RESIDUE ENERGY AND RESIDUE UTILISATION PATTERN IN SON WATERSHED BIOMASS POWER PLANTS

Gopal Sonkar PhD
Research Associate, Indian Institute of Public Administration, New Delhi, India.

Abstract
The paper presents the ground reality of crop residue consumption patterns as an alternative energy resource. The electricity and heat produced by residues present a highly feasible approach for addressing the energy requirements of small villages. Moreover, residues make them independent and develop regional self-resource-based power. Several benefits of energy derived from crop residues, such as their widespread availability and variable distribution, distinguish it from other renewable energy resources. The study conducted a primary survey to address concerns about five biomass power plant residue consumption patterns in the Patna and Rohtas districts. An applied research approach shapes the study through quantitative and qualitative methods. The study demonstrates sustainable and alternative energy development. The concept of crop residue-based energy is framed in the context of increasing ecologically based energy capacity.

Keywords

Residue-Energy,

Bioenergy Task 29 Project,

Gasifier,

Wheat Straw,

Rice Straw,

Rice Husk,

Arhar Straw,

Arhar Husk and Maize Straw.

1. Introduction

Crop residue energy significantly contributes to the renewable energy sector. Therefore, its utilisation pattern enables the efficient management of crop residue on a broad scale as an energy source. The accessibility of energy is an important factor in the development of any region. Indian agricultural communities contain abundant crop residues due to India's status as an agrarian nation. However, the depletion of non-renewable energy sources is occurring fast, highlighting the need to understand and construct renewable energy systems based on ecological principles. Crop residue can function as a viable substitute for fossil fuels as an energy source. However, it is important to exercise careful maintenance in order to sustain their role as regional energy resources (Datye, 1997).

The significance comes from the fact that energy organisations in many nations consider agricultural residues a promising renewable energy source. Crop residue is a renewable resource of biomass that can be used as an energy source called "residue- energy". Overall, biomass energy resources are the remaining solid component of all organic plant and animal waste. Traditionally, wood has been the predominant biomass fuel. However, the significance of crop residue is generally acknowledged and immediately substitutes the use of wood. 'Residues-Energy' refers to using remaining crop residues to generate energy, such as heat and electricity. That is related to particular biomass power plants. The energy derived from residue is a remarkably advantageous and sustainable resource, mainly due to its widespread availability across different geographical locations and its ability to generate heat and power on various levels (MNRE, 2010; Datye, 1997).

The Bioenergy Task 29 program, promoted by the International Energy Agency, urges developed and developing nations to use alternative and renewable energy sources. The Indian government initiated the "New and Renewable Energy Resources" program in partnership with the Danish, British, Irish, Canadian, Norwegian, Swedish, and Austrian governments. The "Economic Drivers in Implementing Bioenergy Projects" initiative lasted from 2003 to 2005, spanning three years. A supplementary endeavour, titled "Residues Aspects of Energy," was launched to determine the overall regional gains and advantages of utilising residues-energy to promote its adoption in places where the benefits can be maximised and broadly appreciated (MNRE, 2008; Administrative Staff Colleges of Hyderabad, 2005).

2. Literature Review

The Expert Committee on "Integrated Energy Policy established by the Planning Commission" acknowledges that India has one of the lowest per capita energy consumption rates. Conversely, for India to fulfil its energy requirements, it is crucial to reduce the energy intensity of GDP to enhance energy efficiency. The need includes the energy needs of rural areas, which can be satisfied by utilising agricultural residue by-products (Planning Commission, 2006). Creating systematic use for waste residue materials can also yield significant socioeconomic advantages. At the same time, sources of residues are inherently generated in a dispersed manner. Residues act as the primary fuel for underprivileged rural communities. Furthermore, it functions as a means of generating revenue for agricultural labourers who do not own land and as a further source of income for small-scale farmers who rely on farming for their basic needs (Administrative Staff Colleges of Hyderabad, 2005). Given the dispersed nature of crop residues, it is vital to study and assess the consumption pattern of crop residues in biomass power plants.

Study on Regional Patterns of Crop Residue Utilization in Biomass Power Plants
Andhra Pradesh

MNRS, Socio Economic Impact of Biomass Power Plants, 2005: The study summarises important information on the crop residues utilisation pattern, price, and amount during a specific period. Biomass power plants often utilise rice husk. In the first half of 2001, rice husk prices were incredibly low. In addition to the cost advantage, husk was a convenient fuel readily available throughout the year. Thus, rice husk became the preferred fuel source for power plants. Rice husk alone accounted for almost 71% of crop residues from 2001-2002. In 2003-04, husk utilisation declined by 68%, and the price of rice husks increased by 95% compared to 2001-02. The state rice yield was most remarkable in 2000-2001. It was lowest in 2003-2004, falling by 8.6 percent and a further fall of 35.7 percent were registered in 2002-03. Due to the increase in cost, the power plant transitioned gradually from husk to woody biomass with other crop residues. Juliflora, woody biomass and other crop residues saw increases of 637% and 413%, respectively, in their rates of use. As a comparison, electricity production increased by 175% over that time.

Table 1: Biomass Residue Usage Trends at 10 Power Plants in Andhra Pradesh (Quantity in MT)

Residues Biomass type	2001-2002	2002-2003	2003-2004	Percentage change in 2 years
Rice Husk	285962	267860	196729	-36.20
Juliflora/ woody biomass	87596	260072	288074	228.87
Crop Residues	13203	29253	37419	183.43
Crop Saw Dust	2827	9740	6730	138.06
Bagasses Residues	1334	1366	821	515.52
G.B Shall	282758	24746	30597	18.79
DoB	811	-----	-----	-100.000
Total Biomass	417491	5930157	567760	35.99

Sources: MNRE (Ministry of New and Renewable Energy), Report on Biomass power plant, 2006, p. 18

Andhra Pradesh has witnessed a 413 % increase in crop residue use over the last two years. Increases in crop residues were more significant than the 202% increase in the use of total residues biomass but less than the increase in woody biomass. The primary reasons appear to be: 1) Collecting, transporting, storing, and processing agricultural residues before use necessitates a great deal of additional effort; 2) These raw materials were available only seasonally and hence, using the same throughout the year requires high storage capacities; 3) In terms of price, most types of crop residues currently do not have much of advantage over woody biomass.

Despite this, there are isolated instances of large-scale usage of crop residues as predominant raw materials for energy. For instance, Vamshi in the east Godavari district uses coconut husk for 50 per cent of its total usage because it is available for a large part of the year. The Veeriah non-conventional power plant in Krishna district overcame seasonality using several crop residues. Thereby, it has increased the usage of crop residue to the extent of 27 per cent of the total biomass usage.

Rajasthan

Rajasthan Renewable Energy Corporation Limited Report, 2010: The report summarises essential data related to the geographic heterogeneity of crop residue utilisation patterns. The Rajasthan biomass power plants' crop residue utilisation trends are mustard and cotton crop residues. Both were used in the plants and harvested only once a year. The most exciting aspect of the state of plants was running entirely on crop residues. Mustard husk constitutes 92.7 per cent of used, and cotton stalks account for the remaining 7.3 percent.

Table 2: Crop Residues Biomass Mix: Rajasthan

	Qty (MT)	Average Price (Rs.)
Mustard husk	25879.70	780.89
Cotton Stalks	2028.30	510.96

Sources: MNRE, Rajasthan Renewable Energy Corporation Limited Report, 2010. p. 43

Tamilnadu

Tamilnadu Energy Development Agency Report, 2005[9]: The study summarises essential information regarding the geographical variation of crop residue utilisation patterns, including bagasse, groundnut shell, wood chip, de-oiled bran and rice husk. Mohan Breweries has been operating long enough to look for Tamilnadu crop residue biomass usage trends. However, the other plant in operation, Renuga Textiles, has an interesting fact about running by de-oiled bran. Mohan Breweries in Tamilnadu was planned when bagasse was abundantly available. Interestingly, the plant used bagasse in substantial quantities along with rice husk, groundnut shell and wood chips, though bagasse costs as much as rice husk, ground nut shell and marginally less than wood chips. It is an interesting choice given that bagasse has a much lower calorific value than rice husk groundnut shell and wood chips.

Karnataka

The Energy and Resources Institute (TERI), 2013: A study on the sustainability of biomass-based power generation in Karnataka examined biomass plants' fuel linkages and the functional status of the tariff structure governing the electricity generated. The study showed six biomass-based plants in operation, five of which were in the rice belt using rice husk as the primary fuel. The idea was to determine whether these plants were cost-effective and estimate the quantum of crop residue being utilised. The cost structure also varied according to the price rise in rice husks at different periods. The effective use of modern technology helped in the better generation of energy. The literature review presents different views about crop residue utilisation patterns in biomass power plants, which are very few. The usage of crop residues in biomass power plants has been studied in the context of local alternative energy use. The technology (biomass power plant) for its generation and usage has been given significant importance. The study identifies the pattern of crop residue utilisation from four states only (Andhra Pradesh, Rajasthan, Tamilnadu, and Karnataka). These four studies provide very few observations. However, crop residue utilisation patterns and quantity data were not available. The literature is missing another important aspect of crop residue utilisation patterns in river watershed areas because river watershed areas are known for highly agricultural residue production zones. In addition, there is no literature on Son River Watershed residue consumption in biomass power plants. So, the study presents the ground reality of crop residue utilisation for power generation and its contribution at the geographical unit level as an alternative energy resource in the Son River watershed.

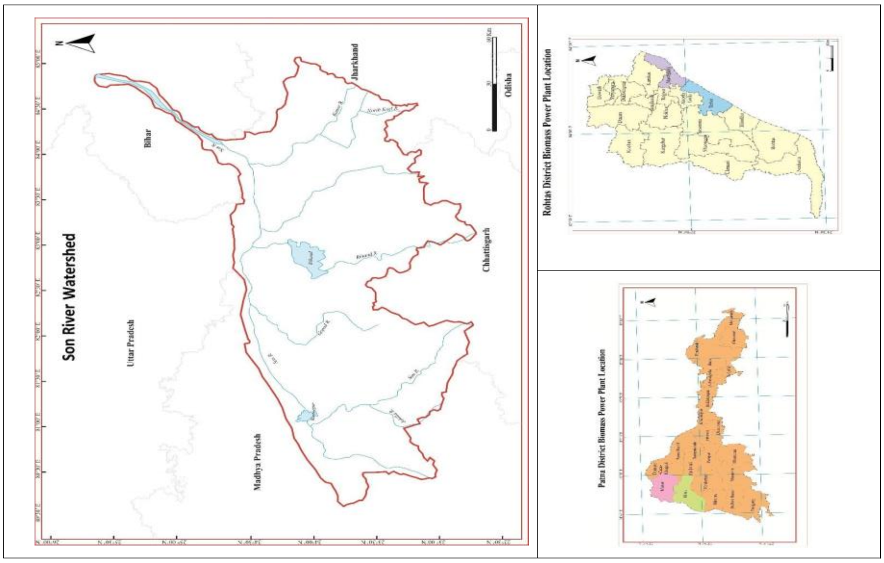
Aims and Objectives

The study aims to provide quantitative information about using residues in biomass power plants by focusing on micro-scale crop residue utilisation patterns in biomass power plants.

Brief Introduction to Survey Area

The Son River is a significant portion of the Ganga River and joins it on its right bank from the southern direction near the Patna district. The Son watershed has been recognised as a sub- basin of the Ganga basin. The basin has a wide catchment area of around 71,258 square kilometres. The river Son originates in the Anuppur area of Madhya Pradesh. The main tributaries of this river include the Johilla, Kunehar, Rihand, Kanhar, and Koel rivers. The Son River spans a distance of 784 kilometres as it flows through the states of Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Bihar, and Jharkhand.

Map of Survey Area



The primary survey was carried out in Patna and Rohtas districts. The two districts are located in the northern and southern halves of Bihar State's Son Watershed region. The Son River Watershed includes Patna and Rohtas districts and a large portion of Bihar. There are two reasons why these two districts were chosen: the rich soil and flat alluvial plains. Second, they are both well known in the agricultural activity.

Research Methodology and Sources

The primary and secondary data collection processes included both quantitative and qualitative methodologies. The first step in the study is to explain the consumption pattern of crop residues through previous studies for biomass power plants. The method of assessing crop residue consumption patterns was adopted from the MNRE study ("25 Years of Renewable Energy in India, 2008")[13]. The study was subsequently undertaken using secondary data to analyse the content of discourses and provide a comprehensive picture of the consumption pattern.

Primary Data

A primary survey was conducted to verify biomass power plants' crop residue consumption patterns. The nine Captive Power Plants were situated in Patna and Rohtas districts. Five of the nine plants are under operation, and four are non-functional. The study covered only the working plants - five working plants were finally included. These were chosen based on a list provided by the Bihar Renewable Energy Development Agency (BREDA), and at least one major and one minor biomass power plant was selected. Subsequently, information analysis and a comprehensive examination of discourses on the consumption pattern were conducted utilising secondary data sources.

Secondary Data

The Bihar Renewable Energy Development Agency (BREDA), Chhattisgarh Bio-fuel Development Authority, Department of Renewable Energy of Madhya Pradesh and Uttar Pradesh New and Renewable Energy Development Agency authorities provided secondary data about biomass power plant information in Son River watershed and crop residues consumption pattern.

Data Analysis and Interpretation

The data collected from both primary and secondary sources were analysed and then interpreted. To simplify, crop residue consumption estimation calculation was done with their respective utilisation for power plants within a geographical location. Values were also measured based on energy (electricity) production. Different cross tables and maps have been prepared for clarity. These tables show crop residue consumption quantity and types through analysis and thematic aggregation of residue data. The formula for calculating residue consumption is based on the MNRE studies after the ascertained crop-residue ratios. MS Office has been used for table presentation. The maps have been primarily prepared by MapInfo software. The delimitation of the Son River watershed is done with the help of the River Basin Atlas of India, published by the Ministry of Water Resources, 2012 and the Watershed Atlas of India, Central Groundwater Board 2012.

3. Result and Discussion

Basic Information about Biomass Power Plant

There are 25 biomass power facilities in the Son River watershed. The plants generate a substantial amount of energy, often used to meet their needs and excess is sold. Bihar Renewable Energy Development Agency

(BREDA) reports the presence of nine Captive Power Plants in Patna and Rohtas. Five of the nine plants are operational, while the others are non- functional. The study is limited to the five operational plants. Table number 3 presents the facts on these five plants.

Table 3: Biomass Power Plant at Patna and Rohtas District

No.	District	Address	Name of Plant	Capacity Units	Year of Installation
1	Patna	Sinha Rice Mill, Station Road; Masaudhhi; Patna	Sinha Gasifier Plant	120 kW	25.01.2008
2	Rohtas	Sri Rameswari ji Haridrar Ji Rice Mill Gram Motha Karakat; Rohtas	Sri Rameswari Ji Haridrar Ji Gasifier Plant	100 kW	05.12.2009
3	Rohtas	Jay Maa Durga Industry Muradabad, Sasaram; Rohtas	Jay Maa Durga Gasifier Plant	100 kW	16.08.2010
4	Rohtas	Sri Takur Ji Hai Tek Industry, Gram Majori Post Torni; Rohtas	Sri Takur Ji Hai Tek Gasifier Plant	150 kW	27.03.2010
5	Rohtas	Vindhvasini Rice Mill Kalster Pro Gram Jakhani Post Penar, Rohtas	Vindhvasini Co-Generation Plant	800 kW	20.06.2011

Sources: Bihar Administration "Report on Biomass based Power Generation in Bihar", 2017; Bihar Renewable Energy Development Agency unpublished document on the power plant.

The availability of rice husk in the two districts is the primary determining factor for installing the power plant. There are four gasifiers and one co-generation plant. The power generation capacity of the plants is determined by four factors: (1) the capacity of the rice mill, (2) the number of hours the mill operates in a year, (3) the ratio of paddy to husk (PHR), and (4) the caloric value of the husk (CV). Rice is the edible grain that is acquired from paddy, whereas rice husk and rice bran are byproducts that are derived from the processing of paddy. Rice bran is extensively utilised for oil extraction and feed composition, whereas rice husk may be incinerated to generate heat for parboiling paddy or other applications. Using husk on- site in the rice processing industry saves transportation costs, requiring thermal and mechanical energy.

Crop Residues Usage Trend and Electricity Production

The study provides a concise overview of the patterns and types of crop residue consumption and their relationship with electricity output in 2017. Both districts consumed 112050 metric tons (MT) of residue and produced 20.115-megawatt hours of energy (MWh).

Table 4: Consumption & Production Outlay of Power Plants

Plant	Years	Share of Residues Consumptions in a Year (MT)	Share of Coal and Solid Wood (MT)	Electricity Generation in a Year
Sinha	2017	11437	--	1625 KWh
Sri Rameswari Ji Haridrar Ji	2017	12140	--	1560 KWh
Jay Maa Durga	2017	10010	--	1460 KWh
Sri Takur Ji Hai Tek	2017	12010	--	1680 KWh
Vindhvasini	2017	82439	1720	13.79 MWh

Source: Field Survey

The consumption analysis indicates considerable changes in the utilisation of major residues and their uses. The residue mixture used by power plants consisted of five different residue types, with rice husk being the most abundant. Furthermore, gasifier plants are more common as they only utilise rice husk, whereas co-generation facilities generally utilise all residues. Power plants primarily utilise rice husk and rice straw as their primary residues. As to the power plant manager of the Vindhvasini Rice Mill, Kalster, rice straw was more affordable than other residues during the first half of 2017. Rice straw is cost-effective and abundantly available as a fuel all year round.

Name of Plants	Types of Crop Residues	Use of Residues Quantity MT

Sinha Gasifier Plant	Rice Husk	11437
Sri Rameswari Ji Haridrar Ji Gasifier Plant	Rice Husk	12140
Jay Maa Durga Gasifier Plant	Rice Husk	10010
Sri Takur Ji Hai Tek Gasifier Plant	Rice Husk	12010
Vindhvasini Co-Generation Plant	Wheat Straw	1988
	Rice Straw	16042
	Rice Husk	49129
	Arhar Straw	1960
	Arhar Husk	1990
	Maise Straw	1870
	Other waste	9460

Table 5: Crop Residues Consumption Pattern
Source: Field Survey

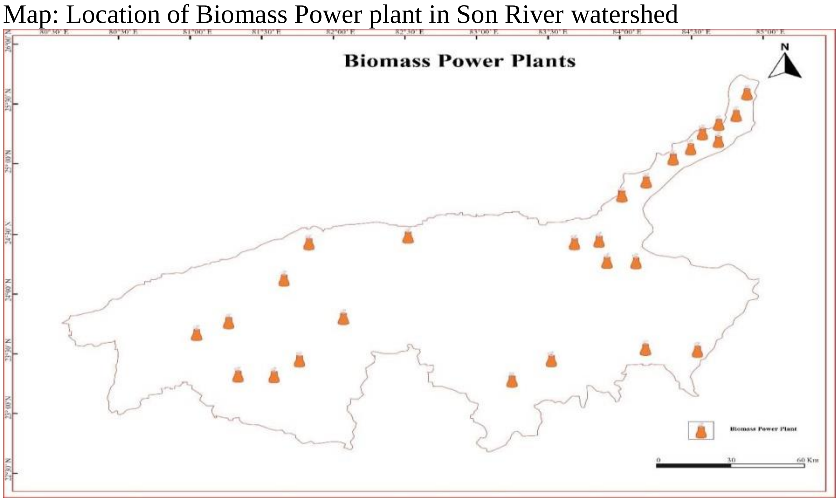
The consumption pattern of residue components indicates that rice residue is utilised more than other residues. According to the table, rice husks comprised over 95% of the residue used in 2017. This was mainly because rice mills produced much rice husk, contributing the largest share. The utilisation of rice husks is influenced by the amount of rice husks and the stock availability. Consequently, all five plants predominantly utilise rice husks as their primary fuel source. The gasifier biomass power plant technology can effectively utilise rice husk, and co-generation facilities can utilise all residues. The analysis of these four gasifier power plants and one co-generation plant showed that all five plants doubled their usage of rice husk.

Plant technology was the main factor responsible for utilising all residues in the Co-generation power plant. Co-generation the relative availability of residues in combination with the price differential. When the industry seeks to acquire residues from the village farmers, the farmers escalate the price. However, when the farmers attempted to provide the residues (except for rice husk) to the plants, plant owners were offered a small price. The residue is subject to significant price fluctuations, which influence supply and demand. The biomass power plant demonstrated that the quantity of residue used in power generation is considerably lower than the amount generated at the village level. The main factors were:
An effective management system is necessary for the collection and transportation.
There is a need for storage and processing the same before the residue can be used.
The storage capacity is essential as the residue availability is seasonally determined.
There is a high price fluctuation of crop residue.

Plants depend on crop residue as their primary supply of raw materials, which provides problems for storage and management. A constant and dependable provision of residue is crucial to maintain the power plant's highest efficiency.

Crop Residues Biomass Utilisation in Son River Watershed Biomass Power Plant
The 25-biomass power plants have been spread over the Son River watershed. The power plants established within the watershed have been listed in Table No. 6. The Rohtas district offers remarkable plants.

Map: Location of Biomass Power plant in Son River watershed



Sources: The Bihar Renewable Energy Development Agency (BREDA); Chhattisgarh Bio-fuel Development Authority; Department Renewable Energy of Madhya Pradesh; Uttar et al. Energy Development Agency; Pillay et al. (2011); Administrative et al.; Ram, R.K. (2011). Administrative Atlas Bihar; Sharma, Neena (2011) Administrative Atlas Utter Pradesh; Sinha, Sachin. (2011). Administrative Atlas Madhya Pradesh; Geological Survey of India. (2006). The school Atlas. Hyderabad, India: Orient Longman and Geological Survey of India (1981), The Vindhyan basin in Bundelkhand Son valley region. Hyderabad, India: Misc.

The region has great potential for generating residues, but the number of developed plant units is insufficient. There is potential for creating additional plant units, which may meet the region's energy needs.

Table 6: The Crop Residues Consumption Quantity of Biomass Power Plants in Son River Watershed: 2017

NO.	State	District	Capacity Units	Use of Residues Quantity MT
1	Bihar	Aurangabad	500 Kw	50477
2	Bihar	Aurangabad	500 Kw	52388
3	Bihar	Bhojpur	40 Kw	4546
4	Bihar	Bhojpur	40 Kw	-------
5	Bihar	Patna	120 Kw	11437
6	Bihar	Rohtas	100 Kw	12140
7	Bihar	Rohtas	80 Kw	------
8	Bihar	Rohtas	60 Kw	------
9	Bihar	Rohtas	60 Kw	------
10	Bihar	Rohtas	100 Kw	10010
11	Bihar	Rohtas	100 Kw	------
12	Bihar	Rohtas	150 Kw	12010
13	Bihar	Rohtas	800 Kw	82439
14	Chhattisgarh	Bilaspur	8 Mw	145367
15	Chhattisgarh	Bilaspur	9.99 Mw	124356
16	Chhattisgarh	Bilaspur	7.5 Mw	------
17	Chhattisgarh	Surguja	10 Mw	134565
18	Madhya Pradesh	Jabalpur	0.2 Mw	20668
19	Madhya Pradesh	Jabalpur	1.2 Mw	-----
20	Madhya Pradesh	Jabalpur	600 Kw	50065
21	Madhya Pradesh	Katni	7.5 Mw	------
22	Madhya Pradesh	Katni	300 Kw	45365
23	Madhya Pradesh	Katni	600 Kw	76543
24	Madhya Pradesh	Satna	100 Kw	24567
25	Uttar Pradesh	Sonbhadra	140 Kw	19422

Sources: Bihar Administration "Report on Biomass based Power Generation in Bihar", 2018. MNRE "The Development Biomass Energy Report", Chhattisgarh Bio-fuel Development Authority, 2019. MNRE "Renewable Energy Report Madhya Pradesh" Department of Madhya Pradesh, 2019. MNRE "Uttar Pradesh New and Renewable Energy Development Agency Report", 2019.

An analysis of residues utilised by biomass power plants in the watershed indicates significant differences in the patterns of residue consumption among the plants. Power plants prioritise the cost of residues as a key factor during survey interactions, besides considering their availability and transit expenses. Initially, rice husk and straw were utilised as byproducts in the watershed. Most of the electricity generated by biomass plants is consumed within the vicinity of the plants. Minimising transmission and distribution (T&D) losses, particularly in isolated areas, offers a significant challenge to efficiently delivering electricity. The significant transmission and distribution losses burden energy resources management, requiring a substantial subsidy to ensure electricity reaches even the most isolated areas. The use of crop residue for energy generation with biomass power can significantly decrease the burden of subsidies and mitigate the issue of transmission and distribution losses. Several biomass plants are located within the Son River basin, yet insufficient information is available about each plant. Certain plants are non-functional. The answer to the query about the non-functional of plants is not accessible. Similarly, the official report does not provide any information.

4. Conclusion

The study evaluates the crop residue consumption patterns in biomass power plants, with 128,036 metric tonnes utilised in both districts in 2017. According to the data, 17 biomass- working plants in the Son River watershed region utilised 876,365 metric tons of crop residues. Crop residues such as wheat straw, rice straw, rice husk, arhar straw, arhar husk, and maise straw have been used in plants. The agricultural residues serve as an energy source without interfering with the traditional utilisation of residues; this is the best observation from the survey study. Rice husks and straw mostly drove the utilisation of residues in the watershed area. Along with advantages such as cost-effectiveness, accessibility, paddy-to-husk ratio, and the energy content of the husk and straw, it is a simple fuel source available consistently throughout the year. Consequently, rice residue emerged as the predominant selection for all five power plants. In 2017, rice husk accounted for approximately 95% of the residue consumed. Before fully harnessing residues' power potential and assuring their year-round availability, several challenges need to be resolved, including collection, transportation, storage, processing, and price elasticity.

References

Government of Chhattisgarh. (2015-2019). The Development Biomass Energy Report. Raipur: Chhattisgarh Bio-fuel Development Authority.

Administrative Staff Colleges of Hyderabad. (2005). Socio Economic Impact of Biomass Power Plants, prepared for MNRE by Administrative Staff Colleges of Hyderabad. Hyderabad: MNRE.

Central Groundwater Board. (2012). Watershed Atlas of India. New Delhi: Government of India.

Datye KR. (1997). Banking of Biomass: A New Strategy for Sustainable Prosperity Based on Renewable Energy and Dispersed Industrialization. Ahmedabad: Center for Environment Education.

Geological Survey of India. (1981). The Vindhyan basin in Bundelkhand Son Valley region. Hyderabad: India: Misc.

Geological Survey of India. (2006). The School Atlas. Hyderabad: Orient Longman.

Government of Bihar. (2016- 2019). Report on biomass-based Power Generation in Bihar. Patna: Bihar Administration.

Government of Madhya Pradesh. (2016-2019). Renewable Energy Report Madhya Pradesh. Bhopal: Department of Madhya Pradesh.

Government of Tamilnadu. (2005). Tamilnadu Energy Development Agency Report. Chennai: Tamilnadu Energy Development Agency.

Government of Uttar Pradesh. (2016-2019). Uttar Pradesh New and Renewable Energy Development Agency Report. Lucknow: Uttar Pradesh Administrator.

Ministry of Water Resources. (2012). River Basin Atlas of India. New Delhi: Government of India.

MNRE. (2005). Biomass Assessment Study Reports for 500 Taluka in 23 States were prepared for MNRE by different consultants and consolidated by CGPL, Indian Institute of Science Bangalore. New Delhi: Indian Institute of Science Bangalore.

MNRE. (2008). 25 Years of Renewable Energy in India. New Delhi: MNRE: Government of India.

MNRE. (July 2010). Biomass – Fast Track to Clean & Green Power. Bioenergy India. New Delhi: Govt. of India.

Pillay GR. (2011). Administrative Atlas Chhattisgarh: Census of India 2011. Raipur: Chhattisgarh Director of Census operation.

Planning Commission. (2006). Report of the Expert Committee on Integrated Energy Policy. New Delhi: Planning Commission, Govt India.

Director of Census operation Bihar. (2011). Ram RK. Administrative Atlas Bihar: Census of India.

Rathore D, Mathur S, Solanki R. (1993). Integrated Rural Energy Planning. Udaipur: Agrotech Publishing Academy.

Reddy AK, Balachandra P. (2002). A Sustainable Energy Strategy for India. The Economic and Political Weekly. Dec; 8.

Sharma N. (2011). Administrative Atlas Utter Pradesh: Census of India 2011.Utter Pradesh: Director of Census Operation.

Sinha S. (2011). Administrative Atlas Madhya Pradesh: Census of India 2011. Madhya Pradesh: Director of Census Operation.

The Energy and Resources Institute. (2013). Study on biomass- based power generation sustainability in Karnataka. New Delhi: TERI.