
29	5478/31	MAH/LAT/-/D/SOYABEAN/SAMPLE06/LEAVES	12.24	10.24	69.13	8.39	4080	11.67	78.77	9.56	4650
30	5478/32	MAH/SOL/-/PE/SUGARCANE/SAMPLE01/CANE	10.42	8.07	62.21	19.30	4350	9.01	69.45	21.54	4860
31	5478/33	MAH/SOL/-/PE/SUGARCANE/SAMPLE06/LEAVES	10.10	7.65	68.60	15.65	4620	8.51	76.33	17.41	5140
32	5478/34	MAH/BRIQUETTS/SAMPLE01	9.54	13.04	65.77	11.65	3620	14.41	72.70	12.89	4000

Test methods: Moisture as per ASTM D7582 : 2015, Ash as per ASTM D7582:2015, Volatile Matter as per ASTM D7582:2015, Fixed Carbon as per ASTM D7582 : 2015, Gross Calorific Value as per IS-1350:2017
Note:The sample code mentioned as per the sample code written on the original sample packet.
Page 1 of 1

K.L.Kanta Rao
Authorized Signatory

GCV test results for different crop residue samples (Batch 02)

LUCID Laboratories Pvt. Ltd.
Testing to the Core

Issued to:
Senior Research Associate
Administrative Staff College of India
Bellavista, Rajbhavan, Hyderabad-500 082

Report No : LL20-21/005686
Issue Date : 27/11/2020
Customer Ref: ASCI/CES/BC-049/2020-21/24
Ref Date : 12/11/2020

Sample Particulars: Crop & Briquette Samples

Qty.: 40nos. Packing: Polybags covers Batch No:2
Test Req'd: Proximate analysis & Gross Calorific Value
Dt. Of receipt of sample : 12/11/2020
Dt. Of starting of analysis : 18/11/2020
Dt. Of completion of analysis : 27/11/2020

TEST RESULTS

S.No.	Lab No	Sample Code	As Received Basis					As Dry Basis			
			Moisture (% by mass)	Ash (%by mass)	Volatile Matter (% by mass)	Fixed Carbon (% by mass)	Gross Calorific Value (K.Cal/Kg)	Ash (%by mass)	Volatile Matter (% by mass)	Fixed Carbon (% by mass)	Gross Calorific Value (K.Cal/Kg)
1	5686/2	MAH/AMR/-/NAN/MOONG/SAMPLE01/LEAVES	11.46	11.07	69.12	8.15	5130	12.53	78.24	9.23	6050
2	5686/3	MAH/AMR/-/NAN/MOONG/SAMPLE02/ STALK	10.53	8.47	70.09	10.31	3920	9.47	79.01	11.52	4380
3	5686/4	MAH/AMR/-/NAN/MOONG/SAMPLE 06/BEANS	11.17	5.41	70.78	12.64	4230	6.09	79.68	14.23	4760
4	5686/5	MAH/AMR/-/-/CASTOR SEED/ SAMPLE 01/GRAINS	12.48	7.12	68.08	12.32	4940	8.13	77.79	14.08	5620
5	5686/6	MAH/AMR/-/-/CASTOR SEED/ SAMPLE 02/ STALK	12.82	7.85	64.93	14.40	4260	9.01	74.48	16.51	4890
6	5686/7	MAH/AMR/-/-/CASTOR SEED/ SAMPLE 06/LEAVES	12.87	15.31	62.73	9.03	3720	17.59	72.05	10.36	4270
7	5686/8	MAH/SOL/-/PEN/NIGER SEED/SAMPLE 02/ STALK	19.95	8.17	65.86	10.02	3670	17.04	77.49	15.47	4580
8	5686/9	MAH/SOL/-/PEN/NIGER SEED/SAMPLE 06/LEAVES	14.26	10.12	64.73	10.79	3720	11.81	75.58	12.61	4340
9	5686/10	MAH/SOL/-/PEN/NIGER SEED/SAMPLE 08/FLOWER	12.43	6.17	67.86	13.54	4860	7.04	77.49	15.47	4640
10	5686/11	SIK/NSIK/SIN/SIN/CARDAMOM/SAMPLE 02/STALK	5.67	4.37	43.72	46.24	5130	7.68	76.71	16.59	5440
11	5686/12	SIK/NSIK/SIN/SIN/CARDAMOM/SAMPLE 06/LEAVES	11.24	7.24	69.76	11.76	5270	8.15	78.59	13.26	6050
12	5686/13	RAJ/HAN/RAW/RAW/MOTH BEANS/SAMPLE 02/STALK	16.11	25.83	56.94	7.12	3950	28.74	63.53	7.91	4590
13	5686/14	RAJ/HAN/RAW/RAW/MOTH BEANS/SAMPLE 06/LEAVES	7.43	40.14	40.32	3.09	2580	53.11	43.53	3.34	2790
14	5686/15	RAJ/SIK/SIK/HAR/GAUR SEED/SAMPLE 02 /STALK	12.95	8.96	67.20	10.89	4190	10.29	77.20	12.51	4810
15	5686/16	MEG/SWS/MAW/MAR/SWEET POTATO/SAMPLE02/STALK	7.69	4.88	46.92	40.51	3670	8.23	79.13	12.64	3970
16	5686/17	MEG/SWS/MAW/MAR/SWEET POTATO/SAMPLE06/LEAVES	17.59	11.62	61.78	9.01	4490	14.11	74.97	10.92	5450
17	5686/18	SIK/NS/KA/PA/GINGER/SAMPLE02 STALK	11.53	16.31	68.70	5.46	4310	16.38	77.65	6.17	4870
18	5686/19	TN/ER/-/-/RAGI/SAMPLE02/STALK	10.94	5.56	72.64	10.86	4290	6.24	81.56	12.20	4720
19	5686/20	TN/ER/-/-/RAGI/SAMPLE05/HUSK	13.26	14.99	60.40	11.35	4150	17.28	69.64	13.08	4780
20	5686/22	MAH/SO/-/PE/SUNFLOWER/SAMPLE02/STALK	11.82	6.56	63.29	18.33	4840	7.43	71.78	20.79	4580
21	5686/23	MAH/SO/-/PE/SUNFLOWER/SAMPLE06/LEAVES	11.72	26.16	58.41	3.77	3550	29.56	66.16	4.28	4020
22	5686/24	KEL/KOZ/SAD/KAD/BLACK PEPPER/SAMPLE 01/GRAIN-LEAVES	10.48	15.04	64.20	10.28	4160	16.80	71.72	11.48	4650
23	5686/27	MAH/SAM/-/-/BLACKGRAM/SAMPLE02/STALK	9.37	18.60	63.72	8.31	2750	20.52	70.30	9.18	3035
24	5686/28	MAH/SAN/-/-/BLACKGRAM/SAMPLE06/LEAVES	9.04	23.63	61.95	5.38	3100	26.01	68.18	5.81	3350
25	5686/29	MAH/SAN/-/-/BLACKGRAM/SAMPLE01/-/BEANS	10.44	8.45	66.54	14.57	4150	9.44	74.30	16.26	4525
26	5686/30	UP/HAM/-/-/SEASAME/SAMPLE02/STALK	11.30	7.90	68.99	11.81	3570	8.90	77.78	13.32	4025

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27	368631	UP/JHAM/-/SESAME/SAMPLE06/LEAVES	13.43	12.59	62.82	11.56	4000	14.31	72.57	13.12	4620
28	368632	TN/TUH/JVSP/HORSE GRAM/SAMPLE02/STALK	9.40	8.85	68.59	13.16	4050	9.77	75.71	14.52	4450
29	368633	TN/TUH/JVSP/HORSE GRAM/SAMPLE06/LEAVES	9.80	14.43	65.86	9.91	3820	13.59	73.01	11.00	4230
30	368634	UP/-/-/MUSTARD/SAMPLE02/STALK	11.76	2.88	70.52	14.84	4260	3.26	79.97	16.81	4800
31	368635	UP/-/-/MUSTARD/SAMPLE02/HUSK	11.96	4.41	70.06	13.59	3960	5.01	79.55	15.44	4500
32	368636	MAH/NAS/SHV-/BAGASSE/DWARKADHISH PLANT/HUSK	13.98	5.36	68.27	12.39	4820	6.23	79.37	14.40	5600
33	368637	MAH/KOL/-/SMALL MILLETS/SAMPLE01/GRAINS	7.66	6.29	35.86	50.19	3390	8.50	75.51	15.99	4100
34	368638	MAH/KOL/-/SMALL MILLETS/SAMPLE02/STALK	3.30	4.62	60.06	30.02	4290	6.07	78.83	15.10	4530
35	368639	MAH/KOL/-/SMALL MILLETS/SAMPLE06/LEAVES	13.06	13.77	62.43	10.74	3660	13.84	71.80	12.36	4210
36	368640	MAH/GO/TUK/ARHAR/SAMPLE02/STALK	11.03	1.42	73.31	14.24	4530	1.60	82.18	16.22	5090
37	368641	MAH/GO/TUK/ARHAR/SAMPLE06/LEAVES	11.72	5.36	67.22	15.60	3940	6.19	76.14	17.67	4460
38	368642	UP/-/-/WHEAT/SAMPLE01/WHEAT HUSK	10.91	6.59	69.20	13.30	3980	7.40	77.68	14.92	4470
39	368643	UP/-/-/BARLEY/SAMPLE01/BARLEY HUSK	11.87	8.59	65.27	14.27	4190	9.74	74.06	16.20	4750
40	368644	UP/JHAM/-/SESAME/SAMPLE01/SHELL	11.33	4.79	70.52	12.35	3800	5.41	79.54	13.95	4290

Test method: Moisture as per ASTM D7582 : 2015, Ash as per ASTM D7582:2015, Volatile Matter as per ASTM D7582:2015, Fixed Carbon as per ASTM D7582 : 2015, Gross Calorific Value as per IS-1350:2017
Note: The sample code mentioned as per the sample code written on the original sample packets.

Page 2 of 2

A.L.Kanta Rao
Authorized Signatory

GCV test results for different crop residue samples (Batch 03)

LUCID Infoservices Pvt. Ltd.
Testing to the Core

Issued to:
Senior Research Associate
Administrative Staff College of India,
Bellavista,Raj Bhavan Road,Hyderabad.

Report No. : LI/20-21/006173
Issue date : 08/12/2020
Customer Ref : ASCI/CES/RC-049/2020-21/25
Ref. Date : 27/11/2020

Sample particulars : Crop samples

Qty.: 3 Nos. Packing: Plastic cover Batch No:3
Test Requ: Proximate Analysis & Gross calorific Value
Date Of receipt of sample : 27/11/2020
Date Of starting of analysis : 28/11/2020
Date Of completion of analysis : 08/12/2020

Test Results

S.No.	Lab No.	Sample Code	As Received Basis					As Dry Basis			
			Moisture (% by mass)	Ash (% by mass)	Volatile Matter (% by mass)	Fixed Carbon (% by mass)	Gross Calorific Value (K.Cal/Kg)	Ash (% by mass)	Volatile Matter (%by mass)	Fixed Carbon (%bymass)	Gross Calorific Value (K.Cal/Kg)
1	617301	KE/KAL/SHU/PAR/TAPIOCA/SAMPLE02/STALK	7.71	7.04	63.49	21.81	4660	8.39	75.55	16.06	5050
2	617302	KE/KAL/SHU/PAR/TAPIOCA/SAMPLE06/LEAVES	10.89	14.05	59.88	15.18	4720	12.77	67.20	17.03	5300
3	617303	AP/ANT/GUN/NUR/PALM OIL SEED/SAMPLE01/SEED	2.82	7.15	92.67	2.36	3940	2.21	95.34	2.43	4050

Test method: Moisture as per ASTM D7582 : 2015, Ash as per ASTM D7582:2015, Volatile Matter as per ASTM D7582:2015, Fixed Carbon as per ASTM D7582 : 2015, Gross Calorific Value as per IS-1350:2017
Note: The sample code mentioned as per the sample code written on the original sample packets.

Page 1 of 1

A.L.Kanta Rao
Authorized Signatory

ANNEXURE-A

Annexure - 03 | Contact Information

Details Of All State Nodal Agencies (SNAs) in India (as On 10.08.2020)

Sr. No.	State	Name & Designation	Mobile	e-mail ID
1	**Andhra Pradesh** New & Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP)	Mr. Nani Babu, Executive Engineer	9849550114	info@nredcap.in bg@nredcap.in
2	**Bihar** Bihar Renewable Energy Development Agency (BREDA)	Mr. Khurshid Anwar Siddiqui (Deputy Director) Mr. Anish Ahmad (HR)	9771048046 8809488987	breda@breda.in
3	**Chhattisgarh** Chhattisgarh State Renewable Energy Development Agency (CREDA)	Mr. Lav Tyagi Technical Officer Mr. Mukesh Borkar (Technical Assistant)	9981004747 9981004747 9977746451	mblborker@gmail.com
4	**Gujarat** Gujarat Energy Development Agency (GEDA)	Mr. Jatin Desai (Jr. Program Officer) Bio Energy	9909922472	sjruparel@geda.org.in harishkhiya@geda.org.in director@geda.org.in
5	**Tamil Nadu** Tamil Nadu Energy Development Agency (TEDA)	Mr. Shankar Narayanan General Manager Mr. Murali Chief Consultant	9840901541 9003217259	gm1@teda.in info@teda.in
6	**Uttar Pradesh** Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA)	Mr. Ajay Kumar	9415609041	ho_ajai@rediffmail.com
7	**Telangana** Telangana Renewable Energy Development Corporation (TSREDCO)	Mr. Anil Kumar, Consultant, Biomass	9440026610	bm@tsreco.telangana.gov.in
8	**Kerala** Department of Power, (ANERT), Kerala	Smt. Kala (Programme Officer) Mr. Rajesh Executive Engineer	9847017228 9188119426	rec@anert.in kala@anert.in rajesh@anert.in
9	**Uttarakhand** Uttarakhand Renewable Energy Development Agency (UREDA)	A J Singh Mr. A K Tyagi	9412051074 9837071245	ajs.uredahq@gmail.com aruntygi@gmail.com cpo.uredahq@gmail.com
10	**Meghalaya** Meghalaya New and Renewable Energy Development Agency (MNREDA)	Mr. Danseng Mr. Jhon Akbar	9089532707 8414927077 0364- 2536138	mnreda.dir@gmail.com
11	**Delhi**			rajneeshsam@gmail.com
12	**Himachal Pradesh** H.P. Govt. Energy Development Agency (HIMURJA)	Mr. Sanjeev Goutam	9418475472	himurja-hp@nic.in Ermanoj1@yahoo.com
13	**Jammu & Kashmir** Jammu & Kashmir Energy Development Agency (JAKEDA)	Mr. Bipul Pathak, IAS Chief Executive Officer Er. Abdul Majid Bhat Executive Engineer	0-1912546495 0-1942495062	xenjakeda@gmail.com

Sr. No.	State	Name & Designation	Mobile	e-mail ID
14	**Jharkhand** Jharkhand Renewable Energy Development Agency (JREDA)	Mr. Shri Ram Singh Sh. Arvind Kumar (Project Director) Mr. Bijay Kumar Sinha Mr. Nilesh Sharma	9431929187 9431102540 9431171470 9726632100	shritvnl@yahoo.com, shritvnl@rediffmail.com info@jreda.com
15	**Mizoram** Zoram Energy Development Agency (ZEDA) Mizoram	(Project Director)	0389-2350664 0389-2350665	zedaaizawal@hotmail.com
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21	**Madhya Pradesh** MP UrjaVikas Nigam Ltd. (MP URJA)	Mr. Bhuvnesh Kumar Patel Director Mr. Ajay Shukla, Executive Engineer	 9425008000 9425382849	bhuvneshpatel@msn.com mpnred.biomass@gmail.com rums.info@mpnrd.com
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24	**Rajasthan** Rajasthan Renewable Energy Corporation Limited (RRECL)	Mr. S K Jewalia (Technical Manager)	9414336390	biomass.rrec01@gmail.com
25	**Sikkim** Sikkim Renewable Energy Development Agency (SREDA)	Sh. A.V. Ray (secretary)	9593274664	abrodung@gmail.com
26	**West Bengal** West Bengal Renewable Energy Development Agency (WBREDA)	Mr. Sushanta Biswas (Assistant Director) Mr. S.K. Das	9836028595 033-23210078 033-23575038 033-23575348	sb.wbreda@gmail.com ceptp.wbsedcl@gmail.com cewbredagedcl@gmail.com amitava.nag@wbsetcl.in angshureda@gmail.com
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28	**Assam** Assam Energy Development Energy (AEDA)	Mr. Mrinal Krishna Chaudhury (AD)	9864094255	mrinal7@gmail.com assamrenewable@gmail.com
29	**Lakshadweep** Lakshadweep Energy Development Agency (LEDA)	Mr. Hassan Director Mr. Nallakoya, JE, Kavaratti	9446745379 9447192067	lk-ktelect@nic.in

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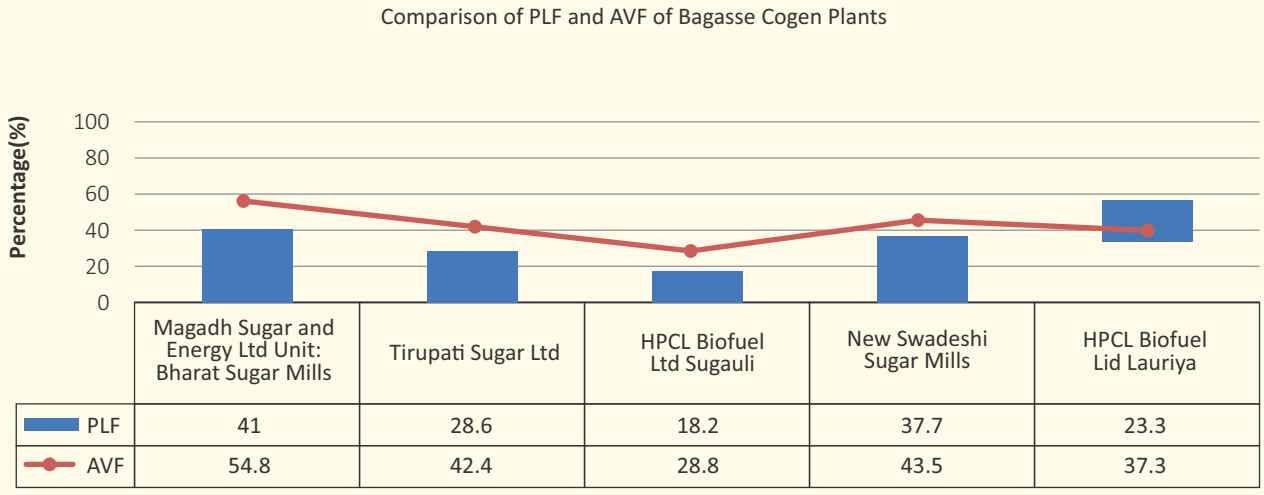
Reference: https://www.allindiarubber.net/contactus/

Annexure - 04

State-wise Analysis on responses received from Bagasse Co-generation plants

Bihar

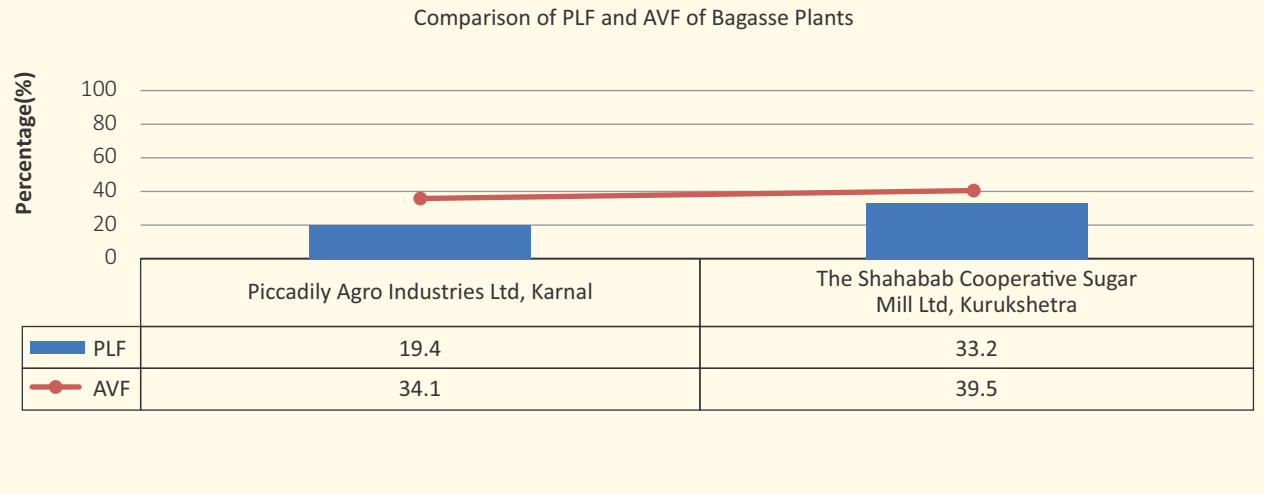


	Magadh Sugar and Energy Ltd Unit: Bharat Sugar Mills	Tirupati Sugar Ltd	HPCL Biofuel Ltd Sugauli	New Swadeshi Sugar Mills	HPCL Biofuel Lid Lauriya
PLF	41	28.6	18.2	37.7	23.3
AVF	54.8	42.4	28.8	43.5	37.3

Figure 195: Comparison of PLF and AVF of Bagasse Co-generation plants in Bihar

Based on the responses received for the state of Bihar, the average Plant Load Factor (Avg. PLF) is 29.76%, average Availability Factor (Avg. AVF) is 41.36%; Max. PLF is 41% and Min. PLF is 18.2; Max. AVF is 54.8 and Min. AVF is 28.8

Haryana



	Piccadily Agro Industries Ltd, Karnal	The Shahabab Cooperative Sugar Mill Ltd, Kurukshetra
PLF	19.4	33.2
AVF	34.1	39.5

Figure 196: Comparison of PLF and AVF of Bagasse Co-generation plants in Haryana

Based on the responses received from the state of Haryana, the average Plant Load Factor (Avg. PLF) is 46.2%, average Availability Factor (Avg. AVF) is 64.3%; Max. PLF is 84.5% and Min. PLF is 19.4%; Max. AVF is 99.1 and Min. AVF is 34.1

Karnataka

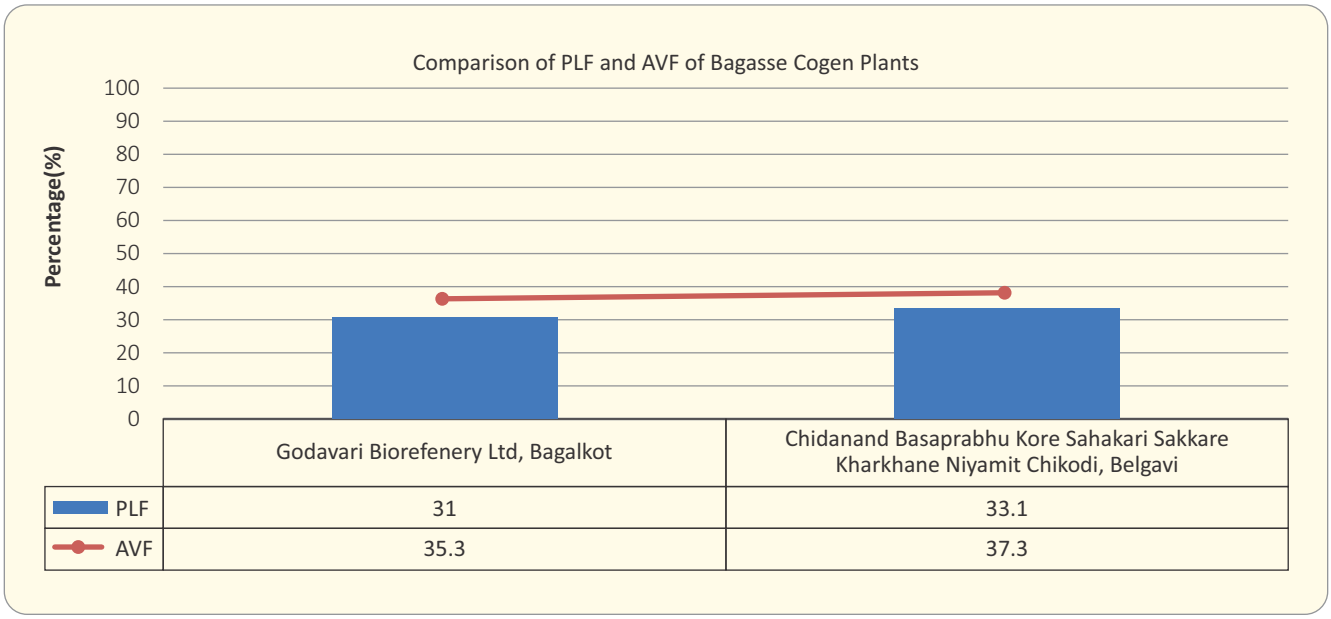


Figure 197: Comparison of PLF and AVF of Bagasse Co-generation plants in Karnataka

Based on the responses, Avg. PLF is 32.05, Avg. AVF is 36.3; Max. PLF is 33.1 and Min. PLF is 31; Max. AVF is 37.3 and Min. AVF is 35.3

Maharashtra

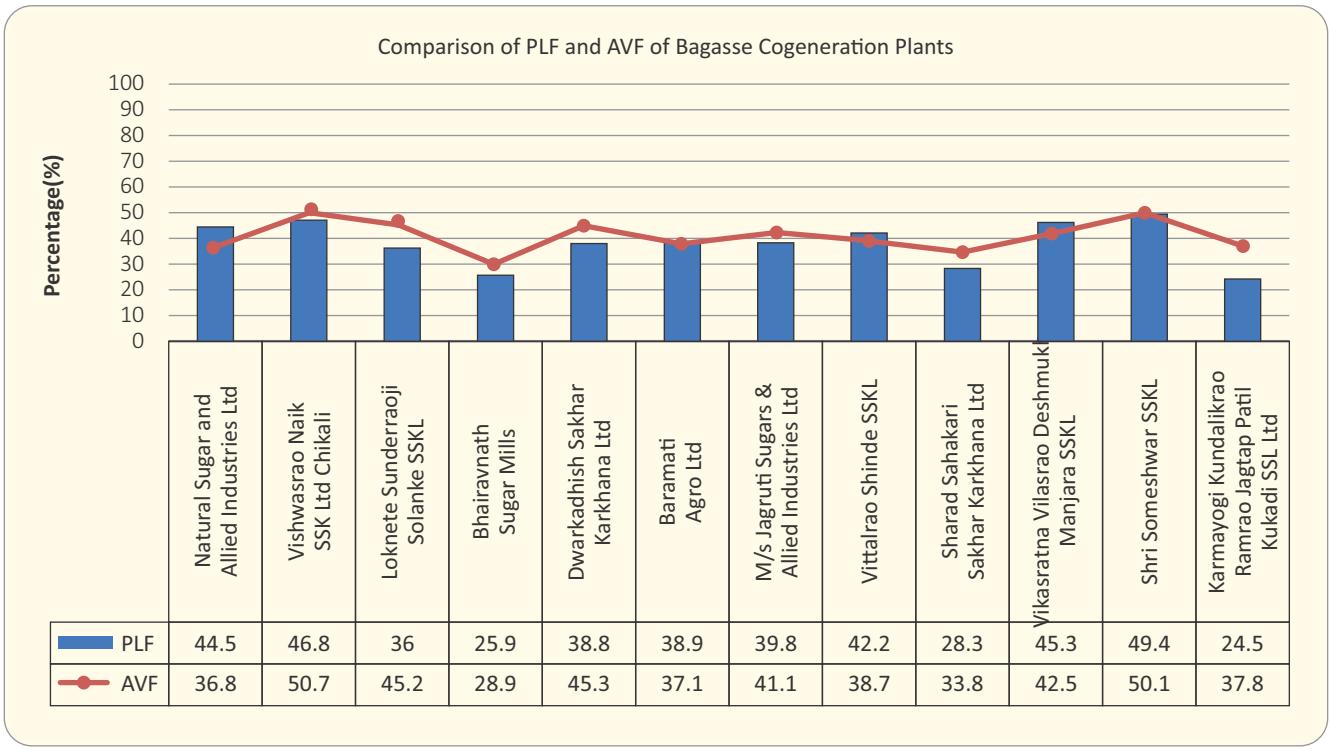


Figure 198: Comparison of PLF and AVF of Bagasse Co-generation plants in Maharashtra

Based on the responses received from the state of Maharashtra, the Average Plant Load Factor (Avg. PLF) is 38.36, Average Availability Factor (Avg. AVF) is 40.66; Max. PLF is 49.4 and Min. PLF is 25.9; Max. AVF is 50.7 and Min. AVF is 28.9

Annexure - 05

Special Report on Assessment of Biomass Power Potential in Lakshadweep Islands

Lakshadweep is a group of 17 islands with a total geographical area of 32 Sq.kms. Ten of the islands are inhabited, with Andrott being the largest with a 4.84 Sq. Km area. Fishery, Tourism and Coconut are the significant contributors to the economy. Coconut production in Lakshadweep is done on a large scale. The Majority of the population is dependent on Coconut for their livelihood.

Every part of the Coconut is commercial significant.

Figure 199: Different parts of the Coconut and its uses

Field observations

Districts Selected for Primary Field Survey	04 (Agalti, Amini, Kadmatt and Kavaratti,)
Average Annual Rainfall	1500-2000 mm (60-80 inch)
Type of soil	Coral Sand
A primary source of irrigation	Rainwater, Tube well
Major Rivers	No surface bodies such as rivers
Major Crops	Coconut
Minor Crops (Horticulture Crops)	Banana, Papaya, Vegetables (Self-consumed by local population only), and other horticulture crops

The coconut tree is a palm tree with a single straight trunk and has been used for many purposes. Every part has a use, including the fruits, wood, and leaves. The trees are widely cultivated across the islands for both commercial and home use. The parts of economic importance and contributing to Biomass generation are Husk, Shell, Leaves, Trunk, Roots, and Coir. Vegetables and other horticulture crops are also grown in Lakshadweep. However, the volumes are less and hence are not considered for biomass (potential) estimation

Key utilizations of Coconut residues:

a. **Domestic Usage**: Husk pith is used as firewood for cooking and heating. The excess un-utilized coconut husk pith is left for open burning

b. **Cattle Feeding**: The coconut leaves are used for feeding cattle like Goats and Cows. The Majority of the feeding is done for goats

c. **Fertilizers and Manure preparation**: Coconut leaves and fronds are used as organic compost through the "Mulching Process", which is believed to increase the growth of palms and production of coconuts;

d. **Industries**: Husk and Pith are supplied to Fibre Factories which are installed in 7 islands. About 19% of coconut fibre is utilized for making different value-added products.

e. **Other Utilization**: Husk Pith is supplied to Hotels and Fisherman for cooking, heating and drying purposes.

Table 115: Coconut harvested in Island (Lakh Nuts)

Name of the Islands	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Agatti	115.9	135.08	135.1	135.85	147.92	151.98	139.98	147.1	136.96
Amini	100.85	100.83	101.2	101.34	101.57	101.59	102.38	100.82	100.66
Androth	41.2	56.45	57.1	70.74	70.88	76.22	84.2	90.31	104.35
Bitra	78.5	77.42	77.87	72.47	77.95	77.95	79.51	80.6	79.03
Chetlath	38.22	55.21	55.37	61.74	78.23	99.79	127.93	136.58	144.1
Kadamat	2.1	2.69	2.7	4.4	4.78	5.91	6.18	8.9	9.36
Kalpeni	60.3	104.79	106	107	112.16	123.31	133.2	139.47	132.04
Kavaratti	100.4	82.4	83.16	102.5	105.92	115.01	116.83	110.8	108.39
Kiltan	22.3	27.46	27.49	31.93	32.65	36.79	40.84	40.88	40.88
Minicoy	32.4	52.66	52.96	50.72	54.66	55.18	52.25	51.74	51.63
Total	**592.17**	**694.99**	**698.95**	**738.69**	**786.72**	**843.73**	**883.3**	**907.2**	**907.4**

Table 116: Crop Area, No. of Palms and Crop Production of Coconut from FY 2016-17 to FY 2019-20)

Sr No	Name of the Islands	Area (Ha)	No. of Palm No.	Coconut Production (Nuts)
FY 2019-20				
1	Agatti	338.1	131859	13524000
2	Amini	243.5	94965	9740000
3	Androth	452.7	176553	18108000
4	Bitra	7.7	3003	308000
5	Chetlah	100.1	39039	4004000
6	Kadamath	306.1	119379	12244000
7	Kalpeni	258.5	100815	10340000
8	Kavaratti	392	152880	15680000
9	Kiltan	149.2	58188	5968000
10	Minicoy	426.1	166179	17044000
Total		2674	1042860	106960000
FY 2018-19				
1	Agatti	338.1	131859	13185900
2	Amini	243.5	94965	9496500
3	Androth	452.7	176553	17655300
4	Bitra	7.7	3003	300300
5	Chetlah	100.1	39039	3903900
6	Kadamath	306.1	119379	11937900
7	Kalpeni	258.5	100815	10081500
8	Kavaratti	392.4	153036	15303600
9	Kiltan	149.6	58344	5834400
10	Minicoy	426.1	166179	16617900
Total		2674.8	1043172	104317200
FY 2017-18				
1	Agatti	338.12	142010	12848560
2	Amini	243.5	102270	9253000
3	Androth	452.75	190155	17204500
4	Bitra	7.7	3234	292600
5	Chetlah	100.1	42042	3803800
6	Kadamath	306.1	128562	11631800
7	Kalpeni	258.5	108570	9823000
8	Kavaratti	392.4	164808	14911200
9	Kiltan	149.6	62832	5684800
10	Minicoy	426.1	146962	16191800
Total		2674.87	1091445	101645060
FY 2016-17				
1	Agatti	339.12	142430	12174408
2	Amini	244.2	102564	8754570
3	Androth	454.34	190823	16617486
4	Bitra	7.7	3234	49896
5	Chetlah	100.1	42042	3378375

Sr No	Name of the Islands	Area (Ha)	No. of Palm No.	Coconut Production (Nuts)
6	Kadamath	306.5	128730	10160475
7	Kalpeni	259.12	108830	9064018
8	Kavaratti	393.4	165228	14032578
9	Kiltan	150.09	63038	5085049
10	Minicoy	426.57	179159	11723423
Total		**2681.14**	**1126078**	**91040278**

In 2017-18, 2018-19 and 2019-20, the coconut production is 1016.45 Lakh nuts, 1043.17 Lakh nuts and 1069.60 Lakhs nuts. It can be observed that there is a gradual increase in the production of Coconut in all islands. It is estimated that the local population consumes around 12.5% of the nuts, and the remaining are consumed for other purposes.

Table 117: Availability & Consumption of Raw Materials of 2017-18

Name of Island	Total Estimated Husk (MT)	Total Consumption			Unutilized Husk (MT)	Un-utilized Husk Fibre (MT)	Production of Pith (MT)
		Husk (Govt.)	Fibre	Fuel			
Agatti	5440	698	52	1360	3383	254	508
Amini	4000	775	58	1000	2225	167	334
Androth	4160	775	58	1040	2345	176	352
Bitra	360	0	0	90	270	20	40
Chetlat	4680	0	0	1170	3510	263	526
Kadamath	3360	775	58	840	1745	131	262
Kalpeni	5120	775	58	1280	3065	230	460
Kavaratti	4320	775	58	1080	2465	185	370
Kiltan	1600	543	41	400	658	49	98
Minicoy	2040	0	0	510	1530	115	230
Total	**35080**	**5116**	**383**	**8770**	**21196**	**1590**	**3180**

A total of 35080 MT of coconut husk is produced, of which 5116 MT of coconut husk is being used for making coir and coir-based products and around 25% is used as fuel for domestic purpose. In addition to these, 3180 MT quantity of coir pitch is produced as mentioned in the above table

Table 118: Biomass Utilization in Lakshadweep (UT)

Crop Type	Open Burning(%)	Cattle Feeding(%)	Domestic Fuel(%)	Compost Fertilizer(%)	Biomass Plants(%)	Other Industries(%)	Total (%)
Coconut	30	21	19	15	0	15	100
Coconut	40	25	10	14	0	11	100
Coconut	50	10	10	15	0	15	100
Coconut	35	15	20	20	0	10	100
Coconut	35	13	25	12	0	15	100
Coconut	50	20	5	15	0	10	100
Coconut	35	10	20	15	0	20	100
Coconut	30	20	20	15	0	15	100
Coconut	25	10	20	30	0	15	100
Coconut	35	10	25	10	0	20	100
Coconut	50	15	10	15	0	10	100
Coconut	50	15	10	15	0	10	100
Coconut	30	25	25	10	0	10	100
Coconut	40	20	10	20	0	10	100
Total	**535**	**229**	**229**	**221**	**0**	**186**	**1400**
	38.2	**16.4**	**16.4**	**15.8**	**0.0**	**13.3**	**100.0**

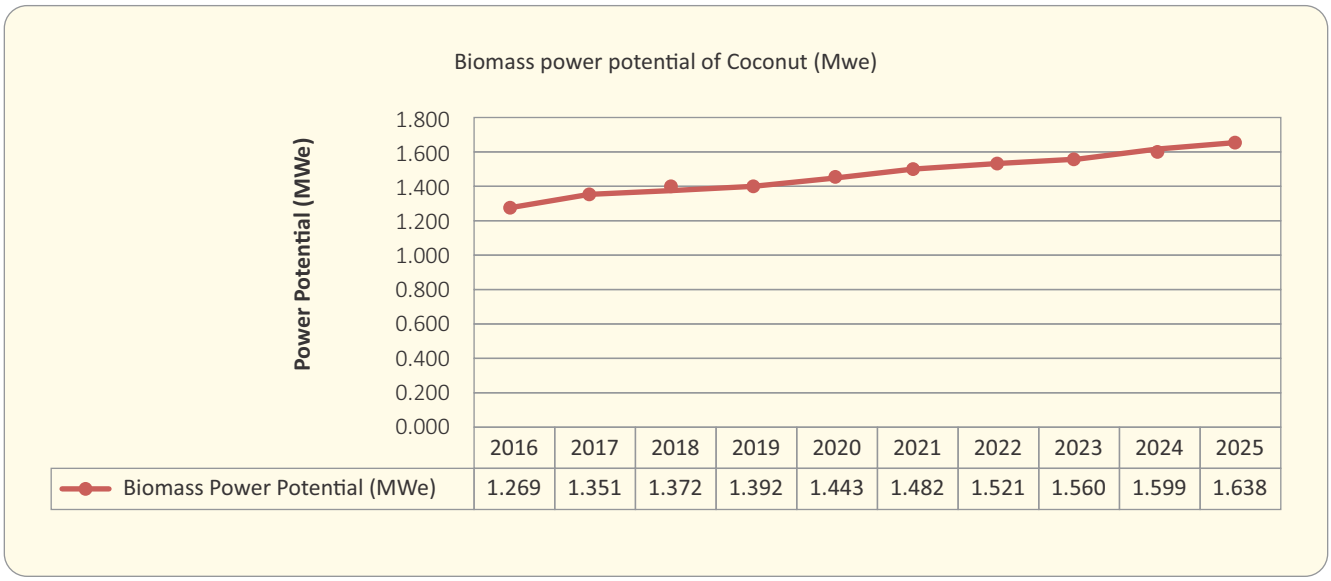
The available surplus biomass in Lakshadweep is 561.54 Tonnes, and the corresponding Biomass Power Potential is 1.39 MWe for the year 2019-20.

Biomass Power Potential in Lakshadweep

The available surplus biomass in Lakshadweep is 561.54 Tonnes, and the corresponding Biomass Power Potential is 1.39 MWe for the year 2019-20.

Table 119: Biomass Surplus and Power Potential in Lakshadweep

Year	Crop	Total Crop Area (Hectare)	Total Crop Production (Tonnes)	Total Biomass Generation (Tonnes)	Total Biomass Utilisation (Tonnes)	Total Surplus Biomass (Tonnes)	Biopower Power Potential (Mwe)
2016-17	Coconut	2681.1	18208.1	24380.6	15115.97	9264.629	1.269254
2017-18	Coconut	2674.9	20329.0	25946.24	16086.67	9859.571	1.350761
2018-19	Coconut	2674.8	20863.4	26346.78	16335	10011.78	1.371613
2019-20	Coconut	2674.0	21392.0	26740	16578.8	10161.2	1.392084



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Biomass Power Potential (MWe)	1.269	1.351	1.372	1.392	1.443	1.482	1.521	1.560	1.599	1.638

Figure 200: Year-wise Biomass Power Potential (MWe) and its projectionsa

The above graph depicts the biomass power potential of Coconut for the year 2016 to 2025. The power potential from 2016 to 2019 is computed using the methodology deliberated in the report, whereas from 2020 to 2025, it is forecasted using Trend analysis

ASCI Team at District Collectorate Office with
Mr Asker Ali, IAS, Lakshadweep

ASCI Team at Department of Industries with
Mr P. Abdul Samad, Director Industries

ASCI Team at Lakshadweep Electricity Development Agency (LEDA)
Head office at Kavaratti with Mr Hassan, Director

ASCI Team at Department of Agriculture, with Mr Sharef,
District Agriculture Officer (DAO), Kavaratti

Picture Description: ASCI has conducted meetings with District Collector, Power Secretary, Department of Industries, Lakshadweep Electricity Development Agency (LEDA), Department of Agriculture, Head Office, Kavaratti discussing the assessment of biomass power potential in Lakshadweep Islands.

"Most of the coconut residue is utilized for compost, Mulching, fiber making and domestic cooking and Heating purposes. The husk and Pitch is left over in the open fields or for land filling, it can be re-utilized for BIOGAS preparation with the help of clean gasifier technology and the left out waste again can be re-utilized as fertilizer or manure back to coconut trees which increases the self-sustainability of the islands and reduces carbon emission"

At Kavaratti seashore

Image Credit: Leela Krishna Vegi

Picture Description: Shells & Copra are dried in open space; Copra has good value in the market and is sold for INR 24,000 per quantal. Shell (coconut residue) is used for charcoal and base material for handicraft etc.

Table 120: Estimated Production of Coconut and its Residue utilization in Lakshadweep

Sno.	Raw Materials	Units	Est. Quantity	Est. Consumption	Identified Value Addition
1	Coconut	Lakhs Nuts	1080	200 (19%)	Cocoa Powder Coconut Oil Vinegar Coconut Oil Coconut Cream Coconut Milk Coconut Milk Powder Coconut Chips Coconut based bakery items
2	Coconut Husk	MT	35080	9121 (26%)	Fibre Pith Baby Fibre
3	Coconut Fibre	MT	1973	383 (19%)	Coir Yarn Curled Rope Coir rope Mat and Matting Doormat Coir Jewellery Mattress Go Textiles Carpets
4	Coconut Pith	MT	3180	159 (5%)	Coconut Pith Block (30 Kgs)
5	Coconut Shells	MT	7000	70 (1%)	Activated Carbon Shell Charcoal Shell Powder Handcraft items
6	Kernel Waste Product	MT	8000	95 (1%)	Kernel Waste Product for Animal Feed
7	Coconut Water	Litres	54000	0	Vinegar Soft Drinks
8	Coconut Leaves	MT	28800	5760 (20%)	Kidu-Roofing/fencing etc. Mid rib for fencing Organic Nutrient Broom Sticks

Source: Department of Industries, Lakshadweep

1. Maximum utilization of coconut residue is as a fertilizer by "Mulching."
2. Land Filling with Coconut Husk which is the leftover in the fibre factories in various islands in Lakshadweep

ANNEXURE B

Annexure - 06 | Glossary

Biomass: An energy resource derived from organic matter. These include wood, agricultural waste, and other living-cell material that can be burned to produce heat energy. They also include algae, sewage, and other organic substances that may be used to make energy through chemical processes.

Recovery percent (%): The Proportion of sugar produced by weight of cane processed, usually expressed as a percentage. For example, 10% recovery means that for every 100 Kg of cane processed 10 Kg of sugar is produced.

Bio-energy: Energy produced from biomass.

Bio-power: The use of biomass feedstock to produce electric power or heat through direct combustion of the feedstock, through gasification and then combustion of the resultant gas, or through other thermal conversion processes. Power is generated with engines, turbines, fuel cells, or other equipment.

Biofuels: Biomass converted to liquid or gaseous fuels such as ethanol, methanol, methane, and hydrogen.

Biomass Processing Residues: Byproducts from processing all forms of biomass that have significant energy potential. For example, making solid wood products and pulp from logs produces bark, shavings and sawdust, and spent pulping liquors. Because these residues are already collected at the point of processing, they can be convenient and relatively inexpensive sources of biomass for energy.

By-Product: Leftover material, generated as a result of an industrial process or as a breakdown product in a living system.

Residues, Biomass: By-products from processing all forms of biomass that have significant energy potential. For example, making solid wood products and pulp from logs produces bark, shavings and sawdust, and spent pulping liquors. Because these residues are already collected at the point of processing, they can be a convenient and relatively inexpensive source of biomass for energy.

or

Any organic matter left in the field after the harvest of a crop, e.g. leaves, stalks, stubble, roots, hulls.

Crop acreage: Acres of a specific crop planted in a cropping season by farmers.

Cropland: Land used primarily for the production of adapted cultivated and close-growing crops for harvest, alone or in association with sod crops, and open land recently in such uses. In some states, land used for fruit and nut trees, grapes, etc., is designated as orchard land or vineyard land rather than "cropland".

Agricultural Land: Land used primarily for the production of farm commodities. The categories of "Agricultural Land" are: cropland and pasture; orchards, groves, vineyards, bush fruits, horticultural areas (such as nurseries); feeding operations; and others.

Calorific Value: A measure of the energy of a substance determined by the quantity of the heat off when a unit weight of the substance is completely burned. Units: Calories or Joules, K.cal/Kg or MJ/Kg.

Crop Residue Index (CRI): A method used for estimating crop residue. This is defined as a ratio of the residue produced primary crop produced for a particular species. The biomass produced by crop plants is usually one to three times the weight of the actual crop itself. The CRI is determined in the field for each crop and crop variety, and for each agro-ecological region under consideration.

Total Biomass Volume: All above ground parts of a plant.

Yield: It is defined as the increase in biomass over a given time and for a specific area, and must include all biomass removed for the area. The yield or annual increment of biomass is expressed in dry tonnes/ha per year. It also should be clearly stated whether the yield is the current or mean annual increment.

Definitions relevant to Bagasse [23]

Bagasse: Residue remaining after extracting a sugar-containing juice from plants like sugar cane(or) the fibrous residue of sugar cane which remains after the crushing operation is done.

Co-Generation: The technology of producing electric energy and another form of useful energy (usually thermal) for industrial, commercial, or domestic heating or cooling purposes through the sequential use of the energy source.

Technical Definitions [24]

Higher Heating Value (HHV): The heat produced by combustion of one unit of substance at constant volume in an oxygen bomb calorimeter under specified conditions. The conditions are: initial oxygen pressure of 2.0–4.0 MPa (20–40 atm), final temperature of 20ºC–35ºC, products in the form of ash, liquid water, gaseous CO2and N2, and dilute aqueous HCL and H2SO4. It is assumed that if significant quantities of metallic elements are combusted, they are converted to their oxides. In the case of materials such as coal, wood, or refuse, if small or trace amounts of metallic elements are present, they are unchanged during combustion and are part of the ash.

Lower Heating Value (LLV): The heat produced by combusting one unit of a substance, at atmospheric pressure, under conditions such that all water in the products remains in the form of vapor. The net heat of combustion is calculated from the gross heat of combustion at 20oC by subtracting 572 cal/g (1,030 Btu/lb) of water derived from

one unit mass of sample, including both the water originally present as moisture and that formed by combustion. This subtracted amount is not equal to the latent heat of vaporization of water because the calculation also reduces the data from the gross value at constant volume to the net value at constant pressure.

TCD (Tons of Cane per Day)[25]: It refers to the amount of cane a processing plant crushes each day and not the amount of sugar produced. Most sugar processing plants are sized according to this figure which is based on a 24-hour day. However, many small-scale factories, and some large ones, only operate for part of a day and in some cases for only part of the year. Therefore, care must be taken when analyzing TCD figures as they only represent a factory's capacity and do not necessarily reflect the actual throughput.

Conversion Factors

1 kW	= 860 Kcal/h
1 Ha	= Hectare = 2.47 Acres
1 MT	= Metric Tonne = 1000 Kgs
1 Kwh	= 3600 J
1 Calorie	= 4.91 J
1 W	= 1 J s – 1
1 HP	= 0.736 kW
1 Kcal	= 3600/860 = 4.1868 J

Metric Equivalent

1 Km	= 1000 m
1 m	= 100 cm
1 cm	= 10 mm
1 Km2	= 100 Ha
1 Ha	= 10000 m3

1 Tonne Agricultural Residues = 10 – 17 GJ

(This large variation is due to moisture content. With moisture content of 20 % of it is 13-15 GJ)

Carbon Content of oven dry bioenergy feedstocks (approximate) [26]

Woody Crops	= 50 %
Graminaceous (Grass and Agricultural residue)	= 45 %

23. Energy Efficiency & Renewable Energy (EERE), bioenergy, full text glossary, bagasse (www.energy.gov)
24. Energy Efficiency & Renewable Energy (EERE), bioenergy, full text glossary, bagasse (www.energy.gov)
25. Sugar Production from Sugarcane, Practical Action.org, Technical Brief, Terminology
26. http://bioenergy.ornl.gov/papers/misc/energy_con.html

Annexure - 07

Year-wise Sugarcane production (Tonnes per hectare)

All India Sugar cane and sugar production - Year-wise

Year	Area (000 ha)	Production (000 t)	Yield (t/ha)	Cane Crushed (000 t)	Sugar production (000 t)	Sugar factories	Average crushing duration (days)	Sugar consump-tion (000 t)	Recovery (%)
1950-51	1707	69220	40.55	10971	1101	138	101	1204	10.03
1951-52	1941	74760	38.52	15743	1483	139	133	1274	9.57
1952-53	1728	61860	35.8	13384	1314	134	113	1657	9.98
1953-54	1410	53848	38.19	10092	1001	134	86	1836	10.08
1954-55	1620	70549	43.55	16267	1690	136	132	1750	9.92
1955-56	1846	72692	39.38	19241	1862	143	145	1971	9.83
1956-57	2051	82908	40.42	21187	2059	147	150	2013	9.73
1957-58	2072	83651	40.37	20055	1978	158	129	2075	10.01
1958-59	1948	86149	44.22	19800	1918	164	120	2113	9.84
1959-60	2137	91394	42.77	24811	2421	168	138	2052	9.91
1960-61	2456	110544	45.01	31109	3028	174	167	2126	9.74
1961-62	2413	103967	43.09	27937	2730	180	146	2588	9.77
1962-63	2242	91913	41	20765	2135	186	108	2486	10.24
1963-64	2249	104225	46.34	25632	2562	194	120	2307	9.68
1964-65	2603	121909	46.83	33459	3232	198	153	2469	9.64
1965-66	2836	123990	43.72	36404	3532	200	159	2810	9.68
1966-67	2301	92826	40.34	21659	2159	200	95	2601	9.91
1967-68	2046	95500	46.68	22599	2243	200	94	2215	9.94
1968-69	2532	124682	49.24	37455	3558	205	150	2605	9.46
1969-70	2749	135024	49.12	45672	4261	215	170	3264	9.33
1970-71	2615	126368	48.32	38204	3740	216	142	4025	9.78
1971-72	2390	113579	47.52	30997	3108	221	107	3795	10.03
1972-73	2452	124866	50.92	40407	3873	229	133	3514	9.57
1973-74	2752	140805	51.16	42278	3948	229	138	3518	9.34
1974-75	2894	144289	49.86	48435	4794	247	140	3476	9.9
1975-76	2762	140604	50.91	41849	4262	253	115	3689	10.19

Year	Area (000 ha)	Production (000 t)	Yield (t/ha)	Cane Crushed (000 t)	Sugar production (000 t)	Sugar factories	Average crushing duration (days)	Sugar consump-tion (000 t)	Recovery (%)
1976-77	2866	153007	53.39	48819	4840	271	126	3757	9.92
1977-78	3151	176966	56.16	67329	6457	280	167	4482	9.66
1978-79	3088	151655	49.11	59717	5842	299	140	6214	9.78
1979-80	2610	128833	49.36	39050	3859	299	86	5108	9.88
1980-81	2667	154248	57.84	51584	5147	314	105	4901	9.98
1981-82	3193	186358	58.36	87342	8436	319	173	5500	9.66
1982-83	3358	189505	56.43	82695	8232	320	158	6479	9.95
1983-84	3110	174076	55.97	59022	5917	325	111	7546	10.03
1984-85	2953	170319	57.68	60092	6144	338	106	6981	10.22
1985-86	2850	170648	59.88	68576	7016	341	116	6581	10.23
1986-87	3079	186090	60.44	85224	8502	353	141	7965	9.98
1987-88	3279	196737	60	93943	9110	357	153	9333	9.7
1988-89	3329	203037	60.99	85693	8752	366	133	9919	10.21
1989-90	3438	225569	65.61	111149	10988	377	158	10283	9.89
1990-91	3686	241045	65.39	122319	12046	385	166	10715	9.85
1991-92	3844	253965	66.07	133987	13404	392	173	11225	10.02
1992-93	3572	228033	63.84	103002	10609	393	123	12005	10.31
1993-94	3422	229659	67.11	98348	9833	394	111	11129	10
1994-95	3867	275540	71.25	147643	14643	408	159	11974	9.92
1995-96	4147	281099	67.78	174726	16452	416	181	13172	9.42
1996-97	4174	277560	66.5	130379	12905	412	130	13625	9.9
1997-98	3930	279541	71.13	129188	12855	400	123	13978	9.95
1998-99	4055	288722	71.2	157560	15539	426	141	14135	9.87
1999-00	4220	299324	70.93	178515	18200	423	152	15508	10.2
2000-01	4316	295956	68.57	176651	18511	436	139	16200	10.48
2001-02	4412	297208	67.36	180321	18527	434	140	16781	10.27
2002-03	4520	287383	63.58	194324	20140	453	141	18384	10.36
2003-04	3938	233862	59.39	132511	13546	423	100	17285	10.22
2004-05	3661	237088	64.76	124771	12691	400	96	18500	10.17
2005-06	4202	281172	66.91	188672	19267	400	126	18500	10.22
2006-07	5151	355520	69.02	279249	28361	453	174	19900	10.17

Year	Area (000 ha)	Production (000 t)	Yield (t/ha)	Cane Crushed (000 t)	Sugar production (000 t)	Sugar factories	Average crushing duration (days)	Sugar consump-tion (000 t)	Recovery (%)
2007-08	5055	348188	68.88	249906	26356	504	149	21900	10.55
2008-09	4415	285029	64.56	144978	14538	516	87	22912	10.03
2009-10	4175	292302	70.01	185548	18912	488	108	21328	10.2
2010-11	4886	342382	70.07	239807	24394	490	135	20769	10.17
2011-12	5038	361037	71.66	256975	26343	527	137	22000	10.25
2012-13	4998	341198	68.27	250598	25141	529	127	23000	10.03
2013-14	4993	352141	70.53	238176	24360	513	115	24427	10.23
2014-15	5144	359330	69.85	273073	28303	538	133	24800	10.37
2015-16	4918	341425	69.42	-	-	-	-	-	-

State-Wise/Year-Wise Biomass Installed Capacity Of Grid Connected Biomass & Bagasse Cogeneration Projects

State	2015 - 16 (in MW)	2016-17 (in MW)	2017-18 (in MW)	2018-19 (in MW)	2019-20 (in MW)	Cumulative Installed Capacity As on 31.07.2019 (in MW)
Andhra Pradesh	378.2	0	0	0	0	378.2
Bihar	104	9	0	0	0	113
Chhattisgarh	228	0	0	0	0	228
Gujarat	65.3	0	0	0	0	65.3
Haryana	96.4	0	25	0	0	121.4
Karnataka	1402	50	301.6	30	28	1811.6
Madhya Pradesh	93	0	0	0	0	93
Maharashtra	1967	98	105	329.7	0	2499.7
Telangana	158.1	0	0	0	0	158.1
Punjab	179	0	15		0	194
Rajasthan	114.35	4.95	0		0	119.3
Tamil Nadu	878	0	48	43	0	969
Uttarakhand	73	0	0	0	0	73
Uttar Pradesh	1933	0	24.5	0	0	1957.5
West Bengal	300	0	0	0	0	300
Odisha	50.4	0	0	0	0	50.4
Total	**8019.75**	**161.95**	**519.1**	**402.7**	**28**	**9131**

STATE-WISE/YEAR-WISE LIST OF INSTALLED CAPACITY OF BIOMASS (NON-BAGASSE) COGENERATION PROJECTS DURING LAST FIVE YEARS AS PER THE DATA RECEIVED FROM SNAs (AS ON 31.07.2019)

Name of State/UT	Up to 31.03.2014 (In MW)	2014-15 (In MW)	2015-16 (In MW)	2016-17 (In MW)	2017-18 (In MW)	2018-19 (In MW)	Cumulative Installed Capacity (as on 31.07.2019)
Andhra Pradesh	75.42	3.17	20.39	-	-	-	98.98
Chhattisgarh	2.50	-	-	-	-	-	2.50
Haryana	35.91	21.65	25.5	1.20	-	-	84.26
Himachal Pradesh	7.20	-	-	-	-	-	7.20
Kerala	0.72	-	-	-	-	-	0.72
Karnataka	15.20		-	-	-	-	15.20
Madhya Pradesh	12.35	-	-	-	-	-	12.35
Maharashtra	16.40		-	-	-	-	16.40
Meghalaya	13.80	-	-	-	-	-	13.80
Odisha	2.94	5.28	0.6	-	-	-	8.82
Punjab	110.65	6.45	-	1	5	-	123.10
Bihar	8.20		-	-	-	-	8.20
Rajasthan	2.00	-	-	-	-	-	2.00
Jharkhand	1.20	3.10	-	-	-	-	4.30
Uttar Pradesh	150.86	5.40	1.75	-	-	-	158.01
Uttarakhand	42.50	5.00	10	-	-	-	57.50
West Bengal	17.42	2.50	-	-	-	-	19.92
Tamil Nadu	16.55	7.50	-	-	4.5	-	28.55
Telangana	-	-	1	-	-	-	1
Gujarat	-	-	-	-	-	12	12
Total	**531.82**	**60.05**	**59.24**	**2.2**	**9.5**	**12**	**674.81**

Source: MNRE Biomass, Bioenergy, Current Status https://mnre.gov.in/bio-energy/current-status

Annexure - 08

Visit to GCV testing Lab Facility in Lucid Labs at Hyderabad

Approached Lucid Labs for testing the crop samples for GCV. Following equipment's are used for Testing the full grown crop samples as shown in the figures.

Image Credit: Leela Krishna Vegi

Figure 201: Apparatus used for testing crop samples for GCV

Standard Procedure for calculating GCV for biomass crop samples: Test method: Moisture as per ASTM D7582:2015; Ash as Per ASTM D7582:2015; VM as Per ASTM D7582:2015; FC as Per ASTM D7582:2015; GCV as PerIS-1350:2017.

ANNEXURE-B

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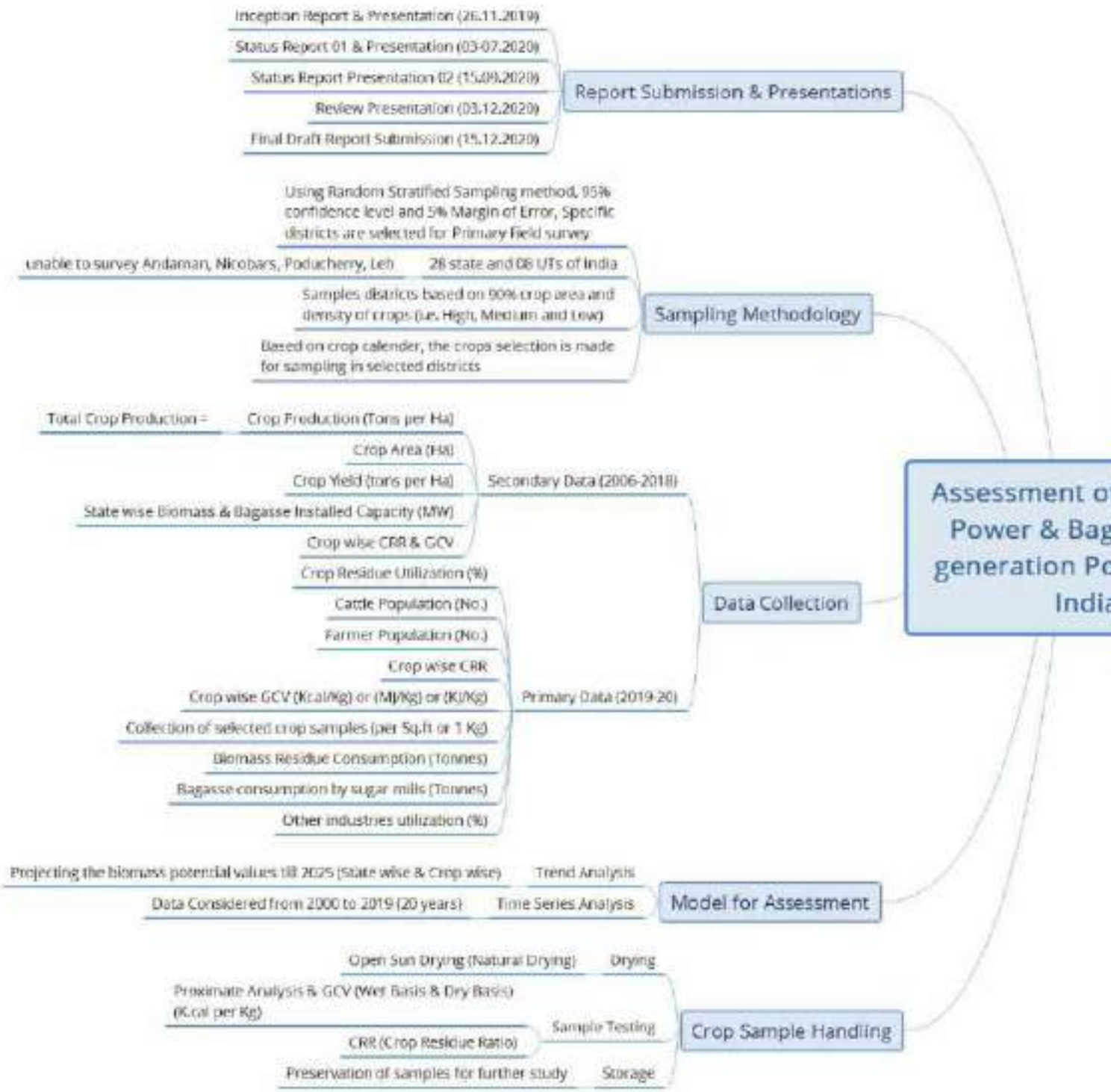
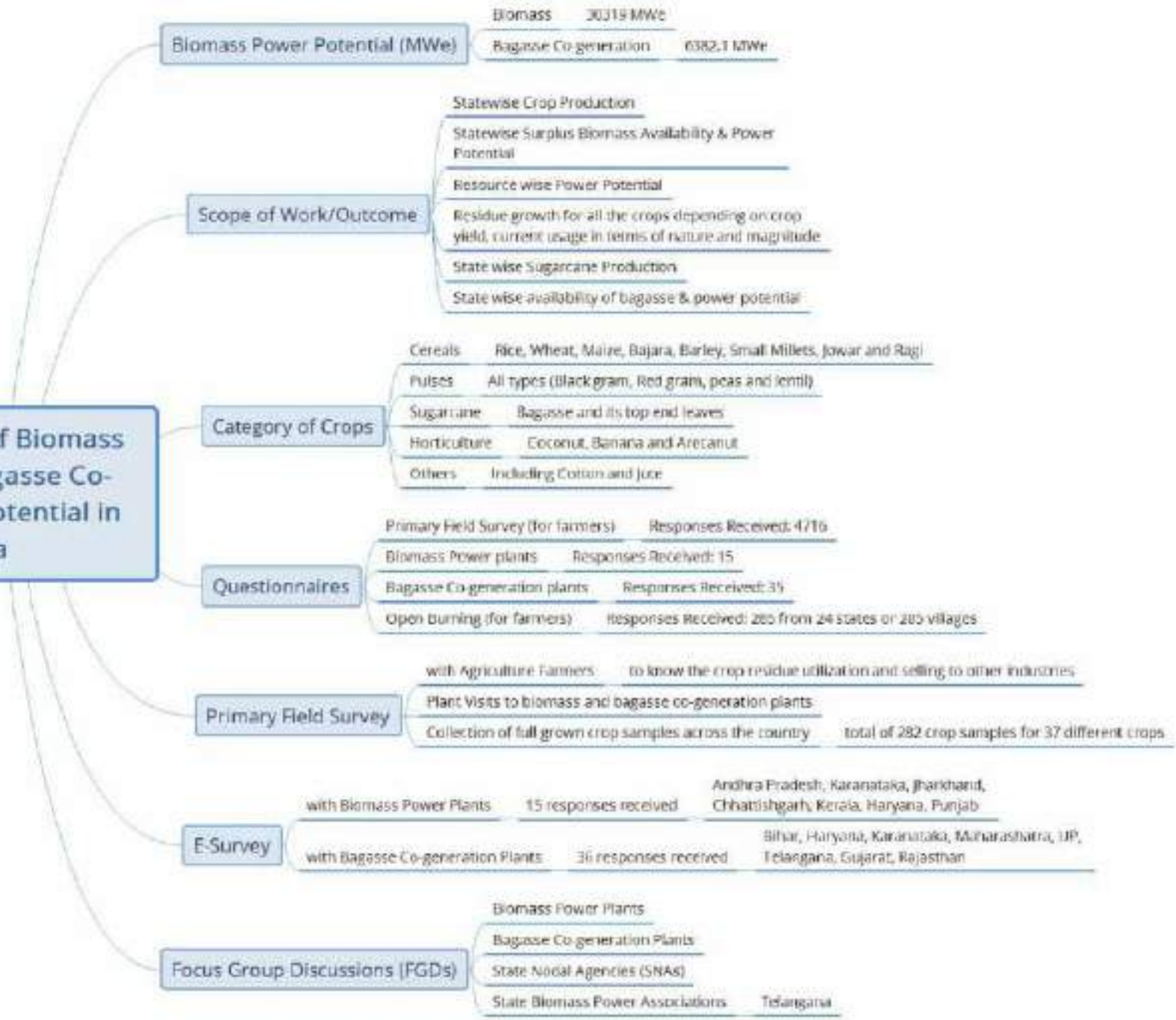
Snapshot of the Project




f Biomass
gasse Co-
otential in
a
Biomass Power Potential (MWe)
Biomass 30319 MWe
Bagasse Co-generation 6382.1 MWe
Scope of Work/Outcome
Statewise Crop Production
Statewise Surplus Biomass Availability & Power Potential
Resource wise Power Potential
Residue growth for all the crops depending on crop yield, current usage in terms of nature and magnitude
State wise Sugarcane Production
State wise availability of bagasse & power potential
Category of Crops
Cereals Rice, Wheat, Maize, Bajara, Barley, Small Millets, Jowar and Ragi
Pulses All types (Black gram, Red gram, peas and lentil)
Sugarcane Bagasse and its top end leaves
Horticulture Coconut, Banana and Arecanut
Others Including Cotton and Juce
Questionnaires
Primary Field Survey (for farmers) Responses Received: 4716
Biomass Power plants Responses Received: 15
Bagasse Co-generation plants Responses Received: 35
Open Burning (for farmers) Responses Received: 265 from 24 states or 265 villages
Primary Field Survey
with Agriculture Farmers to know the crop residue utilization and selling to other industries
Plant Visits to biomass and bagasse co-generation plants
Collection of full grown crop samples across the country total of 282 crop samples for 37 different crops
E-Survey
with Biomass Power Plants 15 responses received Andhra Pradesh, Karanataka, Jharkhand, Chhattishgarh, Kerala, Haryana, Punjab
with Bagasse Co-generation Plants 36 responses received Bihar, Haryana, Karanataka, Maharashtra, UP, Telangana, Gujarat, Rajasthan
Focus Group Discussions (FGDs)
Biomass Power Plants
Bagasse Co-generation Plants
State Nodal Agencies (SNAs)
State Biomass Power Associations Telangana

Ministry of
New and
Renewable
Energy

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