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# Effects of Post-harvest Losses on Smallholder Farmers' Profitability: The Case of Fruit and Vegetable Farmers in the Ashanti Region of Ghana

Kofi Kyei (Corresponding author)
University College of Agriculture and Environmental Studies
Post Office Box 27. Bunso-Eastern Region, Ghana
Tel: +233534660388. Email: kofi.kyei@ucaes.edu.gh

Grace Darko Addy
University of Koblenz
Universitatsstrasse 1 56070
Koblenz, Germany
Tel: +4915218805309. Email: graceaddy@uni-koblenz.de

Isaac Diaka
University of Tsukuba
1-1-1 Tennodai, Tsukuba 305-8577
Ibaraki, Japan
Tel:+233541645097. Email: Ikebigy86@yahoo.com

**Abstract**
This paper estimates the amount of post-harvest loss of fruit and vegetable crops in Ghana.
It also examines the effect of the losses on smallholder farmers' profits. The study selected the Ashanti Region of Ghana. This region is well-known for horticulture production in Ghana. A structured questionnaire was used to collect the data. For the analysis, descriptive statistics and the multiple regression analysis was used to estimate the amount of post-harvest losses as well as identifying the effect of the losses on smallholder farmers' profits. The results showed that vegetable farmers lost about 7% of their total harvest. Fruit farmers on the other hand lost about 6% of their total harvest. The findings further revealed that vegetable farmers experienced more notable losses during harvest, storage and by pest infestation. Fruit farmers experience more losses at the market centers and during storage. This paper suggested possible recommendations to help reduce post-harvest losses at the study area.
**Keywords**: Post-Harvest Loss, Fruit Farmers, Vegetable Farmers, Ashanti Region
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## 1. Introduction

Every year approximately 1.3 billion tons of food is lost before reaching consumers (Buzby et al., 2014). Understanding more about the amount, trend and characteristics of post-harvest loss can better inform farmers and policymakers for effective mitigation measures. Despite this prospect, according to the United Nations, 95% of all food-related researches over the past 30 years focused on increasing crop production whereas only less than 5% was dedicated to reducing post-harvest loss (Xie et al., 2021).

In sub-Saharan Africa, more than 70% of the population is directly involved in agriculture as the primary source of income (Giller et al., 2021). However, farmers in Africa are not able to generate enough income due to post-harvest loss. Post-harvest loss occurs at any stage between harvest and consumption

This paper estimated the amount of post-harvest losses of fruit and vegetable crops in the Ashanti Region of Ghana. It further examined the effect of these losses on the profits of smallholder farmers. In the discussion below, past studies relating to fruit and vegetable losses were discussed, followed by the methodology and findings.

## 2. Literature Review

Studies on fruit and vegetable losses showed varied results by crops and countries. Zaccari et al. (1995) investigated the amount of post-harvest loss of onion in Uruguay and found 21.7% of harvested onions were lost. In Northern Thailand, Poonlarp et al. (2016) measured post-harvest loss of cabbage, celery, spinach, leaf lettuce and head lettuce and found head lettuce (48%-61%) and leaf lettuce (50%-60%) had the highest loss percentage range, followed by spinach (35%-52%), celery (42%-58%) and cabbage (28%-32%). Zheng et al. (2001) measured the post-harvest loss of Chinese cabbage, broccoli and bunching onion and found Chinese cabbage having the highest loss percentage range (12%-15%), followed by broccoli (10%-12%) and bunching onion (8%-10%). Wang and Bagshaw (2001) found 22.7% to 61.6% of harvested Chinese cabbage and 27.2% to 34.5% of harvested pak choi lost in the supply chain. Vilela et al. (2003) estimated the amount of post-harvest loss of tomato, bell pepper and carrot in Brazil and found 30% of loss among harvested tomatoes and bell peppers, and 12% of harvested carrots were lost.

Studies on enhancing farmers' profit looked at providing trainings to farmers about production methods, post-harvest handling techniques, record keeping and marketing. An example is a project carried out in Ghana by the Food and Agriculture Organization in 2009. The project entitled "Increasing Incomes and Food Security of Small Farmers in West and Central Africa through Exports of Organic and Fair-Trade Tropical Products" aimed at giving training support to a farmer-based organization in the Volta Region. Mango farmers were trained on production methods, record keeping, post-harvest techniques, marketing and computer use. This farmer-based organization, the Volta Mango Growers Association (VOMAGA), is made up of mango producers in the Region. The project evaluation revealed that 98% of mango farmers were satisfied with training topics and very optimistic of improving their profits after the project (Pay, 2009).

Some other past studies attempted to identify the impact of post-harvest loss on farmers' profit with an underlying premise that improved agriculture technologies would be the ultimate solution to enhance their profit margins. In Bangladesh, Schreinemachers et al. (2016) found that smallholder farmers who adopted improved technologies on their farms made significant profit gains. A Nigerian study (Aworh, 2015) found value additions to lesser-known indigenous Nigerian horticulture crops such as African star apple (*C. Albidum*), African mango (*I. Gabonensis*), tamarind (*Tamarindus indica*) and roselle (*Hibiscus sabdariffa*) enhanced smallholder farmers' profit in Nigeria. In South Africa, outsourced extension programs led to an increase in smallholder farmers' income (Baiyegunhi et al., 2019).

Other institutional reports also identified some drivers of post-harvest loss. For example, the International Center of Insect Physiology and Ecology (ICIPE) estimated some specific commodities at different stages of the supply chain of Ghana in 2013. These estimates excluded losses at the consumption stage. It illustrated that post-harvest food loss patterns differed within the same commodity groups. For example, 43% of rice was lost during the processing stage, whereas 1.2% of maize was lost (International Center of Insect Physiology and Ecology, 2013).

## 3. Methodology

### *3.1 The Study Area*

The Ashanti Region of Ghana has 30 administrative districts. The Region is located in southern Ghana with a total land surface area of 24,389 square kilometers, which is 10.2% of the total land area of Ghana. It shares boundaries with the Western, Central, Eastern and Brong Ahafo regions. With a population of 4,780,380 people, the Ashanti Region is the most populated region.

The region is well-known for horticulture production in Ghana. Compared to drier two northern regions, the Ashanti Region generally provides the conducive climate to vegetable production. Two major wet seasons of April-July and September-November allow the growth of rich vegetations under rainfed. Here, agricultural households constitute about 82% (Ghana Statistical Service, 2014).

Considering the significance of fruit and vegetable production for Ghana and western Africa, the Sekyere-Kumawu District in the Ashanti Region was purposely selected. In the 2010 Population and Housing Census Survey, this district had a population of 65,402 people (Ghana Statistical Service, 2014). Over 80% or 11,598 households of the total district population were engaged in over 15,453 agricultural activities. This implied that agricultural activity per household at Sekyere-Kumawu District was 1.33 or one in three agricultural households undertook more than one activity. In the district, about 34.3% and 0.7% of households engaged in animal husbandry and tree planting. Only 0.1% engaged in fish farming. Most households (98.2%) were involved in crop farming.

This district is recognized for fruit and vegetable production. According to the 2018 National Census of Agriculture Report, there were 198 fruit farmers and 2,605 vegetable farmers at Sekyere-Kumawu District. These farmers were smallholder farmers who owned small farm plots (Ghana Statistical Service, 2019). Major crops grown in the district include maize, rice, onion, pepper, garden egg, cassava, plantain, orange, banana, mango and avocado (Ghana Statistical Service, 2014).

Other than agriculture, the district has about 6.5% and 3.7% of the employed population engaged in manufacturing and food service industries. About 3.1% are in the construction industry. The district also has 72.8% of the population being economically active. In terms of economic active status by age group, the proportion of the population employed for ages between 15 and 19 years is low (28.3%) as compared with ages between 45 and 49 years (93.3%). This was not surprising because the majority of persons between the ages of 15 and 19 years are students and therefore not working. For district's occupational profile, 61.9% of the employed population are into skilled agriculture, forestry and fishery (Ghana Statistical Service, 2014). This is followed by service and sale workers (14.2%) and craft related traders (10.4%).

***3.2 Data Collection and Analysis***

A structured questionnaire was used for the data collection. The field survey was conducted in March 2022 by purposively sampling 100 vegetable farmers and 70 fruit farmers from five communities (Abotanso, Besoro, Domeabra, Woraso and Banko) at Sekyere-Kumawu District. The vegetable farmers in the survey were engaged in tomato, pepper, cabbage, garden egg and okra production. The fruit farmers in the survey were engaged in orange, banana, avocado and mango production.Information about farmers' socio-demographic variables, post-harvest loss estimates, and costs and returns of farmers were collected. As to socio-demographic variables, variables such as respondents' age, gender, education, household size and years of farming experience were identified. To find post-harvest loss estimations, the amount of fruit and vegetable losses at market centers, during harvest, storage and by pest infestations were determined. Regarding farmers' cost and returns, information about their production cost for fertilizer, seed, fungicide, weedicide, and insecticide along with cost for transportation and labor were collected.

For the analysis, descriptive statistics which included measures of tendency (e.g., percentage, frequency distribution, data tabulation) and estimation of post-harvest losses in the supply chain was used. To better understand the effect of post-harvest losses on farmers' profit, the multiple regression analysis was employed.

The regression model was expressed as:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + B_{11}X_{11}$$

Where Y = Farmers' Profit, $B_0$ = Intercept, $X_1$ = Loss During Harvest, $X_2$ = Loss at Storage, $X_3$ = Loss During Transport, $X_4$ = Loss by Pest Infestation, $X_5$ = Loss at Market Center, $X_6$ = Age, $X_7$ = Gender, $X_8$ = Education, $X_9$ = Experience, $X_{10}$ = Household Size, $X_{11}$ = Land Size and $B_1$ to $B_{11}$ = Regression Coefficients.

## 4. Results and Discussion

### *4.1 Socio-Demographic Features of Farmers*

The first part of the questionnaire survey clarified the socio-demographic features of the respondents (Table 1). The results found 37% of fruit farmers belonging to the age bracket of 50 to 59 years and 38% of vegetable farmers belonged to 40 to 49 years. About 30 % of fruit and vegetable farmers were 60 years and above. Only 18% of vegetable farmers were within the age bracket of 50 to 59 years. This implies that fruit farmers are more aging in the district than vegetable farmers. Male farmers were the majority in the study area. About 80% and 70% of farmers were male producers for fruits and vegetable production at Sekyere-Kumawu District.

Regarding education, fruit farmers were more educated than vegetable farmers. Almost 45% of vegetable farmers had no formal education and only 4% had no formal education in the case of fruit farmers. Most fruit farmers (51%) had completed senior high school education. Vegetable farmers had more experience in farming than fruit farmers in the region. Over 70% of vegetable farmers had more than 10 years of farming experience as compared to 60% of fruit farmers with the same years of farming experience.

However, fruit farmers had more household dependency ratio than vegetable farmers. Over 70% of fruit farmers had household size within the bracket of 6 to 15 as compared to 60% of vegetable farmers within the same household bracket (Table 1).

***4.2 Magnitude of Post-harvest Loss Estimates of Vegetables***

To better understand the amount of post-harvest loss of vegetables in the study area, the respondents were asked to give an estimate (in bag) about their loss of specific type of vegetables. Out of five crops, tomato had the maximum quantity harvested (34,010kg) with a total loss of 3,107kg (9%). Okra was the second most harvested crop (9,516kg) with a total loss of 281kg (Table 2). Cabbage recorded the least quantity harvested (1,205kg) with a total loss amount of 19.15kg (1.6%). However, the amount of post-harvest loss of tomato (9%), pepper (5%), cabbage (1.6%), okra (3%) and garden egg (3.7%) are minimal as compared to other post-harvest loss studies done in Africa. Olayemi et al. (2010) found 20% and 15% of post-harvest loss of tomato and pepper occurring in Kano State farms in Nigeria. Also, 10.7% of post-harvest loss of onions occurred on farms in Ethiopia (Tekeste et al., 2017).

The results also showed that the largest amount of post-harvest loss was caused by pest infestation. In particular, the infestation was the leading cause of loss for tomato (28%), pepper (36.83%), cabbage (26%) and okra (23%) crops. Only garden egg was lost most at market centers (26.3%).

To clearly understand the amount of vegetable loss by type of crop for an average smallholder in the study area, the amount of per capita loss by pest infestation and other causes was calculated. The results showed that tomato harvest had the highest per capita loss that amounted to 31.07kg. Other farmers experienced 5.21kg of per capita loss from pepper harvest and 2.81 kg from okra harvest (Table 2).

The results on per capita loss by pest infestations was 8.8kg for tomato, 0.65kg for okra, 1.92kg for pepper, and 0.049kg for cabbage (Table 2). The estimated loss per farmer during harvesting in the study area was 3.5kg for tomato harvest, 0.34kg for pepper harvest, 0.03kg for cabbage harvest, 0.35kg for garden egg harvest, and 0.47kg for okra harvest. Regarding loss at storage and market centers, a farmer lost 7.5kg of tomatoes at storage and 7.3kg at markets (Table 2). Per capita losses of pepper and cabbage ranged from 0.04 to 0.25kg at storages and from 0.04 to 1.7kg at market centers. For garden egg and okra, the losses ranged from 0.39kg to 0.59kg at storages and from 0.55kg to 0.6kg at markets. For the 2018-2019 cropping year, the respondents harvested a total of 59,940kg vegetables. From this amount, 4,136kg or 6.9% was lost.

### *4.3 Cost and Returns of Vegetable Farmers*

To investigate the profits of vegetable farmers at Sekyere-Kumawu District, the respondents were asked about the cost of their production inputs and revenue generated for the 2019-2020 cropping year. Here, as mentioned in the methodology section above, information on input cost (e.g., fertilizer, seed, weedicide, fungicide, insecticide, transportation, labor cost) was collected.

The result showed that tomato production (US$3,669) recorded the highest variable cost (Table 3), followed by that of okra (US$,1780) pepper (US$1,736) and garden egg (US$878). Cabbage production (US$278) recorded the least variable cost (Table 3). Labor was the highest variable cost for tomato (US$1,189) and pepper (US$567). The least variable cost was fungicide at US$48 and US$13 for tomato and pepper production respectively.

The net profit per farmer stood at 1,505 Ghana cedis (US$283) and 193 Ghana cedis (US$36) for tometoes and peppers (Table 3). The total revenue from the 100 respondents was 170,050 cedis (US$32,024) from tomatoes and 28,545 cedis (US$5,375) from pepper. Mean revenue per farmer was US$320.24 from tomato and US$53.75 from pepper. From cabbage and garden egg production, the total revenue was 3,013 Ghana cedis (US$567) and 28,071 Ghana cedis (US$5,286) respectively. Mean revenue per farmer was US$5.67 from cabbage harvest and US$52.86 from garden egg harvest. Insecticide (US$75) and labor (US$249) was the highest variable cost for the two commodities. The net profit per farmer for cabbage and garden egg harvest stood at 15 Ghana cedis (US$2.82) and 234 Ghana cedis (US$44) respectively.

Regarding okra production, the total revenue was 47,580 Ghana cedis (US$8,960) with US$574 of labor cost. Mean revenue per farmer was US$89.6. Fungicide (US$36.72) was the least variable cost, while the net profit per farmer stood at 381 Ghana cedis (US$72). The results showed that vegetable farmers spent more on labor than the other inputs. These findings confirm a study by Coker and Ninalowo (2016), who found labor cost to be the highest variable cost of smallholder rice farmers in Niger state, Nigeria.

The results further found that the vegetable farmers earned most profits from tomato harvest. This implies that tomato production is a very lucrative business in the study area. Among other crops sales from garden eggs (US$44) profited the respondents more than that from pepper (US$36).

### *4.4 Effect of Post-harvest Loss on Vegetable Farmers' Profits*

After identifying these results, the multiple regression analyses to identify corelations of farmers' profits with their socio-demographic characteristics was conducted. The results showed that losses during harvest, at storage and by pest infestations were significant and negative at 5% probability level (Table 4). This implies that for losses during harvesting and storage reduced farmers' profits by 6.61% and 12.8% respectively.

Education, household size and land size were significant and positive at 5% probability level. This implies that an increase in farmer's household size, land size and education increased profits of vegetable farmers by 9.7%, 7.1% and 0.042% respectively. Coker and Ninalowo (2016) similarly examined post-harvest loss effect on rice farmers' income in Nigeria and found that household size had significant effects on their income. Regarding correlation with gender, it was not found significant. Folayan (2013), however, found gender to be a major determinant of farmers' profit of maize.

The multiple regression equation model from table 4 is written as:

$Y = 726.48 - 6.61X_1 - 6.43X_2 - 12.80X_3 + 0.043X_4 + 9.69X_5 + 7.134X_6$

Where Y is farmers profit, $X_1$ is losses during harvest, $X_2$ is losses at storage, $X_3$ is losses by pest infestations, $X_4$ is education, $X_5$ is household size and $X_6$ is land size.

### *4.5 Amount of Post-harvest Loss Estimates of Fruit Crops*

The respondents were further asked to give an estimate (in bag) about the amount of their fruit loss. A total of 98,166kg was harvested from 70 fruit farmers, and 6,412kg or 6.5% was lost (Table 5). With 40,867kg of the total harvest, orange farmers lost 2,979kg. Although mango is seasonal in Ghana, the respondents lost (2315kg) from the total harvest of 35,630kg. Avocado farmers harvested 5,668kg in total and lost 268kg or 4.7%. These losses mostly occurred at market centers where 30% of orange, 35% of banana, 30% of mango and 26% of avocado were lost. However, this amount of post-harvest loss of mango, orange, avocado and banana seems to be minimal as compared to other studies. Post-harvest loss estimation study in Ethiopia by Tadesse (1991) found 9%, 8.1% and 26.3% of post-harvest loss of orange, banana and mango occurring on horticulture state farms.

Per capita loss by type of fruits and places was also identified (Table 5). The results showed that orange harvest had the highest loss per farmer (42.55kg) followed by mango (33.08kg), banana (12.16kg) and avocado (3.83kg). The estimated loss per farmer at market centers were 12.86kg for orange, 43kg for banana, 10 kg for mango, and 1kg for avocado. The estimated per capita loss due to transportation was 6.43kg for orange, 1.43kg for banana, 4.29kg for mango and 0.61kg for avocado. During harvesting, the respondents lost 6.43kg of orange, 1.43kg of banana, 4.29kg of mangoand 0.61kg of avocado, respectively (Table 5).

***4.6 Cost and Returns of Fruit Farmers***

In this section, the respondents were asked about the cost of their input production and revenue for the 2019-2020 cropping year (Table 6). The results revealed that the production of orange recorded the highest variable cost (US$2928), followed by that of mango (US$2,518), banana (US$1,975), and avocado (US$593).

In terms of revenue, the production of mango (US$15,540) and banana (US$9,040) recorded the highest revenue for the same season. The per capita revenue was US$83.04 (orange harvest), US$129 (banana harvest), US$222 (mango harvest) and US$30.50 (avocado harvest). While fertilizer (US$854) was the highest variable cost for the production of orange, labor (US$459.51) was the highest production cost for banana. The least variable cost was insecticide at US$75 and US$57 for orange and banana production. The net profit per farmer was US$43.88 and US$103.58 for both orange and banana harvest. Regarding mango and avocado production, labor was the highest variable cost. Fungicide was the least variable cost for mango (US$79.10) and avocado (US$0). The net profit per farmer for mango and avocado was US$188.72 and US$22.02.

***4.7 Effects of Post-harvest Loss on Fruit Farmers' Profits***

For this section, the multiple regression analysis of farmers' profits after losses was performed. Each post-harvest source was identified in connection to respondents' socio-demographic features. The results showed that losses at storage, market centers and by pest infestations were significant and negative at 5% probability level. This indicated that an increase in loss at storage, market centers and by pest infestations significantly reduced farmers' profits by 1.14%, 0.17% and 0.29%, respectively (Table 7).

Also, age and years of farming experience were significant and positive at 5% probability level. These results indicate that an increase in age and years of farming experience significantly increased the profits of farmers by 1.39% and 2.91%. This finding partly confirms a study by Abid and Scheffran (2016). In their study, Abid and Scheffran found farming experience to be very significant on wheat farmers' income and productivity in Pakistan.

The multiple regression equation model from table 16 is written as:

$$P = 277.26 – 1.14R_1 – 0.28R_2 – 0.17R_3 + 1.39R_4 + 2.91R_5.$$

Where P is farmers profit, $R_1$ is storage loss, $R_2$ is loss by pest infestations, $R_3$ is loss at market centers, $R_4$ is age, $R_5$ is years of farming experience.

## 5. Conclusion

This paper estimated the amount of post-harvest losses. It also assessed the effects of these losses on farmers' profits. The results showed that vegetable farmers lost 4,136kg or 6.9% of their total harvest (59,940 kg). Regarding vegetable farmers' profits, the respondents experienced most notable losses during harvest, storage and by pest infestations. An increase in the amount of losses reduced vegetable farmers' profit. Those respondents who were more educated with relatively large household members with a large land size gained more profits than the others. Vegetable farmers spent more on labor cost as this also negatively affected their profit. They earned more profit from tomato production than the other vegetables. The per capita profit from tomato was US$283 and that of okra harvest was US$71.75.

The overall percentage of post-harvest fruit loss was 6.5%. Orange harvest had the highest loss (7%), followed by mango (6.4%) and banana (5.3%). Avocado had the least post-harvest loss (4.7%). Regarding fruit farmers' profits, the results from the multiple regression analysis showed that loss at market centers, storage and by pest infestations had significant effects. Years of farming experience were also found to be very significant. This paper also found that mango farmers earned most among other fruit farmers in the study area. The profit per farmer for mango harvest was US$189.05. The second profitable farming business was banana at US$103.58.

It is evident from the results of this study that lack of storage facilities had significant impact on farmers' profits in the district. Fruit and vegetable crops harvested are normally stored in the open at farmers' houses and transported to market centers in wooden crates and baskets. The Ghana government can collaborate with private organizations to construct more cold storage facilities within farming communities. These storage facilities could be managed by farmer organizations. Smallholder farmers can therefore rent and use these facilities to store their harvested products by paying a fee monthly. Also, to reduce post-harvest losses, the government of Ghana together with some development partners can support the Ministry of Food and Agriculture financially to implement Post-Harvest Loss Estimation Survey annually. Collecting post-harvest loss information from farmers annually will help increase their awareness. This becomes the starting point to reduce losses. When farmers become aware of the magnitude of post-harvest losses, they will begin to realize the need to employ good post-harvest management practices.

**References**

Abid, M., Schneider, U. A. and Scheffran, J. (2016). Adaptation to climate change and its impacts on food productivity and crop income: Perspectives of farmers in rural Pakistan. *Journal of Rural Studies*, *47*, 254-266

Aworh, O. C. (2015). Promoting Food Security and Enhancing Nigeria's Small Farmers' Income through Value-added Processing of Lesser-Known and under-utilized Indigenous Fruits and Vegetables. *Food Research International*, *76*, 986-991

Baiyegunhi, L. J. S., Majokweni, Z. P. and Ferrer, S. R. D. (2019). Impact of Outsourced Agricultural Extension Program on Smallholder Farmers' Net Farm Income in Msinga, KwaZulu-Natal, South Africa. *Technology in Society*, *57*, 1-7

Buzby, J. C., Farah-Wells, H. and Hyman, J. (2014). The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States. *USDA-ERS Economic Information Bulletin*, (121).

Coker, A. A. and Ninalowo, S. O. (2016). Effect of Post-Harvest Losses on Rice Farmers' Income in Sub-Saharan Africa: A Case of Niger State, Nigeria. *Journal of Agricultural Science and Food Technology*, *2*(3), 27-34

Folayan, J. A. (2013). Determinants of Post-Harvest Losses of Maize in Akure North Local Government Area of Ondo State, Nigeria. *Journal of Sustainable Society*, Vol. 2, No. 1, 12-19

Ghana Statistical Service (2014). 2010 Population and housing census: A summary report of results. Retrieved on January 23, 2024 from Government of Ghana website: http://www.statsghana.gov.gh/pop_stats.html

Giller, K. E., Delaune, T., Silva, J. V., van Wijk, M., Hammond, J., Descheemaeker, K. and Andersson, J. A. (2021). Small farms and development in sub-Saharan Africa: Farming for food, for income or for lack of better options?. *Food Security*, *13*(6), 1431-1454.

Olayemi, F.F., Adegbola, J.A., Bamishaiye, E. I. and Daura, A.M. (2010). Assessment of post-harvest challenges of small scale farm holders of tomotoes, bell and hot pepper in some local government areas of Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *3*(2), 39-42

Pay, E. (2009). Increasing incomes and food security of small farmers in West and Central Africa through exports of organic and fair-trade tropical products. The Market for Organic and Fair-trade Mangoes and Pineapples, Study Prepared in the Framework of FAO Project GCP / RAF / 404 / GER, FAO of the United Nations, Trade and Markets Division, Rome.

Poonlarp, P., Boonyakiat, D., Chuamuangphan, C. and Chanta, M. (2016). Improving postharvest handling of the Royal Project vegetables. In *VIII International Postharvest Symposium: Enhancing Supply Chain and Consumer Benefits-Ethical and Technological Issues 1194*, 595-602.

Schreinemachers, P., Wu, M. H., Uddin, M. N., Ahmad, S. and Hanson, P. (2016). Farmer training in off-season vegetables: Effects on income and pesticide use in Bangladesh. *Food Policy*, *61*, 132-140.

Tekeste, N., Dechassa, N., Woldetsadik, K., Talae, A., Dessalegne, L. and Takele, A. (2017). Effect of Integrated Nitrogen, Phosphorus, and Farmyard manure on post-harvest quality and storability of onion (Allium cepa L.). *Journal of Postharvest Technology*, *5*(4), 25-37.

Vilela, N.J., M.M. Lana, E.F.do Nascimento, and N. Makishima. (2003). Perdas na comercializacao de hortalicas em uma rede varejista do Distrito Federal (Losses in the Commercialization of Vegetables in a Retail Network of the Federal District, Brazil). Cadernos de Ciencia and Tecnologia. 20(3), 521-541

Wang, X. and J.S. Bagshaw. (2001). Postharvest Handling Systems Assessment of Pak Choi and Chinese Cabbage in Eastern Central China. Postharvest Handling of Fresh Vegetables Proceedings of a Workshop held in Beijing, China, 9 -11-May-2001. ACIAR Proceedings No.105, 22-25

Xie, H., Wen, Y., Choi, Y. and Zhang, X. (2021). Global trends on food security research: A bibliometric analysis. *Land*, *10*(2), 119.

Zaccari, F., J. and A. Bianchi. (1995). Evaluation of Postharvest Losses of Sweet Onion (Allium cepa L.) cultivar Granex 33 harvested in the south of Uruguay for export to the USA (1993-1994). (Evaluacion de las perdidas en poscosecha de cebolla dulce (Allium cepa L.) cultivar Granex 33 cosechadas en el sur de Uruguay con destino de exportacion A Estados Unidos de America ,1993-1994). Harvest and Postharvest Technologies for Fresh Fruits and Vegetables ASAE Conference Proceedings, 414-420.

Zheng, S., L. Wu, G. L. Gao and P. Wu. (2001). Assessment of Postharvest Handling Systems for Vegetables in Beijing. Postharvest Handling of Fresh Vegetables. Proceedings of a Workshop Held in Beijing, China, 9th May-2001. ACIAR Proceedings No.105, 17-21.

Table 1. Socio-Demographic Features of the Farmers

| **Variable** | **Category** | **Fruit Farmers** | **Vegetable Farmers** |
|---|---|---|---|
| | | Frequency (%) | Frequency (%) |
| Age | 20 – 29 | 8 (12%) | 2 (2%) |
| | 30 – 39 | 14 (20%) | 15 (15%) |
| | 40 – 49 | 2 (2%) | 38 (38%) |
| | 50 – 59 | 26 (37%) | 18 (18%) |
| | 60 and above | 20 (29%) | 27 (27%) |
| Gender | Female | 14 (20%) | 30 (30%) |
| | Male | 56 (80%) | 70 (70%) |
| Education | No education | 3 (4%) | 44 (44%) |
| | Junior High School | 29 (41%) | 16 (16%) |
| | Senior High School | 36 (51%) | 12 (12%) |
| | Tertiary | 2 (3%) | 28 (28%) |
| Household Size | 1 – 5 | 20 (29%) | 32 (32%) |
| | 6 – 10 | 29 (41%) | 52 (52%) |
| | 11 – 15 | 21 (30%) | 12 (12%) |
| | 15 and above | 0 | 4 (4%) |
| Years of Experience | 1 – 10 | 30 (43%) | 26 (26%) |
| | 11 – 20 | 19 (27%) | 33 (33%) |
| | 21 – 30 | 17 (24%) | 28 (28%) |
| | 31 – 40 | 4 (6%) | 12 (12%) |
| | 41 and above | 0 | 1 (1%) |
| Total | | 70 | 100 |

Table 2. Amount of Post-Harvest Loss of Vegetables

| Crop | Loss by Pest Infestation (kg) | Loss at Market Center (kg) | Loss at Storage (kg) | Loss during Transport (kg) | Loss during Harvest (kg) | Total Loss (kg) | Quantity Harvested (kg) |
|---|---|---|---|---|---|---|---|
| Tomato | 882 (28%) | 725 (23%) | 750 (24%) | 400 (13%) | 350 (12%) | 3,107 (9%) | 34,010 |
| Pepper | 191.5 (36.83%) | 170 (32.7%) | 25 (4.8%) | 100 (19.2%) | 33.59 (6.47%) | 520.09 (5.5%) | 9,515 |
| Cabbage | 4.95 (26%) | 4 (21%) | 4.2 (22%) | 3.5 (18%) | 2.5 (13%) | 19.15 (1.6%) | 1,205 |
| Garden Egg | 50 (23.9%) | 55 (26.3%) | 39 (18.7%) | 30 (14.4%) | 35 (16.7%) | 209 (3.7%) | 5,694 |
| Okra | 65 (23%) | 60 (21.4%) | 57 (20.3%) | 52 (18.6%) | 46.6 (16.7%) | 281 (3.0%) | 9,516 |

 

Table 3. Summary of Cost and Returns of Vegetable Farmers

| | Tomato | Pepper | Cabbage | Garden Egg | Okra |
|---|---|---|---|---|---|
| Variable Cost Item | Average Cost/Acre (Ghana Cedi) | Average Cost/Acre (Ghana Cedi) | Average Cost/Acre (Ghana Cedi) | Average Cost/Acre (Ghana Cedi) | Average Cost/Acre (Ghana Cedi) |
| Fertilizer | 2,537 | 1,126 | 180 | 750 | 935 |
| Seed | 2,532 | 684 | 35 | 280 | 745 |
| Fungicide | 253 | 69 | 36 | 220 | 195 |
| Weedicide | 1,985 | 1,331 | 52 | 365 | 1,693 |
| Insecticide | 2,450 | 1,069 | 400 | 667 | 833 |
| Transportation | 3,416 | 1,930 | 70 | 1,060 | 2,006 |
| Hired Labor | 6,314 | 3,010 | 390 | 1,320 | 3,050 |
| Total Variable Cost | 19,487 | 9,219 | 1,478 | 4,662 | 9,457 |
| Quantity Harvested(kg) | 34,010 | 9,515 | 1,205 | 5,694 | 9,516 |
| Price per kg | 5 | 3 | 2.5 | 4.93 | 5 |
| Total Revenue | 170,050 | 28,545 | 3,013 | 28,071.42 | 47,580 |
| Net Profit | 150,563 | 19,326 | 1,535 | 23,409.42 | 38,064 |
| Profit per Farmer | 1,505 | 193 | 15 | 234 | 381 |

 

Table 4. Summary Results of Multiple Regression Analysis for Vegetable Farmers' Profits

| Variable | Coefficients | Standard Error | T-Stat | P-Value |
|---|---|---|---|---|
| Intercept | 726.476 | 116.488 | 6.237 | 1.52E-08 |
| Loss during Harvest | -6.615 | 2.95 | 2.242 | 0.0275* |
| Loss at Storage | -6.431 | 2.677 | -2.402 | 0.018* |
| Loss during Transport | 1.269 | 4.024 | 0.315 | 0.753 |
| Loss by Pest Infestation | -12.804 | 5.117 | -2.502 | 0.014* |
| Loss at Market Center | 6.309 | 5.442 | 1.159 | 0.249 |
| Age | -0.187 | 2.089 | -0.089 | 0.929 |
| Gender | 32.593 | 33.948 | 0.96 | 0.339 |
| Education | 0.042 | 2.629 | -0.016 | 0.007* |
| Experience | 2.669 | 2.054 | -1.3 | 0.197 |
| Household Size | 9.691 | 4.953 | 1.956 | 0.023* |
| Land Size | 7.135 | 10.838 | -0.658 | 0.012* |
| F-Stat | 1.646 | | | |
| R-Square | 0.171 | | | |
| Adjusted R-Squared | 0.067 | | | |

*P-Value<0.05

Table 5. Amount of Post-Harvest Loss of Fruits

| Crop | Loss by Pest Infestation (kg) | Loss at Market Center (kg) | Loss at Storage (kg) | Loss during Transport (kg) | Loss during Harvest (kg) | Total Loss (kg) | Quantity Harvested (kg) |
|---|---|---|---|---|---|---|---|
| Orange | 634 (21%) | 900 (30%) | 700 (23%) | 295 (10%) | 450 (16%) | 2979 (7%) | 40,867 |
| Banana | 180 (21%) | 300 (35%) | 200 (24%) | 70 (8%) | 100 (12%) | 850 (5.3%) | 16,001 |
| Mango | 500 (22%) | 700 (30%) | 580 (25%) | 235 (10%) | 300 (13%) | 2315 (6.5%) | 35,630 |
| Avocado | 65 (24%) | 70 (26%) | 60 (22%) | 30 (11%) | 43 (16%) | 268 (4.7%) | 5,668 |

 

Table 6. Summary of Cost and Returns of Fruit Farmers

| Variable Cost Item | Orange | Banana | Mango | Avocado |
|---|---|---|---|---|
| | Average Cost/Acre (Gh.Cedi) | Average Cost/Acre (Gh.Cedi) | Average Cost/Acre (Gh.Cedi) | Average Cost/Acre (Gh.Cedi) |
| Fertilizer | 4,537 | 1,400 | 3,240 | 235 |
| Seed | 3,400 | 2,020 | 2,465 | 105 |
| Fungicide | 1,683 | 800 | 420 | 0 |
| Weedicide | 538 | 1,230 | 1,400 | 80 |
| Insecticide | 399 | 300 | 490 | 630 |
| Transportation | 1,285 | 1,300 | 945 | 840 |
| Hired Labor | 2,673 | 2,440 | 3,412 | 1,260 |
| Total Variable Cost | 14,551 | 9,490 | 12,372 | 3,150 |
| Quantity Harvested(kg) | 30,867 | 12,001 | 20,630 | 5,668 |
| Price per kg | 1 | 4 | 4 | 2 |
| Total Revenue | 30,867 | 48,004 | 82,520 | 11,336 |
| Net Profit | 16,316 | 38,514 | 70,148 | 8,186 |
| Profit per Farmer | 233 | 550 | 1,002 | 117 |

Table 7. Summary Results of Multiple Regression Analysis for Fruit Farmers

| Variable | Coefficients | Standard Error | T-Stat | P-value |
|---|---|---|---|---|
| Intercept | 277.2611 | 89.4601 | 3.0993 | 0.0032 |
| Loss During Harvest | 3.3842 | 1.7554 | -1.9279 | 0.0598 |
| Loss at Storage | -1.1436 | 0.9593 | 1.1921 | 0.0091* |
| Loss During Transport | 3.5782 | 3.9853 | 0.8979 | 0.3737 |
| Loss by Pest Infestation | -0.2870 | 1.6361 | -0.1754 | 0.0015* |
| Loss at Market Center | -0.1669 | 1.3303 | 0.1254 | 0.0007* |
| Age | 1.3930 | 1.3336 | 1.0446 | 0.0015* |
| Gender | 26.0809 | 44.8813 | 0.5811 | 0.5639 |
| Education | -5.6210 | 5.1690 | -1.0874 | 0.2823 |
| Experience | 2.9117 | 3.6659 | -0.7943 | 0.0309* |
| Household Size | 6.1969 | 9.0998 | 0.6810 | 0.4991 |
| Land Size | 12.3280 | 23.5549 | 0.5234 | 0.6031 |
| F-Stat | 0.876 | | | |
| R-Square | 0.167 | | | |
| Adjusted R Square | -0.024 | | | |