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Produce Management and Household Food Security in Kwanza Sub county- Trans Nzoia County, Kenya

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Abstract: *The purpose of this study was to examine how produce management practices affecting household food security in Kwanza sub County. The world has been struggling with food insecurity; postharvest losses is one of the major challenges in the world. Household food insecurity is a recurrent challenge for smallholder farmers. This research employed General systems theory. The research found descriptive research design most appropriate and incorporated a mixed method of data collection. A sample size of 395 farming households, which included county officials and agricultural extension officers; calculated with the help of Yamane formula. The study used questionnaires to collect data. The analysis was done through SPSS version 25. The study revealed that the harvesting mechanism mainly employed was handpicking and activities done mainly at postharvest was threshing. Traditional produce storages were found to be more susceptible to pest storage with losses ranging from weevil attacks, discoloration, spillage contamination, rotten grains to broken grain. Another finding was that the farming households are not able to have access to metal silos because of its high cost. The results demonstrate that effective produce management practices are crucial in transforming household food security. The study recommends the integration of produce management practices in the national strategic plans by engaging all stakeholders. Training for community should be considered in order to enhance household's food security, road network and metal silos should be cost friendly.*

Keywords: *Produce management, Postharvest, Food security, Household, Loss, Wastage*

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1. Introduction

The study was guided by the following objective: to identify existing harvesting, post-harvest mechanisms and its effects in Kwanza sub County. To examine how produce storage affects household food security in Kwanza sub County. To assess the effectiveness of transportation of produce on household food security in Kwanza Sub County. To assess how metal silos can effectively help in produce management and household food security in Kwanza Sub County.

A study by Food and Agriculture Organization (2018) indicated that by 2050, the agricultural sector would

produce food for a global population amounting to 9.1 billion people and over 10 billion by the end of the 21st century. It was projected that food demand would increase from 2020 to 2030 in order to secure and maintain food security; therefore, it was imperative to transform the agricultural systems through an increment in produce management capacity and stability of household farmers. Post-harvest losses was one of the major challenges in the world today especially among small-scale farmers (Cheplogoi, Udoto, Ombati, 2021). However, produce management faces several challenges in keeping safe, good quality and nutritious food to cater for the ever-growing demand and achieve food security (FAO, 2018). Globally, one third of the food produced in the world per annum was lost. One third of food amounts to about 1.4 billion tons of food lost or wasted during the harvest and post-harvest agricultural phases. For example, in developed nations, about $680 billion was lost or wasted, equating to about half of the world's yearly crop production. The reduced loss of produce in the middle phases was attributed to the low availability of modern technology in handling and storage. Still the large part of the produce is wasted or rejected through spoilage because of mechanical damage during harvest and after. Hence, food insecurity becomes the mainstay in most households (Sawicka, 2019). Food security has been a priority and the agenda's focal point is largely on sustainable agricultural development. Sustainable development goal number twelve (12) stipulates that sustainable consumption and production patterns are essential. One of the targets of this goal is to halve per capita global food waste and ensure a reduction in food losses including post-harvest losses (FAO, 2018). For example, Bangladesh is the fourth largest producer of rice in the world, yet still experiences food insecurity because of harvesting and post harvesting losses (Sawicka, 2019). Food loss occurred by inadequacies along the food supply chain such as lack of information, poor infrastructure, insufficient technology or lack of skills from the actors. Thereby, striking response strategies such as investments, trade and technologies will be employed (FAO, 2018).

According to the county government of Trans Nzoia (2017), Kwanza Sub County experiences poor produce quality especially the grains and cereals, which are unsuitable for human consumption. Consequently, farmers are not able to use their harvest as a pledge to access credit. It is pivotal to have fitting, cost friendly storage technologies such as metallic silos that are obtainable to farmers (Gitonga, Hugo, Kassie and Tefera, 2013). The traditional granaries used in the area are not reliable and are prone to storage pests. The causes of losses ranges from weevil attacks, discoloration, spillage contamination, rotten grains, decrease in weight or volume, broken grain and high moisture content due to inadequate drying (FAO, 2014; Gitonga et al., 2013 & Republic of Kenya, 2017). It is against this background that this study will assess produce management practices and its effects on household food in Kwanza sub County-Trans Nzoia County.

2. Literature Review

The international covenant on economic, social and cultural rights treats food security as one of the fundamental rights of human beings that should be enjoyed by all and that all people should be free from hunger (Saul, Kinley and Mowbray, 2014). Food is a basic human right. Quality food contributes to good health, well-being, development and labor productivity. This means that food insecurity is a threat to human wellness, to measures towards poverty alleviation and economic growth (Kirimi, Olunga and Gitau, 2013). Food security concept was first introduced at the world food conference in 1974. The definition on food security has evolved in these past years. The world food summit held in Rome in 1996 came up with this definition; Food security refers to a situation "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and preferences for an active and healthy life" (FAO, 2016). Households are divided into three categories based on their food security stability namely chronically food poor, oscillators and consistently food non–poor households. Chronically food poor households are persons who live below the food poverty line, while the oscillators are households that have had a shift from being food poor to non-poor or vice versa. (Kirimi et al, 2013). Household food security refers to "the ability of the household to secure, either from its own production or through purchases, sufficient food for meeting the dietary needs of all members of the household" (FAO, 2016).

According to Kiaya (2014) post-harvest management had been in existence for some time now, though its management practices has received a new facelift in terms of investment through the twelfth sustainable development goal that talks of minimizing global food wastage and loss with the hopes of having a food secure world. Furthermore, Kiaya (2014) observed that in spite of numerous investments in the agricultural sector to combat food security, post-harvest losses remains as one of the unevaluated and paramount source of food insecurity because of ineffective post-harvest management practices (Kiaya, 2014). The post-harvest losses depends on a number of factors such as the type of the crop, geographical area, produce storage, harvesting mechanisms, mode of transportation and the kind of

economy. For instance, in most developing countries, a reasonable number of produce was lost because of lack of knowledge, lack of markets and insufficient technology for harvesting. For example, in Lesotho most food losses and wastage occur among the poor farmers because of financial incapacities (Sawicka, 2019).

At the regional level, limited infrastructure and transport service has recurrently disrupted food production and distribution. For instance, rural economies in least developed countries are mostly agrarian with 45% of the land area in low-income countries and 51% in lower middle-income nations. Africa transports 70-90% of its produce by road (Araya , Osborne and Pachon, 2014). Furthermore, these nations are located far from the main market, posing a constraint in needing the local food needs. For instance, South Africa has rural farm roads mostly characterized by dirt topped with gravel, with occasional grading during the reaping season by the local administration. Transport limitation is one of the causes of food insecurity as it is a constraint in moving food to markets. Consequently, most small-scale farmers experience losses and spoilage by not delivering their goods on time (Selepe, Sabela and Masuku, 2014). Increasing transport expenses was another challenge noticed, with farmers forced to sell their produce at their gates, sold at a cheaper price compared with the main market price (Morgan, Dogbey and Arimiyaw, 2019).

During the harvesting phase, prices of produce were relatively lower because of oversupply, thus reducing the farmers' income. A study conducted in three countries namely Malawi, Tanzania and Uganda on post-harvest processes through the farmers' perspective. The study observed that insects, rotting and rodents affected post-harvest handling especially during drying, winnowing phases. The research findings indicated that post-harvest losses were linked to humidity and temperatures. The losses were more in hot and humid regions. These factors affected the produce quality negatively (Kaminski and Christiansen, 2014).

Kenya lacked cost friendly, stringent mechanisms, lack of training and development. At the same time, the country had been affected by negligence of post-harvest structures resulting into average post-harvest losses amounting to 20-30%. Enhanced postharvest mechanisms had the ability to minimize imports into Kenya (Njoroge, Ibrahim and Baributsa, 2019). Much of the produce was lost due to lack of initiatives in post-harvest management strategies. For instance, about 50 percent of the fruits produced were lost each year (Republic of Kenya, 2017). Drying had always been a challenge among small-scale farmers especially in arid areas, such that most of the farmers experienced postharvest losses and wastage in the course of that period prior to storage (Njoroge et al., 2019).

Globally, a metal silo is one of the key post-harvest technology and for food security. A metal silo is a cylindrical structure, constructed from a galvanized iron sheet and hermetically sealed (Gitonga, et al., 2013). Metal silos allows grains to be kept for a long time and prevents attacks from pests such as rodents, insects and birds among others. A metal silo with a capacity of 1000 kilograms can preserve the grain for a household of five for a period of one year. Generally, a metal silo can hold up to 3000 kilograms. Metal silos offers several benefits namely: quality of stored produce is maintained, it requires little space, gives farmers an opportunity to benefit from fluctuating produce prices especially grain, it is a tried and tested technology in many other countries. Furthermore, metal silos elevated small scale farmers by giving them the chance to get rid of hunger, and have a stable source of income by storing produce and selling at the best prices. Metal silos is a source of employment and development venture through fabrication and marketing. For instance, in 2007, there were 982 metal silo manufacturers working in Guatemala and Honduras. The tinsmiths earned about $470 from the production of metal silos per annum as an extra income. According to International maize and wheat improvement center (2013) metal silos largely contribute to safeguarding the agro ecosystem through the alternative use of pesticides, which have a negative impact on the environment. A study carried out by Food and agriculture organization in Bolivia on post-harvest project establishes metal silo to be the most accepted and commonly used technology. The household farmers attested that metal silo enhanced food security, minimized post-harvest losses and retained quality. A similar research was carried out to groups such as technology transfer institutions, market authorities, government among other. The report indicates that a metal silo is associated with a positive impact on food security enhancement (FAO, 2018). However, it is paramount to check the moisture content of produce before storing in the metal silo. The recommended moisture content should be less than 14 percent for grain and cereals and less than 10 percent for pulses and oilseeds. It is also vital to clean and properly dry the inside of the metal silo, placing it under cover on a pallet and after putting the produce inside the silo, the container is airtight covered for months or years (CIMMYT, 2013). Rosegrant and Cline (2003) observed that global food security remains a generational concern and beyond. Attaining food security requires policy and investment reforms in various platforms. Capacity building plays a pivotal role in speeding up food security

achievements through education, farmers are able to manage crops and adopt new technologies such as metal silos as a comparative advantage (Rosegrant and Cline, 2003).

The Swiss Agency for development and cooperation introduced metal silos in Embu and Homa regions respectively and 105 metal silos were distributed. These silos were targeted for smallholder farmers and had positive impact such that farmers bought grains at harvest time at lower prices and utilised the grain throughout the year. However, the rate of adoption hugely depended on the cost effectiveness of metal silos. The initial prices of silos were high, for example, a metal silo of 90-kilogram capacity costed 3000 Kenyan shilling in 2009. Considering that, the metal silo could be used for more than ten years, with minimum or no maintenance at all. Another challenge highlighted was the inability to circulate the metal silos to a large number of farmers in different geographical areas; hence, metal silos were not widely available and collaboration on this cause proved futile (Gitonga, et al., 2013 & CIMMYT, 2013).

The literature brought out the elements of the increase in post-harvest losses, climatic changes and pests. Therefore, in order to improve food security, there is need to minimize post-harvest losses. Food insecurity is associated with food loss and wastage through the medium of transportation that either delays, too costly not to talk about the bad condition of the roads. Produce management and food security are interrelated concepts whose main objective is to reduce hunger, achieve food security using storage facilities. Despite the growing interest in research with regard to produce management and household food security; major gaps identified were: limited studies have been done in relation to this topic within the same area; many household farmers were reluctant to adopt metal silos because of the high cost. This study seeks to address this knowledge gap by contributing to the knowledge of research as well as be a solution to household food insecurity in Kwanza Sub County.

3. Methodology

A mixed method research design was adopted by this study. A mixed methods research design involves parallel processing and evaluation of both qualitative and quantitative data (Creswell, 2012). Mixed approach is the use of mixed data (numerical and text) and alternative methods (statistics and analysis), but using the same method (Creswell, 2015). In this type of research, the researcher uses the qualitative research paradigm for one phase of the study and a quantitative research paradigm for another phase of the study (Ranjit, 2019).

The study was carried out in Kwanza Sub County, which is in Trans Nzoia County. Kwanza Sub County in Northwestern Kenya, located 20 kilometers north of Kitale at a latitude of 1.1641, 6,506 feet above sea level. It borders the Republic of Uganda, Bungoma, and west Pokot, Elgeyo Marakwet, Uasin Gishu and Kakamega counties. Kwanza Sub County is one of the five sub counties in Trans Nzoia County. There are four assembly wards in Kwanza Sub County namely: Kwanza, Keiyo, Bidii and Kapomboni. Kwanza experiences the tropical humid climate throughout the year. It has the average annual rainfall of about 127.7 mm (5.03inches) with 179.2 rainy days, annual low temperature of 12.33 degrees calculus and February is the warmth month ranging from 28.13 C to 82.63F ((County, 2017).

The study adopted a descriptive research method aimed at establishing the relationship between produce management and household food security. This method identifies and justifies practical conditions by investigating the causal relationship between independent variables and dependent variables. Kothari (2014) exemplifies that descriptive method outlines the ideologies of a population. It tries to demonstrate systematically the structured moments, challenges, phenomenon, service or data related to living conditions meant for the given society. According to Creswell (2012) the process of descriptive research method is liable for generating perfect interrelationships among the notable variables. Descriptive research method identifies and justifies practical conditions. It is capable of making assessments and comparing factual data depicting relevant phenomena (Creswell, 2012). Questionnaires used were both closed and open ended. This facilitated the interviewee answer the closed questions as per the choices given as well as give their personal views and opinions based on the objectives of the study. According to Kenya National bureau of statistics (2019), Kwanza Sub County has 32,511 households actively engaged in farming spread across in four wards namely Keiyo, Bidii, Kwanza and Kapomboi (KNBS, 2019). The researcher applied Yamane formula.

$$n = \frac{N}{1+N(e)^2}$$

Where n is a sample size and N is the population and e is the (precision level) error margin (0.05) assumed.

Known population of households = 32,511

The study used 95% confidence interval

The calculation follows:

$$\frac{32511}{(1 + 32511(0.0025)}$$

n= 395

Hence applying the formula on a target population of 32511 households, the sample size was 395 and thus the focus was the heads of these households, three agricultural extension officers and two county government officials. The researcher arrived at the sample size of 395 because this was an adequate representation of the population that demonstrated an active involvement in farming. Simple random sampling was used in the distribution of respondents to the four wards in Kwanza Sub County based on the number of wards as below:

Bidii (8111/ 32511)*395 =99 Kapomboi (12506/32511)*395=151

Keiyo (2862/32511)*395 = 35 Kwanza (9032/32511)*395=110

The filled questionnaires were checked for completeness. Data analysis began once the data was collected. Data analysis was done through using both quantitatively and qualitatively approaches. Quantitative data was coded and entered into the computer using software called statistical package for social sciences (SPSS) version 25. Data collected was analyzed using statistical tables and graphs. These included frequency distribution tables, percentages, and bar charts. For qualitative collected data was read, then categorized into major themes in relation to the objectives of the study and coded for ease of analysis.

4. Results and Discussion

The section covers the findings, analysis and discussion, which are given in percentages, frequencies, tables, graphs and figures. The section illustrates the responses from the participants and the demographic characteristics of the respondents on how produce management affect food security through harvesting and post-harvest phases. It highlights harvesting mechanisms, transportation, metallic silos, storage and its effects on food security in Kwanza sub county- Trans-Nzoia County..

Identifying existing harvesting and post harvesting mechanisms on household food security

In order to understand produce management, the researcher found it necessary to first inquire about the various mechanisms employed during harvesting and postharvest phases.. This comprises of harvesting methods and activities mostly done during post-harvest. Household were asked to give their views regarding this matter. 82% (321) of the participants stated that they use manual method (handpicked) when harvesting and 18 % (69) of the participants use machinery equipment to harvest their produce. This finding is in line with Kiaya (2014), Kamwanga et al., (2016) and Sawicka (2019) who attests that produce losses are linked to technical weaknesses in harvesting methods employed. The post-harvest mechanisms activities comprises of drying, packaging, threshing and winnowing. The representation reveals that 68.42% of the participants attest that they mostly thresh their produce after harvesting. This contributes to produce losses and wastage. They pointed out that this method took a lot of time and resulted into food loss due to slow rate of work and damage. The technical weaknesses in harvesting methods was one of the contributors to food insecurity.

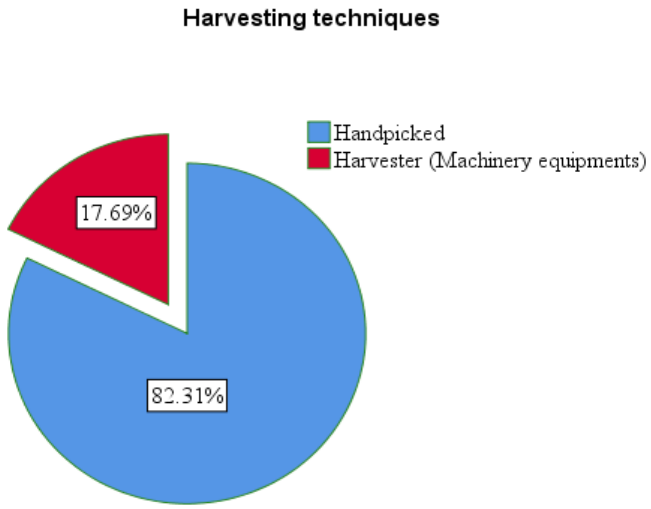

Figure1: Types of harvesting techniques

Table 1:Pearson's chi square test of association between harvesting techniques and kinds of food losses and wastage encountered

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.890[a]	3	0.005
Likelihood Ratio	13.961	3	0.003
Linear-by-Linear Association	12.719	1	0
N of Valid Cases	390		

The results of chi square test of association between harvesting mechanisms aid in improving food security and kinds of losses and wastages encountered indicated that there is a significant association at 0.00 significance level. Pearson chi square value was 49.65, at 6 degree of freedom. Indicating that food losses and wastage are negatively influenced by the harvesting techniques used.

The section below handled the activities mostly done at post-harvest and their effects on household food security. The pie chart shows that 60% of the participants attest that they mostly thresh their produce after harvesting. 8 % of the participants indulge into drying their produce after harvest. Winnowing is presented by 26% responses, while packaging is seen among 6% of the participants. Yeshiwas and Tadele (2021) confirmed that huge quantity of harvested produce was lost each year because of improper postharvest handling and management practices. The findings also resonate with Kaminski and Christiaensen (2014) who observed that produce was affected during post-harvest mechanisms such as drying, winnowing and threshing phases as well as weather changes. Through mycotoxins contamination, insect infestation and shatter losses (Sugri, Abubakari, Owusu and Bidzakin, 2021).

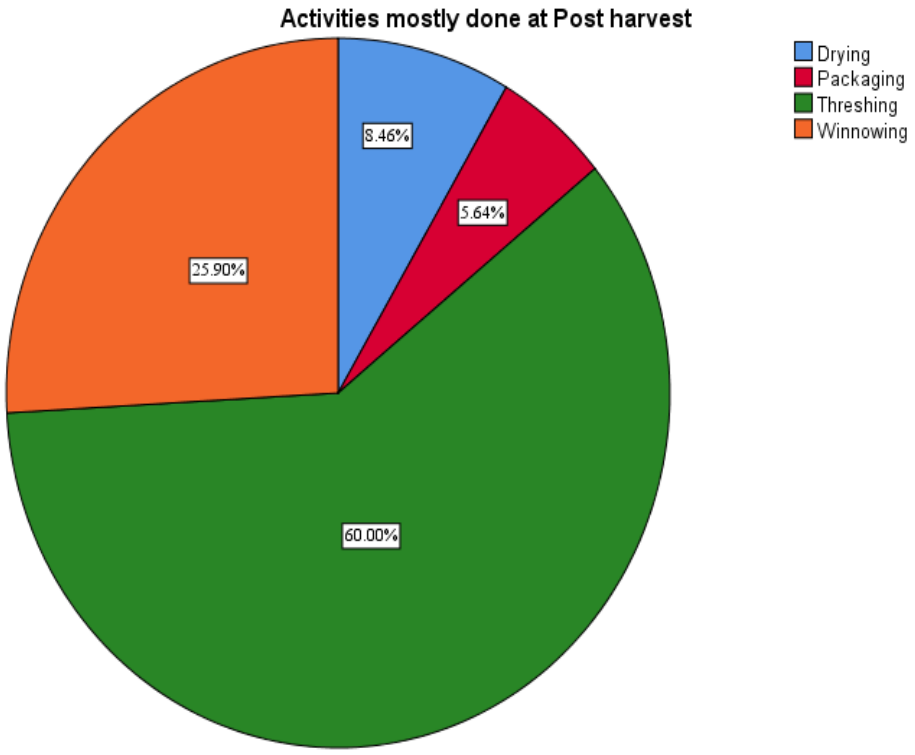

Figure 2: Activities mostly done at postharvest

Produce storage and Household food security

Chi square test was used to examine the association between produce storage and weather changes. There was a significant relationship at 0.00% significant level. Hence, produce storage was greatly affected by weather changes. This was in line with Sasson, (2012) Climatic changes is one of the main causes of food insecurity whose influence has been evident through extreme weather conditions. For instance, high temperatures compromise the quality, palatability, increased cooking time, and a rise in the formation of free fatty acids in stored grain. Storage temperature and time affects the flavor and quality of rice (Suleiman and Laswai, 2017). Thus, traditional storage in African nations was not a surety of protection against major storage pests of staple food such as maize (Gitonga, Groote and Tefera, 2015). Nduku. Hugo and Nzuma (2013) confirmed that traditional storage methods tend to have more loss in comparison to the modern improved storage facilities.

Table 2: Pearson's Chi-Square Tests of association between storage of produce and effects of weather changes on harvest and postharvest

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	35.636[a]	9	.000
Likelihood Ratio	33.670	9	.000
Linear-by-Linear Association	.324	1	.569
N of Valid Cases	390		

Post-harvest transportation and household food security

The study sought to establish the views of the respondents on postharvest transportation and household food security. The respondents were asked to state as to whether they were comfortable with the road network and the mode of transport used in Kwanza Sub County. The results are as in figure 3 below.

The condition of the road shows, 8% (32) participants consider the road condition good. The road condition is extremely affected to a poor proportion of 68 %(265) participants. 24%(93) of the participants state that the road conditions are very poor. Transportation is another important element in produce management. The road condition effects produce management extremely at 68% response rate. According to Selepe, et al., (2014) found that most of the roads in developing countries are poorly developed and dilapidated. Produce transport encounters challenges such as high cost at a response rate of 65%, which is the highest among the challenges.

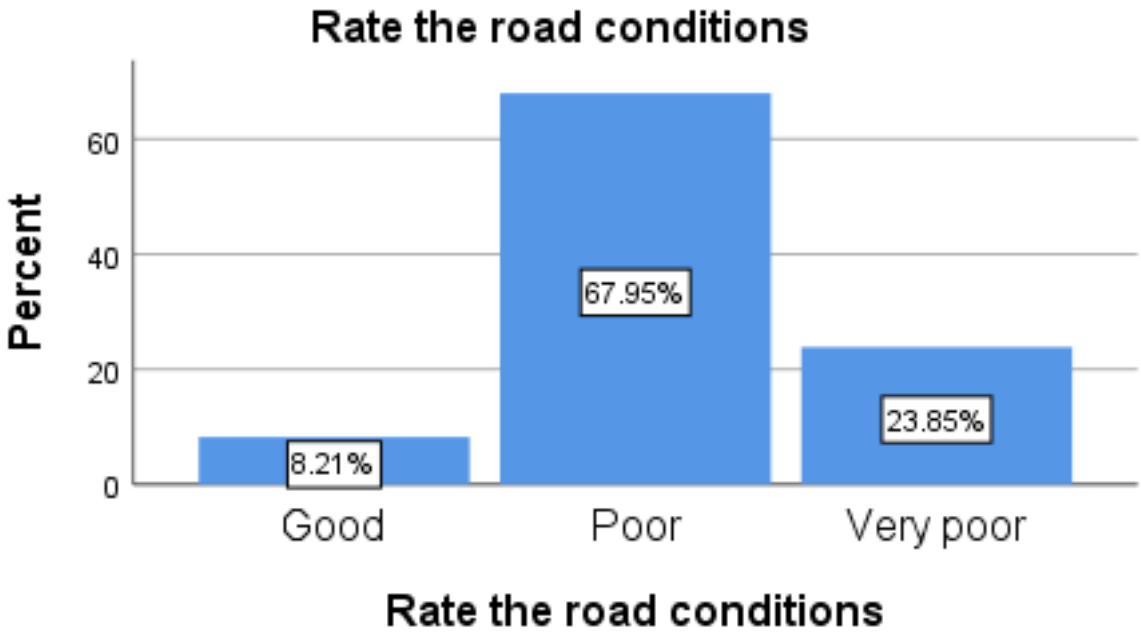

Figure 3: Rate the road conditions

Table 3 below shows mode of transport used when transporting produce among the residents of Kwanza Sub County. Truck as a mode of transport is used at a response rate of 6.7% (7) as presented by the participants. 21% (81) of the respondents use motorcycles to transport their produce. Oxen mode of transport follows at a response of 71% (278). 1% (5) participants present any other form of transportation.

Those who said that they used oxen presented by 66.3% gave the following reasons: One of the household farmers (A) exclaimed:

Due to bad road, they prefer to use oxen to trucks because it is much easier to maneuver. Oxen is cost friendly (Mode of transport, October 2021).

The participants who stated that they used motorcycles supported by the following reason: One of the male household participants (B) explained:

Motorcycles are used because of the poor road network; hence, motorcycles tend to be the most convenient mode of transport (Mode of transport, October 2021).

The participants who stated that they used trucks did so due to the following reason: One household participants (C) stated that:

The farm is closer to the road and a truck can easily transport the produce to the storage area or the market. The truck has much space for the produce (Mode of transport, October 2021).

The participants who stated that they used any other means of transportation were supported by the following reason: A female household participant (D) exclaimed:

Trucks are very expensive thereby they carry the produce themselves (Mode of transport, October 2021).

A Chi square test of association below revealed that mode of transport was negatively influenced by weather changes at 0.003% level of significance. Hence, transport produce and weather changes were supported. According to Sasidharan (2017) during rainy seasons, most of the roads are impassable and transport prices tend to be higher. For example, higher cost charges and worse road conditions were experienced in Kinangop (Sieber, 2013).

Table 3: Pearson's Chi-Square Tests of association between mode of transport used and effects of weather changes on postharvest

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.386[a]	9	.003
Likelihood Ratio	23.666	9	.005
Linear-by-Linear Association	10.361	1	.001
N of Valid Cases	390		

Metal silos and household food security

The respondents were asked whether metal silos prevent produce from pest infestation and whether it is the most needed investment towards food security.

The table below presents metal silos on prevention from pest infestation. Metallic silos are believed to prevent produce from pest infestation as presented by 99% (387) of the participants. 8% (3) of the participants attest that metal silos do not prevent produce from pest infestation. The high representation resonates with Rosentrater and Darfour, (2018) metal silos reduced or prevented to a larger extent exposure to pests, insects and weather conditions and aided in improving food security and price stability.

Table 4: Metallic silos prevent produce from pest infestation

		Frequency	Percent
Valid	Yes	387	99
	No	3	8
Total		390	100.0

Table 5 shows the most needed investment concerning food security. The participants attest that road network is the most needed investment in order to combat household food insecurity in the study area at a response rate of 26% (103). Metal silos is presented as the most needed investment by 56% (218) of the participants. The least needed investment, which is a training facility, accounted for 18% (69) of the participants.

According to CIMMYT (2013), FAO (2018), Rosegrant and Cline (2003) metallic silos are a technology with comparative advantage associated with positive impact on both produce management and household food security. Replication of metal silos in the study area just like in Homa bay will reduce post-harvest losses.

Table 5: most needed investment concerning food security

		Frequency	Percent
Valid	Road Network	103	26.4
	Metallic silos	218	55.9
	Training facility	69	17.7
Total		390	100.0

5. Conclusion and Recommendations

5.1 Conclusions

According to the findings of the research, produce management activities are observable in Kwanza Sub County. Produce management was examined through an analysis of its different components, thus, harvesting and post harvesting mechanisms, produce storage, modes of produce transportation and metal silos. The study main objective was examined and a conclusion was drawn that failure to proper handling of produce management; leads to household food insecurity and vice versa in Kwanza Sub County- Trans- Nzoia County. The study findings established that through the existing harvest and post-harvest mechanisms household food security is not achievable. During harvesting which is done manually, a lot of food is lost and wasted due to slow rate of work and damage. The technical weaknesses in harvesting methods is one of the contributors to food insecurity. Post-harvest mechanisms especially through threshing and winnowing further contribute to food loss. Food insecurity remains a common occurrence in the area.

The study sought to demonstrate how produce storage affects household food security in Kwanza Sub County. Lack of efficient storage facilities was listed among the hindrances to household food security in Kwanza Sub County. The respondents were fully aware of the impact of the food lost through the storage facilities. Majority of the household farmers use granaries and sacks to store their produce. The finding on effectiveness of transportation of produce indicated that the condition of roads are poor and the mode of transport produce used is oxen because it is cost friendly to the majority of the respondents. Most farming households cited high cost of transport as one of the challenges encountered. The finding on metal silos indicated that metal silos were effective in produce management and household food security. The participants presented that metallic silos are effective and efficient in produce management that leads to household food security.

5.2 Recommendation

1. The integration of produce management practices in the national strategic plans and strategies by engaging all stakeholders.
2. Training of household farmers is paramount in attaining food security. Training is a catalyst for awareness of post-harvest losses.
3. Promote use of storage that is cost effective, affordable and safe for humans and the environment.
4. Metal silos should be part of the national post-harvest programme with well-articulated artisans and proximities to easily access metal silos
5. Metal silos should be cost effective for household farmers.
6. Transportation should be cost effective, fast and less dependent on adverse weather conditions.

References

Araya, G. E., Osborne, T., & Pachon, M. C. (2014). *Transporting agricultural goods.* Washington DC: World Bank. http://pubdocs.worldbank.org/en/538601534212778854/EBA15-Transporting-agriculture-goods.pdf

CIMMYT (2013). *From Kenya to Southern Africa Effective grain storage crosses borders.* Texcoco: International maize and wheat improvement center.

Cheplogoi, S., Udoto, M. O., & Ombati, J. M. (2021). Implications of indigenous food storage and preservation strategies on household food security in Baringo County, Kenya. *International journal of scientific research and innovative technology Vol 8. No. 4*, 2313-3759.

Creswell, J. (2012). *Educational Research: Planning, conducting and evaluating qualitative and quantitative research.* London: Prentice hall.

Creswell, J. (2015). *A concise introduction to mixed methods research.* Thousand Orks, CA: Sage..

Gitonga, Z. M., Hugo, D. G., Kassie, M., & Tefera, T. (2013). Impact of metal silos on households' maize storage, storage losses and food security: An application of a propensity score matching. *Journal of food policy*, vol. 43, issue C, 44-55.

Gitonga, Z., Groote, H. D., & Tefera, T. (2015). Metal silos grain storage technology and household

food security in Kenya. *Journal of development and agricultural economics*, Vol. 7(6), pp. 222-230.

Kaminski, J., & Christiaensen, L. (2014). Post-harvest loss in sub-Saharan Africa- what do farmers say. *Journal of global food security.*, 3(3-4).

Kamwaga, J., Macharia, G., Boyd, L., Chiurugwi, T., Midgley, I., Canales, C., Maina, I. (2016). *Kenya wheat production handbook Kenya agriculture and livestock.* Nairobi: Kenya Agricultural and Livestock Research Organization, KALRO .

Republic of Kenya. (2017). *National food and nutrition security policy implemetation framework 2017-2022*. Nairobi: Kilimo House.

Kiaya, V. (2014, January). *Post-harvest losses and strategies to reduce them.* http://www.academia.edu/download/45278162/post_harvest_Losses.pdf

Kiprono, P., & Matsumoto, T. (2014). Roads and Farming: The Effect of Infrastructure Improvement on Agricultural Input Use, Farm Productivity and Market Participation in Kenya.

Kirimi, L., Gitau, R., & Olunga, M. (2013). Household food security and commercialization among smallholder farmers in Kenya. *International Conference of the African Association of Agricultural Economists.* Nairobi: Research in agricultural and applied economics.

KNBS (2019). *Population and housing Census report.* Nairobi: Kenya National Bureau of Statistics.

Kothari, C. (2014). *Research methodology: Methods and Techniques (3rd ed.).* New Delhi: International printing press limited.

Morgan, A. K., Dogbey, E., & Arimiyaw, A. W. (2019). Effect of road transport accessibility on agricultural produce marketing and livelihoods of farmers in the Kasena-Nankana West District of Ghana. *Journal of development practice*, 2394-0476.

Nduku, T. M., Hugo, D. G., & Nzuma, J. M. (2013). Comparative analysis of maize storage structures in Kenya. *African association of agricultural economists (AAAE) 2013 fourth international conference* (p. 18). Hammamet: Research in agricultrual and applied economists.

FAO (2014). *Sustainable food systems concept and framework.* Rome: Food and agriculture organisation .

FAO (2016). *The state of food and agriculture. Climate change, agriculture and food security.* Rome: Food and agriculture organisation .

FAO (2018). *Guideline on the measurements of harvest and post-harvest losses.* Rome: Food and agriculture organisation .

County (2017). *Trans Nzoia intergrated development plan, 2013-2017.* Trans Nzoia County.

Ranjit, K. (2019). *Research metholodogy.* New Delhi: Sage publications.

Rosegrant, M. W., & Cline, S. A. (2003, December 12). *Food security:challenges and policies.* Science 302(5652):1917-9.: https:// 10.1126/science.1092958.

Sasson, A. (2012). Food security for Africa: an urget global challenge. *Agriculture and food security 1,2 (2012)*, 1-2

Saul, B., Kinley, D., & Mowbray, J. (2014). *The international Convenent on economic, social and cultural rights: Commentary, cases and materials.* Oxford: Oxford Univerisity press.

Sasidharan, M. (2017, November 17). *Better rural trasnport is key to food security and zero hunger.* Cambridge: University of Cambridge.

Sawicka, B. (2019). Post-harvest losses of agriculture produce. *Sustainable development 1(1)*, 1-16.

Selepe, M., Sabela, T. S., & Masuku, M. (2014). The effects of infrastructural challenges on food security in Ntambanana, KwaZulu-Natal, South

Africa. *African journal f hospitality, tourism and Leisure 3, 2014*, 1-12.

Sieber, N. (2013). *Rural Logistics for Smallholder Farmers to Meet New Agricultural Market Demand.* International forum for rural transport and development.

Sugri, I., Mutari, A., Owusu, R. K., & Bidzakin, J. K. (2021, March 25). *Postharvest losses and mitigating technologies: evidence from Upper East Region of Ghana*. Sustainable futures Vol 3, 2021: https://10.1016/j.sftr.2021.100048

Suleiman, R., & Laswai, H. (2017). Climate change and its implications on postharvest losses of grains in tropical and subtropical countries. *National Level Post-Harvest Management Conference.* Dar es Salaam.

Yamane, T. (1973). *Statistics: An introductory Analysis.* New York: Harper and Row.

Yeshiwas, Y., & Tadele, E. (2021). *An Investigation into Major Causes for Postharvest Losses of Horticultural Crops and Their Handling Practice in Debre Markos, North-Western Ethiopia.* Advances in Agriculture, vol. 2021, Article ID 1985303, 10 pages, 2021: https://10.1155/2021/1985303