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Estimating post-harvest loss at the farm level to enhance food security: A case of Nepal

Arun GC[1,*] **Kiran Ghimire**[2]

[1]Ministry of Agriculture and Livestock Development (MoALD), Government of Nepal
[2]Plant Quarantine and Pesticide Management Center (MoALD), Government of Nepal

[*]Corresponding Author: gcarun8848@gmail.com

Abstract

Food security is a major concern of the world in the context of increasing population, changing climate and declining scarce natural resources. Reducing food loss is equally important as increasing food production and productivity to feed the world, where 9.7 billion inhabitants were expected by 2050. Food loss can occur at several points along the food chain, however, harvest loss at the farm level is often overlooked which is directly impacting on sustainability. The paper attempts to estimate harvest loss at the farm level. A household survey was executed in 300 households from ten sample districts across Nepal. The percentage of harvest loss at the farm level was calculated for each crop grown as per - the season, plot and priority. Likewise, the multiple regression was executed to determine the level of influence of the socio-economic factors on the post-harvest loss at the farm level for the major crops. The mean harvest loss at the farm level found around 5 percent for the reported crops. The multiple regression model demonstrated that at the farm level, socio-economic factors might have a smaller influence on harvest loss as compared to physical and biological contributing factors. Nevertheless, reducing the post-harvest loss will increase food availability and thus the food security.

Keywords: Food loss, Postharvest loss, Food Security, Sustainability, Nepal

Introduction

Food production is a significant resource consuming function (Wohner, Pauer, Heinrich, & Tacker, 2019). Consequently, to feed the ever-increasing population, the reduction of food loss is as equally important as increase production and productivity. Approximately 3.3 billion metric tons of carbon dioxide, 250 cubic kilometers of freshwater and 1.4 billion hectare land are few resources among several other used to produce food, which is never consumed (Wohner, Pauer, Heinrich, & Tacker, 2019), and it has environmental and socio-economic impacts (Vilarino, Franco, & Quarrington, 2017).

Food loss is getting the heart of discussion around the world. However, a general consensus has not been achieved while defining food loss (Vilarino, Franco, & Quarrington, 2017). It is also differently referred to in the literature – “post-harvest food losses”, “post harvest food losses”, “food loss and waste”, or “postharvest food losses” (Global Strategy, 2015). It is estimated that one-third of produced food never been consumed while around one billion people are hungry at the global level (FAO, 2019). Food loss occurs at several points (Chen, Wu, Shan, & Zang, 2018) along the long food chain – in the farmers’ field, in the processing industry, in the distribution channel and the consumer homes (Borma, 2017). However, on the one hand, farm-level losses are often overlooked (Johnson, et al., 2018). On the other hand, the world is committed to ending hunger by 2030 under the Sustainable Development Goals (SDGs) (UN, 2018). More importantly, reducing food loss and waste is crucial to meet SDG 2 (End-

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ing Hunger) and SDG 12 (Ensuring sustainable consumption and production patterns) (FAO, 2019).

The food system is under pressure of rapid population growth, decline productivity, increasing scarcity of natural resources and increasing diversion of agriculture products to the production of biofuel (McKenzie, Singh-Peterson, & Underhill, 2017). The world is anticipating 9.7 billion inhabitants by 2050 (UN, 2015). Moreover, developing countries have greater challenges in reducing food loss before reaching consumers (Wohner, Pauer, Heinrich, & Tacker, 2019). Post-harvest losses are the main causes of food insecurity in developing countries (Manandhar, Milindi, & Shah, 2018). A consensus can be observed that the reduction of food loss greatly contributes to enhancing food security, strengthening the sustainability of the food system and lowering economic costs (Vilarino, Franco, & Quarrington, 2017).

Spoilage of food may occur due to technical, managerial and/or financial constraints (Manandhar, Milindi, & Shah, 2018) in production, processing, distributing and storing functions. Food loss can be very specific for each product and supply chain but also get influenced by several other factors (Verma, Plaisier, van Wagenberg, & Achterbosch, 2019). It is affected by several factors – physical factors (temperature, moisture and oxygen), biological factors (insect, rodent and mold) and socioeconomic factors (farmers' family size, landholding size, grain storage duration, off-farm income, road accessibility, market price of grain and grain safety during storage) (Manandhar, Milindi, & Shah, 2018). Further, it can be expanded to socioeconomic, biological and/or microbiological, chemical or biochemical, mechanical and environmental factors (Global Strategy, 2015).

Estimation of food loss has many uncertainties (Vilarino, Franco, & Quarrington, 2017). However, it is estimated that around 30 percent of global food loss occurs at the production stage, 20 percent at the post-harvest stage and 35 percent at the consumption stage (Vilarino, Franco, & Quarrington, 2017). From the caloric perspective, loss in cereal has the top position (53%) followed by roots, tuber (14%), fruits, and vegetables (13%), however, fruits and vegetables are at the top (44%) considering the rate of food loss (Vilarino, Franco, & Quarrington, 2017).

The SDG Indicator 12.3.1 (Global food losses) has two components – (a) Food Loss Index and (b) Food Waste Index, and is a Tier II, which means it still demands more work and adoption by member countries (FAO, 2019b). Food loss is the loss along the field to the plate of consumers and food waste is the loss from the consumers' plate.

Reducing food loss is of special importance for developing countries like Nepal due to several reasons. Around two-third population are engaging in agriculture which produces 27.2 percent of the Gross Domestic Product (GDP) (MoF, 2018) and prevalence of the multidimensional poverty is 28.6% in Nepal (NPC, 2018).

The paper attempts to document and to estimate food loss in Nepal. Researches on food loss are very limited in Nepal. Few works have been done on selected commodities at a specific locality. Majority of researches are focused on either specific disease-pest or types of the storage system (Bhandari, Achhami, Karki, Bhandari, & Bhandari, 2015; Manandhar & Mainali, 2000; Paneru, Duwadi, Khanal, & Bhandari, 1996; Paneru, Poudel, & Thapa, 2018).

Meterials and Methods

Food loss has been generally categorized into two types – qualitative and quantitative. The qualitative food loss refers to the degradation of food qualities – taste, appearance and nutritional value (Global Strategy, 2015). On the other hand, quantitative food loss refers to a decline in food volume or quantity. It can be studied by different methods. They are – (a) general baseline survey, (b) probability sample survey, (c) experimental designs – field trails, and (d) multivariate linear regression fitting (Global Strategy, 2015).

This study focuses on quantitative food loss and food loss is considered as all kind of losses at farm level after harvesting – that is neither consumed nor sold from the farm. Purposive sampling of districts was done to make the sample as representative as possible considering resource constraint. Nepal is geographically diverse and thus has greater agro-biodiversity and farming systems (GC & Ghimire, 2018; GC & Yeo, 2019). Nepal produces several kinds of cereals, fruits, and vegetables. However, rice, wheat, and maize are the most consumed staple cereal in the world (Manandhar, Milindi, & Shah, 2018) and also in Nepal. Therefore, instead of crop-specific survey, a general survey has been carried out from randomly selected 300 households from 10 sampling districts in 2015.

The farming practices were recorded using a structured questionnaire. Food loss was taken as quantity loss in the past year based on respondent's reporting instead of physical measurement. The percentage of food loss was calculated from the quantity of post-harvest loss and quantity harvested. The equation (1) was used to calculate percentage food loss for an individual farming household.

Percentage Food Loss (FLP) = $\sum_{i}^{n} \frac{QLa}{QHa} \times 100$ .... (1)

Where, QL = Quantity food lost, QH = Quantity harvested, and the subscript "a" = crop.

The percentage of Food Loss (FLP) was calculated for each season (winter and summer), each plot (single largest plot and additional plots) and each priority of crop (primary crop and secondary crop).

The mean harvest loss was estimated a confidence interval by using STATA command "mean".

Regression analysis was executed for the major crops to determine the socio-economic factors affecting food loss. The generalized equation for regression analysis is given in equation (2).

PC_FoodLoss = $\alpha+\beta Xi+\mathcal{E}$ ……………………….. (2)

Where, PC_FoodLoss = Percentage of Food Loss on a crop reported from individual farming household

α = intercept of the equation

β = a matrix of coefficient for each independent variables

Xi = matrix of independent variables

Ɛ = error term

Selection of independent variable is crucial for any regression model. Food loss is affected by several factors – physical factor (temperature, moisture and oxygen), biological factor (insect, rodent and mold) and socioeconomic factor (farmers' family size, land holding size, grain storage duration, off-farm income, road accessibility, market price of grain and grain safety during storage) (Manandhar, Milindi, & Shah, 2018). However, for the study, we have considered only socio-economic characteristics of farming households. Paneru, et al (2018) also used several socio-economic variables including farming area, education, occupation and household size to estimate food loss. The description of variables used for the regression analysis has been presented in Table 1.

The data analysis was carried out using STATA software. To select the appropriate variables, the stepwise command was employed and the final model was obtained.

Results and Discussion

The food loss on the major crops the farm level was calculated for each season (winter and summer), each plot (single largest plot and additional plots) and each priority of crop (primary crop and secondary crop).

Postharvest loss of major crops

Rice, maize, wheat, potato, mustard, cabbage and lentils were found the major crop growing by the farmers in the surveyed districts of Nepal. For convenience, the annualized mean percentage of the harvest loss for those crops were calculated. The highest post-harvest food loss at the farm level was found for mustard and lentil. However, the lowest was found for potato. The mean harvest loss at the farm level for rice, wheat, maize, potato, mustard, cabbage and lentil was found 3.24±0.44, 4.88±1.11, 4.00±1.18, 3.01±0.87, 5.18±1.52, 4.76±1.55 and 5.18±1.19 percent respectively. The detail with observation has been presented in Table 2.

Moreover, the average weighted mean of harvest loss at the farm level for cereal was found 3.94 percent. Under the cereal group, rice, wheat and maize – both summer and winter were categorized. The graphical presentation of annual mean postharvest loss at the farm level was presented in Figure 1.

Percentage of food loss for winter season (S1) crops

Wheat, potato, mustard and maize were found the major winter season crop in Nepal. Table 3 provides the detail of the food loss at the farm level for winter crops from the single largest plot as the first priority crop. The average percentage harvest loss on wheat, potato, mustard and maize were found 5.40, 2.00, 3.38 and 2.99 respectively. However, the median harvest loss was found 0.60, 0.00, 0.00, and 0.98 percent for wheat, potato, mustard and maize respectively. Among these crops, wheat was found the most commonly grown crop, which was produced by 105 households as a primary crop in the single largest plot.

Potato, lentil, cabbage and mustard were found the popular crop, which was grown in the winter season in the single largest plot as the second choice after the crops described in Table 3. The highest loss was reported for cabbage and the lowest was reported for potato. Average percentage harvest loss at the farm level for potato, lentil, cabbage and mustard was found 4.23, 5.78, 7.03 and 5.71 respectively. However, the median value was found 0.00 percent for all crops under this category. Table 4 presents the detail under this condition.

Wheat, potato, mustard and lentil were the top choice of farmers in the winter season for additional plots. Table 5 presents the detail on harvest loss on the crops from the additional plots as the primary crop. The highest post-harvest loss was reported for mustard and the lowest post-harvest loss was reported for potato. The average percentage of harvest loss on wheat, potato, mustard and lentil was found 3.46, 2.84, 9.13 and 3.90 respectively. However, the median values were observed at 0.00 percent except for Mustard (1.52 percent).

Lentil, potato and mustard were found popular second choices for the winter crop in additional plots. The highest percentage of post-harvest loss was reported for lentil and the lowest post-harvest loss was reported for potato. The average percentage of harvest loss on lentil, potato and mustard was found 5.73, 1.86 and 5.66 respectively. However, the median value was found 0.00 percent for lentil and potato and 1.14 percent for mustard. The detail has been presented in Table 6.

Percentage of food loss for summer season (S2) crops

Rice (or paddy), maize and cabbage were found the most dominating crops in the summer season in the single largest plot. Around 60 percent farmers were found planting rice in the summer season as the first choice crop in their single largest plot. The highest percentage of post-harvest loss was reported for maize and the lowest percentage of post-harvest loss was reported for cabbage. The average percentage of the harvest loss in rice, maize and cabbage was found 3.26, 2.88 and 0.94 respectively. However, the median value was observed 0.00 except for rice (1.04 percent). The detail has been presented in Table 7.

Except for rice and maize, other crops were not found significantly growing during the summer season in the additional plots as a primary choice. The post-harvest loss for rice and maize were reported almost similar. The average percentage loss of the harvest at farm level was found 2.38 and 1.59 for rice and maize respectively. The median value was found 0.00 percent for both rice and maize under this condition. The detail has been presented in Table 8.

Estimation of harvest loss by Multiple Regression Analysis

To determine the determinants of the post-harvest loss of the crops, a multiple regression analysis was executed. The multiple regression analysis will enable to quantify the effect of several variables on the post-harvest loss.

Table 9 presents the result of the multiple regression model for post-harvest loss for rice, wheat, maize, potato, lentils and cabbage. The highest value of R-square was observed 0.81 for lentil and the lowest value was found 0.094 for maize. Furthermore, the majority of dependent variables have produced mix results for different crops. Nevertheless, use of past

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weather information, having access to the internet, a percentage of total income coming from the farm, number of extension workers' visit, gender and household size produced positive results in all models. It means they are a positive contributor to the postharvest loss in all crops.

Moreover, the use of weather information announced, the number of male working in the farm, having access to the extension service, total area and having exclusively rainfed farming has yielded negative coefficients. It implies that they are positive contributors to reduce postharvest loss in those crops.

Table 1. Description of variables

Variable	Description	Observation	Mean	Std. Dev.
WethAnnounce	Use of weather information (Yes =1; No=0)	253	0.40	0.49
WethUsePast	Use of past weather experience (Yes=1; No=0)	284	0.33	0.47
FarmExp	Years of farming experience	300	24.83	14.18
FarmDec	Farming decision taken by HoH (Yes=1; No=0)	300	0.83	0.38
Rainfed	Having exclusively rainfed farming (Yes=1; No=0)	297	0.39	0.49
C_totalarea	Total cropping area in hector	293	0.91	0.86
Primaryocchoh	Agriculture as a primary occupation (Yes = 1; No=0)	300	0.79	0.41
Secondaryocchoh	Agriculture as a secondary occupation (Yes = 1; No=0)	300	0.68	0.47
Internet	Having internet access (Yes=1; No=0)	300	0.21	0.41
Electricity	Having electricity access (Yes=1; No=0)	300	0.92	0.28
Farmadultmales	Number of adult males working in the farm	300	2.09	1.40
Farmadultfemales	Number of adult females working in the farm	300	1.50	1.07
Educhoh	Years of schooling of HoH	300	6.27	4.62
Genderhoh	Gender of HoH (Male =1; Female =0)	300	0.85	0.35
Agehoh	Age of HoH in year	283	50.90	12.44
Hhsize	Household size	300	6.50	3.64
farmarea_numplots	Number of land parcel	300	1.70	0.65
farm_selldist	Distance to the nearest market	298	2.57	3.76
farm_selltime	Time to the nearest market	299	0.49	0.69
Outputcoop	Having membership of output selling cooperative	300	0.58	0.49
Inputcoop	Having membership of input selling cooperative	300	0.61	0.49
Getext	Having access to the extension service (Yes=1; No=0)	300	0.72	0.45
Extvisits	Number of extension visit per year	300	3.56	3.80
totalincome	Total income in NRs 10,000	296	34.32	46.00
pctonfarmincome	% of total income coming from farming	299	66.50	37.27
borrowedyn	Having credit access (Yes=1; No=0)	300	0.40	0.49
PC_Rice	% of postharvest loss on Rice	212	3.24	6.47
Rice_havest	amount of rice harvest in 1,000 kg	212	4.53	17.32
PC_Wheat	% of postharvest loss on wheat	149	4.88	13.58
Wheat_havest	amount of wheat harvest in 1,000 kg	149	1.80	7.21
Maize_havest	amount of maize harvest in 1,000 kg	116	0.74	0.98
PC_Maize	% of postharvest loss on maize	116	4.00	12.66
Potato_havest	amount of potato harvest in 1,000 kg	117	2.69	5.69
PC_Potato	% of postharvest loss on potato	117	3.01	9.46
Mustard_harvest	amount of mustard harvest in 1,000 kg	61	0.22	0.46
PC_Mustard	% of postharvest loss on mustard	61	5.18	11.90
Lentil_havest	amount of lentil harvest in 1,000 kg	45	0.76	3.70
PC_Lentil	% of postharvest loss on lentil	45	5.18	8.00
Cabbage_harvest	amount of cabbage harvest in 1,000 kg	50	9.01	16.48
PC_Cabbage	% of postharvest loss on cabbage	50	4.76	10.99

Table 2. Annual mean percentage of harvest loss of different crops

Crop	Mean	Std. Err.	[95% Confidence Interval]		Observations
Rice	3.24	0.44	2.37	4.12	212
Wheat	4.88	1.11	2.68	7.08	149
Maize	4.00	1.18	1.67	6.33	116
Potato	3.01	0.87	1.27	4.74	117
Mustard	5.18	1.52	2.13	8.23	61
Cabbage	4.76	1.55	1.63	7.88	50
Lentil	5.18	1.19	2.78	7.59	45

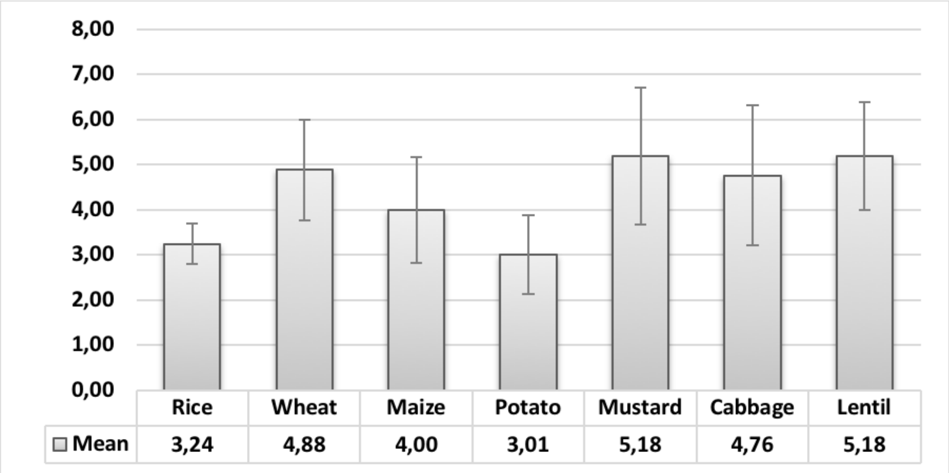

Figure 1. Percentage Food Loss for various crops at Farm Level

Table 3. Harvest Loss in S1P1C1 (in Percentage)

Percentiles	Wheat	Potato	Mustard	Maize
25%	0.00	0.00	0.00	0.00
50%	0.60	0.00	0.00	0.98
75%	5.88	2.44	5.00	6.25
90%	10.00	5.00	10.00	8.96
95%	21.88	11.11	12.50	9.76
99%	50.00	16.67	25.00	9.76
Maximum	100.00	16.67	25.00	9.76
Observation Number	105	42	25	17
Mean	5.40	2.00	3.38	2.99
Standard Deviation	13.10	3.85	5.92	3.82

Table 4. Harvest Loss in S1P1C2 (in Percentage)

Percentiles	Potato	Lentil	Cabbage	Mustard
50%	0.00	0.00	0.00	0.00
75%	0.00	11.11	5.88	0.00
90%	11.67	16.67	19.35	20.00
95%	13.33	33.33	58.33	50.00
99%	88.00	33.33	58.33	50.00
Maximum	88.00	33.33	58.33	50.00
Observation Number	29	14	14	14
Mean	4.23	5.78	7.03	5.71
Standard Deviation	16.44	10.06	15.77	13.99

Table 5. Harvest Loss in S1P2C1 (in Percentage)

Percentiles	Wheat	Potato	Mustard	Lentil
25%	0.00	0.00	0.00	0.00
50%	0.00	0.00	1.52	0.00
75%	4.78	4.84	9.09	10.00
90%	9.09	13.51	20.00	13.50
95%	10.00	14.29	70.00	13.66
99%	50.00	15.89	70.00	13.66
Maximum	50.00	15.89	70.00	13.66
Observation Number	72	24	14	10
Mean	3.46	2.84	9.13	3.90
Standard Deviation	8.03	5.00	18.70	5.93

Table 6. Harvest Loss in S1P2C2 (in Percentage)

Percentiles	Lentil	Potato	Mustard
25%	0.00	0.00	0.00
50%	0.00	0.00	1.14
75%	12.50	2.14	14.29
90%	16.67	9.09	18.33
95%	25.00	10.00	20.00
99%	25.00	10.00	20.00
Maximum	25.00	10.00	20.00
Observation Number	18	18	10
Mean	5.73	1.86	5.66
Standard Deviation	8.02	3.24	8.02

Table 7. Harvest Loss in S2P1C1

Percentiles	Rice	Maize	Cabbage
25%	0.00	0.00	0.00
50%	1.04	0.00	0.00
75%	4.00	0.00	1.39
90%	9.09	12.50	3.57
95%	14.29	20.00	4.67
99%	25.00	25.00	4.67
Maximum	53.57	25.00	4.67
Observation Number	170	45	12
Mean	3.26	2.88	0.94
Standard Deviation	5.89	6.40	1.59

Table 8. Harvest Loss in S2P2C1

Percentiles	Rice	Maize	Cabbage
25%	0.00	0.00	0.00
50%	1.04	0.00	0.00
75%	4.00	0.00	1.39
90%	9.09	12.50	3.57
95%	14.29	20.00	4.67
99%	25.00	25.00	4.67
Maximum	53.57	25.00	4.67
Observation Number	170	45	12
Mean	3.26	2.88	0.94
Standard Deviation	5.89	6.40	1.59

Table 9. Estimation of postharvest loss at the farm level for various crops by regression model

Variables	Rice	Wheat	Maize	Potato	Mustard	Lentil	Cabbage
Rice_havest	0.08						
	(0.07)						
Totalincome	0.01	-0.10**			-0.03	0.06	0.05**
	(0.01)	(0.05)			(0.03)	(0.05)	(0.02)
WethUsePast	2.07*	6.32*	3.62				
	(1.20)	(3.64)	(3.14)				
FarmExp	0.08*	0.07		0.16	-0.12*	-0.32**	0.37**
	(0.04)	(0.09)		(0.12)	(0.07)	(0.13)	(0.17)
FarmDec	0.84	-8.72		-2.66		11.77***	-10.96**
	(1.05)	(7.36)		(2.86)		(4.08)	(4.54)
Rainfed	-1.50*		-4.61	-2.70			-5.80*
	(0.80)		(2.99)	(2.13)			(3.23)
C_totalarea	-2.51***	-1.14	-2.44	1.17			-14.06***
	(0.75)	(0.89)	(2.38)	(1.26)			(4.67)
Primaryocchoh	-2.45**	2.93	-8.07	1.81	-2.76	8.07**	
	(1.22)	(3.85)	(5.63)	(1.50)	(2.41)	(2.85)	
Secondaryocchoh	-2.09*				2.58*		
	(1.10)				(1.51)		
Internet	1.90	-4.50	-3.83	2.94	6.57**		3.11
	(1.46)	(3.12)	(3.01)	(1.93)	(2.82)		(3.06)
Electricity	-9.79	3.52	-5.31		-6.37		
	(8.50)	(2.31)	(3.97)		(4.20)		
Borrowedyn	-1.58		7.82*				-5.61**
	(1.06)		(4.66)				(2.54)
Pctonfarmincome	0.03*						0.13**
	(0.02)						(0.06)
Extvisits	-0.09				0.26	0.99**	0.25
	(0.11)				(0.30)	(0.35)	(0.31)
Inputcoop	2.59**			-1.29		-5.02*	
	(1.24)			(1.47)		(2.82)	
Agehoh	-0.06	-0.28	0.22*	-0.09	0.22**	-0.19**	-0.44*
	(0.04)	(0.20)	(0.12)	(0.08)	(0.09)	(0.06)	(0.24)
Hhsize	0.33**	-0.56				-0.25	3.16***
	(0.16)	(0.55)				(0.33)	(1.04)
farmarea_numplots	1.76**	1.75		-2.07	1.79	-8.58**	3.53
	(0.87)	(2.23)		(2.58)	(1.13)	(3.55)	(2.25)
farm_selldist	-0.11	0.44	-2.68**		-0.62**	0.90***	
	(0.09)	(0.38)	(1.08)		(0.26)	(0.29)	
Getext	-2.25*					-6.18**	
	(1.24)					(2.77)	
Outputcoop	0.82			2.44			
	(1.06)			(3.03)			
farm_selltime		-4.01	10.79**	2.34	4.69**	-5.90***	
		(2.49)	(4.99)	(2.05)	(1.94)	(1.93)	
Farmadultmales		2.34		-0.96	-1.18*		-3.61**
		(1.70)		(0.78)	(0.62)		(1.53)
Educhoh		0.55*	0.99*		0.82***	-0.47***	-0.76
		(0.30)	(0.55)		(0.24)	(0.16)	(0.51)
Genderhoh		3.86	-5.74			14.89***	
		(2.87)	(4.48)			(3.32)	
Maize_havest			-2.29				
			(1.68)				
WethAnnounce			4.00		-2.61	-4.79**	-6.64**
			(2.91)		(1.54)	(1.95)	(3.09)
Potato_havest				-0.15			
				(0.11)			
Farmadultfemales				-0.92	1.09	3.21**	-3.12**
				(0.79)	(0.85)	(1.26)	(1.35)
Constant	11.16	9.58	5.98	9.73	-5.75	13.01*	25.53
	(9.50)	(15.26)	(8.60)	(6.49)	(7.58)	(6.37)	(15.90)
Observations	168	110	90	99	45	37	44
R-squared	0.32	0.20	0.31	0.09	0.62	0.81	0.54

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Discussion

Rice, wheat and maize were found the major cereal crops. Besides cereals, potato, lentils, mustards and cabbages were found the most commonly grown crops. MoALD (2018) listed rice, wheat, maize, millet, barley and buckwheat as the major cereal crops (MoALD, 2016/17).

Joshi et al (2011) and Poudel and Shaw (2016) considered rice, wheat, maize, millet and barley as the major cereal crops (Joshi, Maharjan, & Piya, 2011; Poudel & Shaw, 2016). Regarding potato, MoALD categories it into cash crops, however, Joshi et al (2011) grouped it into cereal basket. Likewise, Maharjan and Khatri-Chhetri (2006) found rice, maize, wheat, millet, barley and pulses as a major crop growing by Nepali farmers (Maharjan & Khatri-Chettri, 2006). This study revealed that for the winter season, wheat, potato and mustard were found the major crops and for the summer season, rice and maize were found the major crop-growing by the Nepali farmers. However, maize and cabbage were found growing in both summer and winter season.

The postharvest loss of rice at the farm level was found 3.24±0.44 percent. In line with this FAO has reported the postharvest loss of 4-22 % in rice (FAO, 1998). Likewise, Boxall and Gillet (1984) found rice 3.3±2.2 percent postharvest loss on (Boxall & Gillett, 1984). Another study found the postharvest losses of rice in China was 7-13 percent (Kumar & Kalita, 2016). However, K.C. (1992) confirmed that the post-harvest loss in cereals was 15-20% in Nepal (KC, 1992). Pradhan and Manandhar (1992) reported the post-harvest loss of 8%, 7.4% and 13% for Mountain, Hills and Terai of Nepal respectively (Pradhan & Manandhar, 1992). Boxall and Gillett (1984) also confirmed altitudinal variation on the post-harvest loss.

The postharvest loss on wheat was found 4.88±1.11 percent. Boxall and Gillett (1984) found a postharvest loss on wheat of 2.4±1.9% in eastern Nepal. Furthermore, the quality of stored wheat was found lower in the hills of Nepal as compared to the plain area (Devkota, Devkota, Acharya, Shrestha, & McDonald, 2018). In Pakistan, the average postharvest loss on wheat is 3.5 percent (Baloch, 1999).

After harvesting, the loss on maize was found 4.00±1.18 percent. However, Paneru et al (1993) reported storage losses of up to 32 percent due to maize weevil (Paneru, Duwadi, Khanal, & Bhandari, 1996). On the other hand, some studies reported 30-35 percent loss on the grain in those ears which are stored in Kuniyo. Likewise, Manandhar and Mainali (2000) reported 7.44 percent losses in maize storage (Manandhar & Mainali, 2000). Another study found a post-harvest loss on maize up to 19.5±12.5 percent due to pests (Paneru, Poudel, & Thapa, 2018). Manandhar et al (2001) reported 40-50 percent losses in maize storage (Manandhar, Ransom, & Rajbhandari, 2001). Bhandari et, al (2015) reported a 10-15 percent loss in maize storage (Bhandari, Achhami, Karki, Bhandari, & Bhandari, 2015).

Postharvest loss on cabbage at farm level was found 4.76±1.55 percent, however, another study found 9 percent on cabbage (Kader & Davis, 2009; Udas, Rai, Khatiwada, Gurung, & Thapa, 2005).

The multiple regression model suggests that socio-economic variables have a smaller influence on the postharvest loss. The R-square value for all cereals was found less than 0.35. For potato, it was just 0.09. This implies that biological, climatic and other factors may have a stronger influence on the postharvest loss. Some other socio-economic variables may have a stronger effect; however, the study has covered all socioeconomic variables generally used for the regression analysis. Nevertheless, the R-square value for crops other than cereals has demonstrated relatively higher values – up to 0.81 for lentil. Furthermore, in the multiple regression model for lentil, cabbage and rice, 14, 12 and 11 explanatory variables were found significant respectively. On the other hand, in the regression model for potato, none of the independent variables was found significant.

The majority of the variables did not produce a consistent relationship with the postharvest loss on various crops. In one crop, the same variable was found contributor for loss and in another crop, the same variable was found as a contributor to the reduction of postharvest loss. Nevertheless, some of the explanatory variables have produced a consistent result for all crops. The use of weather information announced, number of a male family member in the farming, having access to extension services, total area and having exclusively rainfed farming were found a strong contributor to the reduction of postharvest loss in all selected crops.

Conclusion

Agriculture is facing an unprecedented challenge to feed peoples inhabiting the world. More importantly, the pressure on agriculture is ever increasing. At current statistics, around one billion people are in hunger and by 2050 the population in the world is expected to become 9.7 billion. Furthermore, climate change is exerting pressure on agriculture – mainly due to change in precipitation pattern, temperature, drought and other climate-induced disasters. However, production alone might not a single issue because it is estimated that around one-third of all food produced globally is never consumed which is a misuse of the scarce natural resources along with the labour. Developing countries have more issue on the post-harvest loss. However, an appropriate level of attention was not found regarding food loss and waste. Therefore, postharvest loss at the farm level has been estimated for rice, wheat, maize, potato, mustard, cabbage and lentils, which was found the major crops grown by the farmers. The average postharvest loss for those crops were found around 5 percent. Furthermore, multiple regression model suggested that the postharvest loss for those crops can be explained by various socio-economic variables. However, the level of explanation was found widely different from one crop to another. Therefore, careful selection of variables is very important. Moreover, food loss should be addressed from technological, cultural and behavioral and policy solutions which make the agriculture system more sustainable and improve the food security situation. The study concluded that existing postharvest loss can be reduced through effective agriculture extension service and by providing timely and reliable weather information to the farmers. Moreover, increasing farm size may also reduce postharvest loss, which could be achieved through land consolidation.

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