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Solid Waste Management and Reduction of Agricultural Post-harvest Losses Using Cold-storage: Perceptions of Farmers in Benguet, Philippines

ABSTRACT

Vegetable harvest in the Philippines are wasted due to spoilage (~42%) posing a challenge to the country's food security and solid waste management. The study aims to determine current vegetable farming practices and farmer perceptions on the use of cold storage facilities in Benguet Philippines for reducing vegetable waste in the post-handling process system. Specifically, this aims to: identify common high-value crops available and acceptable to farmers for storing in cold storage facilities by developing the actual cropping calendars (planting and harvest schedules) of these high-value crops; quantify waste generated on-farm and during marketing and identify current farmer practices and perceptions on post-harvest handling. Common high value crops for possible cold-storing are green-leafy vegetables since these command high prices when they are available off-season. Waste generated is 7.5% of total produce during harvest while 20-50% is further lost during the marketing. The three main issues of farmers are price, market and the harvesting process. Timely information dissemination on market demands and prevailing vegetable prices, availability and access to storage and cold-storage facilities are necessary to encourage farmers to minimize vegetable waste generated and optimize farmer income.

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INTRODUCTION

All stages of the post-harvest handling system (harvesting, handling, packing, storing, and transportation to final delivery) of the distribution chain of perishables may incur both quantitative and qualitative losses (*Paltrinieri undated*). Several studies reveal that post-harvest losses of fruits and vegetables range from 40 to 50 % (*Ahmad 2016; Kitinoja 2002; Ray and Ravi 2005; Mopera 2016; Arah et al. 2015*).

Post-harvest losses can be defined as the degradation in both quantity and quality of a food production from harvest to consumption (*Kiaya 2014*). Losses are often measured in weight reduction from its potential. Some factors in the supply chain that contribute to postharvest losses are as follows:

Absence of established maturity index. can result in early harvesting which lowers the value and quality of the produce or late harvesting which often causes deterioration of the produce.

Lack of available pre-cooling facilities. inadequate training and lack of information on cost-benefits of the technology.

Poor transportation systems. poor road network which extends the delivery period, lack of refrigerated transport and high cost of transport vehicles.

Lack of storage facilities. high cost operation and maintenance.

Improper packaging and labeling. most of the produce exposed to direct heat and bruises, are sold unpackaged or tied in bundles and result to reduced shelf life.

Environmental factors. climatic conditions including wind, humidity, rainfall, and temperature influence both the quantity and quality of harvest (*Grolleaud 2002*).

On average, 44% of vegetable harvests in the Philippines are wasted due to spoilage. Storing the produce in a cold storage warehouse can prevent spoilage as cool temperature is essential in preserving flavor,

texture, aroma and appearance, and for prolonging shelf-life and maintaining the quality of fresh produce. This reduces the rate of deterioration, allowing more time to market the crops while maintaining high quality produce that reaches consumers (*World Vegetable Center 2017*).

There are several technologies available worldwide to minimize post-harvest losses. Some of these technologies complement cold storage, the most common post storage reduction technology. Fogging and refrigeration (*Tirawat, et al., 2017*), neutral electrolyzed water (NEW) for reduction of microorganisms in vegetables under cold storage (*Pinto, et al. 2015*), controlled atmosphere and 1-MCP during storage for preserving vegetable color and its chlorophyll (F*ernandez-Leon et al. 2013*), atmospheric cold plasma process for vegetable decontamination (*Pascuali et al. 2016*), the use of argon and xenon gases (*Zhang et al. 2008*), the use of warm water and chlorine (*Klaiber et al. 2005*), high intensity light for freshly cut vegetables (*Zhan et al. 2012*), edible coating and gamma-irradiation for cold storing (*Ben-Fadhel 2017; Song et al. 2006*) are some of the new technologies available to reduce spoilage of vegetables.

This study looked into how post-harvest losses can be minimized in the Cordillera Administrative Region (CAR) especially in the highland areas. These losses reduce farmer income and increase vegetable waste generated in vegetable production and post-harvest. The crop subsector is 78.4% of the region's agricultural output (*PSA 2017*). If almost 42% of production is wasted, this translates to 32.928% of the region's agricultural output lost.

Geographical Background

The Cordillera Administrative Region (CAR) is composed of several provinces such as Abra, Apayao, Benguet, Ifugao, Kalinga, and Mountain Province. This is the "Watershed Cradle of North Luzon" since its mountainous topography has provided continuous irrigation and energy for Northern Luzon. From the Philippine Statistics Authority (PSA), the total land area for these six provinces is about 1,961,110 ha. inhabited by 1,616,867 people with an annual population growth rate of about 1.7% for year 2000-2010.

CAR has Type II (no dry period at all throughout the year with pronounced wet season from November to February) and Type III (short dry season usually from February to April) climatic conditions that allows for 9% of its total land area to be dedicated to agriculture. Highland areas (Benguet, Ifugao, and Mountain. Province) have cool climate that are suitable for growing semi-temperate fruits, vegetables, and cut flowers while lowland areas (Abra, Apayao, Ifugao, and Kalinga) are suitable for intensive rice and corn production.

Baguio Weather Station data showed that August has the highest monthly rainfall from year 1981-2010 at 905.0 mm month^{-1} while the least occurred in January (15.2 mm month^{-1}). Average normal temperature pattern in the Baguio Weather station showed consistently narrow ranges of both minimum (12.9-16.5°C) and maximum (22.6-25.8°C) air temperatures. Coolest average minimum temperature occurred in January (12.9 °C) while average warmest maximum air temperature occurred in April (25.0°C). This seasonality of rainfall and relatively uniform temperature is a major factor in the cropping calendar for vegetable growing in the area.

The region is highly vulnerable to climate variability. Low or excessive rainfall, extremes in temperature or typhoons adversely affect the quantity and quality of the produce as well as the health of livestock, poultry, and fish. Thus, continuously posing a threat to agricultural productivity. In previous years, about Php 1.8 billion and Php 2.3 billion (~91.98 billion USD and 117.53 billion USD at a conversion rate of 51.1 Php/USD in Sept 2, 2017) in agricultural losses in the region (PSA, 2017) were due to typhoons Pepeng (Parma) and super typhoon Juan (Megi) in 2009 and 2010, respectively. The losses and low production were continually incurred in the year 2011 due to tropical storm Juaning (Nock-ten), typhoon Pedring (Nesat), typhoon Mina (Nanmadol) and typhoon Quiel (Nalgae). However, in 2012, improvements and expansion in planted area and market reach were made resulting in higher production of several crops.

According to the CAR's Regional Development Plan 2014-2016, the notable key challenges are: low agricultural productivity; unsustainable farming practices; low farm income; and agriculture's vulnerability to weather-related disasters. To address these issues, private and government institutions have developed and implemented various programs and strategies. One of which is the establishment of the Benguet Agri-Pinoy Trading Center (BAPTC) in La Trinidad, Benguet where most of the farmer surveys were conducted.

This study aims to: identify common high-value crops available and acceptable to farmers for storing in cold storage facilities by identify the actual cropping calendar (planting and harvest) in Benguet; quantify waste generated on-farm and during marketing; and identify current farmer practices and perceptions on post-harvest handling in the highland areas of the CAR.

MATERIALS AND METHODS

Field visits in the local markets and cold storage facilities were conducted in Baguio City and La Trinidad. Key informant interviews were initially done with the local government units, academe, farmer groups and non-government units to identify how the vegetable industry in Benguet behaves. Initial stakeholder meetings, focus group discussion and consultations were also done with different stakeholders (LGUs, farmer organizations and the academe) to determine perceptions of Benguet farmers on the possibility of storing their produce in cold storage facilities prior to conducting detailed surveys.

Detailed social survey questionnaires on the vegetable crops grown, quantity of waste generated from farm to market, and perceptions of farmers on how these wastes could be reduced by prolonging the shelf-life of their produce were done using convenience sampling of 119 farmers out of around 80,000 farmer population in Benguet including farmers from neighboring towns of other provinces such as Bauko (within Mountain Province) and Tinoc (a town of Ifugao) (*BAPTC personal communication 2019*) in the main markets of Benguet. Daily, there is an average of about 90 farmers trading in BAPTC. Sample size was determined using G*power 3.1.9.4 for exact correlation tests of bivariate normal model for determining one-tailed correlation ρ H1 =0.3, α error probability = 0.05, power (1-β error probability) = 0.95, r = 0.1541491, actual power = 0.9501151. Total Sample size should at least be 115. Farmer respondents from the municipalities of Atok, Bakun, Bokod, Baguias, Kabayan, Kapangan, Kibungan, La Trinidad, Mankayan, Sablan and Tublay in Benget province as well as the municipalities of Bauko and Barlig in the Mountain province and municipality of Tinoc in Ifugao were covered in the study (**Figure 1**). Personal interviews of farmers and key informants from Benguet were conducted from June to September 2017.

RESULTS AND DISCUSSIONS

Socio-Demographic and Economic Profile of the respondents

A total of 119 vegetable farmers where majority of the

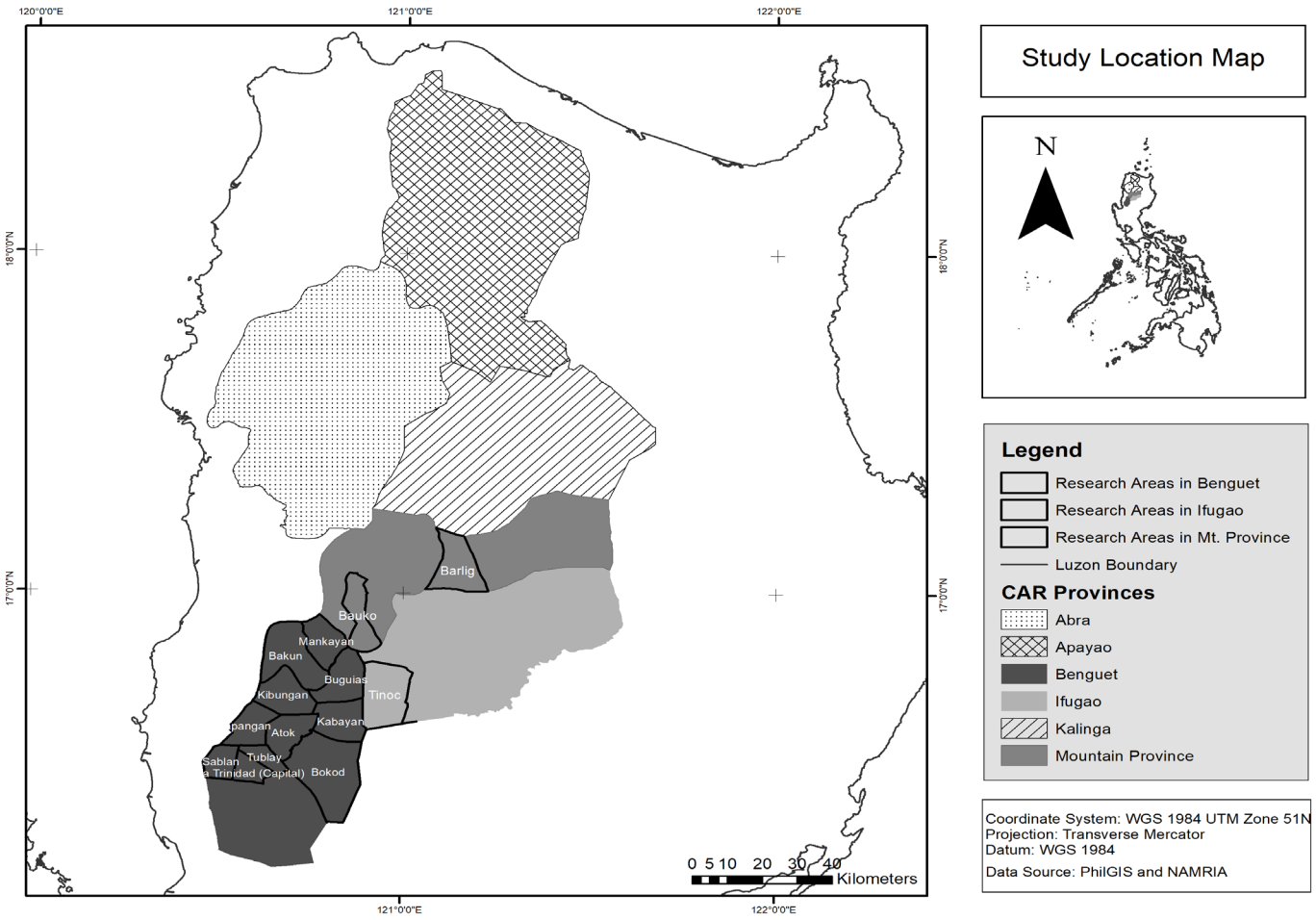

Figure 1. Location map of interviewed farmer fields.

respondents are males (87%), married (68%) and have a household size of 4-5 members (38%). Forty-three of the farmers belonged to the age range of 26-35 years old (36%) followed by twenty-five farmers ranging from 36-45 years old (21%). Most of the farmers were high school graduates (22.69%), self-employed (77%), and had more than 5 years of farming experience (75.6%) (**Figure 2**). The vegetable farming industry in Benguet is still male-dominated with an age range of 26-35 years old, with mostly secondary education or higher degrees, self-employed and more than 5 years farming experience.

Benguet Agricultural Production, Market

Patterns and Actual Cropping Calendar Agriculture plays an important role in the economic sustainability and development of the Philippines. The *Census of Agriculture* (*2012*) reported 5.56 million farms covering 7.19 million ha (average is 1.29 ha per farm holding). From 1980 to 20212, the number of farms increased by 62.6% as the average area of farms decreased (from 2.84 ha to 1.29 ha per farm). Ninety-nine percent (99.9%) of the farms are privately owned by the household. In the CAR region, there were 167,510 farms with a total area of 137,638.422 ha averaging at 0.822 ha per farm (*Census of Agriculture and Fisheries 2012*). This indicates that most farms in Benguet are privately-owned individual land holdings.

The social surveys conducted in 2017 show that majority of the farmlands were privately owned by the farmers and their crops are mostly irrigated except for broccoli (**Table 1**). The three crops with the highest total land area were white/irish potato (*Solanum tuberosum*), cabbage (*Brassica rapa*), and carrots (*Daucus carota* subs. *sativus*). This is congruent to data provided by the Philippine Statistics Authority in 2013 showing about 43.02% of the region's agricultural output from palay (*Oryza sativa*), corn (*Zea mays*), and cabbage production, ranking 1st in nationwide production of cabbage.

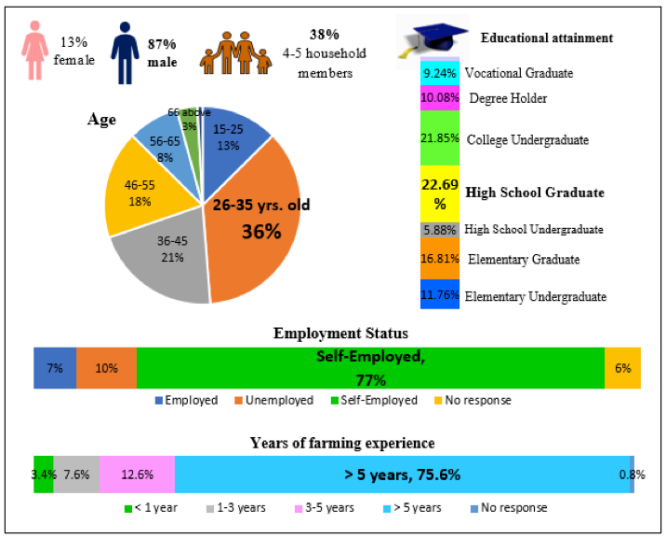

Figure 2. Summary of demographic profile of respondents.

Benguet is the major semi-temperate vegetable producing region in the country owing to its favorable climate. The semi-temperate vegetables cultivated include broccoli (*Brassica oleracea* var. *italica*), cabbage (*Brassica rapa*), sweet potato (*Ipomoea batatas*), carrots (*Daucus carota* subs. *sativus*), cauliflower (*Brassica oleracea* var. *botrytis*), lettuce (*Lactuca sativa*), radish (*Raphanus raphanistrum* subsp. *sativus*), tomato (*Solanum lycopersicum*) and white/Irish potato (*Solanum tuberosum*) (*Pedroche et al. 2013*). Crops recorded with highest production in metric tons for five consecutive years (2012-2016) were white/Irish potato, carrots and cabbage (**Table 2**).

All the crops show a consistent fluctuations (trend) from 2012 to 2016. Decreasing trend from 2012 to 2013, increase in 2014, and decrease in both 2015 to 2016. Broccoli was on average 1,800 metric tons, cabbage was around 84,000 tons, sweet potato around 5,500 tons, carrots 55,400 tons, cauliflower 5,200 tons, lettuce around 1,100 tons, radish around 1,300 tons, tomato 2,900 tons and white/irish potato 90,000 tons. The three most common crops in Benguet are white/irish potato, cabbage and carrots. However, only cabbage is easily affected by post-harvest handling especially fluctuations in storage temperature.

For economic gains to the farmer (**Table 3**) in 2017, investment on labor and materials increased by a factor of 2.25 on white/irish potato, 1.99 on cabbage and 1.28 on carrots. The top three most economically beneficial crops are lettuce (7.3x), cauliflower (2.6x) and white/irish potatoes (2.24x). However, among the surveyed farmer respondents, only 3.58 ha were planted to lettuce while only 1.30 ha were planted to cauliflower. Only white/irish potatoes performed well for 2017. The average price for sweet pea, bell pepper and broccoli were the highest compared to other crops. However, there is quite a variety of day-to-day fluctuations depending on available supply and demand in the market.

The production of semi-temperate vegetables is the major source of income for thousands of small-holder farmers in CAR. It is continuously being developed to improve its productivity to meet the increasing demands for these high value crops (*Pedroche et al. 2013*).

Table 1. Farming details per crop in Benguet, 2017.

Crop	Total Area m²	Area, m² (%)		Area, m² (%)	
		Owned	Leased	Rainfed	Irrigated
White/Irish Potato	369,400	59%	41%	42%	56%
Cabbage	336,850	68%	32%	33%	61%
Carrot	173,530	77%	23%	18%	74%
Radish	64,500	65%	35%	50%	50%
Chinese Cabbage	42,575	60%	40%	29%	60%
Lettuce	35,820	74%	24%	59%	41%
Cauliflower	13,000	69%	31%	0%	100%
Broccoli	6,500	0%	100%	100%	0%
Tomato	5,700	100%	0%	88%	12%
Sweet pea	4,300	70%	30%	7%	93%
Bell pepper	2,000	0%	100%	0%	100%

Table 2. Benguet crop production (in metric tons).

Crop	2012	2013	2014	2015	2016
Broccoli	1,859.30	1,886.80	1,921.76	1,851.55	1,777.48
Cabbage	85,480.84	85,874.21	85,139.34	84,472.43	81,778.02
Sweet Potato	5,644.98	5,552.20	5,669.78	5,570.53	5,453.87
Carrots	55,470.97	55,399.47	55,786.45	55,133.63	54,499.9
Cauliflower	5,289.56	5,193.69	5,130.75	5,167.11	5,040.6
Lettuce	1,157.42	1,161.06	1,155.48	1,082.32	1,049.23
Radish	1,343.55	1,303.66	1,360.95	1,311.8	1,258.89
Tomato	2,915.73	2,920.08	2,976.74	2,943.63	2,837.19
White/Irish Potato	90,147.95	88,372.84	89,918.44	90,094.55	88,771.06

Source: *Philippine Statistics Authority* (*2017*)

Table 3. Farm financial details in Benguet, 2017.

Crops	Average Expenses, Php/1000 m²			Average Yield, kg/1000 m²	Average Price, Php/ kg	Average Sales, Php/ 1000 m²
	Labor (%)	Materials (%)	Total			
White/irish Potato	39.7	60.3	11,913.29	1,257.72	30.77	38,695.70
Cabbage	43.2	56.8	13,119.53	2,102.81	18.70	39,329.03
Carrot	50.2	49.8	12,180.18	1,545.55	18.03	27,861.75
Radish	67.4	32.6	4,962.48	1,358.14	13.77	18,700.54
Chinese Cabbage	50.8	49.2	10,391.71	1,798.24	13.92	25,025.48
Lettuce	63.4	36.6	6,483.95	965.49	55.83	53,906.76
Cauliflower	48.8	51.2	30,688.46	5,307.69	20.86	110,703.30
Broccoli	43.1	56.9	14,461.54	234.62	60.00	14,076.92
Tomato	36.0	64.0	10,963.16	1,087.72	21.50	23,385.96
Sweet pea	47.3	52.7	11,072.56	333.49	73.33	24,455.81
Bell pepper	100	0.0	8,350.00	250.00	65.00	16,250.00

For average sales per 1000 m², cauliflower, lettuce and cabbage are the top three most beneficial crops. These crops may be selected in cold-storage facilities.

The financial sources of farmers for their input costs show that majority of the respondents (53%) had their own financial support, 24% of them borrowed money from private lenders while only 8% borrowed from banks to continue their farming activities. Natural calamities such as typhoons Lawin (Haima), Ondoy (Ketsana), Yolanda (Haiyan), and Pepeng (Parma) significantly affected their yield of produce by 65%, followed by diseases/pests (32%) such as clubroot, backmoth, cutworm, and blight.

Vegetables produced in the Cordillera, which have the potential to use the cold chain system include broccoli (*Brassica oleracea* var. *italica*), carrots (*Daucus carota* subs. *sativus*), bell pepper (*Capsicum annuum*), lettuce

(*Lactuca sativa*), cauliflower (*Brassica oleracea* var. *botrytis*), snap beans (*Phaseolus vulgaris*) and sweet peas (*Lathyrus odoratus*) (*Ramos et al. 2005*).

Cabbage (*Brassica rapa*) is planted in the months of January, March to June, and September instead of the prescribed January to June and October to December. Harvest of cabbage is in April, June to October, and December instead of January to April and June to September.

The developed actual cropping calendars for planting (**Figure 3**) and harvesting (**Figure 4**) are slightly different from the cropping calendar established and prescribed by the Benguet Agri-Pinoy Trading Center since these cropping calendars are based on actual cropping patterns followed by the farmers of Benguet in 2017. Fewer crops are planted and harvested by the farmers as compared to the prescribed cropping calendars.

Based on the planting (**Figure 5**) and harvesting (**Figure 6**) schedules of crops in Benguet for majority of the farmer surveyed in this study, the three major crops (white/irish potatoes, carrots, and cabbages) are planted from January to October and harvested from March to December. The dry months of January to February only have three types of crops harvested (lettuce, sweet pea, and bell pepper). Green leafy vegetables are usually available all year round (e.g., cabbages and lettuce) and were identified as possible crops to prioritize in the cold storage. Other possible options are broccoli (-0.02x profit, tomatoes, sweet pea and bell pepper since these crops did not give very high returns in 2017 and have been planted in less than 1 ha of land. Other crops can be stored in the cold-storage facility depending on which months access to these will become available to the farmers and traders. Carrots are planted all year round except in the months of April, May and November while white/irish potatoes are only planted from January to March and Sept to October. Both crops do not require cold storage facilities.

Post-Harvest Waste Management

Majority of the respondents (72%) left their wastes in the field while 14% of the farmers sell to peddlers and neighbors, and others use it for composting. The selling price of waste products was PhP 11.55 kg^{-1} from 7.55% of total production. This amount is significant in the case for example of cabbage in 2016, total production is 81,778.02 metric tons (**Table 2**) resulting to a possible waste generation of around 6,174 metric tons. Leaving these waste materials on site can be advantageous if it can be easily biodegraded and repurposed to fertilize the soil in the farm.

However, in cases wherein spoilage occurs in the market, hauling out this waste back to the farm can pose additional cost to either the farmer or the market

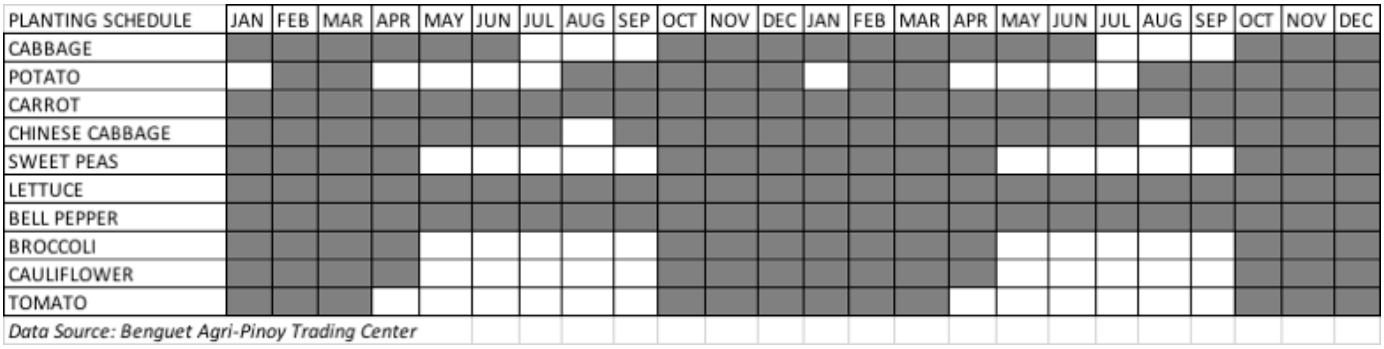

Figure 3. Prescribed Planting schedule in Benguet for majority of the farmers from BAPTC.

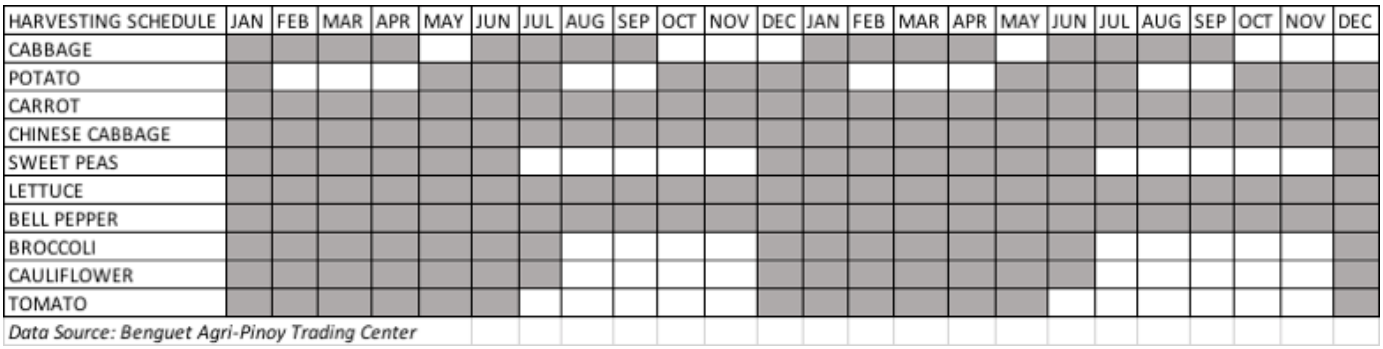

Figure 4. Prescribed Harvesting schedule in Benguet for majority of the farmers from BAPTC.

PLANTING SCHEDULE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CABBAGE												
POTATO												
CARROT												
CHINESE CABBAGE												
SWEET PEAS												
LETTUCE												
BELL PEPPER												
BROCCOLI												
CAULIFLOWER												
TOMATO												
RADISH												

Figure 5. Planting schedule in Benguet for majority of the farmers surveyed in 2017.

HARVESTING SCHEDULE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CABBAGE												
POTATO												
CARROT												
CHINESE CABBAGE												
SWEET PEAS												
LETTUCE												
BELL PEPPER												
BROCCOLI												
CAULIFLOWER												
TOMATO												
RADISH												

Figure 6. Harvesting schedule in Benguet for majority of the farmers surveyed in 2017.

management. The municipality of La Trinidad has a well-implemented ordinance on solid waste management. This includes the vegetable waste incurred from the La Trinidad Vegetable Trading Post (LTVTP). The municipality hauls about 25-40 tons of waste per day from the trading center to Alno Aerated Composting Facility. It does not include the other vegetable wastes that are being loaded back to the farmers. As per several farmers and traders in LTVTP, about 20-50% of the produce is wasted. Vegetable wastes in the LTVTP is collected and hauled manually by the farmers themselves to disposal areas or back to their farms (**Figure 7**).

The Alno Aerated Composting facility is a project partnership between the people of Japan under the Grant Assistance for Grassroots Human Society Projects and Municipal Government of La Trinidad. This facility follows a certain process to produce organic fertilizers that are being sold to farmers at Php 100-130 bag^{-1}.

Current Farmer Practices and Perceptions on Farm Production and Cold Storage Facilities

The purpose of farm production was for commercial and home-consumption (50%), commercial (43%), home consumption (5%) and contract growing (2%).

Figure 7. Vegetable waste in La Trinidad Vegetable Trading Post (LTVTP).

About 45% of the farmers market their crops through middlemen while twenty-four percent (24%) of the farmers market their crops by consolidator/assembler/trader (**Figure 8**). As noted by *Rola* (*2010*), vegetable farmers from Benguet and Mountain. Province bring their produce through commissioned agents, assembler, or direct sales to La Trinidad Vegetable Post and Hanger market. Most of the respondent farmers (74%) were satisfied with the pricing of their products. This satisfaction is a major factor why most of the respondents (45.38%) (**Table 4**) were willing to sell their products to whoever bids a higher price since the prices of vegetable products vary. *Rola* (*2010*) emphasized that the third most widely-observed marketing problem cited by 54.26% of the Cordillera farmers was the usually low and unstable prices of vegetable products. The problem of low selling prices was partly influenced by the dominant role of the traders in determining wholesale buying prices of the farmers' products which in turn may have been aggravated by the farmers' inaccessibility to price information. Key informant interviews conducted during the course of this study showed that the farmer-trader inter-relationships cannot be clearly delineated. This is because some farmers are also traders and some traders have personal relationships with the farmers.

Majority of the respondents sold their products right after harvesting (89%). When farmgate price becomes very low, the farmers still sell their products on the prevailing market price. This current mindset could pose a problem in the acceptability of storing their produce in a cold storage facility since the farmer respondents prefer to sell immediately at prevailing prices instead of storing it for a few days while waiting for better prices.

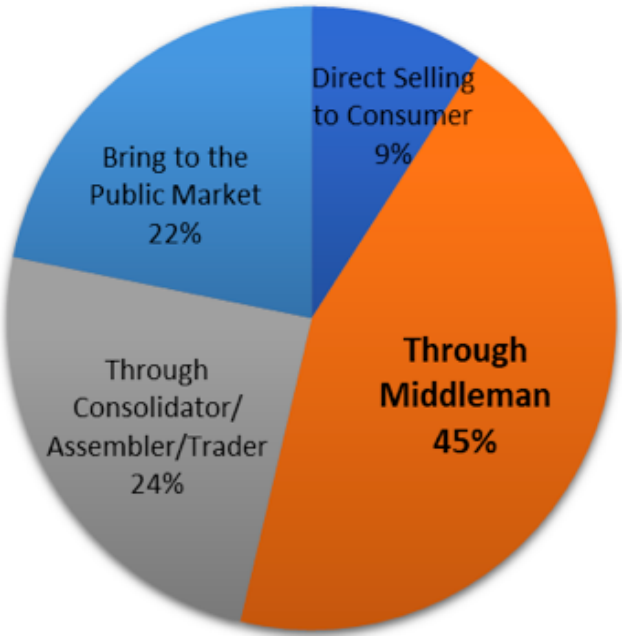

Figure 8. How farmers market their produce.

Table 4. Selling of products to another trader.

Particulars	Percent (%)
Yes. I'm actually looking for another buyer/ trader.	8.40
Yes. I sell my products to whoever bids a higher price.	45.38
No. I prefer my current market due to relationship and trust built.	35.29
No. I have a contract with my current market.	3.36
No response	7.56

The main reason for this is that most farmers surveyed do not have a storage space for their produce (88%). A solution to this is to link the farmer to bidders who are willing to pay a premium for high-quality produce stored at stable temperatures and ready to be transported to high-end customers. However, majority of the respondents were willing to transport the produce in any distance (66%) while 25% are willing to transport within 3 km. This could indicate that farmers are quite mobile and the produce could be transported to longer distances if the price is good.

The top three issues and concerns of farmers were the following: price of produce; marketing of produce; and harvesting process. These were followed by handling produce; transport of produce; harvesting laborers; bagging of produce; harvesting equipment; storage of produce; and handling of waste. *Rola* (*2010*) stated that post-harvest facilities have been deemed necessary due to the high perishability of the vegetables and the low prices due to the overproduction of vegetables at certain times of the year. Benguet and La Trinidad farmers reported that lack of market information from which to base their marketing decisions is also their major concern.

Currently, the Provincial Governor of Benguet has an existing cold storage facility, the Benguet Cold Chain Project (BCCP). The project was established to support the growing vegetable industry in the area. The objective was to increase productivity by minimizing post-harvest losses, preserving quality and freshness of the produce, and prolong shelf life. Currently, the services being offered are refrigerated trucking, cold storage rental (two rooms are operational), and plastic crate rentals. Unfortunately, majority of the respondent-farmers (62%) were not familiar with the existing cold storage facility in the area. Fifty-one (51) of the farmers responded that they are willing to use any available cold storage facility (43%) for their produce. On the average, farmers were willing to pay 3.84 Php kg^{-1} day^{-1} and 7 days to store their crops.

Thirty-seven percent of the farmers were willing to store the produce and use the facility followed by crop waste donation (20%) (**Table 5**). As noted by *Rola* (*2010*), significant proportions of the gross value of the vegetables have been lost due to their high degree of perishability. Provisions for storage facilities to maintain the quality of the vegetables has been desired by the farmers to increase the farmgate prices of their products. Some prerequisites for the successful implementation of a cold chain system include clustering of farms, production organization, market linkages, information dissemination, and post-harvest production practices on the part of growers and traders (*Ramos et al. 2005*).

Information dissemination is a very important determinant on whether farmers will harvest and market their produce or not. The top three most trusted sources of information of farmers were the following:

Table 5. Participation measures of the farmers.

Particulars	Percent (%)
Crop waste donation	20
Store produce and use the facility	37
Promote the project and use of facility to other farmers	13
Give feedback for monitoring effectiveness of the facility	11
Lease/manage the facility by existing farmer groups	2
No response	17

radio, other farmers and government agencies. These are followed by NGOs, others, TV, newspaper, internet, poster and leaflets. Some local radio stations in the area keep track of current market prices and give the farmers ready information on how much to expect for their produce daily. This availability of information could be an excellent avenue for information dissemination not only of market prices but also technological information and research (e.g., radio farm school) that could transmit various information to the farmers. Farmers are willing to try the pilot facility available in BAPTC when it was offered for a 1-month free-trial to them on March 2018. Further information dissemination on the advantages of storing their goods in cold-storage facilities are still necessary to improve their understanding on the socio-economic benefits of these facilities.

CONCLUSIONS AND RECOMMENDATIONS

Common high value crops that are available for possible cold-storing are usually green-leafy vegetables like cabbages and lettuce. Farmers would benefit greatly when these highly perishable goods are stored at controlled temperatures to preserve their freshness. Other possible crops recommended for cold storing are broccoli (*Brassica rapa*), tomato (*Solanum lycopersicum*), sweet pea (*Lathyrus odoratus*), and bell pepper (*Capsicum annuum*) since these crops are not always available all year round. These crops have high potential because they are also planted in limited areas, resulting to limited supply. In 2017, the demand for these products were high. The actual crop calendar developed through this study can be utilized to determine which crops can be stored in cold storage facilities on specific months.

In terms of waste, 7.5% of total produce is wasted during harvest while 20-50% is further lost during marketing. This huge amount of waste during transport and marketing could be reduced if cold-storage facilities are available near their farms and buyers can go directly and pick up the goods on-site. Moreover, it could also preserve the freshness of the produce after harvest.

There is still a wide gap on the common farming and market practices done by farmers versus convincing them to store their produce in cold-storage facilities. Most of them are willing if the technology is available to them at a reasonable price. Commonly, farmers have no storage space but are willing to transport to any distance. Farmers were satisfied with the prevailing market price of the vegetables. Farmers prefer to sell their products to middlemen or the highest bidder soon after harvesting. The top three main issues that the farmers encountered were price, market, and the harvesting process. The farmers stated that they are willing to store their products if these top issues are addressed. Therefore, the link between farm to market and timely information dissemination on available technologies, existing markets, and current price of goods should be addressed to facilitate acceptance of cold-storage facilities by the local Benguet farmers.

It is recommended to revisit the cropping calendar for planting and harvesting of the main crops for possible utilization during cold storing. The solid waste generated during harvest, transport and marketing could be minimized with cold storing. The wide information gap on the significance of cold storage in waste reduction should be bridged to provide farmers with science-based proof of its benefits.

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