International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 4, Jul. - Aug., 2025, pp: 01-06 ISSN: 3048-6874
www.ijhssm.org

A Study on Sustainable Revenue Enhancement Through Effective Byproduct Utilization in Arignar Annasugar Mills -Thanjavur

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ABSTRACT: The success of any organization largely depends on the satisfaction, health, and well-being of its employees. Employee welfare measures play a crucial role in enhancing employee morale, motivation, and productivity. This study aims to assess the effectiveness of the welfare facilities provided at Arignar Anna Sugar Mill, Kurungulam, Thanjavur. It focuses on various welfare aspects, including health and safety measures, recreational activities, canteen facilities, housing provisions, and social security schemes available to the employees. The research methodology involves a structured questionnaire, administered to a representative sample of employees across various departments. Data collected was analyzed using statistical tools to interpret the satisfaction level and expectations of employees regarding existing welfare measures. The study findings reveal that while the management has made commendable efforts in providing welfare amenities, certain areas require improvement to meet the evolving needs of employees. Based on the findings, the study suggests recommendations to enhance welfare measures further, aiming to foster a more supportive and efficient work environment at Arignar Anna Sugar Mill.

I. INTRODUCTION

In today's rapidly evolving industrial landscape, sustainability and resource optimization have become critical concerns for organizations across sectors. As the global focus intensifies on environmental responsibility and economic efficiency, industries are increasingly seeking innovative ways to minimize waste and maximize revenue. One of the most promising avenues in this pursuit lies in the effective utilization of by-products, which can significantly contribute to both environmental sustainability and economic resilience.

In the agro-based manufacturing sector, particularly in sugar production, vast quantities of byproducts such as bagasse, molasses, and press mud are generated. Traditionally viewed as waste, these by-products are now being re-evaluated for their potential to generate additional income streams and reduce environmental impact. Arignar Anna Sugar Mills, located in Thanjavur, Tamil Nadu, is a key player in the regional sugar industry and stands at a strategic point to harness the value of its by-products.

With increasing pressures to adopt sustainable practices and reduce industrial waste, Arignar Anna Sugar Mills faces the modern challenge of transitioning from conventional production models to a more circular economy approach. This involves not only minimizing the environmental footprint of operations but also exploring innovative methods to convert byproducts into marketable goods or energy sources. The strategic use of by-products can enhance overall productivity, improve financial performance, and contribute to broader environmental goals.

This project was undertaken to study the current utilization practices of by-products at Arignar Anna Sugar Mills and assess their potential for sustainable revenue generation and waste reduction. It aims to identify existing gaps, evaluate the economic and environmental feasibility of alternative uses, and recommend practical strategies for improvement. The focus is on creating a model where waste is minimized and value is maximized—supporting both the company's profitability and its commitment to sustainable development.

1.1 STATEMENT OF THE PROBLEM

The sugar industry, while vital to the agricultural and industrial economy of India, generates a significant volume of by-products such as bagasse, molasses, and press mud. These byproducts, if not effectively managed, contribute to environmental pollution and represent a lost opportunity for additional revenue generation. Arignar Anna Sugar Mills, located in Thanjavur, produces substantial quantities of such by-products

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during its operations. However, like many traditional mills, it faces challenges in fully utilizing these materials in a sustainable and economically beneficial manner.

1.2 OBJECTIVES OF THE STUDY

Primary Objective:

To assess the current utilization of by-products at Arignar Anna Sugar Mills and identify opportunities for sustainable revenue generation and waste reduction

Secondary Objectives:

1. To evaluate the existing methods of managing and utilizing sugar industry by-products such as bagasse, molasses, and press mud.
2. To identify gaps and inefficiencies in the current by-product management practices.
3. To analyze the economic and environmental benefits of alternative by-product utilization methods.
4. To study industry best practices and benchmark successful models in by-product valorization.
5. To recommend practical, scalable strategies for enhancing by-product usage and reducing waste at Arignar Anna Sugar Mills.

1.3 SCOPE OF THE STUDY

This study is limited to Arignar Anna Sugar Mills located in Thanjavur and focuses on the utilization of by-products generated during the sugar production process. The by-products considered in this study include bagasse, molasses, press mud, and other process residues. The scope of the research encompasses an analysis of current utilization practices, evaluation of economic and environmental impacts, and identification of opportunities for sustainable revenue generation and waste reduction.

The study was conducted over a period of two months (March 10 to May 10) and involved sample of 204 interactions with key personnel from various departments such as production, operations, maintenance, environmental management, and finance. Data collection was carried out through site visits, interviews, and examination of operational records.

The focus of the study is limited to by-product management and does not include other aspects of mill operations such as core sugar production processes, human resource policies, or marketing strategies. The aim is to provide practical and sustainable recommendations that align with industry best practices and support the mill's long-term environmental and economic goals.

1.4 LIMITATIONS OF THE STUDY

- The study was conducted in only one location (Thanjavur) and may not reflect conditions in other branches or units.
- Only 204 employees were surveyed, which may not completely represent the entire workforce.
- The study was based on self-reported responses, which may include some level of bias or inaccuracy. The study was limited to a single location—Arignar Anna Sugar Mills in Thanjavur—and may not represent practices in other sugar mills or regions.
- Data was collected primarily through interviews and documentation from available personnel, which may not cover all operational aspects or stakeholder perspectives.
- The study focused only on by-product utilization and did not explore other areas of the mill's operations, such as core sugar production processes or human resource management.

II. REVIEW OF LITERATURE

Konde et al. (2021) – Sugarcane Bagasse Based Biorefineries in India: Potential and Challenges. This review discusses the potential of sugarcane bagasse (SCB) as a feedstock for biorefineries in India. It highlights the challenges and opportunities in utilizing SCB for producing biofuels and high-value chemicals like xylitol, succinic acid, and lactic acid. The study emphasizes the need for efficient pre-treatment methods, such as vortex-based hydrodynamic cavitation, to enhance the digestibility of SCB for anaerobic digestion and subsequent biochemical conversion.

Yaashikaa et al. (2022) – Valorization of Agro-Industrial Wastes for Biorefinery Process and Circular Bioeconomy: A Critical Review Yaashikaa and colleagues review the utilization of various agro-industrial wastes, including sugarcane by-products, in biorefinery processes. The study emphasizes the importance of circular bioeconomy approaches, where waste materials are converted into valuable products, reducing environmental impact and promoting sustainability.

Lee et al. (2023) – Sugarcane Wastes as Microbial Feedstocks: A Review of the Biorefinery Framework from Resource Recovery to Production of Value-Added Products This comprehensive review focuses on the use of sugarcane wastes as feedstocks for microbial processes in biorefineries. It covers the production of biofuels, biochemicals, and other value-added products through microbial fermentation,

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highlighting the potential of sugarcane residues in sustainable biorefinery frameworks.

Kumar & Verma (2024) – Microbial Valorization of Kraft Black Liquor for Production of Platform Chemicals, Biofuels, and Value-Added Products: A Critical Review Kumar and Verma review the microbial conversion of kraft black liquor, a by-product of the paper industry, into platform chemicals, biofuels, and other value-added products. The study discusses various microbial processes and their potential applications in biorefineries, emphasizing the importance of waste valorization in sustainable industrial practices

III. RESEARCH METHODOLOGY

3.1 Research Design

This study adopts a descriptive research design, which is suitable for analyzing current trends, perceptions, and practices related to the utilization of by-products in the sugar industry. Descriptive research helps to understand the existing scenario without manipulating any variables. In this context, the objective was to gather detailed information on how Arignar Anna Sugar Mills currently manages its by-products (such as bagasse, molasses, and press mud), assess employee awareness, and identify operational challenges and opportunities for improvement. The design supports both qualitative and quantitative interpretation of the collected data to inform sustainable and strategic decision-making.

3.2 Data Collection Methods

a) Primary Data

Primary data was gathered using a structured questionnaire, which was distributed to a carefully selected sample of employees at Arignar Anna Sugar Mills. The questionnaire consisted of both multiple-choice and Likert-scale questions aimed at capturing the respondents' views on various aspects of by-product utilization. The questionnaire covered areas such as:

- Awareness of different types of by-products.
- Current utilization practices.
- Frequency of review of by-product processes.
- Perceived challenges and effectiveness.
- Opinions on government support and sustainability.

The respondents included individuals from various departments such as production, maintenance, quality control, logistics, and administration, providing a broad organizational perspective.

b) Secondary Data

To supplement and validate the primary data, secondary data was collected from:

- Internal records and operational reports of Arignar Anna Sugar Mills.
- Government policy documents and environmental guidelines related to waste management in the sugar industry.
- Industry-specific journals, case studies, and academic research on sustainable industrial practices and by-product valorization..

3.3 Sampling Method and Size

To ensure objectivity and representativeness in the study, the simple random sampling technique was adopted. This method gives each member of the population an equal chance of being selected, thus minimizing selection bias.

Sample Size: A total of 204 respondents participated in the study. The sample was diverse, including personnel from various levels of the organizational hierarchy and across different functional areas. This sample size was deemed sufficient to draw statistically relevant insights and represent the broader employee population at the mill.

3.4 Tools for Data Collection

The primary tool used for data collection was a structured, self-administered questionnaire. It included:

- Closed-ended questions to capture specific, quantifiable responses.
- Likert scale-based questions to measure attitudes, perceptions, and satisfaction levels regarding by-product utilization.
- Questions were grouped logically and kept clear to avoid misinterpretation.
- Before full deployment, the questionnaire was pre-tested for clarity, reliability, and content validity, and necessary modifications were made to enhance its effectiveness.

3.5 Data Analysis Techniques

The following analytical tools were used to interpret the collected data: After data collection, several statistical tools and techniques were employed to analyze the responses and extract meaningful patterns and relationships:

1. Simple percentage analysis
2. Cross Tabulation
3. Correlation Analysis
4. Descriptive Analysis

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IV. DATA ANALYSIS AND INTERPRETATION

4.1 SIMPLE PERCENTAGE ANALYSIS

Do you believe that better by-product utilization can improve workplace sustainability?

Particulars	No of respondents	Percentage
Yes	73	35.8
No	60	29.4
Maybe	71	34.8
Total	204	100.0

Interpretation:

Table No. 4.1.8 reveals that a majority of respondents (35.8%) believe that better by-product utilization can improve workplace sustainability. However, 29.4% disagree, while 34.8% are uncertain and respond with "Maybe." This shows that while there is significant support for the idea of improving sustainability through better by-product utilization, there remains a considerable portion of respondents who either disagree or are unsure about its impact.

4.2 CHI- SQUARE TEST:

The Chi-square test is one of the simplest and most wickedly used non-parametric tests in statistical work. The quantity x 2 describes the magnitude of the discrepancy between theory and observation.

HYPOTHESIS:

Null Hypothesis (H_0): There is no significant association between the two categorical variables.

Alternative Hypothesis (H_1): There is a significant association between the two categorical variables

Age of the respondent and Do you think government policies support by-product utilization- Crosstabulation

		Do you think government policies support by- product utilization?			Total
		Yes	No	May be	
Age of the respondent	18–25	13	13	16	42
	26–35	18	15	17	50
	36–45	18	16	16	50
	46 and above	22	21	19	62
Total		71	65	68	204

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.826a	6	.991
Likelihood Ratio	.823	6	.991
Linear-by-Linear Association	.471	1	.493
N of Valid Cases	204		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.38.			

Interpretation:

The cross-tabulation and Chi-square test between age of respondents and their perception of whether government policies support by-product utilization show no statistically significant association ($\chi^2 = 0.826$, $p = 0.991$). Since the p-value is far above the 0.05 threshold, we fail to reject the null hypothesis, indicating that respondents' opinions on government policy support do not significantly differ by age group. Additionally, all expected counts are above 5, ensuring the test's validity. This suggests that perception of policy support is relatively uniform across age groups in the sample.

4.3 CORRELATION ANALYSIS

Correlation analysis is a statistical method used to evaluate the strength and direction of the relationship between two variables. It helps you understand whether, and how strongly, variables are related.

Spearman Correlation (ρ or r_s)

Spearman correlation measures the strength and direction of a monotonic relationship using the rank of the data instead of raw values.

Spearman's Correlation Between Market Demand and By-Product Utilization in the Sugar Industry

Correlations		
	Economic: Market demand for by-	Economic: By-product utilization

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			product	
Spearman's rho	Economic: Market demand for by- product	Correlation Coefficient	1.000	.083
		Sig. (2-tailed)	.	.235
		N	204	204
	Economic: By-product utilization	Correlation Coefficient	.083	1.000
		Sig. (2-tailed)	.235	.
		N	204	204

INTERPRETATION:

The Spearman's correlation analysis between market demand for by-products and by-product utilization in the sugar industry shows a very weak positive correlation (ρ = 0.083) with a p-value of 0.235. Since the p-value is greater than 0.05, the correlation is not statistically significant. This indicates that, in the current dataset, there is no meaningful monotonic relationship between perceptions of market demand and the extent of by-product utilization. In other words, respondents' views on market demand do not significantly influence or align with their views on how effectively by-products are being utilized in the sugar industry.

4.4 DESCRIPTIVE STATISTICS

Descriptive statistics are summary measures used to describe and simplify the main features of a dataset. Instead of analyzing every individual data point, descriptive statistics help to give a quick overview of what the data looks like.

Descriptive Statistics of Respondents' Demographics and Perceptions on By-Product Utilization

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Gender of the respondent	1	2	1.50	.501
How often are by- product utilization processes reviewed?	1	4	2.46	1.150
How effectively are sugar by-products currently utilized in Your workplace?	1	5	2.81	1.388
Age of the respondent	1	4	2.65	1.120
Do you think government policies support by-product utilization?	1	3	1.99	.827

INTERPRETATION:

Table presents descriptive statistics summarizing the demographics and key perceptions of respondents regarding sugar industry by-product utilization. The average age category of respondents is 2.65, indicating that most fall within the 26–35 or 36–45 age groups. The gender mean of 1.50 suggests a nearly equal distribution of male and female participants.

The mean score of 2.81 for how effectively sugar by-products are utilized indicates a neutral to slightly positive perception, while the standard deviation of 1.388 suggests varied opinions among respondents. The frequency of reviewing by-product utilization processes has a mean of 2.46, implying that it is done less frequently than weekly, with a high variability (SD = 1.150). Lastly, the mean score of 1.99 for perception of government policy support suggests that opinions are generally neutral or slightly leaning toward disagreement, with moderate variability in responses. Overall, the data reflects mixed awareness and engagement levels concerning by-product utilization practices and policy support in the sugar industry.

V. SUGGESTIONS AND CONCLUSION

5.1 SUGGESTIONS

Increase Awareness Programs:

Conduct workshops and training sessions to educate employees and stakeholders on by-product applications and their economic/environmental benefits.

Improve Utilization Strategies:

- Implement better technology and process optimization to enhance by-product utilization efficiency.
- Establish regular review mechanisms (quarterly audits) to track progress.

Policy Advocacy & Transparency:

- Government and industry bodies should clearly communicate policies supporting by-product utilization.

- Encourage incentives (tax benefits, subsidies) for companies adopting sustainable practices.

Address Key Challenges:

- Invest in R&D to overcome financial and technological barriers.
- Foster public-private partnerships to share best practices.

Sustainability Integration:

- Promote corporate sustainability programs linking by-product utilization with carbon footprint reduction.
- Encourage employee engagement through green initiatives

5.2 CONCLUSION

The study reveals moderate awareness and utilization of sugar industry by-products, with significant variability in perceptions. While some respondents recognize the potential for sustainability and economic benefits, knowledge gaps, inconsistent reviews, and policy awareness issues hinder progress. The lack of strong correlations between market demand, financial constraints, and utilization suggests that multiple independent factors influence by-product optimization.

To maximize the benefits of by-products, targeted awareness campaigns, policy reinforcement, and technological advancements are essential. By addressing these challenges, the sugar industry can enhance sustainability, reduce waste, and improve profitability. Future research could explore sector-specific case studies to identify best practices for large-scale implementation.

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