Does Post-Harvest Losses Matter on Farmers Profitability? Evidence From Smallholder Grape Farmer's in Dodoma, Tanzania

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Abstract
This study analysed post-harvest losses of grapes and their effects on profitability of smallholder grape farmers in Dodoma. Cross section survey using structured questionnaire was used to collect primary data from 240 grape farmers who were selected through a random sampling procedure. Descriptive statistics, paired t-test, gross margin and multiple regression analysis were used to achieve the objectives of this study. Results show that, the average quantity of grape yields by smallholder grape farmers' in Dodoma was 7.7 tonnes/ha. Out of these, 1.65 tonnes/ha equivalent to 20.9% of the total grape harvested were lost. Based on multiple regression model, results showed that post-harvest losses have significant effect on the profit of smallholder grape farmers in Dodoma (p<0.01) by 13.9%. The observation is implied by a lower profit with loss (1.8 million/ha) compared to profit without loss (2.9 million /ha) received by farmers' from the gross margin analysis. The study concludes that a substantial proportion of grapes produced did not reach the final consumers due to post-harvest losses which had significant effect on farmers' profitability. It is recommended that reduction in post-harvest losses in grape farming should be of utmost priority in any efforts of improving farmers' profit. These efforts may entail provision of adequate training to farmers on post-harvest losses and handling techniques to create awareness among actors and investing in post-harvest technologies to prolong grapes' shelf life, reduce post-harvest losses and increase profit of smallholder grape farmers.

Keywords: *Grape, Post-harvest losses, Profitability, Smallholder Farmers', Dodoma, Tanzania.*

INTRODUCTION
Small scale production of fruits and vegetables plays an important role in income generation, poverty alleviation and in improving the nutrition and food security of the rural population (Hena and Soni, 2013; Honja, 2014;

food security of the rural population (Hena and Soni, 2013; Honja, 2014; Musasa *et al.*, 2015; Travis *et al.*, 2020; Camillus *et al.*, 2023). Grape (*Vitis vinifera*) belonging to the *Vitaceae* family is one of the world's most important economic fruit crop consumed both fresh and used in wine production (Creasy and Creasy, 2009; Senthil *et al.*, 2011, FAO, 2021). Although grapevine is adapted to a wide range of climates, it generally performed better in tropical climatic conditions (Jogaiah *et al.*, 2013). Countries such as Brazil, India, Thailand, and Venezuela play a leading role in the tropical grape production. Other countries include Bolivia, Colombia, Peru, Guatemala, Madagascar, Namibia, Tanzania, Vietnam, and China (Jogaiah *et al.*, 2013). Globally, grapes are grown in an area of about 7.5 million hectares with the production of about 75.8 million tonnes contributing to about 16% of the total fruit production (FAOSTAT, 2016; OIV, 2017; FAO, 2021; FAO, 2022). In productivity, India ranks the first with 21.7 tonnes/ha, followed by USA 17.6 tonnes/ha, China 17.1 tonnes/ha, and Chile 14.60 tonnes/ha in the year 2016 (FAOSTAT, 2016; OIV, 2017).

Dodoma region, particularly Dodoma Municipality and Chamwino District, is a key grape-growing area in Tanzania (DCR, 2014). Grape production is largely carried out by smallholder farmers and local Makutopora red is the common grape variety grown in Dodoma which is used in wine making and consumed as fresh fruit (Hussein, 2010; Njovu *et al.*, 2018). Despite the region's immense potential for grape cultivation due to its unique tropical climate and the ability to harvest grapes twice or even thrice a year with proper irrigation (MAFS, 2006), the grape industry in Dodoma has not reached its maximum potential in terms of yields (Budotela, 2006; Hussein, 2010; Safari *et al.*, 2015). According to Detry (1986 cited in Hussein 2010), 25 tonnes of grapes can be harvested in one hectare under good crop management. Currently, the average yield of grape fruit by smallholder farmers in Dodoma is estimated to be 7 tonnes/ha (RAS, 2014; TIC, 2020). This yield is lower than the yields in other tropical climate conditions of grape producing countries. For example, in China, grape yield is estimated to be 17.1 tonnes/ha, India 21.7 tonnes/ha, Brazil 12.9 tonnes/ha, and in South Africa 14.6 tonnes/ha (OIV, 2017).

According to scholars (e.g., Ogundari, 2006; Ojo *et al.*, 2009; Saysay *et al.*, 2016), low level of productivity in crop production reflects low profitability and inefficient use of resources. However, Bala *et al.* (2016)

argue that, efficient resource allocation is a necessary condition for increased crop productivity, but not sufficient for a firm to be profitable. Profit can be increased by increasing efficiency of the crop production system and by increasing efficiency in post-harvest operations in other words, reducing the post-harvest losses of the crop (Bala *et al.,* 2016; Hengsdijk and de Boer2017; Assane and Komarek, 2020). This is because food production system consists of two sub-systems, that is, crop production and post-harvest operations systems, which have significant effects on profitability, food security, environment, and economic development (Bala *et al.*, 20l0, FAO, 2019; Pera *et al.*, 2023).

Being among the perishable fruit commodities, grapes undergo huge post-harvest losses which usually occur as the fruit is transferred from the vineyard to the final consumer (Wanjari, 2005; Yaldiz *et al.*, 2008; Vilas *et al.,* 2011; FAO, 2021). Grape losses vary across countries and are estimated to be 53% in Iran at various stages of the post-harvest chain (Rajabi *et al.,* 2015), 16-23% in Pakistan (Aujla *et al.*, 2011) and 14-27% in India (Murthy *et al.,* 2009). These losses have adverse effect on profit because they tend to affect output resulting into a scenario where marginal revenue is less than marginal cost, hence causing low profitability (Goldsmith *et al.*, 2015). This means that smallholder farmers' who are faced with post-harvest losses and low productivity are both inefficient in crop production and post-harvest management. To achieve profit maximization goal, farmers need to be more efficient not only in their production activities but also in post-harvest management practices.

Many studies have examined profit of agricultural produce (e.g., Nyekanyeka, 2011; Mlote *et al.*, 2013; Acharya and Shiva, 2014; Noonari *et al.,* 2015; Katema *et al.,* 2017; Kispal, 2018) and post-harvest losses mainly on grains at the global level (e.g. Amantae *et al.,* 2016; Sebeko, 2015; FAO, 2014; Hodges *et al.,* 2011; Muyengi *et al.,* 2014; Kereth *et al.*, 2013; Msogoya and Kimaro, 2011; Travis *et al.,* 2020; Strecker *et al.,* 2021;Chikez *et al.*, 2023; Camillus et al., 2023; Pera *et al.*, 2023). Limited attention has been given to measuring post-harvest losses and their effects on profit of agricultural produce at the national level and particularly to a specific crop like grapes among smallholder farmers'. The few studies which exist have examined technical efficiency of grape production (Changyang *et al.,* 2012; Lwelamira *et al.,* 2016), grape value chain (Hussein, 2010), profitability (Kamble *et al.,* 2014; Appasmandril *et al.,*

2017) and determinants of post-harvest losses (Kulwijila, 2021). While these studies have contributed to the understanding of the importance of grapes, the aspects of post-harvest losses are not known. In this regard, the study aims to address this research gap by examining the extent of PHLs and their effects on the profitability of smallholder grape farmers in Dodoma.

Basing on the fact that studies that provide background on post-harvest losses of grapes and their effects on profit are scanty, this research seeks to provide valuable insights for policy decision-makers, grape value chain actors, and the government to formulate effective post-harvest loss management policies/strategies and interventions that can help smallholder farmers improve their post-harvest management practices, enhance profitability, and contribute to sustainable economic development in the region. Additionally, this study aims to contribute to the existing literature by providing a comprehensive analysis of the economic implications of PHLs in the grape industry, which has received limited attention in previous studies. Finally, the study is in line with Sustainable Development Goal (SDG) 12.3 that seeks to reduce food loss and waste along the entire food value chain for improved productivity, profitability and food security.

THEORETICAL MODEL

This section describes the theoretical model for analysis which assumes profit maximization as the farmer's objective; and thus, profit maximization model was used in this study. According to de Janvry and Sadoulet (1991), Salazar (2006) and Saysay (2016), the restricted profit maximization function subject to production technology constraint can be expressed as follows:

$$Max\ \pi = py - \sum_{i=1}^{n} w_i x_i \quad \text{s.t. } h(y, x, z) = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: π is the profit received, *p* represents price of output, w_i is the cost of inputs, x_i is the variable inputs used and z is the fixed inputs.

The profit function and the constraint in equation (1) were further combined to obtain Lagrangian equation as presented in equation 2.

$$L = py - \sum_{i=1}^{n} w_i x_i + \lambda h(y, x, z) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where λ is the Lagrange multiplier associated with production technology constraint.

The derivative of equation 2 (first order condition) gives the output supply and input demand functions as presented in equation 3 and 4.

$$y = y^*(p, w_i, z_i) \qquad (3)$$
$$x_i = x_i^*(p, w_i, z_i) \qquad (4)$$

Where y represents yield per hectare and x_i inputs used in grape production (i.e., labour/ha, farm yard manure/ha and pesticides/ha in this study).

Since the output supply (3) and input demand (4) functions give profit maximizing choices as functions of the parameters, substituting these equations into equation 1 gives the indirect profit function (equation 5) that gives us maximal profit as function of the parameters.

$$\pi^*(p, w_i\, z_i) = py^* - \sum_{i=1}^{n} w_i x_i^* \qquad (5)$$

However, output supply is affected by how much post-harvest losses a firm is faced with. Losses reduce the output that reaches the market even though cost was incurred. This makes loss a cost that has to be considered when deciding the quantity to supply if an individual has an objective of maximizing profit (Rutten, 2013, Godsmith *et al.,* 2015; Somanje 2016). Thus, the cost of loss in this study was taken into consideration to see their effects on farmer's profitability.

METHODOLOGY

The study was conducted in Dodoma Municipality and Chamwino District in Dodoma city, in the Central Zone of Tanzania. The two districts were purposively selected because they are the leading areas in respect of grape production in Dodoma region. The population of interest constituted smallholder grape farmers in the study area while the sampling unit was farmers engaged in the production of red grapes. A two stage random sampling was adopted in this study. At the first stage, six villages were sampled randomly from a list consisting of villages cultivating grapes obtained from District Agricultural Irrigation and Cooperative Officers (DAICOs) of Dodoma Municipality and Chamwino

District namely: Mpunguzi, Mbabala, and Hombolo in Dodoma Municipality and Mvumi Mission, Mvumi Makulu, and Makang'wa in Chamwino District. These villages were selected based on high proportion of farmers and their potentials in grape production. In the second stage, 41 respondents from each village were then randomly selected making a total of 246 respondents. Only 240 respondents were included in the analysis because other questionnaires missed important information.

Cross-sectional survey was used to collect data from grape farmers using pre-tested structured questionnaires. The questionnaire collected information on quantity of grapes produced, inputs used, prices of inputs and output, socio-economic characteristics of respondents and post-harvest losses (quantity of grapes lost) by each farmer at various stages. Personal observation, key informants interview and focus group discussion were also used to supplement the questionnaire data.

Descriptive and quantitative analyses were employed in this study to analyse the data collected. For descriptive analysis: percentages, means and frequencies and standard deviation were used in analysing post-harvest loss and the variables entered into the model. Profitability analysis was employed in this study to calculate the profit made by grape farmers per hectare. Paired sample t-test was used to compare the mean revenues with and without losses .Profit was determined by subtracting the total cost (variable costs and fixed costs) from the revenue for each individual farmer as presented in equation 5. The total variable cost (TVC) consisted of expenses or costs of farm yard manure (tonnes), pesticides (litres), trailing system, cost of loss (monetary value of quantity of grapes lost), and labour (man-days) which were calculated on per hectare basis.

To enable calculation of labour costs, number of person (labour unit) required to perform a particular amount of work was estimated as well as the number of days spent on doing a particular activity in the field. Labour (family and hired) costs were quantified from grape production activities of trailing, pruning, pesticides application (spraying), manuring, and weeding. For family labour, the wage rate paid to hired labour was used. That is, the income the family member would lose by not hiring himself/herself out of an activity on someone else's farm and instead doing the same activity on his/her own farm. The total cost of labour was obtained by taking the average cost of labour multiplied by the total number of labourers for all activities.

Fixed costs included the value of fixed assets such as land, tools, machinery and buildings. Farmers in the study area did not have machinery and building as assets for production. Smallholder farmers in the study used small basic farm implements as fixed equipment (e.g. hoes, solo pumps), which was not only used for grape production but also for other crops production. These small tools were used until they were worn out. As such, the final value for such type of fixed equipment is valued at zero (Omotesha *et al.*, 2010; Mulie, 2014). Therefore, they were not included in the analysis for this study.

Furthermore, for the case of land under grape, farmers were the owners of land and were not paying taxes for farm land. Following this, land was not included in the quantification of the costs. From the above mentioned reasons, fixed cost was not included in the analysis and it has been noted as a negligible portion of farming enterprise, especially in the case of small scale subsistence farming (Abdullahi, 2012; Ohen and Ajah 2015).

On the revenue side, grape production revenue is the amount that a farm receives from the sales of output. To obtain the total revenue, the quantity of grape produced was multiplied by the average market price per kilogram of grape. From equation 1 and the reasons explained above on fixed costs, profitability of grape production among farmers was determined using equation 6. Similar model was used by Katema *et al.* (2017) which is the difference between the total revenue (TR) and the total variable cost (TVC) that is:

$$\pi_i = TR_i - TVC_i \quad \text{……………………………………………………………………..} (6)$$

Where: π_i is the profit from grape by ith respondent (TZS), TR_i = represents total revenue from sale of grapes by i^{th} respondent (TZS) obtained by multiplying the quantity of grapes (Y_i) in kg by their corresponding unit price (P_i) in TZS/kg. Total revenue (TR) was categorized as actual and potential total revenues. The actual total revenue (ATR) and potential total revenue (PTR) were differentiated using the physical quantity of grapes produced/harvested as potential output without taking into account PHLs and the quantity sold as actual output when PHLs were taken care off in order to obtain gross margin with and without post-harvest losses. TVC_i = Total variable costs spent on grape production (TZS) by i^{th} respondent and was computed as presented in equation 7.

$$VC_i = Lab_i * P_l + Man_i * P_m + Pest_i * P_p \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where: Lab_i = Quantity of labour used by i^{th} respondent (man-days/ha), P_l = wage of labour per man-day, Man_i = quantity of farm yard manure used by i^{th} respondent (tonne/ha), P_m = price of manure (TZS/tonne), $Pest_i$ = Quantity of pesticides used by i^{th} respondent (litre/ ha) and P_p = Price of pesticides (TZS/litre).

Moreover, from equation 5, multiple linear regression model was used to assess the effect of PHLs and other variable which were considered to influence farmers profit as presented in equation 8 and 9, respectively. The variables are as presented in section 1.4 (Table 1). Similar model was used by Mlote *et al.* (2013) to assess different variables which are considered to affect profit of cattle fattening in Lake Zone, Tanzania. Saysay (2016) employed multiple regressions to determine the effect of agroecology and technology on farmers' profit in Liberia. The model was specified as follows:

$$\pi_i = \beta_0 + \beta_i x_i + \cdots + \beta_n x_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where:
π_i = profit of i^{th} respondent; X_i - X_n = variables considered to affect profit for i^{th} respondent, $\beta_0 = \text{constant}$ and $\beta_i - \beta_n$ are parameters to be estimated.

To achieve the objective of this study, equation 8 was expanded to include all variables entered in the model as specified in equation 9.

$$\pi_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon \ldots\ldots\ldots (9)$$

Where
π_i = profit (TZS/ha) for i^{th} respondent, X_1 = cost of pesticides (TZS/ha), X_2 = Cost of trailing (TZS/ha), X_3 = farm size (ha), X_4 = Costs of labour (TZS/ha), X_5 = Cost of manure (TZS/ ha), X_6 = Cost of loss (PHLs)

(TZS/ ha), X_7 = grape selling price (TZS/ kg), β_0 = constant, $\beta_1 - \beta_6$ are parameters to be estimated and ε is the error term.

Description of variables entered in regression model and their effects on profit

Variables affecting grapes profit of farmers and their expected effects are as defined in Table 1.

Table 1: Definition of Variables Used in the Model

Variable	Definition	Measurement	Expected sign and explanation
X_1	Pesticides	TZS/ha, expressed in natural logarithm (Ln)	(+) Pesticides control pest and diseases in grapes thus, farmers who use pesticides on their farms are expected to increase their profit due to good grape quality.
X_2	Trailing	TZS/ha, expressed in natural logarithm (Ln)	(+) Good trailing system improves the quality of grape hence higher profit
X_3	Farm size	ha	(+) Farmers with large area under grape are expected to get higher output and increase profit
X_4	Labour	TZS/ha, expressed in natural logarithm (Ln)	(+) Labour was expected to increase grape output and hence higher farmers profit
X_5	Manure	TZS/ha, expressed in natural logarithm (Ln)	(+) Farmers who use farm yard manure are expected to produce more and increase their profit.
X_6	PHLs	TZS/ha, expressed in natural logarithm (Ln)	(-) PHLs reduce the quantity of grapes produced thus lowering farmers profit from grape sales
X_7	Grape selling price	TZS/kg, expressed in natural logarithm (Ln)	(+) Farmers who sell their grapes at a higher price are expected to get more profit

FINDINGS AND DISCUSSION

Distribution of grapes output and post-harvest losses at farm level

The average quantities of grapes produced, sold, and lost at farm level per hectare in the study area are presented in Figure 1. The results show that 1.35 out of 7.5 tonnes of grapes produced per hectare in Dodoma Municipality were lost and did not reach the final consumer. Similarly, 1.95 out of 7.9 tonnes per hectare of grapes produced per hectare in Chamwino District were lost and did not reach the final consumer. This translates to a loss of 17.9 and 24.8% of the total yield in Dodoma Municipality and Chamwino District respectively (Figure 1).

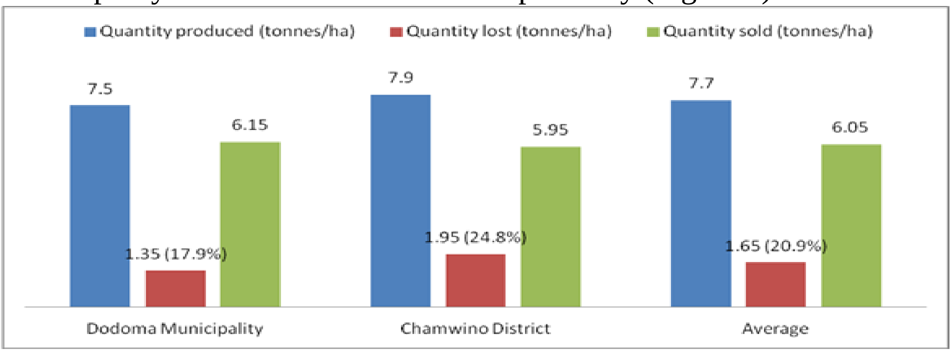

Figure 1: Average quantity of grapes produced, sold and lost at farm level per hectare

Moreover, the average grape yield by smallholder farmers in both areas was estimated at 7.7 tonnes/ha. The average quantity of grapes lost per hectare was 1.65 tonnes/ha, which translates to a loss of 20.9% of the total yield. This implies that, 1650 kg of grapes out of 7 700 kg produced per hectare did not reach the final consumer due to post-harvest losses (Figure 1). This loss of grapes implies a loss of profit to farmers and all the scarce resources that contributed to producing the crop. These findings are in line with the findings by other studies such as Somanje, (2016); Goldsmith *et al.* (2015); Rutten (2013); Sebeko (2014); Gustavsson *et al.* (2011); Lipinski *et al.* (2013a); Lundqvist *et al.* (2008b) who reported that post-harvest losses reduced farmers profit.

Analysis of production costs in grape farming

Before analysing the profits accrued by farmers from grapes, descriptive statistics of the production costs in grapes and other variables entered into the model was done as presented in Table 2.

Table 2: Grape farming production costs per hectare (TZS)

Variable	n	Min	Max	Mean	SD
Farm size (ha)	240	0.1	3.2	1.0046	0.7704
Selling price	240	500	1500	700	182. 9270
Cost of loss	240	287 000	1 400 000	1 155 000	234 031.52
Variable costs					
Farm yard manure	240	100 000	550 000	360 385	105 317.90
Pesticides	240	150 000	750 000	474 000	98 100.12
Labour	240	508 000	2 700 000	1 270 974	536 438.87
Trailing	240	75 000	490 000	300 000	92 167.64
Total production costs	240	833 000	4 490 000	2 405 359	

The results in Table 2 showed that the total production costs per hectare was TZS 2.4 million/ha during dry season. Compared to other costs, the biggest share of the costs were labour cost (52.8%), followed by pesticides (19.7%), farm yard manure (15%) and trailing system (12.5%) as indicated in Table 2. However, these figures could change depending on the climate conditions and variation in input prices each season.

Profitability analysis of grapes

Gross margin analysis with and without loss was carried out to assess the profitability of grape farming per hectare as presented in Table 3.

Table 3: Costs, revenues and profit for grape farming with and without loss between grape farmers (n= 240)

Variables	Amount (TZS/ha)	% Costs
Gross margin without loss		
Gross revenue		
Average grape harvested = 7700kg - A		
Average price/kg = 700/= - B		
Total Revenue without loss (TR) – C	5 390 000	
Variable costs		
Trailing – a	300 000	12.5
Labour costs – b	1 270 974	52.8
Farm yard manure - c	360 385	15.0
Pesticides – d	474 000	19.7
Total variable costs –D = (a + b + c + d)	2 405 359	100.0
Gross Margin without loss = C - D	2 984 641	
Gross margin with loss		
Gross revenue		
Average grape sold = 6050kg - B		
Average price/kg = 700/= - C		
Total Revenue with loss (TR) – E = B* C	4 235 000	
Variable costs		
Trailing – a	300 000	12.5
Labour costs - b	1 270 974	52.8
Farm yard manure - c	360 385	15.0
Pesticides – d	474 000	19.7
Total variable costs –F = (a + b + c +d)	2 405 359	100.0
Gross Margin with loss = E - F	1 829 641	

The results reveal that grape farmers received a total revenues of TZS 5.4 million/ha without taking into consideration post-harvest loss during dry season. The profit received was TZS 2.98 million without loss in the study area (Table 3).This indicates that grape production is a profitable venture despite higher production costs in the study area. This finding is consistent with the findings of many studies that subsistence grape production is a profitable enterprise (Kamble *al.*, 2014; Kalimang'asi *et al.*, 2014; Lwelamira *et al.*, 2015).

On the other hand, results revealed that grape farmers received actual total revenues with loss of TZS 4.2 million/ha during dry season. The profit received when loss was taken into consideration was TZS 1.83 million per hectare. This profit was lower than the profit of TZS 2.98 million when PHLs were not taken into consideration (Table 3). This implies that post-harvest loss is a cost to grape farmers as it reduces their profit. Thus, PHLS need to be reduced for grape farmers to attain higher profit. These findings are in agreement with the findings in a study by Somanje (2016), Assane and Komareck (2020) and Tadesse (2022) who found that post-harvest losses lower farmer's profits.

Moreover, the mean revenues with and without losses were compared using paired sample t-test. The results revealed that gross margin accrued by farmers with and without loss from grape sales were statistically significant ($p<0.05$), implying that the gross margin with and without losses differs significantly in the study area (Table 4).

Table 4: Means comparison results of gross margins with and without loss between grape farmers

Variables	Average Gross margin	Mean difference	SD	t-value
Gross margin without loss	2 984 641	1 155 000	2 330 027.4	7.679*
Gross margin with loss	1 829 641			

*Significant at $p<0.05$

Effects of post-harvest losses on profit generated from grape Sales

The gross margin (a proxy for profitability) was used as a dependent variable in the multiple regression model to determine the effect of PHLs on farmers profit. However, prior to the estimation of the model, multicollinearity and autocorrelation test was conducted. Durbin-Watson test was found to be 1.872 indicating absence of autocorrelation and the Variance Inflation Factor (VIF) was found to be 1.637 and 2.152 in Dodoma municipality and Chamwino district, respectively which was less than 10 confirming the absence of multi-collinearity among the independent variables and the dependent variable (Gujarati, 2004) as indicated in Table 5.

Table 5: Regression results on the effect of PHLs on grape farmers profit in Dodoma Municipality and Chamwino District (n = 120)

Variables	Dodoma Municipality			Chamwino District		
	Coefficients	SE	t	Coefficients	SE	t
Constant	8.198***	1.503	5.455	7.516***	1.499	5.014
Pesticides	0.419*	0.239	1.750	0.405*	0.245	1.654
Trailing	0.010	0.049	0.200	0.019	0.050	0.386
Farm size	-0.070	0.097	-0.714	-0.006	0.053	-0.109
Labour	-0.222***	0.027	-8.198	-0.172***	0.026	-6.660
Manure	-0.054*	0.032	-1.662	-0.044	0.033	-1.348
Post-harvest losses	-0.135***	0.051	-2.633	-0.263**	0.100	-2.623
Price	0.020	0.052	0.391	0.147*	0.076	1.940
R-square	0.600			0.754		
Durbin-Watson	1.449			1.861		
VIF	1.637			2.152		

*, ** and *** denotes significant levels at ($p<0.10$, 0.05 and 0.01) respectively.
Dependent variable: Profit (TZS/ha)

The result in Table 5 and 6 show that the cost of loss (PHLs), manure, labour and pesticides were found to have significant effects on grape farmers profit in both areas of the study. These findings are supported by the findings from the FGD where participants reported lower profit from grape production due to higher input costs and post-harvest losses.

The cost of loss (PHLs) was negative and statistically significant at $p<0.01$ indicating that a one percentage decrease in the cost of loss (PHLs) would increase the mean profit of grape farmers, holding other factors constant. This implied that reducing grape losses would increase farmers' profit by 13.5% in Dodoma municipality and 26.3% in Chamwino district (Table 5). In addition, farmers profit in both districts would be increased by 13.9% when PHLs are minimized (Table 6). The results are in agreement with the results in a study by Rutten (2013) in Netherland, Goldsmith *et al.* (2015) in Brazil on soy bean, and Somanje (2016) in Ethiopia on fish who revealed that PHLs had significant effect on farmers' profit and thus, reducing PHLs could improve farmers profit (Chikez *et al.*, 2023; Pera *et al.*, 203). These results were however in contrast to the findings of Alidu *et al.* (2016) who reported that PHLs increased mean profit of tomato farmers in Ghana, holding other factors constant. This could be due to geographical differences and the crop under study.

Table 6: Combined Regression results on the effect of PHLs on grape farmers profit in (n = 240)

Variables	Coefficients	SE	t	Sig	VIF
Constant	6.369	1.857	3.430	0.001	
Pesticides	0.983	0.291	3.383	0.001	1.061
Trailing	0.038	0.061	0.622	0.534	1.063
Farm size	0.069	0.040	1.709	0.089	1.026
Labour	-0.360	0.050	-7.141	0.000	1.385
Manure	-0.256	0.119	-2.146	0.033	1.051
PHLs	-0.139	0.045	-3.084	0.002	1.333
Price	0.006	0.062	0.101	0.919	1.029
R-square			0.590		
Durbin-Watson			1.872		

Dependent variable: Profit (TZS/ha)

Moreover, the coefficients for farm yard manure and labour were negative, indicating that these variables influence grape farmer's profit. The cost of farm yard manure was statistically significant at 5% level in both district implying that holding all factors constant (ceteris paribus), a one percentage decrease (increase) in the cost of manure would increase (decrease) the mean profit of grape farmers. Labour cost was negative and statistically significant ($p<0.01$) implying that a one percentage decrease in the cost of labour would increase the mean profit for grape farmers, other factors held constant (Table 6). The results concur with of the results in a study by Kamble *et al.* (2014) who reported labour cost as one of the cost reducing farmers' profit in grape production in Marathwada region in India.

The coefficient for area cultivated with grape is positive and significant at 10% when both districts were combined (Table 6). The positive coefficient implies that an increase in the area cultivated with grape increases farmers' mean profit by 0.069 percent. Similar results were reported by Hyuha (2006) and Jude (2012) that an expansion of the land area cultivated under rice can achieve higher output (yield) and increase profit. Furthermore, the coefficient of pesticide costs was positive and statistically significant ($p<0.01$). This means that a one percentage increase in the cost of pesticides increased grape farmers' mean profit. This was due to the reason that pesticides are important variables in grape production for protecting grapes from diseases and pests. Thus, other factors remaining constant, as more pesticides are used by farmers' in grape production, output will increase, which in turn would increase farmers mean profit. Similarly, farmers' who make effective use of pesticides are in a position of receiving higher profit from grapes because pesticides improve the quality of grapes by controlling pests and diseases, which affect the crop and hence reduce post-harvest losses (Table 6). This finding agreed with the findings by Tanko *et al.* (2015) on yam production, Ojo *et al.* (2009) on rice production in Nigeria, and Alidu *et al.* (2016) on tomato in Ghana, who affirmed that an increase in pesticides usage increase profit of farmers.

Hypothesis testing

The study tested the hypothesis that post-harvest losses have no significant effects on the profit of smallholder grape farmers. To achieve this, the calculated t-value from Ordinary Least Square (OLS) regression estimate for the cost of loss in Table 6 was compared with tabulated t-value at 5% level in order to make the right decision. The decision rule was that: if the calculated t-value (Tc) is greater than the tabulated one (Tt), the null hypothesis is rejected (Ho) and the alternative hypothesis is retained (Ha). The results show that the calculated t-value for PHLs was 3.084 and the tabulated one was 1.895 which was less than the calculated one. Basing on this finding, the study rejected the null hypothesis and accepted the alternative hypothesis that ''PHLs have significant effect on farmers' profit in the study area.

CONCLUSION AND RECOMMENDATIONS

A substantial proportion of grapes produced did not reach the final consumers in Dodoma Municipality and Chamwino District due to post-harvest losses. The analysis of the effect of PHLs on profit using multiple regression model showed that the cost of the loss (PHLs) has significant effect on the profit of grape farmers and that the reduction of these losses could increase farmers' profit. This observation is based on the lower profit with loss compared to the average profit without loss which was received by farmers in the study area. The cost of labour, pesticides, and farm yard manure also contributed to lower profit among grape farmers.

Based on these conclusions, the following recommendations are put forward for policy decisions in order to guarantee economic prosperity among grape farmers: the reduction of post-harvest losses in grape farming should be given top priority in any effort of improving farmers' profit in the study area. The reduction of post-harvest loss can be achieved through adequate training on post-harvest handling techniques. In addition, interventions on post-harvest technologies including packaging, processing, and storage technologies to increase grape shelf life and reduce post-harvest losses are also vital in increasing farmers' profitability. Furthermore, programs aiming at reducing other costs such as use of farm yard manure, labour and pesticides in grape production, and provision of subsidies to grape farmers could also improve farmers' profit, improve grape quality and encourage more farmers' involvement in grape production to increase productivity.

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