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Farmers' Perception of Loss in Post–harvest of Rice Yield in Cambodia

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Upgraded post–harvest technology has recently been diffused to farmers in Cambodia in order to increase rice yield production and farmers' economic foundation. However, traditional method is predominantly practiced by rice producers even though it could be inefficient, resulting in loss of rice yield through grain shattering during harvesting, insect storage pest infestation or rodent damage. In light of these problems, the aim of this paper is to identify farmers' perception of loss and to estimate the relationship between the perceptions and socio–economic characteristics. A total of 200 rice farmers were selected from Kampot province in which the sources of loss were validated by the farmers rating 5 points of the Likert scale. Data undertaken from August to September 2014 were analyzed by using descriptive and regression analysis. The descriptive analysis, the finding ascertained that the farmers perceived rodent attacks as the most serious contributor to loss resulting from freely open rice granaries whereas rice loss by spoilage and contamination during storage was perceived by household heads as the least serious contributor because the stored rice that was dried properly was not aggregately favorable for insect growth. Hence, we strongly recommend that rice farmers should consider enhancing their rice granaries, especially grains should be dried properly before storage. The regression analysis, found that age, gender, number of family members, training access, credit access, and rice income were significantly associated with the perceptions. Interestingly, training access and rice income positively influenced the perceptions. Thus, we suggest that policy makers should provide training about post–harvest technology, including rodent protection and harvesting techniques to farmers to improve rice quality and income generation. Finally, farmers should cooperate with neighbors in the same community to treat rodents together, which is an efficient method for post–harvest loss reduction.

Key words: Cambodia, Loss, Perception, Post–harvest, Rice yield

INTRODUCTION

Cambodia is an agrarian country where just over 80 percent of total rural populations depend mainly upon the agricultural sector for economic foundation, domestic animal rearing, and self–food consumption. Therefore, growing in agricultural production, especially rice production employs a critical role for eradicating extreme poverty and striving hunger reduction in the country. However, rice yield remains relatively lower among other neighboring countries, for example, Vietnam where rice yield produced for commercials is upward overwhelmingly 4.89 tons per hectare since 2008 while Cambodia may have produced only 2.54 tons per hectares at the same period, in terms of rice post–harvest technology that have been using for rice production is a modern up–gradation, especially Vietnamese rice farmers have dominantly adopted an innovative agricultural technique and post–harvest technology diffusion. In contrast, Cambodian farmers in some local regions have not adopted the introduced post–harvest technology yet (Bingxin, 2009).

The lower rice yield, indicotes that post–harvest losses of rice crops being induced are significant. To tackle this problem, the newly agricultural post–harvest technology that is a highly mechanized and efficient tool has widely been inserted into Cambodia since 2004 by the Royal Government of the third mandate in order to stimulate rice yield production and farmers' income generation (MAFF, 2006). However, most of Cambodian farmers, who predominantly produce rice for consumption and commercial market, have continuously utilized traditional post–harvest method even though it is believed that the method is applicably ineffective and triggers systematically in post–harvest losses (Desilva, Johnston and Sellamuttu, 2014). Related to this consequence, it is estimated that yield losses occurring are being struggled by the farmers during post–harvest operation because of capital shortage, less accessory information, socio–economic constraints, and traditional attributes.

Furthermore, post–harvest loss of the rice industry in Cambodia is perceived to be noticeably high and variable as most of rural farmers lacked of facilities and expertise for efficient post–harvest operation. Through regional estimates of the total grain losses amount to 37%, the losses from harvest to storage, ranged from 20% to 50%, and followed by grain milling 30%, remarkably (Desilva, Johnston and Sellamuttu, 2014). Additionally, due to applying the traditional method, there have mainly emerged issues affected farmers in post–harvest loss of rice. As an instance, a traditional rice variety produced by farmers appears to be lost hugely during harvesting if compared to a new rice breeding variety because of insect outbreaks, especially brown–plant hoppers that

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frequently occur in wet seasonal rice (Matsukawa *et al.*, 2014). Simultaneously, owing to numerous threats of post–harvest loss, farmers have currently perceived that rodent damage as a big problem for grain losses not only quality loss but also quantity loss during storage stage (Chusak, 2010). Furthermore, the traditional post–harvest techniques have been carried out by rice farmers, especially poor and small–scale farmers keeping practices including hand–harvesting, wooden threshing, wind winnowing, sun–drying and bamboo or wooden granaries storage, lead to post–harvest loss in respective stages including harvesting (3%), handling (3.6%), threshing (1.6%), drying (2%), storage (10.7%), and milling (14.7%) (Kann *et al*., 2008).

As recent years, there have been few findings related to perceived sources of post–harvest losses resulting from grain shattering during the over–ripened stage, grain breaking due to over–loading, grain scattering in threshing, bird invasion, insect storage pest infestation, especially rodent storage damage through weight loss, and growth of pathogenic microorganism (fungus and bacteria), which are regarded as more influential (Genova *et al*., 2006). Moreover, according to Yonas *et al*. (2010) has found that post–harvest loss induced by rodent deterioration is considered as a major problem leading to pest infestation during grain storage. Through these sources of loss, rice farmers may have widely dealt with yield loss not only quality loss but also quantity loss, especially economic loss that appears to be more impressive concern and fundamental constraints for rice production.

Therefore, the main objective of this study is to identify farmers' perception of loss in post–harvest of rice yields and to estimate the relationship between the perceptions and socio–economic characteristics of household heads.

METHODOLOGY

Data collection

A cross–sectional data for this survey were conducted in Kampot province, where is stretched in the south–west part of Cambodia, and where is generally realized as being main–rice–producing region. According to MAFF (2012), the total farmland in the province being produced crops by farmers, is totally 129,000 hectares which is divided into land for both seasonal rice land, wet seasonal rice and dry seasonal rice, separately. Furthermore, approximately 95% of the total provincial populations mainly occupy rice production as the main occupation for their livelihood challenges and most of the rice farmers have constantly applied the traditional post–harvest method during rice post–harvest operation.

Take into account for this, the pre–survey test was performed to generate the appropriate questions and to establish its reliability, and also the randomized sampling designs were generated for the ultimate selection of rice growing farmers residing in Bontey Meas district of the province. In this study, a total 200 of rice farmers, who cultivated rice in three villages (Samrong, Domnaktroyeng and Senponloung) from the aforementioned district, was randomly selected for face–to–face interviews by using the semi–structured questionnaire that was launched from August to September, 2014.

Modelling approach

Specifically, data for this survey were gathered by the administration of a two–section approach. The first approach, which was concentrated on the farmers' perception of loss in post–harvest of rice yield, constituted 14 sources of loss. Meanwhile, the farmers' perceptions of loss were evaluated by 5 points of the Likert–scale that requested responses on a scale from 1 (no loss) to 5 (extremely high loss). Scores of scale were assigned to each source of loss, while ascertaining that the mean and the standard deviation of the empirical descriptive analysis were followed by disseminating the level of loss. Apparently, if a respondent assessed the maximum rating of 5 (extremely high loss); the perception of loss was assumed to be the highest level of perceived sources of loss whereas the minimum rating 1 (no loss) was accounted for the lowest perception.

The second approach, the multiple linear regression analysis was applied to estimate the relation between the perceptions and socio–economic characteristics; therefore, the designed questionnaire comprised questions that focused on the respondents' socio–economic characteristics. The socio–economic characteristics were represented as independent variables included age, gender, education level, main occupation, number of family member, family labor, training access, extension service, credit access, and rice income. Adhering to the perceptions, principal component analysis (PCA) was consumed to the perceived sources of loss, and undertaken to identify which sources of loss may be important as dependent variables in subsequent analysis regressing with the socio–economic characteristics. Before caring for regression analysis, principal component analysis (PCA) that was a popular–processing and dimension–reduction technique was measured by 5 points of the Likert–Scale. Consequently, the regression model was explored to estimate the relationship between the perceptions and socio–economic characteristic as illustrated in the following formula:

$$Y_1 = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k x_{ki} + e_i$$

Where Y_i is the perception of loss consisted of the component score in PCA, β_0 is the constant term; β_1 to β_k are the coefficients relating the K independent variables to the variables of interest; x_i is the independent variables that belonged to socio–economic characteristics of respondents, and e_i is the error term. Nevertheless, regardless of whether the model was fit or not, the coefficient determination R^2–value of the goodness–of–fit of the estimated regression was denoted as giving the proportion or percentage of the total variation in the dependent variables, which was depicted by the independent variables and ranked from 0.0 to 1.0 with higher

values indicating better fitness of the model. The coefficient determination was limited in that value increased with increasing numbers of independent variables in K; this was adjusted and called as adjusted R^2. Thus, the indices could be measured the optimums of the models in estimating the perception of loss as the values should be closed to 1.0 for the most optimum prediction methods (Gujarati and Handelshoyskolen, 2011).

RESULTS AND DISCUSSIONS

A result of socio–economic characteristic of household head

The descriptive statistic result of socio–economic characteristics of household head is ascertained in Table 1. The result delineates that the average age of household head was just almost 50 years, most of whom had experienced and engaged in rice production on average just nearly 30 years. Mainly, there were 93% of household heads working in rice production; and about 73% were males whilst another 27% were females. Moreover, 36.5% of household heads used family labor whereas another 63.5% hired labors. On average, most of household heads graduated in junior high school almost at 6 years; and only about 20% who received the training, while another 80% did not access the training. Similarly, around 37% of household heads accessed extension services. At least 24% of household heads accessed credit coping with an average of land size nearly over 1.0 ha. Additionally, rice production that cultivated in the study areas is considered as a small–scale or traditional rice production by providing an average rice yield of 2.45 ton/ha due to the small land size that mostly produces rice for self–consumption rather selling (Maltsoglou, Dawe and Tasciotti, 2010). In terms of rice production, household heads might receive the average rice income of 415.64 $USD.

Identifying farmers' perception of loss

Table 2 illustrates the descriptive statistics of sources of loss. The result corroborates that the household heads perceived rice grains devastated by rodents as the highest loss (4.04), with standard deviation (0.92) is smaller than 1.0 with indicating that the perception is high consensus (Meuwissen, Huirne and Hardaker, 2001), due to the freely open stored rice granaries and long–term storage before catering for markets. This corresponds to the prior finding of Yonas *et al*. (2010), showing that rice farmers in Northern Ethiopia perceived rodent attacks as the most serious pest storage loss. Due to the actual physical loss, rice grains were found to be devastated in the highest loss by rodents 11.7% during the stored rice per year and also lost a 117 kg in 1,000 kg of the stored rice (Brown, McWilliam and Khamphoukeo, 2013). However, farmers in Africa perceived rice loss in the storage stage that mostly was devastated by rodents as the least serious contributor to loss (Appiah, Guisse and Dartey, 2011). This implies that rice grains were stored safely in jute–bags and sealed bags in terms of proper covering that do not allow rodents to go inside granaries for attacking easily, which is commensurate with the earlier finding of (Bishaw, Struik and Van Gastel, 2011). Whereas opposite to the study sites, rice farmers stored rice in traditional storage structure such as wooden or bamboo granaries as an open granaries, which easily suffers from rodent attacks.

However, interestingly household heads perceived rice loss by spoilage and contamination in storage as the least serious due to the mean of 1.66 and standard deviation of 0.83. This means that they are likely to work and maintain rice carefully by indicating that rice grains may be dried properly before storage which is an efficient and safe way to avoid triggering the emergence of rice insects and rice spoilage. This finding is not consistent with an earlier study of Mendesil *et al*. (2007), corrobo-

Table 1. Socio–economic characteristics of household head

Variables	Description	Unit	Mean	Std. Dev.	Min	Max
Age	Household head' age	Year	49.82	12.69	22	78
Gender	(1=Male, 0=Female)	Dummy	0.73	0.44	0	1
Education level	Years of education of household head	Year	6.01	3.03	0	16
Occupation	(1=Rice production; 0=Other)	Dummy	0.93	0.24	0	1
Experience	Years of experience in rice production	Year	29.88	13.26	4	60
No. family members	Numbers of family members	Number	5.07	1.89	2	15
Family labor	(1=Family labor; 0=Other)	Dummy	0.36	0.48	0	1
Training access	(1=Training; 0=Other)	Dummy	0.2	0.40	0	1
Extension service	(1=Access extension; 0=Other)	Dummy	0.37	0.48	0	1
Credit access	(1=Access credit; 0=Other)	Dummy	0.24	0.43	0	1
Rice land size	Total rice land size	Hectare	1.04	0.61	0.15	3
Rice yield	Total rice yield	Ton/ha	2.53	1.48	0.4	8.5
Rice income	Net rice income from rice selling	$USD	415.64	302.33	22.5	1582.5

Source: Self–survey (2014), Sample size: 200
Note: The exchange ratio: 1 $USD = 4,000 Riels (Cambodian National bank, September 20th, 2014)

Table 2. Descriptive statistics of sources of loss

Source of loss	Mean	Std. Dev.	Min	Max
Rodent attacks	4.04	0.92	2	5
Using traditional seed varieties	3.92	1.02	1	5
Weight loss in sun–drying	3.70	1.01	1	5
Leaving over–ripened rice	2.58	0.68	1	4
Weather damage	2.37	0.65	1	4
Less packaging	2.16	0.44	1	4
Poor seed separation	2.07	0.36	1	3
Grain scattering	2.04	0.64	1	4
Keeping stacks in field	2.03	0.42	1	4
Poorly threshed rice	2.01	0.38	1	4
Insect attacks	2.01	0.55	1	4
Grain spilling	1.99	0.53	1	4
Bird attacks	1.87	0.63	1	4
Grain spoilage and contamination	1.66	0.83	1	5

Source: Self–survey (2014), Sample size: 200
Note: Five points of Likert–scale are used from 1 (no loss) to 5 (extremely high loss), respectively

rating that farmers in Southwestern Ethiopia stored grains in sacks and bamboo containers perceived grain spoilage by insect infestation as more serious caused in yield loss. This would be resulted from improper drying as remaining more moisture content in the stored grain, which is aggregately favorable for growing insects and mold spoilage. In contrast, rice farmers in the study sites might dry rice enough and also the granaries appear to be clean well before storage. Therefore, rice farmers should dry rice properly before storage as it is really important that rice can be enhanced its shelf–life and quality.

Perceived sources of loss by principal component analysis (PCA)

Table 3 shows the component loading matrix of

Table 3. Component loading matrix of sources of loss

Sources of loss	The most important components					
	1	2	3	4	5	6
Leaving over–ripened rice	–0.04	**0.63**	0.04	0.09	–0.03	–0.10
Keeping stalks in field	–0.11	0.33	**0.48**	0.06	–0.04	–0.27
Birds attacks	**0.45**	0.01	–0.17	0.16	–0.12	0.10
Weather damage	0.28	0.13	–0.11	0.02	**0.61**	–0.09
Using traditional seed varieties	–0.30	–0.02	0.14	0.38	0.24	0.31
Less packaging	0.07	–0.07	0.00	**0.66**	–0.11	–0.18
Grain scattering	**0.52**	0.07	0.02	–0.01	0.09	0.04
Poorly threshed rice	0.02	–0.03	**0.69**	–0.02	0.03	0.09
Poor seed separation	0.23	–0.08	0.27	0.35	–0.03	0.24
Grain spilling	**0.47**	–0.07	0.17	–0.02	0.05	–0.10
Weight loss in sun–drying	0.00	0.03	0.00	–0.06	–0.05	**0.79**
Grain spoilage and contamination	0.09	**0.61**	–0.04	–0.17	0.01	0.22
Rodent attacks	–0.13	–0.10	0.07	–0.06	**0.70**	0.00
Insect attacks	–0.12	0.22	–0.32	**0.44**	0.11	0.03
Eigen value ≥1	2.37	1.46	1.32	1.17	1.10	1.07
Cumulative percent of variance explained (%)	14.33	24.94	34.2	43.2	52.22	60.73

Source: Self–survey (2014), Sample size: 200
Note 1). Loadings of component ≥ |0.4| are in bold
2). Components (1–6) needed to be represented for dependent variables may not be labeled

sources of loss. The total variance explained account for 60.73% is satisfactory in which the test of sample adequacy KMO (Keiser–Meyer–Olkin) is 0.60, implying that overall variables accepted by principal component analysis (PCA) are mediocre (Hair *et al*., 2010). As a result, basing on this analysis, there were mainly six extracted components constituting the Eigen values and loading component scores larger than 1.0 and 0.4, respectively, needed to be grouped and labeled. However, these components that represented the dependent variables are extremely intricate for labeling due to inverse meaning and small numbers of variables even though each component consists of a higher loading score of more than 0.4. Hence, applying the principal component analysis (PCA) may not be suitable for this regression due to the fact that labelling on each component is impossible and inconsistent regardless of the fact that labeling the component depends on the feeling of researchers that have different backgrounds. For this reason, the process of labeling is under considerable criticism (Hair *et al*., 2010). As a result, responding to this issue, the sources of loss perceived by respondents as a ranked score (i.e extremely high loss, at least a high loss, at least a medium loss etc.) were essentially consumed as dependent variables due to the perception of respondent provided and validated by scoring is higher and personally more confident and independent among other sources (Gloy, Akridge and Whipker, 2000).

Estimating the relationship between the perceptions and socio–economic characteristics

The results of relationship between the farmers' perception of loss and socio–economic characteristics are ascertained in Table 3. Regarding to the regression analysis, the adjusted R^2–value of the goodness–of fit model in each equation was noticeably low due to the naturally cross–sectional data with diverse observations (Gujarati and Handelshoyskolen, 2011), and simultaneously the perceptions of loss validated by rice farmers were very person–specific (Asai *et al*., 2014).

As can be certainly seen that age was negatively associated with using traditional seed varieties and weight loss in sun–drying, respectively, with suggesting that if age increases, especially old household heads believed that yield loss by using traditional seed varieties and weight loss in sun–drying as less serious than younger household heads. Meanwhile, older household heads are more likely to reduce yield loss efficiently during rice harvesting and drying because of having more experience and efficient working. This finding is inconsistent with a previous finding, illustrated that the perspective of older farmers growing rice in Bangladesh rated cultivating traditional rice varieties as more risks in yield loss than modern rice varieties (Sall, Norman and Featherstone, 2000). This suggests that older farmers may be difficult to manage and harvest traditional rice efficiently, and therefore, they seem to be ambitious in searching for new technology by shifting traditional method into modern method in rice production. However, older rice farmers in the present study areas are likely to prefer the traditional method including growing traditional rice or drying rice by sun–drying allowing them to believe that those practices are certainly simple and normal due to the long–term experience in practices. Hence, we can conclude that older farmers maintaining the traditional practices in the long–term run or less adopting to a new technology yet, may feel less concern in yield loss from these practices. Similarly, it is possibly concluded that farmers are less likely to be impressive on new method practices even though this practice is spread into their areas due to the fact that those who attempt to believe that the practice is more risky (Tatlıdil, Boz and Tatlidil, 2009).

Moreover, gender was negatively associated with loss from leaving over–ripened rice in the fields, implying that male household heads perceived rice loss by leaving over–ripened rice as less serious than female household heads, due to the fact that the male household heads appear to harvest rice timely without leaving rice over–ripened at paddy fields because of having properly manpower labor and also getting assistance from their children or wives during harvesting, whereas female household heads obviously are widowers or divorced, who lack of helpers in harvesting that could not help harvest rice efficiently. This finding also corresponds to the aforementioned research of Djokoto and Blackie (2014), disseminating that the perception of male farmers in harvesting loss was reduced because of male farmers having more experience engage in rice production than females.

In addition, the number of family members was negatively associated with weight loss in sun–drying. This shows that household heads who had more family members regarded rice loss by weight loss in sun–drying as less serious. Meanwhile, having more family members was an indicator as main labor in rice production due to the assistance in working for rice drying courteously. This is consistent with the earlier finding of Naivinit *et al*. (2010) and Rugumamu (2011) who delineated that the increasing of family members being more efficient in rice drying, Northern Thailand and Eastern Tanzania, influenced the perception of drying loss as less relevant. Therefore, this suggests that family labors can be employed a critical role in post–harvest loss reduction in terms of proper helping and efficient working.

Training access was positively associated with leaving over–ripened rice and weather damage, separately, ascertaining that household heads who had training identified leaving over–ripened rice, and weather damage as more serious than other sources of loss. This means that the household heads are more likely to be aware that if rice was leaving over–ripened during harvesting; it would be faced with a huge yield loss because of rice shattering easily that affected by strong wind and raining. However, it reveals that the household heads who did not have training seem to be less impressive concerns about such loss, even though there have ripened rice or bad weather. Meanwhile, the household heads are likely to believe that those events incur normally during rice harvesting. This is a consistent with an ear-

lier finding of Manzanilla *et al*. (2011), indicating that the perception of farmers, who had training in breeding rice varieties (Sub1) in Southeast Asia, perceived weather loss as more serious than bird attacks affecting on harvesting stage.

Credit access was negatively associated with weather damage, which suggests that household heads, who accessed credit, perceived weather damage as less serious than household heads who did not access the credit. This shows that if household heads accessed credit, they seemed to invest rice production efficiently because of timely rice harvesting without leaving ripening rice becomes over–ripening at the paddy field. This is also due to the fact that the household heads could hire labors for helping in harvesting properly, whereas household heads who did not access credit, were likely to delay harvesting during the peak of ripening rice in terms of lack of helpers, especially capital shortage for hiring labor. Our finding is in line with the previous study convincing that rice farmers, who accessed credit from local traders, felt less impressive concern in weather loss as timely harvesting and selling direct their rice harvest to local traders (Totin *et al*., 2015).

Rice income was positively significant with rodent attack and leaving over–ripened rice, suggesting that household heads who increased rice income perceived rodent attacks and leaving over–ripened rice as more serious contributor to loss. This can be concluded that if household heads produce rice for commercial or large–scale rice production, they may have felt more concern about rice quality loss and quantity loss, especially rice loss by rodent attacks during rice storage, which would be a big major issue leading to be difficult in treating as reported already in Table 2. This finding is not dissimilar from the previous finding of Simelton *et al*. (2009) and Bonora *et al*. (2014), who elaborated that rice farmers that had better economy perceived rodent damage and ripening stages of crop loss as more serious than disease occurred during harvesting stage. Thereby, our finding suggests that rice farmers or rice sellers should generate their rice granaries and find main strategies for rodent treatment.

CONCLUSION AND IMPLICATIONS

Our findings in this study suggest that rice farmers perceive yield loss by rodent attacks as the most serious contributor to loss, so we strongly recommend that the

Table 4. Results of multiple regression analysis of farmers' perception relation to socio–economic characteristics

Variables	Rodent attacks	Using traditional seed varieties	Weight loss in Sun–drying	Leaving over–ripened rice	Weather damage
Age	–0.0009	–0.0137**	–0.0128**	0.0022	0.0025
	(–0.17)	(–2.23)	(–2.13)	(0.55)	(0.7)
Gender	0.21	–0.0281	–0.122	–0.189*	0.134
	(1.35)	(–0.16)	(–0.72)	(–1.67)	(1.32)
Education level	–0.0023	–0.0162	–0.0068	–0.0033	0.0080
	(–0.10)	(–0.61)	(–0.26)	(–0.19)	(0.52)
Occupation	–0.205	–0.0116	0.392	–0.121	–0.0962
	(–0.76)	(–0.04)	(1.32)	(–0.61)	(–0.54)
Number of family members	–0.0251	0.0079	–0.0832**	0.0067	–0.0086
	(–0.70)	(0.2)	(–2.13)	(0.26)	(–0.37)
Family labor	0.0426	–0.0079	0.133	0.0441	0.104
	(0.31)	(–0.05)	(0.88)	(0.44)	(1.16)
Training access	–0.0809	0.0878	0.124	0.265**	0.526***
	(–0.45)	(0.44)	(0.64)	(2.05)	(4.54)
Extension service	–0.0226	0.182	–0.147	0.0406	–0.0094
	(–0.16)	(1.17)	(–0.96)	(0.4)	(–0.10)
Credit access	0.0809	–0.191	0.108	–0.0662	–0.221**
	(0.51)	(–1.09)	(0.63)	(–0.58)	(–2.15)
Rice income	0.0005**	0.0003	0.0001	0.0004**	0.0002
	(2.35)	(1.14)	(0.33)	(2.52)	(1.5)
_cons	4.017***	4.530***	4.447***	2.458***	2.053***
	(8.41)	(8.54)	(8.55)	(7.09)	(6.62)
R^2_{adj}	0.0503	0.0521	0.0703	0.102	0.199

Source: Self–survey (2014), Sample size: 200

Note: (t) statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01

strategy of rodent management and appropriate granaries structure should be introduced to the farmers. However, farmers perceive yield loss by spoilage and contamination as the least serious contributor to loss due to the proper drying before rice storage. Hence, rice grains should be dried properly because of rice quality improvement and rice self–life extension.

From the results of multiple regressions, we conclude that age, gender, number of family member, training access, credit access, and rice income, have significantly associated with the perception of loss. Interestingly, training access and rice income have positively influenced the perceptions. As a result, we firmly suggest that government policy, policy–makers, and involved non–government organizations (NGOs) should offer training program about post–harvest management which mainly focuses on a timely harvesting technique, especially rodent attack prevention through agricultural extension staff to the local rice farmers and rice traders desiring the necessary knowledge and skills for rice quality enhancement and income boosting.

In addition, we also highly suggest that rice farmers who obtained training should cooperate with neighbors in the same community to treat rodents together, especially during the peak of reproductive rodents that generally occur in the pre–and post–harvest season. Endingly, farmers' cooperative which is helpful in rice production networks between rice farmers and rice traders should be established and supported firmly by providing incentives and post–harvest techniques. Meanwhile, rice traders should have introduced new technologies to farmers including rice storage facilities so that enable farmers to read technology adoption efficiently, and therefore the desirable grain quality will be achieved for the pressing market demands.

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