Impact of Post-Harvest Losses on the Profitability of Rice Production Amongst Smallholder Farmers in Liberia

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Abstract

Crop losses, especially along the post-harvest value chain, have been identified as one of the major causes of food shortages in most developing countries including Liberia. Rice farmers often record a great amount of loss which translates to a waste of resources, a reduction in their income, and ultimately their welfare. This study examined the effects of post-harvest losses on the profitability of rice production among smallholder rice farmers in Liberia. The analytical tools used in the study include descriptive statistics, gross margin analysis, and multiple regression models. The gross margin analysis results revealed that the average gross margin with post-harvest loss was 3,512.475 Liberian Dollars, lower than the average gross margin without post-harvest 8,826.114 Liberian Dollars. This implied a 39.79% reduction in the gross margin of rice farmers valued at over 2.8 million Liberian Dollars. The results also found the Value of Post-Harvest Loss, Market Participation Rate, Quantity Harvested, Quantity sold, and Education Level significantly affect the per-capita gross margin of farmers. The study recommends that farmers engaging in rice production be adequately trained on post-harvest crop handling techniques whereas, priority be given to investment in post-harvest processing technologies and the establishment of processing industries especially in the major production areas.

Keywords: Gross Margin; Post-Harvest; Smallholder Farmers; Education level; Management skills

Abbreviations: PHL: Post-Harvest Losses; LPFSA: Liberia Post-harvest and Food Security Assessment; BLUE: Best Linear Unbiased Estimator; VIF: Variance Inflation Factor; MPR: Market Participation Rate; FAO: Food and Agriculture Organization

Introduction

Food security is an important basis for eradicating extreme poverty, and hunger, thus, achieving the United Nations Sustainable Development Goals. While significant progress has been made to maximize rice production in Liberia, more than half of the population does not have access to adequate rice supplies due to several factors influencing the rice value chain. One of the factors that reduces production and limits the availability of rice like other crops, is post-harvest losses (PHL), despite the increase in the area used for rice production. For instance, since the end of the Liberia civil war (Vorrath, 2018), many people have taken up rice farming, and the agriculture sector, including rice cultivation now employs more than 51% of the Liberian population [1]. Concerted efforts of the government, and its partners have seen the rice sector supported in the form of agricultural equipment and inputs such as fertilizers and improved varieties and subsidies [2].

However, rice output continuously declined [2]. For example, production declined by 20.55% from 257,995 metric tons in 2018 to 170,000 metric tons in 2021 [3,4] with post-harvest losses accounting for about 40 to 50% (NRDS-Liberia). These losses reduce farmer's income and contribute to the continuous reliance on importation to meet its needs since rice is the nation's major staple food. In 2021, importation reached 350,000 metric tons (valued at over USD 100 Million) and accounted for about 65% of the total consumption.

An increase in domestic production along with a better post-harvest handling technique and infrastructure could satisfy the local demand. This requires significant investments in the rice value chain and well-thought policy actions. Any services for reducing PHL by around 10%-40% would go a long way. More than 50% of smallholder rice farmers experience high PHL in Liberia. These postharvest losses impact the economic well-being of the smallholder farmers and the efforts of the government to fight food insecurity.

If special attention is not given to reverse this situation, the country stands a chance of increasing its importation bills, facing severe food insecurity and negative outcomes that would hinder poverty reduction efforts. Additionally, a knowledge gap limits farmers' ability and extension services to act towards reducing these losses. It also impedes policymakers from formulating appropriate policies capable of mitigating these losses. To remedy the situation, this study aimed at filling such a gap, thereby assessing the determinants of gross margin and analyzing the effects of PHL on smallholder rice farmers' gross margin.

Methodology

Data and Sampling

The Liberia Post-harvest and Food Security Assessment (LPFSA) 2021, conducted by the World Food Program was used to analyze the Impact of Post-Harvest Losses on the Profitability of Rice Production Amongst Smallholder Farmers in Liberia. Stata 15.5 was used to perform statistical analysis, while MS Excel was used to develop various graphs and charts. The data was subjected to descriptive statistics, t-tests, and multiple regression analysis. A Random Cluster Sampling method was used in the survey with a total of 823 rice farmers sampled in the research region and interviewed.

Effect of PHL on Smallholder Rice Farmer Gross Margin

The study implored t-test analysis to determine the average gross margins incurred due to PHL and its effects on rice farmers' gross margins. The hypothesis tested was that the average gross margins of farmers with PHL were the same as those without PHL. The formula used for calculating the t-test is:

$$t = \frac{GM_L - \mu GM_{WL}}{\sqrt{[S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)]}}$$

where t is the t value, S2 is the standard error of the two groups, n1 and n2 are the number of observations in each group and was tested at (α = 0.05). The gross margin without PHL and the gross margin with PHL (value of PHL) were computed as the difference between total revenues and total variable costs of inputs.

The gross margin was calculated using the below formula [5]:

$$GM = TR - TVC$$

Where $TR = P * Q$

where: GM = Gross Margin, TR = Total Revenue, TVC = Total Variable Cost, and TR = Value of output (amount realized from the sale of Rice). P = price, Q = quantity, and TVC = Cost of all inputs.

$$Market\ Participation\ Rate = \left(\frac{Value\ of\ Rice\ sold}{Value\ of\ Total\ Rice\ Harvested}\right)$$

The study also analyzed the impact of PHL on the gross margin of smallholder rice farmers using multiple regression analysis in the specific model:

$$\log Y = \alpha + \beta_j \log X_{ij} + \varepsilon i$$

where: Y is the gross margin of rice farmer i, α is a constant, βj are Regression coefficients, Xj are the vector of independent variables, and εi = Error term.

The selected model has also been used by [5,6] where determinants such as the value of postharvest losses, market participation rate, gender, quantity harvested, and quantity sold were analyzed. The model has also been tested for the Best Linear Unbiased Estimator (BLUE) to obtain the best possible coefficient estimates.

Specifically, this study tested for multicollinearity, homoscedasticity, and normality of data. Considering multicollinearity inflates the variance of coefficients and causes type II errors, the study took essential steps to detect and correct it by using the Variance Inflation Factor (VIF) and tolerance to determine whether the variables are correlated, and was computed as:

$$VIF = \frac{1}{1 - R^2} = \frac{1}{Tolerance}$$

where R^2 represents the unadjusted coefficient of determination for regressing the independent variable on the remaining ones. If the VIFs are greater than 10, then the presence multicollinearity is present in the model. The test for homoscedasticity was done using the Breusch-Pagan test for the hypothesis:

$$H_0 : Var\left(\varepsilon i \mid x_i\right) = \sigma 2$$

This means homoscedasticity is present (the residuals are distributed with equal variance)

$$H_1 : Var\left(\varepsilon i \mid x_i\right) = \sigma 2_i$$

This means that heteroscedasticity is present (the residuals are not distributed with equal variance)

The Chi-Square test was calculated as:

$$LM = n * R^2 \sim X^2 (K)$$

where n is the total number of observations, k is the degree of freedom, and R^2 is the R-squared of the new regression model used as the response values in the squared residuals. If the P-value of the auxiliary regression is less than α of 0.05, the presence of heteroscedasticity is in the regression model.

Results and Discussion

Effect of Post-Harvest Losses on the Gross Margin of Rice Farmers.

The quantity of rice loss reduces its economic value and makes it unsuitable for human consumption. These losses play a critical role by influencing and reducing the gross margins of smallholder rice farmers, while agricultural inputs used to produce are also wasted. Table 1 presents the results of the gross margin analysis for evaluating the effect of postharvest losses on smallholder rice farmers' gross margin in Liberia. The result shows a significant difference between the gross margin with postharvest loss and the gross margin without postharvest loss by smallholder rice farmers in Liberia. The average gross margin with a post-harvest loss of Liberian Dollars 3,512.475 was much lower than the average gross margin without a loss of LRD 8,826.114. This implies that post-harvest loss incurred by smallholder rice farmers reduced their gross margin by 39.79% valued at over 2.8 million Liberian Dollars. The gross margins for male and female rice farmers were not significantly different as seen in Table 2.

Table 1: Gross Margin Analysis of Post-Harvest Loss.

Category	Total Variable Cost (LRD)	Total Revenue (LRD)	Total Gross Margin (LRD)	Average Gross Margin (LRD)
Without Post-Harvest Loss	3,226,467	13,223,550	9,997,083	8,248.418[a]
With Post-Harvest Loss	3,226,467	8,951,100	5,724,633	4,723.295[b]

LRD: Liberian Dollars; the different Superscript letters indicate significant difference.

Table 2: Gross Margin Analysis of Post-Harvest Loss on Gender.

Category	Total Variable Cost (LRD)		Total Revenue (LRD)		Total Gross Margin (LRD)		Average Gross Margin (LRD)	
	Male	Female	Male	Female	Male	Female	Male	Female
Without Post-Harvest Loss	1875925	1350542	7682400	5541150	5806475	4190608	7919.175[a]	8687.048[a]
With Post-Harvest Loss	1875925	1350542	5314350	3636750	3438425	2286208	4622.766[b]	4998.966[b]

LRD: Liberian Dollars; the different Superscript letters indicate significant difference

These results agreed with Emmy Owoicho [7] report that the gross margin (US$18,658) with losses of rice farmers is lesser than the gross margin (US$139,498.40) without losses. It also shows that post-harvest losses reduce smallholder rice farmers' income by 13.38% in Benue state.

Similarly, this study's findings correspond to Robert Aidoo, [8] report that farmers incurred postharvest losses of up to 40% and received only 60% of the potential revenue during major production season in Offinso North District of Ghana.

Additionally, Ayandiji [6] also analyzed the impact of post-harvest on the income of smallholder farmers by computing the gross margin with loss and the Gross margin without loss. They found that the average Gross margin with loss (₦9,251.41) is lesser than the average gross margin without loss (₦72,251.41). It indicated that post-harvest losses reduce the income of farmers in the Imeko-Afon local Government Area of Ogun State. The percentage loss incurred by the farmers was about 87.3%. The effects of post-harvest losses lead to wastage of the products and tend to frustrate the efforts put into production and their income on the produce.

The gross margins analysis per county shows that Nimba, Lofa, Bong, and Grand Bassa incurred reductions by 65.12%, 64.38%, 57.59%, and 55.68%, respectively compared to Bomi, Grand Cape Mount, Sinoe, and Grand Kru (Table 3). Higher reduction in gross margins faced by these major rice-producing counties contributes more than 50% of the total rice produced in Liberia [9].

Determinants of Gross Margins of Smallholder Rice Farmers

The result of the multiple regression estimates as shown in Table 4 explains the impact of post-harvest losses on smallholder rice farmers' gross margin in Liberia. The model was examined in terms of appropriateness as confirmed by the F-statistic with an overall joint significance of (P < 0.000). The value of the R2 implies that about 76.70% of the variation in the gross margins of smallholder rice farmers is explained by the variables included in the model multiple. The model was tested for multicollinearity,

heteroscedasticity, and normality of data. The results of these tests show that multicollinearity and heteroscedasticity are not present in the regression model and the error term is normally distributed (Table 4).

Table 3: Income Distribution per County and % Losses.

Counties	Average Gross Margin Without Loss	Average Gross Margin With Loss	% Loss
Margibi	6008.0356	3000.1606	49.9358
Grand Kru	4370.4082	1955.1021	44.735
Sinoe	11747.204	4513.061	38.4182
Bomi	23097	4275.75	18.5121
Bong	11512.82	6631.1538	57.598
Grand Cape Mount	12050.202	4729.1841	39.2457
Grand Bassa	2867.4348	4146	64.3781
Lofa	3844.8379	2140.8242	55.6805
River Cess	7110.9033	3724.1936	52.373
Maryland	8782.333	2678.7917	30.5021
Rivergee	9150	3823	41.7814
Nimba	3702.2656	2411	65.1223
Gbarpolu	10462.215	3122.9141	29.8495
Grand Gedeh	10709.68	2219.3396	20.7227
Montserrado	10513.982	3656.0876	34.7736

Table 4: Ordinary least squares regression Result of the effects of Post-harvest losses on the Income of Smallholder Rice Farmers.

Variables	Coef.	Std. Err	P-value
Ln Value of Post-Harvest Loss	-0.0786	0.0211	0.000***
Ln Market Participation Rate	0.3076	0.0489	0.000***
Education Level (No Education Omitted)			
· Complete Primary	0.0196	0.1236	0.874
· Complete Secondary	0.0394	0.0473	0.404
· Complete College/University	0.1778	0.0656	0.007***
Gender	0.0404	0.0431	0.35
Ln Quantity Harvested	0.7829	0.0126	0.000***
Ln Quantity sold	0.0055	0.0014	0.000***
Cons		0.1916	0.000***
R2 = 0.7670			
Prob. > chi2 = 0.0000			
Number of Observations 823			

***; ** and *: statistically significant at 1, 5% and 10% respectively.

As presented below, quantity harvested was found to be significant at 1% with a P-value of (0.000). A 1% increase in the quantity of rice harvested, increases smallholder rice farmers' gross margin by 0.7829%. This means, that the more the quantity of rice is harvested, the farmer will increase the quantity to be sold thus increasing his or her gross margin. This corroborates with the findings of Mujib et al. [10], who stated that an increase in the quantity harvested results in more gross margin/income generation.

Also, the Market Participation Rate (MPR) was significant at 1%, and the positive relationship implies that a 1% increase in MPR increases smallholder rice farmers' gross margin by 0.3076%. A high market participation rate implies an increase in the number

of smallholder rice farmers who are actively engaged in the market subsequently increasing the quantity of rice sold. When the market participation rate increases, it leads to several benefits that can significantly impact the gross margins of smallholder rice farmers. A higher participation rate expands the customer base, increasing the potential number of buyers and sales. This increased demand can drive up prices, resulting in higher income generation. Additionally, a larger market participation rate fosters competition, encouraging farmers to innovate and improve their products or services to attract customers. This increased competition can lead to higher quality offerings and ultimately higher profits.

These findings agree with Abimbola [5] who argued that a higher market participation rate is fare better and can significantly impact the increase of farmers' income and welfare. Moreover, the value of post-harvest losses negatively impacted the gross margin of smallholder rice farmers. It was significant at 1% and has a coefficient of (-0.0786). The results show that a 1% increase in the value of postharvest losses reduces the farmer's gross margin by 0.0786%.

The value of post-harvest losses decreases the quantity of sellable products and waste of production inputs resources. It measures the economic losses incurred by farmers, which is very significant, especially in developing countries where agriculture is a major source of livelihood for many. According to the Food and Agriculture Organization (FAO), post-harvest losses account for up to 40% of the food produced in developing countries. This translates to an estimated value of $310 billion per year. This means that farmers are not able to sell all the rice they produce, which leads to a decrease in revenue.

Additionally, Education level was significant at 1% for farmers who have completed college or university. The results show that the gross margin for farmers who completed college or university increased by 0.17% compared to those with no level of education. A farmer who has completed college/university education will be knowledgeable about improved farming techniques, access to new markets, understanding market trends, consumer preferences, and quality standards, value addition, financial management skills, and access to government support and subsidies, including information on crop rotation, soil management, pest control, and irrigation methods. These techniques are capable of increasing crop yields and reducing production costs; ultimately leading to higher gross margins.

These findings concur with those of Maziku P [11] and Lubungu, Chapoto, & Tembo (2012) who reported that farmers with higher levels of education may have better abilities to adopt new technologies and therefore have more information than those with relatively less or no education. It also agrees with Amentae et al. (2016) who argued that education can influence the adoption of new post-harvest technologies and other factors like management skills, household income, and access to capital, which would all have a positive effect on post-harvest reduction and increase the gross margins of farmers [12,13].

Conclusion

The study discoveries agreed that post-harvest losses negatively impact the gross margin of smallholder rice farmers in Liberia. It shows that five (Lofa, Bong, Grand Bassa, and Nimba) out of the 15 counties incurred the highest reductions in their gross margins of 39.79% valued at over 2.8 million Liberian Dollars. Therefore, reducing post-harvest losses with priority to these counties will increase outputs, and productivity and enhance the quality of grains. The study further revealed that quantity harvested, Market Participation Rate, value of post-harvest losses, and Education level are major factors influencing the profitability of rice production in Liberia.

Recommendation

It is unfavorable and counter-productive for farmers after directing so much of their narrow resources to production, to lose the harvested produce before it gets to the market or consumers due to factors beyond their control. This connotes a waste of productive resources as well as a significant reduction in expected income and consequently welfare of the farmers. The problem of post-harvest losses, which has long not been recognized as one of the major factors responsible for food insecurity in Liberia, should be of utmost priority in any effort to achieve food self-sufficiency. The constraints encountered by the farmers also need to be effectively addressed. This could be through:

i. The adequate training of farmers on post-harvest handling techniques and the provision of good storage facilities could help prevent crop losses, especially at the farm level.

ii. The improvement of linkage roads would also help curb losses during transit to the market.

iii. Investment in postharvest processing technologies and establishment of processing facilities.

Acknowledgment

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