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Impact of Secondary Agriculture on Farmer Profitability, Sustainability, and Waste Reduction in Eastern and Northeastern India

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Abstract:

Secondary agriculture, encompassing value-addition to farm produce and agricultural residues, has emerged as a critical driver of rural economic diversification, waste reduction, and environmental sustainability. This study examines its role in Eastern and North-Eastern India—regions with significant agricultural potential yet relatively underdeveloped agro-processing infrastructure. Drawing on secondary data from 2015–2024 and a theory-driven framework, the analysis links secondary agriculture to three core outcomes: farmer profitability, environmental sustainability, and waste minimization. Findings indicate that states with greater agro-processing activity exhibit enhanced income opportunities for farmers, reflected in the near doubling of India's processed-food exports between FY2018 and FY2024. Environmental gains include increased adoption of residue-to-value technologies such as biomass energy plants, composting, and briquetting, contributing to reduced stubble burning and post-harvest losses. However, regional disparities persist, with Eastern and North-Eastern states—particularly Bihar and Assam—lagging in processing capacity, productivity, and market integration. Policy alignment with national schemes such as PMKSY and PMFME is evident, yet gaps in infrastructure, financing, and regulatory compliance remain significant. The study underscores the need for micro-level income assessments, longitudinal environmental monitoring, and targeted interventions to unlock the sector's full potential in lagging regions.

Keywords **— Secondary agriculture, Agri-processing, Waste valorization, Farmer income, Sustainability, Eastern India, North East, Circular economy**

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I. INTRODUCTION

Secondary agriculture, also referred to as agro-processing or agro-based industries, involves value-adding activities that use either primary farm produce or agricultural waste. Typical examples include food processing, bioenergy production, and the manufacture of animal feed or biocompost from crop residues. In India's predominantly agrarian economy, this sector is recognized as a critical growth driver capable of stabilizing markets, improving nutrition, and creating rural employment [1].

Policy frameworks such as the Doubling Farmers' Income report have explicitly promoted secondary enterprises as a means to enhance farmer profitability and utilize surplus produce. By transforming seasonal surpluses and residues into

marketable products, secondary agriculture extends shelf life, reduces wastage, and diversifies income sources. A study by the Central Institute of Post-Harvest Engineering and Technology (CIPHET) estimated post-harvest losses at nearly USD 15 billion annually, with the highest losses in fruits and vegetables (CIPHET, 2020).

The Eastern and North-Eastern regions of India, with diverse agricultural outputs such as rice, horticulture, and spices, remain underutilized in terms of secondary agriculture potential. For instance, Assam has adopted agro-processing strategies to help achieve the goal of doubling farmers' incomes, yet infrastructure gaps remain significant [2].

II. LITERATURE REVIEW

A. Secondary Agriculture and Farmer Profitability

A growing body of literature establishes a positive association between secondary agriculture and improved farm incomes. Secondary agriculture, defined as value-addition at or near the farm level (e.g., village-level processing, agro-enterprises), enables farmers to capture a larger share of the agri-food value chain. Shukla (2019) [3] emphasizes that transitioning from a conventional "agriculture" paradigm to an "agri-business" mindset—through incentives for farm-level processing—can both generate rural employment and substantially enhance farm incomes. Similarly, Azad et al. (2021) [4] highlight the profitability gains from converting agricultural residues into by-products, such as utilizing sugarcane waste for industrial applications. Empirical examples reinforce these findings. Small processing units—such as those producing briquettes from paddy husk or value-added spice products—enable farmers to secure higher price realization. Data from the Indian Economic Survey indicate that between FY2018 and FY2024, the value of India's processed-food exports more than doubled (from approximately USD 5.3 billion to USD 10.4 billion), reflecting expanded market opportunities and premium pricing for processed produce. Policy documents further note that investments in agro-processing infrastructure, such as cold storage and food parks, aim explicitly to reduce waste and increase farmer earnings.

Table 1 summarizes selected empirical studies. Across contexts, the evidence consistently suggests that value-added rural enterprises improve price stability, reduce losses, and enhance farmer cash incomes.

TABLE I. STUDIES LINKING SECONDARY AGRICULTURE TO FARMER PROFITABILITY

Study (Authors, Year)	**Context/Region**	**Key Findings on Profitability**
Azad *et al.* (2021)	India	Residue-to-product conversion improves productivity and profitability, ensuring regular income.
Shukla (2019)	India	Value-addition through an "agri-business" approach creates rural jobs and raises farmer incomes.
Bora & Baruah (2023)	Assam, India	Agro-processing identified as a strategy to double farmer incomes.
Kahlon *et al.* (2025) [5]	India	Policymakers link processing to price stabilization and waste reduction; estimate USD 15 billion in potential gains from reducing perishables loss.

B. Secondary Agriculture and Environmental Sustainability

Secondary agriculture also contributes to environmental sustainability by supporting a circular economy framework—reducing waste, conserving resources, and lowering pollution. Converting crop residues into bioenergy, compost, or industrial feed stocks reduces greenhouse gas emissions and nutrient runoff (Rao et al., 2024) [6]. Azad et al. (2021) [4] specifically link secondary agriculture to "sustainable production systems," citing examples such as converting sugarcane bagasse into marketable by-products.

The Indian Economic Survey similarly emphasizes this circular logic, with schemes such as the Pradhan Mantri Kisan SAMPADA Yojana (PMKSY) aiming to minimize post-harvest losses and improve supply chain efficiency. Empirical studies corroborate these benefits: Rao et al. (2024) [6] detail waste-to-energy applications (biogas, biochar) that simultaneously address waste disposal and renewable energy production, while WRI India (2021) [7] underscores the role of food loss reduction in achieving Sustainable Development Goal 12.

TABLE 2. STUDIES LINKING SECONDARY AGRICULTURE TO ENVIRONMENTAL SUSTAINABILITY

Study (Authors, Year)	Context	Sustainability/Environmental Findings
Azad *et al.* (2021)	India	Residue utilization addresses waste and energy challenges, enabling sustainable production systems.
Rao *et al.* (2024)	India	Waste-to-energy technologies (biogas, ethanol) mitigate pollution and support a circular economy.
WRI India (2021)	Nationwide	Reducing food loss/waste lowers land and water pressures and reduces GHG emissions.
Nagar & Kumar (2024)	India	Utilization of 500–550 Mt annual residues (currently 65–75% burned) could improve soil health and prevent air pollution.

C. Secondary Agriculture and Waste Reduction

Waste reduction is a direct and measurable outcome of secondary agriculture. By transforming agricultural by-products into valuable inputs—such as feed, fuel, or organic fertilizer—secondary agriculture limits post-harvest losses and field burning. Azad et al. (2021) [4] note that converting crop residues into biofuel or animal feed offers a practical waste-management solution.

The Economic Survey explicitly connects agro-processing with loss minimization, and WRI India (2021) [7] reiterates that waste reduction not only improves food availability but also increases farmer incomes. Empirical evidence is particularly strong in the case of perishables, where secondary processing (e.g., cold storage, dehydration, preservation) can drastically reduce spoilage. Nagar & Kumar (2024) [8] further document technologies such as happy seeders, mulchers, biogas plants, and vermicomposting as effective residue-management strategies.

TABLE 3. STUDIES ON WASTE REDUCTION THROUGH SECONDARY AGRICULTURE

Study (Authors, Year)	Waste Reduction Outcomes
Azad *et al.* (2021)	Processing residues reduces burning and waste by generating marketable by-products.
Rao *et al.* (2024)	Conversion to bioenergy and use of mulchers prevent open-field burning.
WRI India (2021)	Reduction in losses increases food availability and incomes, aligning with SDG 12.3.
Nagar & Kumar (2024)	Advocates conversion of residues to compost or fuel to replace burning practices.

D. Secondary Agriculture in Eastern and North‐Eastern India

Despite rich agricultural potential, Eastern and North‐Eastern India lag behind the national average in agro‐industrialization. Bora & Baruah (2023) [1] highlight that in Assam, agro‐processing is considered central to achieving the government's target of doubling farmer incomes, yet the sector remains underdeveloped. Das & Singh (2022) [9] find that Assam's growth in processing units and value‐addition per unit is slower than the national average.

Government statistics confirm substantial regional disparities. In 2019‐20, West Bengal had 2,067 registered processing units, Odisha 1,211, and Bihar 896—numbers well below those of more industrialized states. In the North‐East, Assam hosted 1,582 units, while most other states had fewer than 50, reflecting underdeveloped processing infrastructure. Given the region's production of high‐value crops (e.g., pineapple, medicinal herbs), targeted investment in processing technology, credit access, and market linkages is critical for unlocking the sector's potential.

TABLE 4. SECONDARY AGRICULTURE INDICATORS IN EASTERN/NORTH - EASTERN INDIA

Study/Source	Region/Indicators	Key Points
Bora & Baruah (2023)	Assam (NER)	Agro-processing viewed as key to doubling farmer incomes; sector underdeveloped despite rich crop base.
Das & Singh (2022)	Assam vs. India	Assam's processing unit growth and profitability lag behind national levels.
Government Statistics (2022)	Eastern States (WB, Odisha, Bihar)	ASI 2019–20: WB = 2,067 units; Odisha = 1,211; Bihar = 896. Lower than more industrialized states.
Government Statistics (2022)	North-East States	ASI 2019–20: Assam = 1,582 units; Tripura = 117; most others < 50. Highlights infrastructural gaps.

III. RESULT

The analysis of secondary data supports the patterns identified in the literature review.

E. Farmers Profitability

Regions with greater agro - processing activity demonstrate higher farmer earnings potential. Government statistics indicate that India's processed - food exports nearly doubled from USD 5,273.9 million in 2017 – 18 to USD 10,420.0 million in 2021 – 22. While direct farm - level income data are limited, this growth in processed - food output suggests that farmers, particularly those cultivating perishable crops, have benefited from improved price realization. State - level Annual Survey of Industries (ASI) data show expansion of processing units even in traditionally underdeveloped regions. For example, Assam's units increased to 1,582 by 2019 – 20, providing additional income opportunities for local producers through agro - enterprises.

F. Environmental and Waste Management Outcomes

Evidence also points to gradual environmental gains. Adoption of residue - collection equipment (e.g. happy seeders, balers) has contributed to reductions in stubble burning in some states such as Punjab and Haryana, though systematic data for the 2015 – 2024 period remain scarce. Nationally, biomass energy plants and composting projects have expanded under government schemes, facilitating residue valorization through activities such as rice straw briquetting and fruit canning. The share of processed produce in India's agricultural exports increased from 14.9% to 23.4% by 2024, implying that more produce is being marketed in a form less prone to spoilage.

G. Regional Disparities

The Eastern and North - Eastern states show mixed progress. West Bengal and Odisha have recorded steady growth in processing capacity, whereas Bihar and Assam lag behind in both infrastructure and productivity. ASI 2019 – 20 data report 2,067 units in West Bengal, 1,211 in Odisha, and 896 in Bihar. Despite these gains over past decades, these figures remain substantially below those of more industrialized states. Although Assam's sector has benefited from new food parks and Farmer Producer Organisations (FPOs), output and profitability per unit remain significantly lower than national averages [9].

IV. DISCUSSION

This study's findings reinforce the proposition that secondary agriculture yields measurable economic, environmental, and waste - reduction benefits.

1)Economic benefits: Consistent with prior research, the evidence shows that value - addition activities —such as village - level processing and agro - enterprise development—enhance farm profitability, diversify rural employment, and improve price realization for perishable commodities.

2)Environmental benefits: Residue - to - value processes help mitigate pollution, reduce resource wastage, and contribute to the transition towards circular agricultural systems. Although farm - level environmental metrics are scarce, the observed increase in biomass energy projects and composting capacity suggests progress towards more sustainable production systems.

3)Waste reduction: Processing reduces post - harvest losses by extending shelf life and converting by - products into usable inputs such as compost, animal feed, and biofuels. These changes not only minimize waste but also generate secondary revenue streams.

4)Policy alignment and gaps: These outcomes align with the objectives of flagship schemes such as the Pradhan Mantri Kisan Sampada Yojana (PMKSY) and the PM Formalisation of Micro Food Processing Enterprises Scheme (PMFME), which aim to enhance processing capacity and minimize waste. Nevertheless, the analysis reveals persistent challenges — especially in Eastern and North - Eastern India — where limited cold - chain infrastructure, low mechanization, insufficient financing, and compliance barriers (e.g. with FSSAI standards) restrict the sector's growth.

5)Limitations: The study is constrained by the absence of comprehensive time - series data linking processing activity directly to farm incomes, as well as a lack of consistent environmental indicators at the farm scale. Most available evidence is aggregate or case - based, requiring cautious interpretation of causal relationships.

6)Future research needs: Micro - level comparative studies (e.g. between farmers engaged in processing and those who are not) would allow for more precise income effect estimates. Longitudinal research could better quantify environmental gains such as reduced emissions or improved soil health. Moreover, comparative analysis between emerging and mature processing clusters could identify transferable success factors.

V. CONCLUSIONS

The findings of this research demonstrate that:

1. Profitability – Value - added processing enhances farm incomes by enabling better price realization and creating additional employment opportunities.
2. Sustainability – Residue utilization contributes to resource efficiency and pollution reduction, supporting a circular economy framework.
3. Waste reduction – Post - harvest and processing losses are minimized as by - products are converted into economically useful outputs.

The observed growth in processed-food exports, expansion of processing units, and development of waste-to-value initiatives corroborate these effects. However, the persistence of infrastructure, technology, and financing gaps—particularly in Eastern and North-Eastern India—limits the sector's transformative potential.

To fully realize the benefits of secondary agriculture, targeted investment in cold-chain facilities, improved market linkages, credit access, and skill development is essential. More granular data and region-specific impact studies are needed to design interventions that address local constraints.

Overall, the evidence underscores the potential of secondary agriculture as a driver of rural prosperity and sustainable resource management, provided that enabling conditions are strengthened through coordinated policy and investment.

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