



Impact of Paddy Straw Management Practices On Farmers' Income and Adoption Behavior in Hanumangarh, Rajasthan

Sukhvinder Singh¹, Vinod Kumar²

¹ MBA Guru Kashi University Talwandi Sabo Bathinda.

² Assistant Professor Guru Kashi University Talwandi Sabo Bathinda.

Abstract- This study investigates the impact of paddy straw management practices on farmers' income and evaluates the determinants of adoption behavior in the Hanumangarh district of Rajasthan. The research aims to quantify the current rate of adoption for various straw management methods and analyze the socio-economic factors influencing these decisions. Key variables examined include farm size, annual income, social participation, and the level of technological awareness among farmers. The findings highlight that adopting sustainable paddy straw management practices leads to the highly efficient utilization of crop residue, significant improvements in soil health, and enhanced financial returns through cost reduction and the commercial sale of straw. Despite these benefits, the study identifies several critical barriers to widespread adoption, including the prohibitive cost of required machinery, a lack of awareness regarding long-term benefits, labor shortages, and the absence of reliable market linkages for straw. The insights derived from this research provide actionable recommendations for policymakers, extension agencies, and agricultural institutions operating in the region. By fostering technological adoption and offering targeted support structures, stakeholders can simultaneously improve farmers' economic livelihoods and mitigate the severe environmental impacts associated with crop residue burning.

Keywords: Paddy straw management, adoption behavior, farmers' income, crop residue burning, Hanumangarh, agricultural economics, sustainable agriculture.

I. INTRODUCTION

Agriculture remains the backbone of the Indian economy, with paddy serving as one of the most vital staple crops cultivated across the country. In Northern India, particularly within the intensive rice-wheat cropping system, the cultivation of paddy generates a substantial volume of crop residue. While this residue holds potential agricultural and commercial value, its management has emerged as a critical ecological and economic challenge. In the Hanumangarh district of Rajasthan, an area characterized by intensive agricultural practices, managing paddy straw has become a focal point for both farmers and policymakers. Traditionally, the narrow turnaround time between the paddy harvest and the sowing of the subsequent wheat crop leaves farmers with a highly limited window to clear their fields. Consequently, crop residue burning has become the most widely adopted, cost-effective, and expedient method for field clearance. However, this practice triggers severe negative externalities, including massive emissions of greenhouse gases that exacerbate regional air pollution, the destruction of vital soil organic carbon, and the depletion of essential nutrients, ultimately threatening long-term agricultural sustainability.

To combat these adverse environmental and agronomic effects, various sustainable paddy straw

management practices have been introduced, broadly categorized into in-situ and ex-situ methods. In-situ management involves incorporating the straw back into the soil using specialized machinery or using it as surface mulch, which improves soil health, retains moisture, and reduces the need for synthetic fertilizers. Conversely, ex-situ management involves removing the straw from the field by baling it for alternative commercial uses, such as biomass power generation or animal feed, providing farmers with an opportunity to generate additional income. Despite these clear ecological and economic benefits, the transition from burning to sustainable management remains uneven. A farmer's decision to adopt these new technologies is complex and heavily influenced by socio-economic variables such as farm size, annual income, social participation, and the degree of technological awareness. Furthermore, farmers face several practical barriers that hinder widespread uptake, including the high capital cost of specialized machinery, acute labor shortages during the harvesting season, and the absence of reliable, accessible markets for selling baled straw.

Understanding the dynamics of these adoption behaviors is crucial for developing effective interventions. Therefore, this study is conducted in the Hanumangarh district of Rajasthan to empirically evaluate how the implementation of



paddy straw management practices impacts farmers' income. By analyzing the current adoption rates and identifying the specific socio-economic drivers and constraints influencing these farmers, this research aims to bridge the gap between technological availability and field-level execution. The findings of this study are intended to provide actionable insights for policymakers, extension agencies, and agricultural institutions. By addressing the identified barriers and leveraging the factors that encourage adoption, stakeholders can design targeted support systems that not only enhance farmers' economic livelihoods but also mitigate the severe environmental hazards associated with crop residue burning.

II. REVIEW OF LITERATURE

Reviewing extant literature is imperative for identifying established paradigms, emerging trends, and critical research gaps within a specific domain. Numerous scholars have investigated the environmental externalities of crop residue burning, the efficacy of remedial technologies, and the complex socio-economic matrices governing farmers' adoption of sustainable agricultural practices.

2.1 Pertinent Concepts and Theories Recent literature highlights the pivotal role of mechanization and biological interventions in transitioning away from traditional crop residue burning. Studies by Singh and Jha (2023) and Buttar et al. (2023) underscore the increasing reliance on technological innovations—such as the Super SMS, Happy Seeder, Smart Seeder, and rotavators—to facilitate effective in-situ residue management in rice-growing regions, significantly mitigating the need to burn stubble. The adoption of these technologies, however, is a gradual process heavily reliant on institutional support and machinery access (Singh et al., 2020). Beyond mechanical solutions, Jambagi et al. (2023) evaluated the combined role of the Happy Seeder and PUSA decomposers, concluding that these interventions reduce production costs and bolster profitability in subsequent wheat farming, though financial constraints remain a hurdle for smallholders. Exploring ex-situ management, Kathpalia et al. (2025) conducted sociological research on straw baler technology, finding that while farmers generally perceive baling as a profitable venture, high capital costs and limited localized availability act as primary barriers to widespread adoption.

2.2 Studies on the Economic Impact of Paddy Straw Management Practices A substantial body of research indicates that the strategic management

of paddy straw can significantly enhance farm profitability through input cost optimization and soil health amelioration. Technologies such as the Happy Seeder and biological decomposers effectively reduce land preparation costs and improve the yield of succeeding crops. Furthermore, the in-situ incorporation of crop biomass enriches soil organic carbon, thereby reducing long-term dependency on synthetic fertilizers and supplementary irrigation. However, a recurrent theme in the literature is the barrier posed by the high initial capital expenditure and ongoing maintenance costs associated with specialized machinery, which disproportionately affects small and marginal farmers. Consequently, the economic viability of residue management is highly contingent upon economies of scale—specifically farm size—as well as the accessibility of government subsidies and Custom Hiring Centers (CHCs).

2.3 Studies on Socio-Economic Factors Influencing Farmers' Adoption Behaviour The decision to adopt novel agricultural technologies is not solely an economic calculation but is deeply embedded in the socio-economic profile of the farmer. Literature consistently demonstrates a positive correlation between technology adoption and variables such as educational attainment, social participation, and integration with extension services. Educated farmers who maintain active contact with agricultural extension workers exhibit a higher propensity to experiment with and adopt sustainable practices. Farm size acts as another critical determinant; larger landholdings provide the necessary financial buffer to absorb the capital risks associated with heavy machinery. Furthermore, adoption behavior is heavily influenced by the "perceived ease of use" and "perceived utility" of the technology. Continuous training, robust extension support, and clear field demonstrations are paramount in demystifying these technologies and accelerating their acceptance at the grassroots level.

2.4 Studies on Government Initiatives and Policy Support Institutional intervention and policy support are foundational to scaling crop residue management practices. Government initiatives have predominantly focused on incentivizing sustainable practices through financial subsidies for machinery procurement and the establishment of Custom Hiring Centers (CHCs). These CHCs democratize access to expensive technology, making both in-situ and ex-situ management economically viable for resource-constrained farmers. Alongside financial mechanisms, state-sponsored capacity-building programs and awareness campaigns play a crucial role in educating farmers on the dual ecological and economic benefits of residue management.



However, researchers caution that the efficacy of these policies depends entirely on targeted execution and the comprehensive dissemination of information. Sustained governmental backing, streamlined subsidy disbursement, and localized policy adjustments remain essential to ensuring the long-term success of crop residue management frameworks.

III. RESEARCH GAP

A comprehensive review of the existing literature reveals a substantial body of research dedicated to crop residue management, technological interventions, and the environmental degradation associated with paddy straw burning. However, the geographic focus of these studies has been overwhelmingly concentrated within the traditional rice-wheat belts of Punjab and Haryana, where stubble burning has historically been a severe crisis. While these studies provide foundational insights into the technological, ecological, and broad economic dimensions of residue management, their spatial confinement limits their broader applicability.

Notably absent is empirical research situated in Rajasthan, particularly within the Hanumangarh district. In recent years, Hanumangarh has witnessed a significant expansion in paddy cultivation, driven by improvements in regional irrigation infrastructure. The limited research that does exist concerning such transitional agricultural zones tends to be heavily skewed toward macro-environmental impact assessments or the mechanical efficacy of specific implements, such as the Happy Seeder. Consequently, there is a glaring scarcity of literature examining the direct, micro-level impact of diverse paddy straw management practices on farmers' net income and the socio-economic factors dictating their adoption behavior.

Furthermore, current literature lacks a nuanced understanding of the specific economic rationales that drive or deter the adoption of these practices in regions where intensive paddy cultivation is a relatively recent development. There is a critical deficit of empirical, ground-level evidence demonstrating the financial viability and cost-benefit outcomes of various residue management techniques in these newer agricultural contexts. To address these empirical and geographical voids, the present study is designed to evaluate the impact of paddy straw management practices on farmers' income and to decode their adoption behavior specifically within the Hanumangarh district of Rajasthan. By documenting current field practices, analyzing decision-making drivers, and quantifying

actual financial outcomes, this research aims to provide localized, actionable intelligence. The findings will serve as a crucial resource for policymakers, agricultural extension agencies, and researchers seeking to formulate targeted, region-specific strategies for promoting economically viable and ecologically sustainable crop residue management.

IV. SCOPE AND OBJECTIVES OF THE STUDY

4.1 Scope of the Study Agriculture serves as a foundational pillar of the Indian economy; however, the intensive cultivation of staple crops, particularly paddy, generates substantial volumes of agricultural biomass. In northern Indian regions such as Rajasthan, the expedient and cost-effective practice of burning paddy straw to rapidly clear fields for subsequent sowing remains highly prevalent. This practice precipitates severe environmental externalities, including critical air pollution, the destruction of vital soil microflora, and the depletion of essential soil nutrients.

To mitigate these adverse effects, agricultural scientists and governmental bodies strongly advocate for sustainable paddy straw management (PSM) practices. These include in-situ methods like soil incorporation and surface mulching using advanced machinery (e.g., Happy Seeders), as well as ex-situ applications such as utilizing the straw for composting, animal feed, or bioenergy generation. Proper residue management is proven to enhance soil health, optimize fertilizer expenditure, and ultimately increase farm profitability. Nevertheless, the adoption of these methods remains inconsistent due to knowledge gaps, financial constraints, lack of machinery access, and insufficient institutional support.

The Hanumangarh district of Rajasthan has recently emerged as a highly productive paddy cultivation zone, facilitated by significant improvements in regional irrigation infrastructure. Consequently, managing the resulting surge in paddy straw has become a pressing challenge for local farmers. This study focuses geographically on Hanumangarh to investigate the intersection of PSM practices and farm economics. It meticulously examines the socio-economic profiles of the farmers, their awareness levels, the extent of technological adoption, the economic benefits derived, and the practical constraints encountered. Ultimately, the insights generated will equip policymakers, agricultural extension agencies, and researchers with the empirical data required to promote sustainable



residue management and improve the economic resilience of the farming community.

4.2 Objectives of the Study The research is guided by the following specific objectives:

- **Primary Objective:** To identify and evaluate the various paddy straw management practices currently adopted by farmers in the Hanumangarh district.
- **Secondary Objective:** To assess the direct economic impact of these adopted management practices on the net income of the farmers.

V. RESEARCH METHODOLOGY

5.1 Research Design A descriptive and analytical research design was adopted for this study. This methodological framework is optimal for empirically documenting the current state of affairs specifically, the socio-economic characteristics of the farmers and their baseline technological adoption rates. Furthermore, the analytical component allows for a rigorous examination of the causal relationships between the adoption of specific paddy straw management practices, the driving factors behind these decisions, and the resulting financial outcomes.

5.2 Study Area The study was purposively conducted in the Hanumangarh district of Rajasthan. This region was selected due to its favorable agro-climatic conditions and robust irrigation networks, which have catalyzed a rapid expansion in paddy cultivation. Consequently, the district is currently confronting an escalating challenge regarding the ecologically sound disposal of post-harvest paddy residue, making it an ideal locale for this investigation.

5.3 Population and Sampling

- **5.3.1 Population:** The target population comprises all active paddy-cultivating farmers within the Hanumangarh district who generate and manage paddy straw post-harvest.
- **5.3.2 Sampling Technique:** A multi-stage random sampling technique was employed to construct a representative sample. In the first stage, two major paddy-producing blocks within the Hanumangarh district were selected. In the second stage, four prominent paddy-cultivating villages were randomly selected from each block. Finally, farmers were randomly sampled from these villages to achieve a total sample size of 100 respondents. This stratified approach ensured adequate representation across various socio-economic strata, landholding sizes (marginal, small,

medium, and large), and residue management techniques.

5.4 Data Collection

- **5.4.1 Primary Data:** Primary data was gathered directly from the sampled farmers using a pre-tested, structured interview schedule. The instrument was designed to elicit comprehensive information regarding socio-demographic profiles (age, education, family size, landholding, income), current PSM practices, the extent of technology adoption, precise cultivation costs, farm revenues, operational constraints, and engagement with government extension services.
- **5.4.2 Secondary Data:** To contextualize the primary findings, secondary data was systematically collated from official records of the Department of Agriculture (Rajasthan), local agricultural cooperative societies, extension office databases, and relevant peer-reviewed research publications.

5.5 Variables of the Study The analytical framework incorporates the following dependent and independent variables:

• 5.5.1 Dependent Variables:

1. **Farmers' Income:** The net financial return generated from paddy and subsequent wheat cultivation after integrating crop residue management costs.
2. **Adoption Behaviour:** The degree to which farmers integrate scientifically recommended PSM practices, measured utilizing a standardized adoption index.

• 5.5.2 Independent Variables:

1. **Socio-Demographic Profile:** Age, educational attainment, farming experience, annual income, and operational landholding size.
2. **Information Accessibility:** The frequency and quality of contact with agricultural extension personnel and related institutional support.
3. **Resource Availability:** The financial capacity and physical access to specialized agricultural machinery.
4. **Perceived Utility:** The farmers' subjective understanding of the environmental and agronomic benefits associated with residue management.

5.6 Tools for Data Analysis To extract meaningful inferences from the raw data, the following analytical tools were utilized:

- **5.6.1 Descriptive Statistics:** Frequencies, percentages, means, and standard deviations were calculated to summarize the socio-



economic characteristics of the respondents and baseline adoption trends.

- **5.6.2 Economic Analysis:** A comparative financial assessment was conducted to evaluate profitability. This involved calculating the Cost of Cultivation (expenditure on land preparation, inputs, labor, and machinery), Gross Returns (total revenue from crop yield), and Net Profitability (returns minus costs) for different residue management cohorts.

5.7 Operational Definitions

1. **Paddy Straw Management Practices:** The specific physical or mechanical interventions utilized by farmers to handle post-harvest residue, encompassing burning, soil incorporation, surface mulching, or ex-situ removal for alternative applications.
2. **Adoption Behaviour:** The measurable extent and consistency with which a farmer accepts, implements, and sustains recommended, scientifically validated agricultural technologies.
3. **Farm Income:** The net operational profit derived from agricultural enterprises, calculated by deducting total cultivation and residue management expenditures from gross agricultural revenue.

VI. LIMITATIONS OF THE STUDY

While this research provides valuable insights into paddy straw management, it is subject to certain limitations:

1. **Geographical Constraints:** The empirical scope is confined to selected villages within the Hanumangarh district. Consequently, the findings may not be entirely generalizable to other agro-climatic zones across Rajasthan or India.
2. **Crop Specificity:** The research exclusively focuses on paddy-cultivating households, excluding the residue management dynamics of other major agricultural crops grown in the region.
3. **Self-Reported Data Bias:** The economic analyses, including cultivation costs and farm income, rely heavily on the self-reported recall of the respondents. Such data may be subject to memory bias or estimation discrepancies.
4. **Exogenous Variables:** The study primarily focuses on socio-economic and technological factors, without accounting for exogenous macroeconomic variables—such as climate fluctuations and market price volatility—which can also significantly influence farmers' adoption behaviors.

VII. KEY FINDINGS

The analysis of the primary data collected from 100 farmers in the Hanumangarh district reveals several critical insights regarding socio-economic profiles, awareness levels, and adoption patterns:

- **Demographic Profile:** Paddy cultivation and residue management are predominantly handled by older demographics. The majority of respondents are between 41–50 years old (39%), followed by those above 50 years (27%), 31–40 years (22%), and below 30 years (12%).
- **Educational Deficit:** A significant educational barrier exists among the sample. Nearly half of the farmers (49%) are illiterate, while 36% possess only primary education. Only 12% and 3% have secondary and higher education, respectively. This low educational attainment presents a major hurdle in comprehending and adopting advanced management technologies.
- **Landholding Patterns:** The distribution indicates that 51% of respondents operate medium-sized farms, 28% are small/marginal farmers, and 21% manage large agricultural holdings.
- **Prevalence of Traditional Practices:** Despite environmental concerns, burning remains the most prevalent method of residue disposal due to its expediency and low cost. In-situ and ex-situ sustainable practices are being adopted, but the transition is remarkably slow.
- **Economic Impact:** A notable segment of the respondents reported no immediate or significant increase in their farm income after transitioning to sustainable residue management practices, reducing the immediate financial incentive to change.
- **Primary Barriers to Adoption:** The major constraints hindering the adoption of sustainable practices include a severe lack of technical awareness, the prohibitive capital cost of specialized machinery, and inadequate access to financial credit.
- **Information Asymmetry:** Farmers predominantly rely on mass media for information regarding agricultural practices, indicating a critical gap in direct, grassroots-level intervention by agricultural extension services.
- **Environmental Awareness:** Despite the slow adoption rate, farmers demonstrate a clear understanding that proper paddy straw management is essential for reducing regional air pollution and preserving soil health, indicating a strong baseline willingness to adapt if provided with adequate support.



VIII. SUGGESTIONS AND POLICY RECOMMENDATIONS

Based on the empirical findings, the following interventions are recommended to accelerate the adoption of sustainable paddy straw management in the Hanumangarh district:

- 1. Strengthening Extension Services:** Agricultural extension officers must establish direct, frequent communication with farmers. Regular training camps, field schools, and grassroots awareness campaigns should be organized to educate farmers on the long-term economic and ecological benefits of residue management.
- 2. Field Demonstrations:** Establishing localized demonstration plots is crucial. Experiencing the tangible benefits of technologies like the Happy Seeder or Super Seeder firsthand will build trust and "perceived ease of use" among uneducated farmers.
- 3. Financial Subsidies:** The government must enhance targeted capital subsidies for agricultural implements to alleviate the financial burden on small and marginal farmers attempting to transition away from stubble burning.
- 4. Expansion of Custom Hiring Centers (CHCs):** To bypass the high costs of machinery ownership, the network of CHCs must be aggressively expanded, ensuring that rental equipment is affordable, well-maintained, and readily available during the narrow harvesting window.
- 5. Promoting Cooperative Models:** Encouraging farmers to form cooperatives or Farmer Producer Organizations (FPOs) can facilitate the communal sharing of expensive machinery and collective bargaining for better market rates.
- 6. Developing Market Linkages:** Supply chains must be developed for ex-situ residue applications. Connecting farmers with industries that utilize paddy straw for biomass energy, cardboard manufacturing, or commercial animal feed will transform a waste byproduct into a lucrative income stream.
- 7. Leveraging Mass Media:** Since farmers heavily rely on media for information, utilizing localized radio, television, and digital platforms to disseminate targeted agricultural advisories can effectively bridge the knowledge gap.

IX. CONCLUSION

Paddy straw management remains a complex and pressing challenge for the agricultural sector in the

Hanumangarh district of Rajasthan. The persistence of crop residue burning is not driven by a sheer lack of environmental awareness, but rather by systemic constraints: a narrow turnaround time between crop cycles, an aging and undereducated farming demographic, the prohibitive costs of specialized machinery, and a pronounced lack of institutional support. While the immediate economic benefits of sustainable practices have not yet materialized uniformly for all farmers, there is a clear willingness within the community to adopt environmentally friendly alternatives provided they are economically viable.

Ultimately, mitigating the environmental hazards of stubble burning while safeguarding farmers' livelihoods requires a multi-pronged, synergistic approach. By integrating robust financial subsidies, expanding accessible mechanization through Custom Hiring Centers, and deploying aggressive, grassroots extension services, policymakers can facilitate a permanent behavioral shift. Effective paddy straw management is not merely an environmental imperative, but a critical step toward ensuring the long-term economic and ecological sustainability of agriculture in the region.

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