

## **COST BENEFIT ANALYSIS OF USING COLD STORAGE FACILITIES: EVIDENCE FROM ONION FARMERS IN BONGABON AND SAN JOSE CITY, NUEVA ECIJA, PHILIPPINES**

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### **ABSTRACT**

The use of cold storage facility presents an opportunity for small-scale onion farmers to augment their net income by taking advantage of intertemporal price arbitrage. The study examines the economic benefits and costs of cold storage activity among onion farmers and identifies the factors associated with its use in Bongabon and San Jose City, Nueva Ecija, Philippines. A survey of 214 farmers from the top three onion-producing villages of Bongabon and San Jose City was conducted in 2024. Descriptive analysis, comparison of median and proportion, partial budget analysis and binary logit analysis were employed. In 2023, cold storage activity generated an average additional net income of USD 3,376.48 and provided off-farm employment opportunities for the rural population. However, participation remains to be low due to the predominantly small hold farming, reliance on trader-financier and high upfront storage cost. To encourage storage participation, the Department of Agriculture can consider bundling the provision of cold storage facilities operated by cooperatives followed by intensive training on proper storage techniques since results show that cooperative membership and training are related positively with onion cold storage. Given the design and implementation efforts to scale up cold storage for onion, the willingness to pay of farmers should be taken into consideration to guide operators of cold storage in estimating charges for the use of the facility.

**Key words:** choice model, onion marketing, postharvest management, price arbitrage, storage cost

### **INTRODUCTION**

The Philippine onion industry has been expanding with its supply growing by 7.49% from 2010 to 2022. The most common varieties grown are Red Creole and Yellow Granex onion which combines for 77.00% of the domestic supply. Their volume of production increased by 10.68% and area expanded by 4.57% annually (PSA 2023). While production growth has been remarkable amidst occurrence of destructive onion armyworm, it will only become significant if the onion reaches the consumer at reasonable price. Thus, efforts should be made both at production and postharvest stages since losses at any of these stages affect the net food available (Choudhury 2006). In the Philippines, the estimated postharvest loss for onion is 31.49% and the bulk of the loss comes from storage (Calica and Cabanayan 2018). In the interest of abating postharvest losses, the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) suggested the establishment of village-level storage facilities.

As a response, the government has been allocating funds under the High Value Crops Development Program (HVCDP) for the construction of cold storage facilities and this development is slowly changing the landscape of postharvest infrastructure in the Philippines. In 2019, there were 14 cold storage facilities in Nueva Ecija with a capacity of 2.42 million bags of onion (SEARCA 2022). Since 2022, at least four cooperatives situated within the province have received cold storage facilities under state funding in the province of Nueva Ecija<sup>1</sup> (Department of Agriculture Philippine Rural Development Project 2023; PNA 2023). This is a stark contrast to the previous situation wherein cold storage facilities are dominated by private institutions and only one cooperative, *Katipunan at Samahan ng Magsisibuyas ng Nueva Ecija* (KASAMNE), owns two establishments and are in operation since the 1990s.

Storage activity is driven by price arbitrage and food security motive (Renkow 1990; Saha and Stroud 1994). For instance, maize farmers in Uganda predominantly store for consumption in the lean period and only 17% is sold after storage (Omotilewa et al. 2019). On the other hand, potato farmers in India store potato because they expect the price to increase after harvest season (Minten et al. 2014). The price arbitrage motive is more pronounced for cash crops while the food security motive is observed in food staples. Since onion is considered as a cash crop, farmers are assumed to be motivated by exploiting intertemporal price arbitrage. Onion is highly seasonal and is planted after rice is harvested in the wet season. Based on seasonal indices<sup>2</sup>, the farmgate price of onion in the Philippines during the peak harvest month of March is 39.35% lower than the average monthly price and 46.82% higher during December when supply is lean. To examine if the price premium is realized, this study examines the economic benefit of using the cold storage facility. Onion farmers who store at the cold storage facility paid explicit costs including cold storage fee and additional costs related to storage such as re-sorting, repacking and transfer of onion, and the opportunity cost of cold storage activity. Whether they earn or not from their storage activity is an empirical question, hence economic benefits and costs associated with its performance were estimated.

Despite the potential economic benefits from using cold storage, farmers are also hindered by transaction costs and risk aversion (Gitonga et al. 2013; Cardell and Michelson 2022). On the other hand, the absence of liquidity constraint as measured by loan provision at harvest time prompted the farmers to sell less and purchased more grains in the period immediately following harvest time (Burke et al. 2018). This is consistent with the results obtained by Stephens and Barrett (2010) suggesting that farmers with access to credit and off-farm income reduced the likelihood of them selling during the harvest period. Farmers with more land area and more quantity sold also have better chances to use cold storage (Minten et al. 2014). Moreover, cooperative membership and training related to improved storage technology increased their likelihood of adoption (Alemu et al. 2021; Bokusheva et al. 2012). Given that cold storage facilities were provided to farmer groups, this study attempts to further understand the storage behavior of farmers by examining the factors associated with the use of cold storage facility by onion farmers in Bongabon and San Jose City, Nueva Ecija, Philippines. These municipalities are major growing areas for onion in the country.

## **RESEARCH METHODOLOGY**

**Sampling procedure.** The municipality of Bongabon and San Jose City in Nueva Ecija were purposively selected since these have the greatest volume of production in both Red Creole and Yellow Granex onion varieties and each has one cold storage facility provided by the Department of Agriculture. The top three producing villages in each area were also purposively selected with each

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<sup>1</sup> Nueva Ecija is a province in Central Luzon and is the major contributor (58.5%) of the domestic supply of onion in the Philippines.

<sup>2</sup> Farmgate price was obtained from PSA (2023) and seasonal indices were calculated by the author.

village regarded as stratum. Since there is a considerable variation in the population of farmers across strata, stratified random sampling with proportional allocation was employed.

Assuming a 50% proportion of farmers who are using the cold storage facility, a confidence level set at 95% and a margin of error at 5%, the computed sample size was 274 which exceeds 5% of the population (i.e.,  $N=946$ ). Hence, Cochran's sample size correction formula was used (Bartlett et al. 2001) to arrive at the sample size of 213 but the survey was for 214 respondents. The pre-test of questionnaire followed by the training of enumerators were conducted in December 2023. The survey was conducted from January to February 2024.

**Data collection.** Data on the socio-economic and farm characteristics of onion farmers were collected to model storage behavior in 2023. Socio-economic characteristics include sex, age, years of formal education, years of farming experience, membership to any farmer-based organization, access to off-farm income, attendance to training on postharvest management practices, and absence of liquidity constraint. Off-farm income includes agricultural wages, non-agricultural wages, and self-employed income. Farmers were also classified whether they engage in tied output-credit market and whether they participate in onion trading.

The absence of liquidity constraint was measured in two ways. Aside from access to formal credit, the status of credit constraint in the formal sector was also obtained using the elicitation method of Boucher et al. (2006). The line of questioning starts with whether the farmer respondent borrowed in the 2023 calendar year. If the respondent did not apply for a formal loan, the reason was asked. If the farmer stated that it was not necessary, interest rate is too high, onion farming does not generate enough to pay for loan, or prefers working with own liquidity, then the farmer is classified as credit unconstrained. If the farmer did not apply either because of the lack of collateral or the lack of access to credit source, the farmer is classified as quantity rationed. Transaction cost constrained farmers are those who either do not know where to apply for a loan, opt not to apply because of the number of requirements, do not have a bank account, or not a member of any financial institution. Risk rationed farmers are those who expressed fear losing collateral, fear of being rejected, or do not like the feeling of being indebted. While they are specifically categorized, they fall into a broader term referred to as credit constrained. On the other hand, if the respondent borrowed, the follow-up question was whether the farmer received the desired amount of credit. If the farmer received an amount lower than the desired amount, the farmer is classified as quantity rationed. Otherwise, an additional question is asked whether the farmer would have wanted a greater amount of loan given the same interest rate. If the answer is yes, the farmer was asked why the greater amount wanted was not actually applied. If the farmer reasoned the lack of collateral, farmer is classified as quantity rationed while risk rationed farmers expressed fear losing collateral or being rejected or do not like the feeling of being indebted. These close-ended questions exactly appeared in the survey instrument.

The level of risk preference was assessed using the hypothetical investment choice elicitation method adopted from Fausti and Gillespie (2000) and is shown in Table 1. Given a hypothetical investment amount of USD 1,797.58 or PHP 100,000, farmers were asked to choose from five crops with varying degrees of possible low, average and high returns. Respondents who choose Crop 1 is assured of a return worth USD 179.76 or PHP 10,000 and is considered as highly risk averse. On the other extreme end, Crop 5 yields the highest possible return and the lowest possible return and is hence considered as highly risk preferring.

On the other hand, farm characteristics include total land area cultivated, total land area owned, and area allocated for onion production. Data on production, marketing, and storage behavior of onion farmers during the harvest and off-season in 2023 were obtained. The peak harvest months are March and April and any onion sold within these months were considered under onion sold immediately after harvest (for conciseness, the phrase is hereinafter referred to as onion sold immediately).

**Table 1.** Level of risk preference using the elicitation method from Fausti and Gillespie (2000)

Crop Choice	Possible Return (PHP)			Coefficient of Absolute Risk Aversion	Level of Risk Preference
	Lowest	Average	Highest		
Crop 1	10,000	10,000	10,000	[0.000317, +∞]	Highly risk averse
Crop 2	8,170	10,600	13,030	[0.000109, 0.000317]	Moderately risk averse
Crop 3	6,420	11,200	15,980	[0, 0.000109]	Risk neutral
Crop 4	5,420	11,200	16,980	[-0.000109, 0]	Moderately risk preferring
Crop 5	3,440	10,600	17,760	[-∞, -0.000109]	Highly risk preferring

With a probability of 1/3 for lowest, average, and highest possible return

Marketable surplus was calculated by deducting the quantity consumed and given away from the total quantity of harvest. Quantity sold was categorized into three: good quality onion sold immediately, marketable rejects sold immediately, and onion sold after cold storage.

**Data analysis.** Descriptive analysis was employed to summarize socioeconomic and farm characteristics, production, marketing, and storage behavior. As a preliminary step in identifying the factors that are associated with cold storage use, comparison of median and proportion was employed using Mann-Whitney U test and chi-square test of independence. The test statistic and p-value were generated by Stata version 18.0.

Partial budget analysis was used to compare a proposed change from a current practice. In this analysis, the status quo is the immediate selling of onion after harvest and the alternative is to sell a portion of the total marketable surplus after cold storage. The partial budget typically has four major components: additional income, reduced cost, reduced income, and additional cost. In this study, however, there were no items under reduced cost. Mathematically,

$$\text{Benefits: AI} = P_{2i}Q_{2i} + P_{3i}Q_{3i} \quad (1)$$

$$\text{Cost: RI} + \text{AC} = P_{1i}Q_{1i} + r_iQ_{1i} \quad (2)$$

$$\text{Difference: } (P_{2i}Q_{2i} + P_{3i}Q_{3i}) - (P_{1i}Q_{1i} + r_iQ_{1i}) \quad (3)$$

As a result of using the cold storage facility, farmer *i* is expected to gain an additional revenue due to a greater selling price of onion after storage denoted by  $P_{2i}$  (USD/bag) at quantity  $Q_{2i}$  (bags) and  $P_{3i}$  at quantity  $Q_{3i}$ . It was observed that farmers gradually release onion at cold storage facility when price is enough to cover their out-of-pocket expenses and some profit. Hence,  $P_{2i}$  denotes the price one to two months after cold storage and  $P_{3i}$  refers to the price three to five months after cold storage. On the other hand, the quantity that must be given up to make way for storage activity is denoted by  $Q_{1i}$  and the price foregone equivalent to the farmgate price of onion at immediate selling is denoted as  $P_{1i}$ . Thus, the reduced income is obtained from the product of  $P_{1i}$  and  $Q_{1i}$ . The loss of moisture content in kilogram was obtained but it was not considered as part of reduced income since the farmers procure and sell onion in bags. Hence, the weight reduction did not affect the income of farmers.

Additional costs represented the total losses in the partial budget. Farmers need to pay for the use of cold storage facility and other postharvest activities associated with storage were also considered and represented by  $r_i$ . This includes re-sorting, repacking, transfer of onion from farm to the cold storage facility. The opportunity cost of capital is also accounted and is measured by the summation of

operational cost multiplied by the monthly interest rate assuming that the money could have been saved and consequently earn interest during the storage period.

Binary logit analysis was employed to determine the factors influencing the use of cold storage facility. This non-linear model is assumed to follow a logistic distribution. Mathematically,

$$Y_i^* = \beta' x_i + \varepsilon_i, Y_i = \begin{cases} 1, & \text{if } Y_i^* > 0 \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

$Y_i^*$  is the latent utility that represents the preference of farmer  $i$  on the use of cold storage facility,  $\beta'$  is the vector of coefficients representing the effect of unit changes in the vector of observable factors,  $x_i$ . Any factor that increases the value of the latent variable means greater likelihood of cold storage use. If the latent variable is greater than zero, a value of  $Y_i = 1$  is observed. The selection of covariates is based on the literature review (Table 2). There were two explanatory variables with two measures, quantity sold and its proxy (i.e., land area for onion), and absence of liquidity constraint measured by access to formal credit and status of credit constraint in the formal sector. Thus, a total of four logit models were estimated and the selection of the most appropriate model was based on the number of explanatory variables that are statistically significant. Interaction terms were also included in model estimation (i.e., the interaction between quantity sold and land area owned, land area for onion and land area owned, and the interaction between price expectation and risk preference. The estimated coefficients, marginal effects, and p-values were generated by Stata version 18.0.

**Table 2.** Description of variables

Variables	Description
Used CSF in 2023	Onion farmer used the cold storage facility (CSF) after the harvest season in 2023
Quantity sold	Quantity of onion sold in 2023 in bags
Land area for onion	Total land area allocated for onion production in hectares
Land area of owned	Total land area owned in hectares
Distance	The distance from the farm to the closest cold storage facility expressed in kilometers
Farm profit in 2022	The profit of farmer from onion production in 2022 expressed in USD
Age	The age of the farmer in years
Farming experience	Number of years in farming
Formal education	Number of years spent in formal education in years
Price expectation (Expect = 1)	The farmer expected the price of onion to increase after the harvest season
Risk preference	Classification of risk preference according to a hypothetical investment choice elicitation method
Cooperative membership (Member = 1)	The farmer is a member of a cooperative
Training (Attend = 1)	The farmer attended a training on postharvest management
Access to formal credit (Access = 1)	Farmer loaned from formal sector in 2023
Status of credit constraint (Unconstrained = 1)	Status of credit constraint in the formal sector using the elicitation method by Boucher et al. (2006)
Access to off-farm income (Access = 1)	Farmer has access to off-farm income

Variables	Description
Participation into trading (Trader = 1)	The farmer also procures onion from other farmers
Municipality (Bongabon = 1)	The farmer is situated in the municipality of Bongabon
Quantity sold and land area owned	An interaction term of quantity sold and land area owned
Land area for onion and land area owned	An interaction term of land area for onion and land area owned
Price expectation and risk preference	An interaction term of price expectation and risk preference

## RESULTS AND DISCUSSION

**Farmer and farm characteristics.** On the average, the age of farmers in the top onion producing villages in Bongabon and San Jose City is 52.80. These farmers finished secondary education and have spent about half of their life in farming. Using the Shapiro-Wilk test for normal data, only age has a normal distribution. The remaining variables presented in Table 3 are affected by extreme observations resulting to skewed distribution. Thus, median was deemed more appropriate to use. Onion farming is predominantly small-scale with an average land area of 0.50 hectares and onion production is marginal at 160.53 bags. Moreover, the marketable surplus rate is about 96.35% indicating that onion is considered as a cash crop. From the remaining produce, farmers set aside one or two bags for home consumption and the rest are given away to farm workers and farmers' relatives.

There is only one cropping season per year for onion and it is usually planted in the months of October to December and harvested during March and April. One month before the harvest date, farmers start to plant tomatoes, chili pepper, bell pepper, peanut, string beans, or eggplant depending on their choice. This serves as an additional source of farm income. During the wet season, in July, either rice or corn is planted. Typically, the same plot is used but there are additional plots of land devoted for growing staples.

**Table 3.** Quantitative characteristics of onion farmers, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines

Characteristics	Mean	Std. dev.	Median	Coefficient of skewness	Shapiro-Wilk p-value	sig.
Age	52.80	11.31	53.00	-0.03	0.44	
Farming experience	27.73	12.67	27.00	0.30	0.02	**
Formal education	9.20	2.94	10.00	-0.03	0.00	***
Total land area	1.56	2.69	0.80	5.68	0.00	***
Land area for onion	1.13	2.05	0.50	5.32	0.00	***
Quantity of harvest	490.48	1,290.64	160.53	5.80	0.00	***
Marketable surplus	487.40	1,288.63	154.67	5.79	0.00	***
Distance	23.61	17.65	25.00	0.17	0.00	***
Farm profit in 2022	1,561.08	5,625.98	719.03	2.00	0.00	***

Asterisks denote statistical significance (\*\*\*) at 1%, and \*\* at 5%)

There is a median difference in total land area, land area devoted for onion production, quantity of onion harvest, quantity of marketable surplus, and distance, at 1% level of significance. On average, users of cold storage facility have 1.75 ha of land devoted to onion production and a total marketable

surplus of 876.50 bags – a stark contrast to the average marketable surplus of non-users at 145.50 bags (Table 4).

**Table 4.** Median comparison by storage behavior, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

Characteristics	Median		Mann-Whitney U test statistic	p-value	sig.
	User (n=22)	Non-user (n=192)			
Age	56.00	53.00	1,852.50	0.35	
Farming experience	28.50	27.00	1,898.00	0.44	
Formal education	10.00	10.00	1,694.50	0.12	
Total land area	2.25	0.70	870.50	0.00	***
Land area for onion	1.75	0.50	792.50	0.00	***
Quantity of harvest	878.00	145.50	796.00	0.00	***
Marketable surplus	876.50	145.50	803.50	0.00	***
Distance	6.85	30.00	1,322.50	0.00	***
Farm profit in 2022	1,835.61	550.68	1,460.00	0.02	**

Asterisks denote statistical significance (\*\*\* at 1%, and \*\* at 5%)

In 2023, only 10.28% of the respondents stored onion in the cold storage facility (CSF), from 21.03% in 2022 and the previous years (Table 5). Onion storage has been started by the small-scale farmers as early as the 1990s but they were left with no choice but to stop since they cannot meet the large volume requirement by privately operated and owned CSF. It can also be seen in Table 5 that with the threshold level of two hectares or less for small farms, 92.71% of small-scale farmers did not use CSF. This is consistent with the narrative that if the farmers possess little land, they are likely to be poorly integrated into the agrifood value chains (IFPRI 2020).

**Table 5.** Qualitative characteristics of onion farmers by storage behavior, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines

Characteristics	Percentage			$\chi^2_c$	p-value	sig.
	Both groups (n=214)	User (n=22)	Non-user (n=192)			
Used the cold storage facility in 2023	10.28	10.28	0.00	-	-	
Male farmers	71.96	81.82	70.83	1.18	0.28	
Stored previously	21.03	95.45	12.50	81.79	0.00	***
Price expectation	49.07	63.64	47.40	2.08	0.15	
Small farm	88.32	50.00	92.71	34.89	0.00	***
Municipality	32.71	81.82	27.08	26.87	0.00	***
Membership in farmer-based organization	44.39	63.64	42.19	3.68	0.06	*
Cooperative membership	12.15	45.45	8.33	25.48	0.00	***
Training	9.81	40.91	6.25	26.79	0.00	***
Land ownership	67.76	77.27	66.67	1.02	0.32	

Characteristics	Percentage			$\chi^2$	p-value	sig.
	Both groups (n=214)	User (n=22)	Non-user (n=192)			
Access to off-farm income						
Agricultural wage	8.88	9.09	8.85	0.00	0.97	
Non-agricultural wage	11.21	13.64	10.94	0.14	0.70	
Self-employed income	21.03	59.09	16.67	21.39	0.00	***
Into trading	6.54	45.45	2.08	60.73	0.00	***
Access to credit						
Formal	25.23	40.91	23.44	3.19	0.07	*
Informal	66.36	36.36	69.79	9.88	0.00	***
Tied output-credit	23.36	0.00	26.04	7.48	0.01	***
Status of credit constraint						
Credit unconstrained	57.01	59.09	56.77	0.04	0.84	

Column percentages are presented. The chi-square test statistic is denoted as  $\chi^2$  and asterisks denote statistical significance (\*\*\*) at 1%, \*\* at 5%, and \* at 10%).

In addition, cooperative membership provides an opportunity for small hold farmers to store onion at CSF. A direct involvement among farmer-members was observed on Bongabon and San Jose City farmers where each area has one cooperative with own CSF. In these, farmers are not constrained by the large volume requirement unlike in private CSF. This explains why almost half (44.44%) of the farmer-members of Valiant PMPC stored in the cold storage facility (Table 6). Based on the survey, the least volume stored by a farmer-member was 100 bags.

On the other hand, Kalasag FPC practices storage as an organization and was able to use the CSF for the first time after the turnover in March 2023. In this case, the farmers are indirectly involved in the cold storage activity such that only two members of Kalasag FPC have stored at CSF (Table 6). Members stated that they participate in onion trading which allows them to store in privately-owned CSF implying that onion trading increases the capacity of farmers to engage in cold storage activity. Among the users of CSF, 45.45% are traders.

**Table 6.** Cooperative membership and storage behavior, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines

Storage behavior	Bongabon (n=70)		San Jose City (n=144)	
	Member of Valiant PMPC	Non-member	Member of Kalasag FPC	Non-member
Did not use CSF in 2023	10 (55.56)	42 (80.77)	6 (75.00)	134 (98.53)
Used CSF in 2023	8 (44.44)	10 (19.23)	2 (25.00)	2 (1.47)
Total	18 (100.00)	52 (100.00)	8 (100.00)	136 (100.00)

Column percentages are in parentheses

Onion production is also capital-intensive. According to PSA data for 2021, a hectare of onion farm requires USD 3,669.20 or PhP 186,300.00 for production with 28.08% accounted for by seeds, fertilizer, and pesticide. Consequently, farmers resorted to loans either from formal, informal or both sources. As seen in Table 5, two-thirds of the farmers availed credit in the informal sector as compared to a fourth from the formal sector. The preference for informal loan is due to less transaction costs despite the interest rate ranging from 7 to 20%. Based on survey data, short-term loans (i.e., loans that mature within a year) is about 1.18%, on the average.



Onion farmers are reliant on trader-financier. About one-fourth of them were under tied output-credit market scheme which can be of two modes, *samak* and *pabuto* system. Under *samak*, the financier provides non-cash items such as fertilizer and insecticide, and cash to cover hired labor. During the harvest period, the farmer pays for all the costs incurred by deducting the total variable cost from the gross revenue and the gross margin is shared by the two parties. On the other hand, in *pabuto* system, the trader-financier typically provides the *buto* (seed) which the farmer needs to pay the cost plus interest and is obliged to sell all the harvest to the financier.

**Onion marketing.** Before harvesting, an agent commissioned by village-level traders visits the farm to check on the about to be harvested onion and provides red bags for packaging the produce. Village-level traders have their own buying station, and their trading activity extends to neighboring villages. Farmers are prone to sell to village-level traders since their marketable surplus is low. This supports the Philippine Onion Roadmap for 2021 to 2025, which showed that trader-financiers are a key player in the onion value chain. These traders are a special type of village-level trader that provides inputs to the farmers. Table 7 shows to whom farmers sold their onion. To examine sales composition, the quantity used is in the aggregate instead of average. The combined share of village-level traders and trader-financiers composed the majority (around 70%) for both varieties. Itinerant traders engage in buying or selling onion without a nearby physical establishment for trading. In terms of share in onion sales, itinerant traders may not be as important although it must be emphasized that this type of trader usually engage in buying marketable rejects and selling to retail markets. Marketable rejects are typically a mix of undersized and deformed onion and are sold immediately to itinerant traders. The role of cooperative as a buyer of farm produce is evident in Yellow Granex onion. Kalasag FPC is composed of Yellow Granex onion farmers, which has built a strong vertical relationship with Jollibee Foods Corporation – a Filipino multinational company that owns the fast-food brand Jollibee.

Cold storage is documented as one of the postharvest activities in the onion value chain (SEARCA 2022). Although storage participation is reported to be low at 10.28%, this study however found around 19.46 to 24.31% of Yellow Granex and Red Creole onion were sold to traders at the CSF.

**Table 7.** Composition of onion sales by type of buyer and by variety, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

Type of buyer	Red Creole onion (n=190)		Yellow Granex onion (n=86)	
	Quantity (bags)	Percentage	Quantity (bags)	Percentage
Village-level trader	24,249.65	52.87	35,135.30	53.25
Trader-financier	8,324.22	18.15	10,377.57	15.73
Cooperative	0.00	0.00	5,214.00	7.90
Itinerant trader	1,890.27	4.12	2,353.70	3.57
Retailer	257.57	0.56	59.00	0.09
Trader at the cold storage facility	11,148.90	24.31	12,842.30	19.46
Total quantity sold	45,870.60	100.00	65,981.87	100.00

Disaggregating the data by storage behavior, village-level traders have less influence on farmers who stored at the CSF. The common practice is to sell half of their marketable surplus immediately and the remaining half after cold storage. It can also be observed the total quantity of Red Creole onion stored is close to the quantity of Yellow Granex onion stored. On the average, farmers stored 506.76

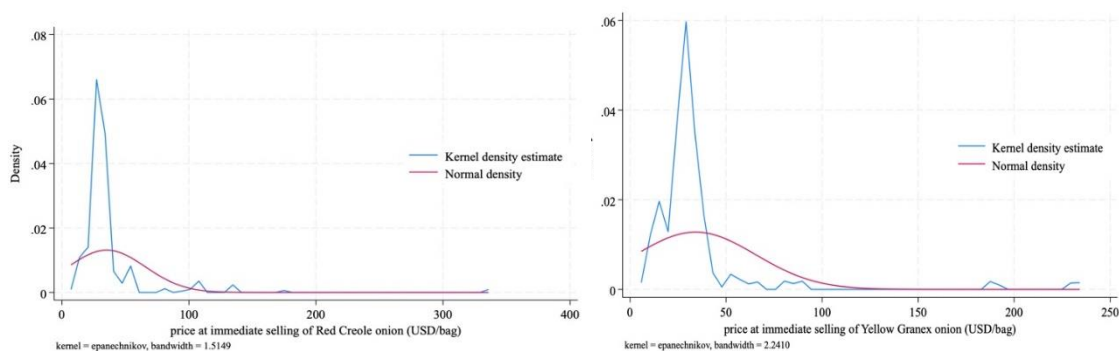
bags of Red Creole and 583.74 bags of Yellow Granex onion. Farmers were motivated to store both varieties because they can take advantage of a high price for both.

On the other hand, farmers who did not do cold storage sold immediately to village-level trader and trader-financier. While the role of trader-financiers in terms of input provision is vital for onion production, IFPRI (2020) describes this situation as a form of control that disallows farmers to “play the market,” thereby leaving the potential market gains to the trader.

**Table 8.** Composition of onion sales by type of buyer and by storage behavior, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

Type of buyer	Red Creole onion				Yellow Granex onion			
	User (n=22)		Non-user (n=192)		User (n=22)		Non-user (n=192)	
	Quantity	%	Quantity	%	Quantity	%	Quantity	%
Village-level trader	8,250.23	41.09	15,999.37	62.04	24,864.83	58.69	14,643.75	62.01
Trader-financier	0.00	0.00	8,324.23	32.28	0.00	0.00	6,004.25	25.43
Cooperative	0.00	0.00	0.00	0.00	3,420.00	8.07	1,794.00	7.60
Itinerant trader	584.67	2.91	1,305.57	5.06	1,239.17	2.92	1,114.50	4.72
Retailer	96.10	0.48	161.47	0.63	0.00	0.00	59.00	0.25
Trader at CSF	11,148.90	55.52	0.00	0.00	12,842.30	30.31	0.00	0.00
Total quantity sold	20,079.90	100.00	25,790.63	100.00	42,366.30	100.00	23,615.50	100.00

**Price at immediate selling and after cold storage.** Farmers store onions in CSF in anticipation of higher price in the lean season. To check if there is a price premium from cold storage activity, the farmgate price at immediate selling is compared to the price after cold storage. Before a comparison is made, it is important to check price distribution and identify which measure of average is more appropriate to use. As seen in the kernel density estimate (Figure 1), the distribution of farmgate price of good quality Red Creole and Yellow Granex onion at immediate selling are positively skewed and reached a maximum of USD 334.35 per bag of Red Creole while Yellow Granex had USD 231.89 per bag. The extreme price observed during the first quarter of 2023 is a continuation of the price hike experienced in the last two months of 2022.



**Figure 1.** Kernel density estimation of the price at immediate selling of Red Creole and Yellow Granex onion, 188 and 81 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines

Given the extreme price variations, mean is not the most appropriate but rather median price. On the average, the price of good quality onion was USD 29.66 per bag for both varieties. On the other hand, since users of the CSF were observed to gradually release onion, the price of onion after cold storage was summarized into two categories: price obtained after two months or less in storage (early release) and price after three to five months in storage (late release). Comparative analysis revealed that the selling prices of Red Creole onion (USD 52.85 per bag) and Yellow Granex onion (USD 55.58 per bag) at early release were greater than the selling price at late release (USD 51.30 per bag and USD 48.44 per bag, respectively). This implies that late release of onion also involves risk as the price during the lean supply period is also affected by external factors such as release of imports which affects the domestic price of onion.

**Costs associated with cold storage activity.** According to the respondents, onions are placed in an ante room to reduce the temperature of onion after harvest. After at least two hours, the onions are placed in the CSF. The use of this facility involves a contract usually for the period of four months with an average fee of USD 3.60 per bag. If the farmers decide to extend the duration of storage, they must pay USD 0.80 per bag monthly. Thus, for late release, the storage fee is more expensive at USD 4.40 per bag as compared to early release which only costed USD 3.60 per bag. Among the cash costs, storage fee serves as the highest upfront cost faced by farmers. Non-users claimed that they do not have additional capital to pay for the storage fee.

Also, when storing, farmers buy their own bags and repack onions to a uniform size (e.g., 27.50 kg) for proper stacking at the facility. Weighing, unloading from the consolidation area, loading into the CSF, and transportation are only done once, hence a similar value is imputed. Whether the farmer sold its onion at early or late release, the cost of these activities remain the same. On the other hand, re-piling of the stored onion bags is done every month which resulted into higher cost if the farmers delayed selling their onion.

Since the farmers who chose to store onion have operational costs associated with cold storage, this amount could have been spent or saved elsewhere. The opportunity cost of capital was accounted for, and the capital could have earned interest if saved in a bank. The interest rate on time deposit with a minimum term of 30 days is 0.125% (LBP 2024). For early release, the per unit cost items summed up to USD 4.87 per bag multiplied by the sum of bags stored at early release (44.47 bags of Red Creole and 47.76 bags of Yellow Granex). This was multiplied by the monthly interest rate of about 0.01%. For early release, the average number of months is only 1. Therefore, accounting for the withholding tax, the net interest earned is USD 0.04. On the other hand, for late release with four months as the average storage duration, it is USD 0.21. This indicates the increasing opportunity cost of capital as the farmer chooses to further delay the sale of onion.

The loss of moisture content ranged from 2.99 to 3.97% (0.80 to 1.05 kg) for early release and around 5.56 to 9.09% (1.46 to 2.29 kg) for late release. The reported weight loss is in kilograms and then expressed as percentage. However, the weight loss was not reflected as reduced income since farmers procure and sell onion in bags.

**Quantity used in the partial budget analysis.** As discussed in the marketing of onion, the 22 farmer-respondents who used the CSF stored 506.76 bags of Red Creole onion and 583.74 bags of Yellow Granex onion which indicates that farmers typically store both varieties at roughly equal distribution. This was taken into consideration when estimating the net income from cold storage activity. To provide insights to small-scale farmers on the net income that is generated from cold storage activity, 100 bags of each variety are considered. This quantity is also near the median marketable surplus of 154.67 bags.

*Cost benefit analysis of using cold storage facilities.....*

Based on the responses of 22 farmers who stored onion, about 44.47% of Red Creole onion and 47.76% of Yellow Granex onion are sold at early release. This proportion implies that majority of the stored onion is sold at late release due to farmers' expectation of higher prices. However, in 2023, the expectation differed from the actual price as the farmgate price at early release was greater than that of late release.

**Table 9.** Net income from storing 100 bags of Red Creole onion and Yellow Granex onion, 22 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

Item	Storage duration	
	Early release	Late release
<b>Additional Income (AI)</b>		
Quantity of Red Creole onion sold after storage (bag)	44.47	55.53
Selling price after storage (USD/bag)	52.85	51.30
Quantity of Yellow Granex onion sold after storage (bag)	47.76	52.24
Selling price after storage (USD/bag)	55.58	48.44
<b>Total Additional Income (USD)</b>	<b>5,004.94</b>	<b>5,381.24</b>
<b>Reduced Income (RI)</b>		
Quantity of Red Creole onion sold immediately (bag)	44.47	55.53
Selling price immediately after harvest (USD/bag)	29.66	29.66
Quantity of Yellow Granex onion sold immediately (bag)	47.76	52.24
Selling price immediately after harvest (USD/bag)	29.66	29.66
<b>Total Reduced Income (USD)</b>	<b>2,735.65</b>	<b>3,196.35</b>
<b>Additional Cost (AC)</b>		
Re-sorting	0.40	0.40
Repacking	0.40	0.40
Weighing	0.02	0.02
Transportation cost	0.22	0.22
Unloading and loading cost	0.14	0.14
Re-piling	0.09	0.25
Payment for the use of cold storage	3.60	4.40
Opportunity cost of capital	0.04	0.21
<b>Total cost per unit (USD/bag)</b>	<b>4.87</b>	<b>5.83</b>
<b>Total Additional Cost (USD)</b>	<b>449.20</b>	<b>628.51</b>
<b>Net income</b>	<b>1,820.10</b>	<b>1,556.38</b>

Note: The cost items are expressed per unit while the opportunity cost of capital is expressed in total.

Using the partial budget table (Table 10), farmers were found to generate an additional net income of USD 3,376.48. Apart from this, it generates off-farm employment opportunities for the rural population including sorting, packing, unloading and loading, and transport service.

**Table 10.** Partial budget analysis of cold storage, 22 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

<b>Total Gains</b>	<b>USD</b>	<b>Total Loss</b>	<b>USD</b>
Added income from selling onion at early release	5,004.94	Additional cost at early release	449.20
Added income from selling onion at late release	5,381.24	Additional cost at late release	628.51
		Reduced income from immediate selling	5,932.00
Subtotal	10,386.18		7,182.23
Change in net income	3,376.48		

**Analysis of storage behavior.** It has already been established that cold storage activity generates additional net income. Even then, there was low participation rate among onion farmers. Thus, it is of interest to understand the factors associated with storage behavior. The binary logit estimation was performed and it examined four models since there are two explanatory variables, each having an alternative measure was performed. The dependent variable was given a value of one if the farmer stored onion in a cold storage facility and zero, otherwise. Two measures of quantity were considered: quantity sold and total land area allocated to onion both expressed in logarithm. Land area devoted to onion production was considered a proxy for quantity sold because 96.35% of the harvest is marketed. There were also two measures of the absence of liquidity constraint: access to formal credit and status of credit constraint.

After the diagnostics, the model with the most number (9) of statistically significant variables including the interaction term of quantity sold and land area owned was taken as the best fit for the collected data (Table 11).

**Table 11.** Determinants of storage behavior, 214 farmer-respondents, Bongabon and San Jose City, Nueva Ecija, Philippines.

<b>Variables</b>	<b>Coefficient</b>	<b>dy/dx</b>	<b>p-value</b>	<b>sig.</b>
Intercept	-27.10	-	-	
Total quantity sold (log)	2.15	0.0606	0.00	***
Land area owned (log)	-4.65	-0.1314	0.00	***
Distance	0.08	0.0023	0.18	
Farm profit in 2022	0.00	0.0000	0.54	
Age	-0.04	-0.0012	0.41	
Farm experience	0.19	0.0055	0.02	**
Formal education	-0.04	-0.0011	0.71	
Price expectation	1.84	0.0523	0.45	
Risk preference	0.15	0.0041	0.80	
Cooperative membership	4.28	0.1208	0.00	***
Training	1.86	0.0526	0.05	**
Status of credit constraint	1.87	0.0527	0.09	*
Participation into trading	9.52	0.2689	0.00	***
Municipality (Bongabon = 1)	3.87	0.1093	0.10	*
Quantity sold*land area owned	0.51	0.0143	0.01	**

<b>Variables</b>	<b>Coefficient</b>	<b>dy/dx</b>	<b>p-value</b>	<b>sig.</b>
Price expectation*risk preference	-0.05	-0.0015	0.679	
Wald $\chi^2$	54.04			
Prob $\chi^2$	0.0000			
Pseudo $R^2$	0.7157			
Correctly classified	96.73			

Note: Average marginal effects are denoted by dy/dx. Asterisks denote statistical significance (\*\*\*) at 1%, \*\* at 5%, and \* at 10%).

The result is consistent with Minten et al. (2014) suggesting that more quantity sold, and larger land area owned increase the likelihood of storing onion. It was also found that the absence of liquidity constraint or being credit unconstrained in the formal sector increases the likelihood of storage by 5.27%. Transaction cost was the most cited constraint of the farmers when borrowing from the formal sector. In particular, farmer-respondents are restricted to borrow due to the lack of knowledge where to apply or disincentivized to borrow due to the number of requirements.

Access to off-farm income is positively related with storage behavior and the results conform with previous studies (Gitonga et al. 2013; Minten et al. 2014). The study highlights onion trading as source of off-farm income. Participation in onion trading increases the likelihood of storage by 26.89%. Self-employment also includes owning a small convenience store and tricycle driving, but these practically generate meager income.

Consistent with the assertion that cooperative provides an opportunity for small-scale farmers to store, the estimated logit model shows that membership in cooperative increases the likelihood of farmers to store by 12.08%. It should be noted that cold storage facilities in Bongabon and San Jose City were recently provided by the Department of Agriculture High Value Crops Development Program.

In addition, farmers who attended trainings related to postharvest management were more likely to store by 5.26%. Based on frequency count, there were 18 farmer-respondents who received training on postharvest management and eight of them stored onion in 2023. Topics include proper temperature, storage life span, and onion drying. The Department of Agriculture is the provider of most trainings received by farmers including its regional offices, the Philippine Rural Development Project, and the Philippine Center for Postharvest Development and Mechanization.

## **CONCLUSION, RECOMMENDATION, AND FUTURE RESEARCH DIRECTION**

Cold storage participation among onion farmers in key producing villages of Bongabon and San Jose City, Nueva Ecija remains low despite generating additional net income and providing off-farm employment opportunities in the rural area. There is an obvious challenge for small hold farmers and farmers under tied output-credit situation to participate in cold storage activity.

To ensure that small hold farmers are integrated into the value chain, the establishment of cold storage facilities that are operated by farmer groups should be supported since results show that cooperative membership is positively related with onion cold storage. Trainings related to postharvest management was also documented to increase the likelihood of cold storage. The Department of Agriculture takes the lead in providing these capacity building measures and the planned construction of cold storage facilities as stipulated in the Philippine Onion Roadmap for 2021 to 2025. In order to further enhance storage behavior, the Department of Agriculture can consider bundling these two support services. This means the provision of cold storage facilities should be followed up with intensive training on proper storage techniques.

Given the design and implementation efforts to scale up cold storage for onion, the willingness to pay (WTP) values should be taken into consideration to check if it matches the current market price. Since this study finds that cold storage fee serves as a high upfront storage cost, this could possibly reduce their willingness to store and hence, WTP values shall guide cooperatives and other providers of cold storage in estimating charges for the use of the facility.

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