

Agrowaste Management in Rajasthan: Strategies for Sustainable Transformation

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Abstract:

Rajasthan, the largest state in India, produces an estimated 20–25 million tons of agricultural residue annually. Historically, this biomass was managed through traditional fodder use or environmentally damaging in-situ burning. This paper examines the strategic shift in Rajasthan's agrowaste management up to 2023, focusing on the transition from a "disposal-based" mindset to a "valorization-based" circular economy. Key strategies analyzed include the **Rajasthan Biomass and Waste to Energy Policy (2023)**, the decentralization of briquetting units, and the integration of agrowaste into the industrial supply chain.

Key words: Agrowaste, Sustainable Agriculture, Rajasthan, Biomass

Introduction

Agricultural waste, or agrowaste, refers to the non-edible parts of plants left in the field after harvest—husks, stalks, straws, and shells. In Rajasthan, the management of this waste is not merely an environmental concern but an economic opportunity. The state's unique agro-climatic zones result in a diverse waste profile, ranging from mustard stalks in the east to pearl millet (bajra) residue in the west. Prior to 2024, the state government identified agrowaste as a critical pillar for achieving its renewable energy targets. The central challenge remained the **collection-logistics gap**: the high cost of transporting low-density biomass from fragmented landholdings to centralized processing units.

Resource Assessment: The Rajasthan Agrowaste Profile

Rajasthan's agrowaste potential is dominated by four major crops. Data from the *Department of Agriculture (2022-23)* indicates a gross cropped area of **28.17 million hectares**, leading to massive residue generation.

Crop-wise Residue Generation

The table below illustrates the estimated residue-to-product ratio (RPR) for dominant crops in the state:

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Crop	Major Residue	RPR (Estimated)	Primary Management Strategy
Mustard	Stalks/Husk	2.5 : 1	Biomass Power Plants / Briquettes
Pearl Millet	Stalks/Husk	2.0 : 1	Fodder / In-situ mulching
Wheat	Straw	1.3 : 1	Animal Feed (Bhoosa)
Cotton	Stalks	3.0 : 1	Open burning (Traditional) / Gasification
Guar	Stalks/Pods	1.8 : 1	Industrial Gum extraction waste

Regional Concentration

- **Eastern Rajasthan (Alwar, Bharatpur):** Known as the "Mustard Belt," this region is the primary hub for biomass power generation due to the high calorific value of mustard husk (approx. 3,400–4,000 kcal/kg).
- **Western Rajasthan (Jaisalmer, Barmer):** Focuses on Bajra residue, though lower in energy density, it serves as a critical survival fodder for the state's large livestock population.

Strategies for Sustainable Transformation

The "Sustainable Transformation" of agrowaste in Rajasthan evolved through three distinct strategic layers:

Policy Framework:

The **Rajasthan Biomass and Waste to Energy Policy (2023)** replaced the aging 2010 policy. It introduced several groundbreaking incentives:

- **Co-firing Mandates:** Thermal power plants were incentivized to use biomass pellets for 5–10% of their fuel mix.
- **Operational Incentives:** Exemption from electricity duty and land conversion charges for biomass collection hubs.
- **Waste-to-Energy (WTE) Focus:** Shifting from just crop residue to including urban organic waste, creating a holistic bio-energy circuit.

Technological Interventions

- **Briquette and Pellet Production:** Small-scale industrial units (predominantly in Jaipur and Jodhpur) began converting loose mustard husk into high-density briquettes. This solved the "bulkiness" problem, making transport economically viable.
- **In-situ Management:** Under the **PM-KUSUM** and state-subsidized schemes, farmers were encouraged to use *Mulchers* and *Happy Seeders*. These machines incorporate residue back into the soil, increasing Soil Organic Carbon (SOC).

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The Biomass Energy Landscape:

As of late 2023, Rajasthan had one of the highest installed capacities of biomass power in India, although it remained eclipsed by solar and wind.

Installed Capacity and Potential

The following table reflects the status of biomass energy projects in Rajasthan (based on RRECL data through 2023):

District	Number of Plants	Capacity (MW)	Primary Fuel Source
Ganganagar	2	15.0	Paddy Husk / Cotton Stalk
Alwar	3	22.5	Mustard Husk
Tonk	1	10.0	Mustard / Multi-crop
Sirohi	1	6.0	Mustard Husk
Total (Statewide)	13-15	~120.45 MW	Mustard dominate

Economic and Environmental Impact

The transformation of agrowaste management has yielded measurable benefits:

1. **Carbon Sequestration:** By avoiding the burning of 1 tonne of crop residue, approximately **1.5 tonnes of CO₂** emissions are prevented.
2. **Farmer Income:** The "Farm-gate" price for mustard husk rose to **₹2,500 - ₹3,500 per tonne** by 2023, providing a secondary revenue stream for farmers.
3. **Soil Health:** In-situ management reduced the requirement for chemical nitrogenous fertilizers by approximately **10-15%** due to natural nutrient recycling.

Challenges and Future Outlook

Despite the success of the 2023 policy, three major bottlenecks persist:

- **Seasonal Availability:** Agrowaste is generated in two short windows (April-May and October-November), requiring massive storage infrastructure to ensure year-round industrial supply.
- **The "Bhoosa" Competition:** In drought years, crop residue prices skyrocket because they are needed for cattle fodder, making them too expensive for power plants.
- **Technology Costs:** The capital investment for a pelleting machine remains high for individual farmers or small cooperatives

Summary

Prior to 2024, Rajasthan's strategy was redefined by the **Rajasthan Biomass and Waste to Energy**

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Policy (2023). The state generates approximately **20–22 million tonnes** of crop residue annually.

A. Resource Mapping (The "Waste" Profile)

The agrowaste in Rajasthan is highly seasonal and district-specific:

- **Mustard Stalks:** Concentrated in Bharatpur and Alwar; used primarily for biomass power and industrial briquettes.
- **Pearl Millet (Bajra):** Common in Western Rajasthan; essential for cattle fodder but generates significant husk waste.
- **Cotton Stalks:** Primarily in Ganganagar and Hanumangarh; often burned in-situ, representing a major target for gasification projects.

B. Core Transformation Strategies

1. **Biomass Energy (The Powerhouse):** By 2023, Rajasthan established over **120 MW** of biomass power capacity. The strategy shifted toward **Co-firing**, where thermal power plants blend 5–10% biomass pellets with coal to reduce carbon emissions.
2. **The Briquetting Revolution:** Small-scale industries convert loose, low-density husk (like mustard) into high-density "biocoal" briquettes. This solves the logistical nightmare of transporting bulky waste across the desert.
3. **In-Situ Management:** Promotion of "decomposer capsules" and subsidized machinery like **Mulchers** and **Happy Seeders** allows farmers to mix residue directly back into the soil, enhancing organic carbon.

Quantitative Overview: Potential vs. Utilization

The following table summarizes the status of major crop residues in Rajasthan based on 2022-23 data:

Crop Residue	Yearly Generation (Est.)	Calorific Value (kcal/kg)	Primary Sustainable Strategy
Mustard Husk	6.5 Million Tonnes	3,800 - 4,200	Biomass Power / Briquettes
Wheat Straw	8.0 Million Tonnes	3,200 - 3,500	Animal Fodder / Bio-ethanol
Cotton Stalk	2.5 Million Tonnes	4,000 - 4,400	Industrial Gasification
Rice Husk	0.8 Million Tonnes	3,000 - 3,300	Brick Kilns / Particle Boards

Export to Sheets

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Conclusion:

The "Sustainable Transformation" of agrowaste in Rajasthan is a successful case study of the **Circular Bioeconomy**. By the 2024, the state will be successful decoupled agricultural growth from environmental pollution in several key districts.

Key Findings:

- **Economic Empowerment:** Agrowaste has moved from being a liability to a "cash crop." Farmers in the mustard belt can earn an additional **₹2,500 to ₹3,500 per tonne** for residue that was previously burned.
- **Environmental Gains:** Systematic management has led to a reduction in PM10 and PM2.5 levels during the harvest seasons and improved the Soil Organic Carbon (SOC) through mulching.
- **Future Resilience:** The transition to "Waste-to-Wealth" is vital for Rajasthan's energy security. However, for full transformation, the state must address the **Logistics Gap** by establishing district-level "Biomass Banks" to stabilize prices during off-seasons.

Rajasthan's approach to agrowaste management up to 2024 serves as a model for semi-arid regions. The state successfully moved beyond viewing crop residue as a "pollution problem" and began treating it as a "commodity." The 2023 Policy laid the groundwork for a decentralized energy network. For future sustainability, the focus must shift toward **District-level Biomass Banks** to stabilize prices and ensure a steady supply for the growing bio-energy sector.

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