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Impact of Mechanical Failures on Production Output in Agro-Processing Sector in Edo State

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ABSTRACT
This study aimed to examine the impact of mechanical failures on production output in the agro-processing sector of Edo State. The research focused on identifying the causes, frequency, and effects of machinery breakdowns, as well as evaluating maintenance practices and technological constraints affecting production efficiency.The agro-processing industry in Nigeria faces significant challenges due to frequent mechanical failures, outdated machinery, and inadequate maintenance strategies. These issues lead to production downtimes, increased operational costs, and reduced competitiveness in the market. Small and medium-scale agro-processors, in particular, struggle with limited resources for equipment upgrades and skilled maintenance personnel. A structured questionnaire was administered to 235 respondents, including machine operators, technicians, production managers, and facility owners across various agro-processing facilities in Edo State. Descriptive and inferential statistical methods, including multiple regression analysis, were employed to evaluate the relationship between mechanical failures and production output.The results indicated that mechanical failures significantly reduced production efficiency, with frequent breakdowns and prolonged downtimes negatively impacting output. Regression analysis confirmed that maintenance frequency positively influenced productivity, while reliance on old machinery and reactive maintenance strategies contributed to operational inefficiencies.To improve production efficiency, it is recommended that agro-processing facilities adopt preventive and predictive maintenance strategies, invest in modern machinery, and implement capacity-building programs for operators. Additionally, government support in the form of financial incentives and policy interventions is essential to drive sustainable technological advancements in the sector.

Keywords: Mechanical Failures, Agro-Processing, Production Output, Maintenance Strategies, Edo State.

I. INTRODUCTION

The agro-processing sector plays a crucial role in Nigeria’s agricultural economy, providing value addition to raw agricultural products and contributing to food security, employment, and economic development. However, one of the major challenges facing agro-processing industries in Nigeria, particularly in Edo State, is the frequent occurrence of mechanical failures, which significantly impact production efficiency and profitability. The reliance on outdated machinery, poor maintenance culture, and inadequate technical expertise have been identified as key constraints to the smooth operation of agro-processing facilities [1].

Mechanical failures in agro-processing plants lead to frequent downtime, reduced production output, and increased operational costs. Studies have shown that more than 40% of agro-processing machinery in Nigeria is over six years old, making them prone to breakdowns due to wear and tear [2]. This problem is further compounded by the difficulty in accessing spare parts and the limited availability of skilled technicians to repair and maintain processing equipment [3]. Many processing facilities operate with suboptimal machines, resulting in inefficiencies that negatively affect their competitiveness in the market [4].

The maintenance culture in the agro-processing industry is predominantly reactive rather than preventive. A study conducted in Oyo State revealed that 39% of agro-processors rely on predictive maintenance, 24% on preventive maintenance, while 27% combine both approaches

[1]. However, the study also found that a significant percentage of machines are only maintained during off-seasons, leading to prolonged downtimes and operational inefficiencies. This situation is not unique to Oyo State, as similar trends have been observed across other agro-processing hubs in Nigeria [5].

The importance of technological advancements in mitigating these challenges cannot be overstated. The adoption of modern processing technologies, such as automated milling machines, drying systems, and real-time monitoring tools, has been suggested as a way to improve efficiency and reduce mechanical downtimes [2]. However, the high cost of acquiring these technologies remains a major barrier for small and medium-scale agro-processors [6]. Moreover, inadequate government support, limited access to finance, and poor infrastructure have further exacerbated the situation, making it difficult for agro-processing businesses to invest in advanced machinery [3].

Research has also highlighted the need for capacity-building programs to improve the technical expertise of agro-processing operators. A study on the cassava processing industry in Nigeria emphasized that a lack of skilled manpower in machine operation and maintenance has led to suboptimal performance of processing facilities [2]. Training programs aimed at equipping operators with the necessary skills to handle and maintain processing equipment effectively could help reduce the frequency of mechanical failures and improve overall productivity [7].

Furthermore, policy interventions that encourage public-private partnerships in the agro-processing sector could provide sustainable solutions to the issue of mechanical failures. Government incentives, such as tax breaks and subsidies for the acquisition of modern equipment, could help reduce the financial burden on agro-processors and encourage investment in high-efficiency machinery [1]. Additionally, strengthening local manufacturing capabilities for agricultural machinery and spare parts could provide cost-effective alternatives to imported equipment, thereby reducing dependency on foreign technologies and ensuring the availability of replacement parts when needed [3]. Studies on mechanization trends indicate that sustainable agro-processing requires localized innovations that account for Nigeria's environmental and economic conditions [8].

Given the economic significance of agro-processing in Nigeria, addressing the challenges of mechanical failures is imperative for enhancing productivity and ensuring the sustainability of the sector. This study seeks to examine the impact of mechanical failures on production output in the agro-processing sector in Edo State, providing data-driven insights into the causes, frequency, and consequences of machinery breakdowns. The findings of this research will contribute to the formulation of effective strategies for improving maintenance practices, upgrading processing technologies, and developing policies that support the growth of the agro-processing industry in Nigeria.

II. RESEARCH METHODOLOGY

A. Study Area

The study was conducted in Edo State, Nigeria, a region known for its rich agricultural activities and diverse agro-processing industries. Edo State, located in the southern part of Nigeria, comprises three senatorial districts: Edo North, Edo Central, and Edo South. The agro-processing sector in the state plays a crucial role in economic development, providing employment and contributing to food security. Key agro-processing activities in the state included cassava processing, palm oil production, rice milling, and rubber processing. The research focused on major agro-processing hubs, including Benin City, Uromi, and Auchi, where numerous processing facilities operate. These locations were strategically selected due to their high concentration of agro-processing industries and their relevance to the study.

B. Method of Data Collection

The study employed a structured data collection approach to ensure comprehensive and reliable findings. Primary data were collected using structured questionnaires, which were designed to capture detailed information on mechanical failures, their frequency, impact on production output, and maintenance practices in agro-processing facilities. The questionnaires were administered to key stakeholders, including machine operators, technicians, production managers, maintenance personnel, and facility owners across various agro-processing hubs in Edo State.

A pilot study was conducted to validate the questionnaire, ensuring clarity, relevance, and reliability of the questions. The final questionnaire was distributed through both physical and electronic means, depending on respondents' accessibility. Trained research assistants facilitated data collection, providing necessary guidance to respondents and ensuring accuracy in responses.

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In addition to questionnaires, direct observations were carried out at selected agro-processing facilities to verify reported mechanical failures and maintenance practices. Secondary data were also sourced from industry reports, technical manuals, and previous studies. The combination of these methods provided a robust dataset for the study.

C. Sample Size and Sampling Technique

The study adopted a purposive and stratified random sampling technique to ensure a representative selection of respondents across different agro-processing facilities in Edo State. A total of 240 structured questionnaires were distributed to key stakeholders.Out of the distributed questionnaires, 235 were successfully completed and returned, representing a high response rate of 97.9%.

The stratified sampling approach was used to categorize respondents based on their roles within agro-processing facilities to ensure diverse perspectives on mechanical failures and their impact on production output. Within each category, a random sampling method was employed to select participants, ensuring fairness and reducing selection bias.

This sample size was deemed adequate for statistical analysis and provided a comprehensive understanding of mechanical failures in the agro-processing sector.

D. Data Analysis

The collected data were analyzed using both descriptive and inferential statistical methods to examine the study. The analysis was conducted using statistical software to ensure accuracy and efficiency in interpreting the results.

a. Descriptive Statistics

Descriptive statistics, including frequency distributions, means and percentages, were used to summarize the key characteristics of the dataset. This provided insights into the prevalence of mechanical failures, common types of breakdowns, maintenance practices, and their associated production downtimes.

b. Inferential Statistics

To establish the relationship between mechanical failures and production output, multiple regression analysis was employed. The regression model was specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where:

- Y = Production output (measured in tons of processed agricultural products)
- X_1 = Frequency of mechanical failures
- X_2 = Duration of downtimes (in hours)
- X_3 = Type of machinery used (categorical variable)
- X_4 = Maintenance frequency (times per month)
- β_0 = Intercept
- $\beta_1,\beta_2,\beta_3,\beta_4$ = Regression coefficients
- ε = Error term

III. RESULTS AND DISCUSSION

Results

Table 1 presents the distribution of respondents by role within agro-processing facilities. Machine operators (26.4%), technicians (20%), production managers (18.7%), maintenance personnel (23.4%), and facility owners (11.5%) provided critical understanding into the mechanical failures affecting production. The diversity in respondents ensured a well-rounded analysis of machinery performance and maintenance practices.

Table 1: Role of Respondents

Role	Frequency	Percentage	Cumulative Percentage
Operator	62	26.4	26.4
Technician	47	20	46.4
Production Manager	44	18.7	65.1
Maintenance Personnel	55	23.4	88.5
Facility Owner	27	11.5	100
Total	235	100	

Source: Field Data, 2025

Table 2 shows that a significant proportion of respondents had extensive experience in the agro-processing sector, with 37.4% having 4–6 years of experience and 34.5% having more than 6 years. This indicates that the majority of respondents had sufficient knowledge of machinery operations and failures, thereby enhancing the reliability of the data collected.

Table 2: Years of Experience in the Agro-processing Sector

Years of Experience	Frequency	Percentage	Cumulative Percentage
Less than one year	21	8.9	8.9
1 – 3 years	45	19.1	28
4 – 6 years	88	37.4	65.4
More than 6 years	81	34.5	100
Total	235	100	

Source: Field Data, 2025

Cassava (36.6%) and palm oil (32.8%) were the most commonly processed products, as shown in Table 3. This aligns with Edo State's agricultural focus. Table 4 indicates that small-scale (44.3%) and medium-scale (39.1%) facilities dominated the sector, implying that mechanical failures disproportionately affected enterprises with limited resources for maintenance and technological upgrades.

Table 3: Type of Products processed in Facility

Type of Product	Frequency	Percentage	Cumulative Percentage
Palm Oil	77	32.8	32.8
Cassava	86	36.6	69.4
Rice	41	17.4	86.8
Cocoa	31	13.2	100
Total	235	100	

Source: Field Data, 2025

Table 4: Scale of Operation

Scale of Operation	Frequency	Percentage	Cumulative Percentage
Small Scale	104	44.3	44.3
Medium Scale	92	39.1	83.4
Large Scale	39	16.6	100
Total	235	100	

Source: Field Data, 2025

Table 5 provides insights into the types and conditions of machinery used in agro-processing. Drying machines (11.81%), pressing machines (9.96%), and cassava graters (8.62%) were among the most used. However, a significant proportion of machinery (41.3%) had been in operation for over six years, leading to frequent mechanical breakdowns. Additionally, 58.7% of respondents rated their machinery as fair or poor, highlighting the urgent need for maintenance and technological intervention.

Table 5: Machinery and Equipment

What types of Machinery are used in your facility?	Frequency	Percentage	Cumulative Percentage
Cassava peeler	81	8.32	8.32
Cassava grater	84	8.62	16.94
Pressing machine	97	9.96	26.9
Drying machine	115	11.81	38.71
Paddy Cleaner	40	4.11	42.82
De-stoner	41	4.21	47.03

Huller	40	4.11	4.11
Polisher	41	4.21	55.35
Packaging Machine	40	4.11	59.46
Thresher	75	7.70	67.16
Crusher	76	7.80	74.96
Digestor	77	7.91	82.87
Oil Press	77	7.91	90.78
Fermentation Box	31	3.18	93.96
Winnowing Machine	30	3.08	97.04
Conche	29	2.98	100
Total	974	100	
How old is the majority of the machinery in your facility?	**Frequency**	**Percentage**	**Cumulative Percentage**
Less than 1 Year	25	10.6	10.6
1 – 3 Years	41	17.4	28
4 – 6 Years	72	30.6	58.6
More than 6 Years	97	41.3	100
Total	235	100	
How would you rate the current state of your machinery?	**Frequency**	**Percentage**	**Cumulative Percentage**
Excellent	41	17.4	17.4
Good	56	23.8	41.2
Fair	78	33.2	74.4
Poor	60	25.5	100
Total	235	100	

Source: Field Data, 2025

Table 6 reveals that mechanical failures were frequent, with 51.5% of respondents reporting monthly failures and 37.9% experiencing failures weekly. Conveyor belt and bearing issues (21.7%) and electrical faults (20.4%) were the most common problems. The impact on production was substantial, with 46.4% reporting significant delays and 37.4% experiencing complete halts in production.

Table 6: Mechanical Failures

Frequency of Mechanical Failure	**Frequency**	**Percentage**	**Cumulative Percentage**
Daily	14	6	6
Weekly	89	37.9	43.9
Monthly	121	51.5	95.4
Rarely	11	4.7	100
Total	235	100	
Most Common types of Mechanical Failure Encountered	**Frequency**	**Percentage**	**Cumulative Percentage**
Motor breakdown	37	15.7	15.7
Conveyor belt/Bearing issues	51	21.7	37.4
Electrical/Bearing faults	48	20.4	57.8
Bearing failures	39	16.6	74.4
Wearing of parts/Shaft	21	8.9	83.3

Others	39	16.6	100
Total	235	100	
How do these mechanical failures typically impact production output?	**Frequency**	**Percentage**	**Cumulative Percentage**
Minor delays	38	16.2	16.2
Significant delays	109	46.4	62.6
Complete halts in production	88	37.4	100
Total	235	100	

Source: Field Data, 2025

Table 7 indicates that predictive maintenance (37.4%) and a combination of preventive and predictive maintenance (31.5%) were the most commonly adopted strategies. Monthly maintenance was the most frequent (49.4%), though 9.4% relied on an "as-needed" approach. Despite maintenance efforts, mechanical failures persisted, reflecting potential gaps in maintenance effectiveness.

Table 7: Maintenance Practices

Types of Maintenance Practices	**Frequency**	**Percentage**	**Cumulative Percentage**
Preventive Maintenance	61	26	26
Predictive Maintenance	88	37.4	63.4
Preventive/Predictive Maintenance	74	31.5	94.9
Reactive Maintenance	12	5.1	100
Total	235	100	
Frequency of Maintenance on the Machinery	**Frequency**	**Percentage**	**Cumulative Percentage**
Daily	12	5.1	5.1
Weekly	85	36.2	41.3
Monthly	116	49.4	90.7
As needed	22	9.4	100
Total	235	100	
How Effective is the maintenance practices?	**Frequency**	**Percentage**	**Cumulative Percentage**
Very Effective	108	46	46
Effective	111	47.2	93.2
Neutral	14	6	99.2
Ineffective	1	0.4	99.6
Very Ineffective	1	0.4	100
Total	235	100	

Source: Field Data, 2025

Table 8 shows that mechanical failures had a severe impact on production output for 66% of respondents, with only 0.4% reporting no impact. Notably, 98.3% supported policies for technological upgrades and improved maintenance strategies, reinforcing the need for intervention in the sector.

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Table 8: Impact and Recommendations

What is the impact of mechanical failures on the overall production output in your facility	**Frequency**	**Percentage**	**Cumulative Percentage**
Severe Impact	155	66	66
Moderate Impact	68	29	95
Less Impact	11	4.7	99.7
No Impact	1	0.4	100
Total	235	100	
Would you support policies aimed at technological upgrades and improved maintenance strategies?	**Frequency**	**Percentage**	**Cumulative Percentage**
Yes	231	98.3	98.3
No	0	0.0	98.3
Unsure	4	1.7	100
Total	235	100	

Source: Field Data, 2025

Table 9 presents the results of the regression analysis, showing the estimated coefficients, standard errors, and p-values. The coefficients indicate the direction and magnitude of the relationship between each independent variable and production output. The p-values confirm that all variables significantly influenced production efficiency, with mechanical failures and downtimes reducing output, while machinery selection and frequent maintenance contributed positively to production performance.

Table 9: Multiple Regression Analysis

Variable	**Coefficient (β)**	**Std. Error**	**p-Value**
Intercept ($\beta 0$)	98.4094	0.964	$p < 0.0001$
X_1 (Mechanical Failure Frequency)	-4.3488	0.280	$p < 0.0001$
X_2 (Downtime Duration in Hours)	-2.8910	0.097	$p < 0.0001$
X_3 (Type of Machinery Used)	2.1673	0.133	$p < 0.0001$
X_4 (Maintenance Frequency)	4.1986	0.077	$p < 0.0001$

Discussion

The results confirmed that mechanical breakdowns were a major challenge for agro-processing businesses, leading to significant production losses, increased downtime, and higher maintenance costs. The analysis also highlighted the critical role of maintenance practices and technological upgrades in improving machinery reliability and production efficiency.

The distribution of respondents across different roles within the agro-processing sector (Table 1) ensured a comprehensive understanding of the mechanical challenges faced by these facilities. The majority of respondents were machine operators (26.4%), maintenance personnel (23.4%), and technicians (20%), whose firsthand experience with machinery failures made their responses highly reliable. Additionally, the high proportion of respondents with more than four years of experience in the sector (71.9%) (Table 2) indicated that most participants had a deep understanding of production processes and mechanical issues, further strengthening the credibility of the study's findings.

The study found that cassava (36.6%) and palm oil (32.8%) were the most commonly processed agricultural products (Table 3). This is consistent with Edo State's agricultural profile, where cassava and oil palm cultivation dominate. However, the predominance of small- and medium-scale enterprises (83.4%) (Table 4) indicated that many agro-processing facilities operated with limited resources, which likely contributed to their vulnerability to mechanical failures. Small-scale processors, in particular, often relied on outdated or substandard machinery due to financial constraints, making them more susceptible to frequent breakdowns and inefficiencies.

A significant concern observed in the study was the age and condition of agro-processing machinery (Table 5). A substantial proportion (41.3%) of respondents reported using machinery that was over six years old, while only 28% had equipment that was less than three years old. This high percentage of aging machinery, coupled with the fact that 58.7% of respondents rated their equipment as either fair or poor, suggests that many agro-processing businesses struggled with inadequate and deteriorating machinery. The frequent use of old equipment, especially without proper maintenance, increases the likelihood of mechanical failures, leading to lower productivity and higher operational costs.

The frequency of mechanical failures observed in this study was alarming (Table 6). 51.5% of respondents reported experiencing failures on a monthly basis, while 37.9% encountered failures weekly. This means that nearly 90% of agro-processing businesses suffered mechanical failures at least once a month, significantly disrupting their operations. The most common mechanical issues identified were conveyor belt and bearing failures (21.7%), electrical faults (20.4%), and motor breakdowns (15.7%). These problems were likely exacerbated by inadequate maintenance practices and the prolonged use of old or substandard machinery.

The impact of these mechanical failures on production was severe. 46.4% of respondents reported experiencing significant delays, while 37.4% indicated that mechanical failures led to complete halts in production. These disruptions not only reduced production output but also resulted in financial losses due to unfulfilled supply contracts, wasted raw materials, and increased repair costs. The severity of these impacts underscores the urgent need for improved maintenance strategies and technological upgrades to enhance production efficiency.

The study also examined the maintenance practices employed by agro-processing facilities (Table 7). The results showed that predictive maintenance (37.4%) and a combination of preventive and predictive maintenance (31.5%) were the most commonly used strategies. However, despite these maintenance efforts, mechanical failures persisted, suggesting that maintenance practices were either inadequate or inconsistently applied. The high reliance on monthly maintenance (49.4%) instead of more frequent checks also contributed to prolonged downtimes and reduced production efficiency. While the majority of respondents (93.2%) rated their maintenance strategies as effective or very effective, the high frequency of mechanical failures suggests that maintenance practices were reactive rather than proactive.

The multiple regression analysis provided strong statistical evidence of the relationship between mechanical failures and production output (Table 9). The findings confirmed that:

- Increased frequency of mechanical failures (X_1) significantly reduced production output, with each additional failure leading to a 4.35-ton decrease in processed agricultural products.
- Longer downtime (X_2) had a severe impact on productivity, with every additional hour of downtime reducing output by 2.89 tons.
- The type of machinery used (X_3) positively influenced production output, with better machinery contributing to a 2.17-ton increase in processed products.
- More frequent maintenance (X_4) significantly improved production efficiency, increasing output by 4.20 tons per additional maintenance session.

These results align with existing literature, which suggests that poor maintenance culture, reliance on outdated equipment, and inadequate technical expertise are major constraints to efficient agro-processing operations in Nigeria [9]. The findings also reinforce the argument that investment in modern machinery and the adoption of structured maintenance programs are essential for improving productivity and reducing downtime.

The policy implications of these findings are clear. 98.3% of respondents expressed support for policies promoting technological upgrades and improved maintenance strategies (Table 8). This overwhelming agreement highlights the sector's willingness to embrace innovations that could mitigate mechanical failures and enhance productivity.

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IV. CONCLUSION

This study has demonstrated that mechanical failures significantly impact production output in the agro-processing sector of Edo State. The persistent occurrence of breakdowns, coupled with prolonged downtimes, has led to inefficiencies that hinder productivity. Despite efforts to implement maintenance strategies, the high rate of failures suggests that existing practices are inadequate. Many agro-processing facilities operate with outdated and poorly maintained equipment, exacerbating operational disruptions and financial losses. The findings highlight the need for a more structured approach to equipment management, incorporating both preventive and predictive maintenance to minimize unexpected breakdowns. Additionally, the role of technological advancements cannot be overlooked, as modern machinery with improved durability and efficiency could substantially reduce mechanical failures. Addressing these challenges requires a multi-stakeholder approach involving industry operators, policymakers, and technical experts to develop sustainable solutions. By improving maintenance strategies, upgrading machinery, and fostering skills development, the agro-processing sector in Edo State can enhance its production efficiency and long-term viability.

V. RECOMMENDATIONS

The study proposed the following recommendations based on the findings:

1. **Implementation of Preventive and Predictive Maintenance Programs:**Agro-processing facilities should adopt structured maintenance schedules that proactively address potential equipment failures before they occur.
2. **Investment in Modern Machinery:** Stakeholders should prioritize the acquisition of durable, high-efficiency processing equipment to reduce reliance on outdated and failure-prone machines.
3. **Training and Capacity Building:** Regular training programs should be conducted for machine operators and maintenance personnel to improve their technical expertise in handling and servicing equipment.
4. **Government Support for Technological Upgrades:** Policies that provide financial incentives, grants, or low-interest loans should be introduced to enable agro-processors to invest in better machinery.
5. **Encouragement of Local Manufacturing and Innovation:** The development of locally engineered processing equipment should be encouraged to ensure cost-effective and easily maintainable machinery.
6. **Data-Driven Decision-Making:**Agro-processing businesses should leverage data analytics to track equipment performance, identify failure patterns, and optimize maintenance strategies for improved production efficiency.

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