Effectiveness of training farmers on sugarcane gleaning during loading in reducing post-harvest loss among smallholder farmers in Awendo Sub-County, Kenya

.

ABSTRACT

|  |
| --- |
| Post-harvest sugarcane loss (PHSL) experienced in the sugarcane production process reduces incomes of smallholder farmers worldwide who invest their limited resources. As a result, Sony Sugar Company instituted infield practices in 2011 to reduce PHSL within its cane catchment areas. Training of farmers on sugarcane gleaning forms part of the company’s quasi-public extension (QPE) service to reduce PHSL. However, limited information is available on its effectiveness. In order to fill this gap, this study sought to examine effectiveness of training of farmers on sugarcane gleaning during loading in reducing PHSL among smallholder farmers in Awendo Sub-County. The study was guided by Theory of Change (ToC) using descriptive survey design. A sample of 105 contracted smallholder farmers were obtained from accessible population of 2,403 farmers distributed proportionately across North-East, Central, South and West Sakwa wards. The sample was increased by 40% to 147 taking cognizance that questionnaire was to be used to collect data. Cronbach’s Alpha Coefficients for questionnaires were 0.749 for smallholder farmers’ and 0.711 for other stakeholders. Only 132 smallholder farmers’ questionnaires were valid giving 89.8% response rate. Descriptive statistics and spearman’s correlation were used to analyze data using SPSS version 21. Positive relationships were realized between PHSL and training farmers on sugarcane gleaning (*r* (130) = .142, *p* > .05.). This study recommends that farmers or their agents should enhance their participation on sugarcane gleaning and attend aligned trainings by the company. Sony Sugar Company should enhance training of farmers on sugarcane gleaning during loading. County and National governments should formulate sound policies to safe guard farmers. |

***Keywords:*** *Agricultural extension, Effectiveness, Nucleus Estate, Outgrowers, Post-harvest loss, Quasi-public extension service, Smallholder farmers, Sugarcane gleaning*

1. INTRODUCTION

Farmers worldwide devote their limited resources to cultivate sugarcane in order to earn income for improved livelihood (Farooq et al., 2020). However, in the production process, they experience post-harvest sugarcane loss (PHSL) that reduces their income (Khan et al., 2020). Post-harvest sugarcane loss refers to both quality and quantity losses that occur in the field after harvest (Ambler et al., 2018; Caixeta-Filho & Péra, 2018). Qualitative losses are in terms of losses in sucrose content occasioned by delayed cut-to-mill time (Solomon, 2009; Datir & Joshi, 2015; Ali et al., 2018). Quantitative losses remain the greatest concern to farmers as they are paid in terms of tonnes (quantity) of sugarcane delivered to the mills (Duncan, 2021). Nanjala (2022) asserts that quantity losses in form of spillage make farmers suffer huge losses.

Post-harvest sugarcane quantity losses are caused majorly by spillage (A. Singh, 2020; Nanjala, 2022), non-collection of all canes from the field (Josphat, 2020) and delayed cut-to-mill time leading to reduction in cane weight (Datir & Joshi, 2015; Afsharnia et al., 2018; Ali et al., 2018). According to Caixeta-Filho and Péra (2018), 0.094 tonnes out of 1.0 tonne of harvested cane remain in the field while only 0.824 tonnes reach the mill. As a result, PHSL due to spillage is alarming as witnessed when trailers are carelessly packed and overloaded by cane grabbers (Duncan, 2021). Research and Development Division [RDD] (2018) reveals infield spillage of 1.89 tonnes per acre. Reduced sugarcane tonnage delivered to the factory adversely affects farmers, cane cutters and millers economically (Duncan, 2021). In India for example, farmers lose an estimated INR 43,760.64 (Kshs. 63,452.93) per 100 tonnes of cane milled at the same period (Singh et al., 2019).

Post-harvest sugarcane loss has pulled in far-flung attention as one of the alarming problems of sugar industry (Kashyap & Kumar, 2018). Sugar Industry Stakeholders Taskforce Report [SISTR (2019) assert that sugarcane spillage in the field greatly contributes to PHSL. Consequently, sugarcane millers employ multiple infield practices to reduce it (Rai, 2020). Gleaning is one of the infield practices that check sugarcane spillage as the greatest contributor of PHSL (Zhao et al., 2019). Sugar Research Institute [SRI] (2018) opines that quasi-public extension (QPE) services such as training on gleaning during loading of sugarcane equally have a bearing in reducing PHSL. These practices vary by region.

South Nyanza Sugar (Sony Sugar) Company, a Kenyan quasi-public organization obtains part of its sugarcane from outgrowers in nine sub-counties spread in Migori, Homabay, Kisii and Narok counties (Outgrowers Extension Service Division [OESD], 2019). In Awendo Sub-county in Migori, farmers have commericalized sugarcane production since inception of Sony Sugar Company (Bundeh, 2018). Blum (2020) avers that contracted sugarcane farmers receive extension services hereby termed as QPE services embedded in agricultural department of the contracting miller. In this regard, Sony Sugar Company’s agricultural extension field supervisors (AEFS) link with farmers in maintenance of the crop for optimum yields (Oliveira, 2018). The company instituted multiple infield practices in 2011 in bid to cushion her contracted farmers and herself from PHSL. Some of the infield practices include but not limited to cane standard stack sizing, proper gleaning during stacking and cane loading, proper loading and trailer loading limit for both single and double bucket trailers. Besides, the Company management installed Agriculture Management System (AMS) in 2013 to monitor harvesting and transport operations (Harvesting & Transport Division, 2017).

According to United Nations (2017) effectiveness explains how well an intervention works towards the intended result. As a result, Sony Sugar Company undertakes spot assessments of its instituted practices that reduce PHSL. The company in its nucleus estate, gleaned 0.36 tonnes in 2012, 0.33 tonnes in 2013 and 0.18 tonnes in 2014 where percentage infield losses were 0.07%, 0.20% and 3.67% respectively. Actual percentage PHSL in 2012 and 2013 were within the set target of less than one percent attributed to proper gleaning (RDD, 2014). Gleaning as an instituted infield practice thus effectively reduced PHSL in 2012 and 2013. In 2014 the infield practices were ineffective in reducing PHSL since percentage actual loss was greater than the set target. Sampled infield assessments in 2018 reveal that outgrowers lose an average of 4.52 tonnes of cane per acre. However, no clear information on the effectiveness of training farmers on sugarcane gleaning in reducing post-harvest sugarcane loss between 2018 and 2021. Thus, this study seeks to examine the effectiveness of training of farmers on sugarcane gleaning during loading in reducing post-harvest loss experienced by smallholder farmers in Awendo Sub- County, Kenya.

The study findings would be useful to the smallholder sugarcane farmers, millers and other stakeholders. Farmers could use the information obtained to improve their participation accordingly in reducing PHSL. Sony Sugar Company could also get feedback and learn on their PHSL mitigation strategies. The study findings could also inform the decisions of County and National Governments in sound policy formulations on PHSL reduction strategies. This could help in improving farmers’ income and livelihood thereby contributing in part to poverty eradication envisioned as a Sustainable Development Goal (SDG).

2. materials and methods

**2.1 Survey Design**

Descriptive survey design was used for this study as it enabled investigations of the variables of study without manipulating any of them but only observing and measuring them (McCombes, 2019). Besides, the design enabled study of the variables using the selected large sample size in a relatively short time by face-to-face administration of questionnaire (Asenahabi, 2019).

**2.2 Location of the Study**

The study was carried out in Awendo Sub-county located in Migori County in the South Western part of Kenya. Awendo Sub-county has four wards, namely Central Sakwa, South Sakwa, West Sakwa and North Sakwa (Okoth, 2018). The total number of households is 27,033 with an average household size of 4.3. The sub-county has a population density of 427 per Km2 (Kenya National Bureau of Statistics, 2019). In this Sub-county, sugarcane remains the main cash and industrial crop while maize is the main staple food (Okoth, 2018). Awendo Sub-county had the highest number of contracted farmers (3,123) among the nine Sonysugar’s cane catchment Sub-counties where sugarcane was harvested between 2018 and 2021. Other sub-counties with their farmers in parenthesis included Uriri (1,774), Transmara West (891), Suna East (758), Rongo (536), South Mugirango (315), Rangwe (158), Ndhiwa (91) and Kuria West (69) (OESD, 2019). Sony Sugar Company is a quasi-public organization run by the National Government of Kenya that significantly benefits from its sugar (Okoth, 2018).

**2.3 Population of the Study**

Table 1 shows summary of the target and accessible populations.

**Table** **1. Summary of the Target and Accessible Populations**

|  |  |  |
| --- | --- | --- |
| **Category** | **Target Population**  | **Accessible Population** |
| Contracted smallholder sugarcane farmers | 3,123 | 2,403 |
| Agricultural extension field supervisors | 10 | 8 |
| Agricultural extension field assistants | 4 | 3 |
| Harvesting and transport supervisors | 6 | 6 |
| Harvesting and transport field assistants | 10 | 6 |
| Harvesting contractors | 12 | 7 |
| Transport contractors | 4 | 4 |
| Tractor drivers | 45 | 12 |
| Graber/bell operators | 9 | 4 |
| Winch operators | 7 | 3 |
| Cane cutters | 600 | 21 |

*Target population from Sony sugar, 2021.*

**2.4 Sampling Procedures and Sample Size**

Both probability and non-probability sampling techniques were used to select samples (Rahi, 2017). Awendo Sub-County was purposively selected on the basis of high number of farmers and their longevity in commercialized sugarcane production. In this Sub-County, Sony Sugar Company was purposively selected as it had commercialized sugarcane production since 1979. This served the longest period compared to Transmara and Sukari Sugar Companies that were established in 2011 and 2012 respectively. Besides, Sony Sugar Company instituted infield practices in 2011 to minimize PHSL.

Nassiuma (2000) formula contends that co-efficient of variance in the range of 21% ≤ c ≤ 30% and standard error in the range of of 2% ≤ e ≤ 5% are acceptable for descriptive studies. Thus, sample size was calculated as follows (Nassiuma, 2000):

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

Where:

$ n$ - is the sample size,

$N$ - is the accessible population,

c - is the coefficient of variance, while

e - is the standard error.

In this study N was 2403, c was 21% (0.21) and e was 2% (0.02) thus a sample size of 105 was obtained by substituting these values in the formula as follows,

$$n =\frac{2403(0.21^{2})}{0.21^{2}+ (2403-1)0.02^{2}}$$

$$n =105$$

Taking cognizance that questionnaires was used to collect data, the sample size was increased by 40% to 147 (105 + 40% of 105) to cater for non-response and missing data (Bujang, 2021).

All the four wards in Awendo Sub-County were purposively selected since the accessible population of 2,403 smallholder sugarcane farmers were distributed across the wards. The sample size from each ward was selected through a proportional sampling technique (Cochran, 1977) as shown below.

$$ n\_{i}=\frac{N\_{i }x n}{N}$$

Where:

$ n\_{i}$ - is the number of smallholder farmers to be interviewed in the selected ward,

$N\_{i }$ - is the accessible smallholder sugarcane farmers in the selected ward,

n - is the sample size for the whole study, while

N - is the accessible smallholder sugarcane farmers in the area of study.

Table 2 shows the summary of sampling frame and sample size of respondents from each Ward calculated using Cochran (1977) formula aforementioned.

**Table** **2. Sampling Frame and Sample Size of Respondents from Each Ward**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ward** | **Cane Area in Ha** | **Sampling frame** | **Sample size (n =105)**  | **Sample size (n = 147)** |
| Central Sakwa | 256.04 | 600 | 26 | 37 |
| North-East Sakwa | 233.49 | 505 | 22 | 31 |
| South Sakwa | 354.69 | 667 | 29 | 41 |
| West Sakwa | 238.94 | 631 | 28 | 38 |
| **Total** | **1,083.16** | **2,403** | **105** | **147** |

A systematic random sampling technique was used to select farmers that were interviewed in each ward since the sampling frame was available (Memon et al., 2017). According to Cochran (1997), systematic random sampling involves selection of a unit at random from the first *k* units and every *k*th unit thereafter. This is known as every *k*th systematic sample. In this case, selection of the first unit determines the whole sample. This technique was chosen for this study as it enabled the researcher to draw samples easily without mistakes (Cochran, 1977). Besides, the technique gives each farmer equal chance of probability to be selected in the sample (Rahi, 2017). Purposive technique was used to include all other 67 accessible stakeholders.

**2.5 Data Collection**

Researchers sought and obtained clearance from Egerton University Board of Post Graduate Studies, Ethical Approval by Egerton University Institutional Scientific and Ethics Review Committee and research permit from the National Commission for Science, Technology and Innovation (NACOSTI). Subsequently, a visit was made to the study area and appointments made with respondents during which two different sets of questionnaire were administered. First questionnaire was for farming household. Second questionnaire was used to corroborate information from other stakeholders. Both survey questionnaire were pre-tested for reliability using 30 smallholder farmers and 30 other stakeholders obtained by systematic random sampling from Suna East Sub-County in Migori County. According to Cochran (1997), systematic random sampling is a probability sampling technique which involves selection of a unit at random from the first *k* units and every *k*th unit thereafter. The *k*th unit for pilot study was every 25th farmer from a sample frame of 758 smallholder farmers’ list arranged alphabetically resulting in a sample of 30 smallholder farmers. The 30 other stakeholders were purposively included. Cronbach’s alpha reliability coefficients of α = 0.749 and 0.711 were achieved for smallholder farmers’ and other stakeholders’ questionnaires respectively before data collection.

Respondents freely chose to either participate or not to participate in the study. Researchers’ opinions were not considered so that personal biases and opinions did not get way into the research. A document review guide, a means of triangulation was also developed to collect secondary data related to the study variables (Bowen, 2009). It involved reviewing printed and electronic materials related to post-harvest sugarcane loss experienced by Sony Sugar farmers as from the year 2018 to 2021.

**2.6 Data Analysis**

Data in the questionnaire was coded and entered in the computer for processing using Statistical Package for Social Sciences (SPSS) version 21 where both qualitative and quantitative data were analyzed using descriptive statistics (percentages, frequencies and mean) as shown in Table 3 that indicates summary of data analysis. Mean values of estimated tonnes of cane left spilled in the field was used to determine amount of Post-harvest sugarcane loss as well as mitigation measures. Frequency and percentage counts of number of smallholder farmers trained on sugarcane gleaning during loading over the study period were used to determine their effectiveness. Frequency and percentage counts of smallholder farmers and other stakeholders based on their ranking of training farmers on sugarcane gleaning during loading in reducing PHSL was also used to determine their effectiveness. Spearman’s rank correlation was used to test the strength of relationship between training farmers on sugarcane gleaning during loading and PHSL. In Spearman’s rank correlation coefficient formula, *p* = 1 - $\frac{6 \sum\_{}^{}d\_{i}^{2}}{n(n^{2}-1)}$ where;

p = Spearman’s rank correlation coefficient;

$d\_{i}$ = difference between the two ranks of each observation

$n$ = number of observations

**Table** **3. Summary of Data Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Research Objective** | **Independent****Variable** | **Dependent****Variable** | **Statistical****Tests** |
| To establish the effectiveness of training farmers on sugarcane gleaning in reducing PHSL among smallholder farmers | Training of farmers on sugarcane gleaning. | Post-harvest sugarcane loss (PHSL). | Descriptive statistics (Frequencies, Percentages and Mean); Spearman’s RankCorrelation. |
|  |  |  |  |

3. results and discussion

**3.1 Smallholder Farmer’s Source of Land**

Figure 1 indicates that most (56.8%) of the smallholder farmers grew contracted sugarcane on their own lands while few (1.5%) produced on gifted land.



**Figure 1. Smallholder Farmers’ Source of Land**

**3.2 Trend of Post-Harvest Sugarcane Loss between 2018 and 2021**

The results in Figure 2 show that mean PHSL in form of infield spillage in Awendo sub-county was high in the tear 2020 at 6.58 tonnes per hectare (TCH) and lowest in 2019 (5.23 TCH).



**Figure 2. Trend of Post-Harvest Sugarcane Loss Between 2018 And 2020 (Std. Deviation – 6.5)**

Results in Table 4 indicate that majority (83.3%) of the smallholder farmers lost an estimated percentage of over 1.0% of the total cane tonnage delivered to the factory.

**Table 4. Estimated percentage infield loss (n=132)**

|  |  |  |
| --- | --- | --- |
| **Estimated percentage infield PHSL** | **Frequency** | **Percentage** |
| Below the objective of less than 1% of total cane delivered to the factory.  | 22 | 16.7 |
| Above the objective of less than 1% of total cane delivered to the factory.  | 110 | 83.3 |

*SPSS Version 21 result (2022)*

[ n = 132 is total sample size for smallholder farmers whose questionnaire were valid]

**3.3 Causes of Post-Harvest Sugarcane Loss between 2018 and 2021**

Figure 3 shows how sugarcane post-harvest value chain relationship was conceptualised. It highlights stakeholders responsible for various activities in sugarcane post-harvest value chain in Awendo Sub-County. They include farmers or their agents as owners of the raw material and other stakeholders.

 Weighbridge

 Activities

 & Losses

***Activities***

 ***&***

***PH Losses***

 Transit

 Activities

 & Losses

 In-Field

 Activities

 & Losses

**At the Weighbridge**

**Off-Farm to the Mill**

 **At the Farm**

***Cane Flow***

***Stakeholder***

Harvesting

Contractors

* FA
* Cane cutters

Transporters

* FA
* Drivers
* Operators
* Loaders

Sony Sugar Company Staff

* Extension Staff
* H&T Staff
* Weighbridge Staff

 Farmers

* Agents

**Key:**

FA - Field Assistants

H&T Staff - Harvesting and Transport Staff

PH Losses - Post-Harvest Losses

 - Direction of Cane Flow

 - Communication between Actors

 - Actors Point of Activities on Cane Flow

 - Point of Activities and Post-Harvest Losses

*Adopted from South Nyanza Sugar Company harvesting and transport flow chart and modified by authors*

*Adopted from South Nyanza Sugar Company Limited harvesting and transport flow chart and modified by authors*

**Figure 3. Sugar Cane Post-Harvest Value Chain Relationships**

Results in Table 5 shows that 28.0% of farmers attributed greatest contributors of infield PHSL to failure to glean during loading. A small number (0.8%) of farmers observed that poor terrain make loading difficult thus causing PHSL.

**Table 5. Farmers’ observations on greatest contributors of infield PHSL**

|  |  |  |
| --- | --- | --- |
| **Greatest contributors of infield PHSL** | **Frequency** | **Percentage** |
| Scattering cane by grabber | 32 | 24.2 |
| Failure to glean during loading | 37 | 28.0 |
| Faster loading speed than gleaning speed | 11 | 8.3 |
| Poor harvesting standards | 9 | 6.8 |
| Overloading of tractors | 6 | 4.5 |
| Gleaned cane never picked | 22 | 16.7 |
| Some stack(s) never picked | 4 | 3.0 |
| Destroyed cane by grabber when running over them | 2 | 1.5 |
| Poor terrain/topography making loading difficult | 1 | 0.8 |
| Bad weather making cane stick in mud hence difficult to collect | 8 | 6.1 |

*SPSS Version 21 result (2022)*

**3.4 Methods of contacting farmers for Training on Sugarcane Gleaning in Reducing Post-Harvest Sugarcane Loss**

Table 6 shows main method by which Sony Sugar company’s AEFS and AFA contact smallholder farmers. The results reveal that majority (97.0%) of sugarcane farmers were contacted through varied methods. The most popular methods of extension delivery was farm field visits (75.8%). However, 3.0% of farmers are never contacted.

**Table 6. Main method by which AEFS and AEFA contact smallholder farmers**

|  |  |  |
| --- | --- | --- |
| **Main method of contact** | **Frequency** | **Percentage** |
| Farm field visits | 100 | 75.8 |
| E-extension | 15 | 11.4 |
| Agricultural training centres | 2 | 1.5 |
| Agricultural information desks | 11 | 8.3 |
| Not contacted | 4 | 3.0 |

*SPSS Version 21 result (2022)*

Smallholder farmers who were never trained on sugarcane gleaning cited their busy schedule as the main reasons for missing such training. However, they stated that they benefited from their trained counterparts through social interactions.

**3.5 Effectiveness of Training on Sugarcane Gleaning in Reducing Post-Harvest Sugarcane Loss**

Effectiveness of training on sugarcane gleaning in reducing PHSL was measured by smallholder farmers ranking it on a five-point Likert scale. This involved not effective (1), slightly effective (2), effective (3), very effective (4) and excellently effective (5). Frequency and percentages of ratings produced an estimate of effective rate. Besides, the ratings were confirmed by estimated percentage loss per farmer’s plot compared to set target of less than one percent (1.0%) of total tonnes of cane delivered to the factory. PHSL of less than 1.0% means training on sugarcane gleaning is effective while above 1.0% means it is not effective.

All farmers who were trained on sugarcane gleaning during loading and practised the same believed that the training was effective in reducing PHSL in Awendo Sub-County Kenya. Majority ranked the effectiveness level of training of farmers on sugarcane gleaning in reducing effective (74.5%). Results of the percentage loss they experienced in their cane fields confirmed their statements. They formed majority (54.5%) of 22 farmers who lost less than the set target of one percent (1.0%) of total tonnes of sugarcane delivered to Sony Sugar factory. Similarly, 100% of AEFS and AEFA stated that training on sugarcane gleaning as a QPES was effective in reducing PHSL. Majority of these other stakeholders ranked the training as effective (57.1%). Table 7 indicates ranking of effectiveness of training on sugarcane gleaning in reducing PHSL.

**Table 7. Ranking of effectiveness of training on sugarcane gleaning in reducing PHSL**

|  |  |  |
| --- | --- | --- |
| **Ranking level of effectiveness of training in sugarcane gleaning in reducing PHSL**  | **By Smallholder farmers** | **By AEFS and AEFA (n=7)** |
| **Frequency** **n=51 n=132** | **Percentage** **n=51 n=132** | **Frequency** | **Percentage** |
| Very effective | 4 | 4 | 7.8 | 3.0 | 2 | 28.6 |
| Effective | 38 | 43 | 74.5 | 32.6 | 4 | 57.1 |
| Slightly effective | 9 | 9 | 17.7 | 6.8 | 1 | 14.3 |
| Not effective |  | 76 |  | 57.6 |  |  |

*SPSS Version 21 result (2022)*

[ n = 51 is number of smallholder farmers who were trained on sugarcane gleaning and practiced the same

n =132 is the total sample of smallholder farmers whose questionnaire were valid

n = 7 is the number of Agricultural extension field supervisors and assistants whose questionnaire were valid]

Smallholder farmers noted that their participation in gleaning after training was vital to implement the knowledge and skills gained to effectively reduce PHSL. Besides, the Spearman’s test results in Table 8 reveal that the relationship between training on sugarcane gleaning and post-harvest sugarcane loss was positive. The relationship between the two variables was statistically significant, *r* (130) = .142, *p* > .05.

**Table 8. Relationship between training on sugarcane gleaning and PHSL**

|  |  |  |
| --- | --- | --- |
| **Scale** |  | Post-harvest sugarcane loss |
| Training on sugarcane gleaning | Correlation coefficient | .142 |
| P-value | .105 |
| N | 132 |

*SPSS Version 21 result (2022)*

[Variables subjected to test were training on sugarcane gleaning and post-harvest sugarcane loss as independent and dependent variables respectoively]

Nasiche et al.(2020) assert that sugar millers invest in farmers through provision of training and other extension services since they depend on them for the raw materials (sugarcane). Results of this study agree with SRI (2018) study on farmers’ perception on improved sugarcane varieties in Western Kenya. The findings of the study revealed that agricultural extension agents packaged and disseminated sugarcane production technologies to majority of farmers through field visits (23.1%), field days (22.3%) and Barazas/meetings (22.3). A farmer research group (6.4%) was least popular whereas in Awendo sub-county, the least popular method was agricultural training centre (1.5%). A study by Farooq et al. (2020) in Pakistan also found out that Fatima sugar mills’ extension field staff majorly diffused information to sugarcane farmers through farm/home visits. Other methods included result and method demonstrations, shows, office calls and group meetings.

Results of this study are still consistent with study by Dlamini (2018) in Swaziland. The study was geared towards reducing sugarcane productivity gap between large scale and smallholder farmers. Study findings revealed that Swaziland sugar industry was ready for e-extension via cell phones. This enhanced smallholder farmers’ access to timely and reliable information from agricultural extension officers.

Results are consistent with findings of the study by Farooq et al. (2020) on comparison between public and private extension services for sugarcane production in Muzaffagarh district, Punjab in Pakistan. The study found out that Fatima Sugar Mill performed better than public sector in providing technical facilities such as trainings and skills improvement. However, the training programmes were not timely and regularly conducted. Farooq et al. (2020) further found out that agricultural extension field supervisors remain key drivers of sugarcane farmers’ training. They noted that training of sugarcane farmers on sugarcane production activities empowers them with knowledge and skills to be experts in sugarcane production. This was attributed to the fact that farmers cultivate sugarcane to earn income for improved living and meeting their social needs.

Similarly, the study by SRI (2017a) on impact assessment of outreach activities on uptake of improved sugarcane production technologies found out that over 50% of majority of farmers who attended training on improved cane production technologies practiced the various practices after the training. The end result was that most of them (61%) obtained high yields. Further, 97% of the trained farmers agreed that the knowledge they gained increased their earnings from sugarcane farming by between 20% and 30% per acre from previous earnings.

The study by Mgendi et al. (2021) in Tanzania equally found out that trained farmer groups adopted some technology. This indicated that agricultural training programs had an influence on technology adoption and improvement of smallholder farmers’ yield. The evidence was in the study findings that farmers who were trained on seed selection by using water and adopted it significantly increased their rice yield by 381 kg per acre than their trained non-adopters counter parts. Regarding spillover effects of training, the results are in line with this study in that they also found out that non-trained farmers benefited from trained farmers through their social interactions.

The results also concur with that of Nasiche et al. (2020) on the study on influence of supplier training on performance of sugarcane enterprises in Kenya. The study found out that enhanced training of sugarcane farmers on input, planting and weeding resulted in improved sugarcane yield (tonnage) reaching the factory. This would minimize perennial shortage of raw material often experienced in the industry. Thus, training and education of sugarcane suppliers has a positive impact on performance improvement of both the miller as the buyer and smallholder farmers as the supplier. Moodley (2011) has similar belief and asserts that training is an essential component to enhance farm operations. This may have a turnaround effect on some of the 57.6 percent of the smallholder farmers who were never trained on sugarcane gleaning to reduce PHSL.

The results are consistent with that of Stathers et al. (2020) on a scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia. The study found out that training of farmers and other actors in the value chain prevents most of post-harvest losses Training farmers on post-harvest loss reduction strategies is effective in reducing the loss when combined with suitable technologies, sound policies and infrastructure. Research by Acharjee et al. (2021) also found out that training farmers raises their level of awareness in PHL management hence significantly reduce PH fish loss. Similar findings were also obtained by Pretari et al., 2019 that training of farmers as a post-harvest intervention alongside provision of plastic sheets for sun-drying maize contributed to reduction of afflatoxin contamination in rural Kenya by over 50%.

Results of this study further concurs with that of Tiwari et al.(2020) that revealed that farmers play important role in reducing post-harvest loss of tomato, therefore public awareness should be increased through mass media on proper harvesting and storing of tomato. The study accordingly found out that insufficient knowledge about tomato post-harvest management practices such as storage, packaging and transportation led to the maximum loss of tomato. Moreover, Ndiritu and Ruhinduka (2019) found that extension services matter significantly for both improved storage and preserving. House-holds with access to extension services such as training are 7 percent more likely to adopt improved storage compared to their counterparts. (Ndiritu & Ruhinduka, 2019)

The findings of this study are also similar to that of Shee et al. (2019) on post-harvest losses during transport, drying and milling stages of maize. The study found out that the coefficients of the training received on PHL were negative and significant, which indicated that farmers who received training on PHL management were less likely to experience high losses at transport, drying, and milling stages. About 24% of their sample of maize farmers had received trainings on PHL management that mainly delivered by NGOs. Farmers who lacked the training and skills on postharvest management were largely responsible for postharvest food losses.

Results concur with that of Ahimbisibwe (2021) that showed a significant relationship between participation in PHT and adoption of PHL technologies. Results showed that trained farmers were more likely to adopt improved post-harvest technologies as compared to the non-trained farmers. The study also showed that there was a very strong association between participation in PHT and total post-harvest loss (χ² 12.844, p=0.000).

4. Conclusion

Based on the results of this study, conclusion was made that training farmers on sugarcane gleaning as a selected quasi-public extension service does not adequately reduce post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County if farmers do not implement the training. However, the relationship between the two variables was statistically significant. Thus, it is recommended that South Nyanza Sugar Company should enhance its quasi-public extension service of training farmers on sugarcane gleaning. Agricultural extension field supervisors should deliver the training through varied methods such as field visits, e-extension, field demonstrations and field days. In this way many sugarcane farmers will gain viable knowledge and necessary skills on gleaning to reduce post-harvest sugarcane loss to the set target of less than 1.0% of total tonnes of cane delivered to the factory.

Ethical approval and consent:

The researchers explained to the participants the purpose of the study and procedures that were to be used. Researchers assured participants that the data was confidential. This was done by using the information without mentioning the specific names where the data was collected. the researcher sought respondent’s consent before collection of data. Subsequently, participants responded to the questionnaire voluntarily. They were informed that they could withdraw from responding to the questionnaire if they were not comfortable. The researcher did not threaten or victimize the respondents who declined or withdrew from the study. Researchers’ opinions were not considered so that personal biases and opinions did not get way into the research.

Researchers sought clearance from Egerton University Board of Post Graduate Studies, Ethical Approval by Egerton University Institutional Scientific and Ethics Review Committee with approval number EUISERC/APP/202/2022 and research permit from the National Commission for Science, Technology and Innovation (NACOSTI) with License number NACOSTI/P/22/21363.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

Acharjee, D. C., Hossain, M. I., & Alam, G. M. M. (2021). Post-harvest fish loss in the fish value chain and the determinants: Empirical evidence from Bangladesh. *Aquaculture International*, *29*(4), 1711–1720. <https://doi.org/10.1007/s10499-021-00711-8>

Afsharnia, F., Marzban, A., & Abdeshahi, A. (2018). Sugarcane transportation process modeling by time series approach. *Iran Agricultural Research*, *37*(2), 117–126. <https://doi.org/10.22099/iar.2019.5192>

Agriculture Department. (2021). *Agriculture Management System - Statistical data of sugarcane farmers in Awendo Sub-county*. South Nyanza Sugar Company Limited

Ahimbisibwe, S., Ikendi, S., Buyinza, T., Namata, M., Waaswa, A., & Kaaya, A. N. (2021). Retrieved April 13, 2025, from https://www.academia.edu/download/112909697/Postharvest.pdf

Ali, M. N. H. A., Jamali, L. A., Soomro, S. A., Chattha, S. H., Ibupoto, K. A., Abbasi, N. A., & Qumi, N. M. (2018). Post-Harvest Losses and Control of Unprocessed Sugarcane. *Pakistan Journal of Agricultural Research*, *31*(4). <https://doi.org/10.17582/journal.pjar/2018/31.4.355.360>

Ambler, K., Brauw, A. de, & Godlonton, S. (2018). Measuring postharvest losses at the farm level in Malawi. *Australian Journal of Agricultural and Resource Economics*, *62*(1), 139–160. <https://doi.org/10.1111/1467-8489.12237>

Asenahabi, B. M. (2019). *Basics of Research Design: A Guide to selecting appropriate research design*. *6*(5), 14.

Blum, M. L. (2020). *Agricultural extension in transition worldwide: Policies and strategies for reform*. FAO. <https://doi.org/10.4060/ca8199en>

Bowen, G. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*, 27–40. <https://doi.org/10.3316/QRJ0902027>

Bujang, M. A. (2021). A Step-by-Step Process on Sample Size Determination for Medical Research. *The Malaysian Journal of Medical Sciences : MJMS*, *28*(2), 15–27. <https://doi.org/10.21315/mjms2021.28.2.2>

Bundeh, L. W. (2018). *Effects of Sugarcane Farming on Food Production in Dede Division, Migori County, Kenya* [Thesis, Maseno University]. <https://repository.maseno.ac.ke/handle/123456789/3476>

Caixeta-Filho, J. V., & Péra, T. G. (2018). Post-harvest losses during the transportation of grains from farms to aggregation points. *International Journal of Logistics Economics and Globalisation*. https://www.inderscienceonline.com/doi/10.1504/IJLEG.2018.093755

*Cochran, W. G. (1977). Sampling techniques (3rd ed.). John Wiley & Sons—Google Search*. (n.d.). Retrieved October 17, 2021, from [https://www.google.com/search?q=Cochran%2C+W.+G.+%281977%29.+Sampling+techniques+%283rd+ed.%29 .+John+Wiley+%26+Sons&client=firefox-b-d](https://www.google.com/search?q=Cochran%2C+W.+G.+%281977%29.+Sampling+techniques+%283rd+ed.%29%20%20%20%20%20%20.+John+Wiley+%26+Sons&client=firefox-b-d)

Datir, S., & Joshi, S. (2015). *Post Harvest Sugarcane Quality under Manual (Whole Cane) and Mechanical (Billet)Harvesting*. 15.

Dlamini, M. M. (2018). *Towards reducing sugarcane productivity gap between largescale and smallholder farmers: Influence of ICT among sugarcane growers in Swaziland.* [Thesis]. <https://researchspace.ukzn.ac.za/handle/10413/16707>

Duncan, M. (2021). Transportation: The un-slayed dragon in sugarcane farming in Western Kenya. *Net Journal of Social Sciences*, *9*(1), 11–16. <https://doi.org/10.30918/NJSS.91.20.029>

Farooq, M. Z., Siddiqui, B. N., Masud, K., Khan, M. R. A., Tareen, W.-H., Ali, M., Rayit, A., Shah, S. A. A., Dawood, K. M., Muhammad, & Naeem, G. (2020). Comparison between public and private extension services for sugarcane production in Muzaffargarh District, Punjab, Pakistan. *Journal of Agricultural Extension and Rural Development*, *12*(1), 1–5. <https://doi.org/10.5897/JAERD2018.0946>

Harvesting and Transport Division. (2017*Quality management system documented information.* Issue No. 5. South Nyanza Sugar Company Limited

Josphat, G. (2020). *Sugarcane Farming in Kenya.* Retrieved August 13, 2022, from <https://kenyacradle.com/sugarcane-farming/>

Kashyap, L., & Kumar, R. (n.d.). *Punjab Agricultural University, Regional Research Station, Kapurthala—144 601, Punjab, INDIA e-mail: xxxxxxt@pau.edu*. 6.

Kenya National Bureau of Statistics.(2019). Kenya population and housing census: Vol 1: Population by county and Sub-county. Republic of Kenya.

Khan, M. T., Yasmeen, S., & Khan, I. A. (2020). Comparative analysis of sugarcane genotypes for post-harvest deterioration under natural conditions. *Pakistan Journal of Botany*, *52*(4). [https://doi.org/10.30848/PJB2020-4(26)](https://doi.org/10.30848/PJB2020-4%2826%29)

McCombes, S. (2019, May 15). Descriptive research | Definition, types, methods & examples. Scribbr. https://www.scribbr.com/methodology/descriptive-research/

Memon, M. A., Ting, H., Ramayah, T., Chuah, F., & Cheah, J.-H. (2017). A review of the methodological misconceptions and guidelines related to the application of structural equation modeling: A Malaysian scenario. *Journal of Applied Structural Equation Modeling*, i–xiii. [https://doi.org/10.47263/JASEM.1(1)01](https://doi.org/10.47263/JASEM.1%281%2901)

Mgendi, G., Mao, S., & Qiao, F. (2021). Is a Training Program Sufficient to Improve the Smallholder Farmers’ Productivity in Africa? Empirical Evidence from a Chinese Agricultural Technology Demonstration Center in Tanzania. *Sustainability*, *13*, 1527. <https://doi.org/10.3390/su13031527>

Moodley, S. (2010). *A review of whole-stick sugarcane transfer systems* [PhD Thesis, University of KwaZulu-Natal Pietermaritzburg South Africa]. <https://efwe.ukzn.ac.za/wp-content/uploads/2021/11/Moodley_S.pdf>

Nanjala, J. N., Immonje, M. M., & Wasike, N. (2022). The Economic Challenges Facing Small Scale Sugarcane Farmers in Malava Sub-County, Kakamega County, Kenya. *East African Journal of Interdisciplinary Studies*, *5*(1), 1. <https://doi.org/10.37284/eajis.5.1.907>

Nasiche, F. A., Ngugi, D. P. K., Kiarie, D. D., & Odhiambo, P. R. (2020). Influence of Supplier Training on Performance of Sugarcane Enterprises in Kenya. *Global Journal of Management And Business Research*. <https://journalofbusiness.org/index.php/GJMBR/article/view/3285>

Nassiuma, D.K. (2000). Survey sampling: theory and methods. Nairobi University Press

Ndiritu, S. W., & Ruhinduka, R. D. (Eds.). (2019). Climate variability and post-harvest food loss abatement technologies: Evidence from rural Tanzania. *Studies in Agricultural Economics*. <https://doi.org/10.22004/ag.econ.287548>

Okoth, O. K. (2018). *Technical efficiency of sugarcane monoculture and sugarcane- soybean integration among smallholder farmers in Awendo Sub-County, Kenya* [Thesis, Egerton University]. <http://41.89.96.81:8080/xmlui/handle/123456789/1589>

Oliveira, A. D. (2018). *Sugarcane: Technology and Research*. BoD – Books on Demand.

Outgrowers Extension Service Division. (2017). *Quality management System procedure manual.* Issue No. 4. South Nyanza Sugar Company Limited

Outgrowers Extension Service Division. (2019). *Farmers distribution per subcounty as at November 30, 2019 cane census report*. South Nyanza Sugar Company

Pretari, A., Hoffmann, V., & Tian, L. (2019). Post-harvest practices for aflatoxin control: Evidence from Kenya. *Journal of Stored Products Research*, *82*, 31–39. <https://doi.org/10.1016/j.jspr.2019.03.001>

Rai, P. (2020). The geographies of intermediation: Labor intermediaries, labor migration, and cane harvesting in rural western India. *Environment and Planning A: Economy and Space*, *52*(6), 1221–1236. <https://doi.org/10.1177/0308518X20903728>

Rahi, S. (2017). Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development. *International Journal of Economics & Management Sciences*, *06*(02). <https://doi.org/10.4172/2162-6359.1000403>

Research and Development Division. (2014). *Infield loss assessment on sampled plots in the nucleus estate*. South Nyanza Sugar Company Limited

Research and Development Division. (2018). *Infield loss assessment on outgrower farmer's complaints*. South Nyanza Sugar Company Limited

Shee, A., Mayanja, S., Simba, E., Stathers, T., Bechoff, A., & Bennett, B. (2019). Determinants of postharvest losses along smallholder producers maize and Sweetpotato value chains: An ordered Probit analysis. *Food Security*, *11*(5), 1101–1120. <https://doi.org/10.1007/s12571-019-00949-4>

Singh, A. (2020). Benefits of crop diversification in Fiji’s sugarcane farming. *Asia & the Pacific Policy Studies*, *7*(1), 65–80. <https://doi.org/10.1002/app5.291>

Singh, P., Singh, S. N., Tiwari, A. K., Pathak, S. K., Singh, A. K., Srivastava, S., & Mohan, N. (2019). Integration of sugarcane production technologies for enhanced cane and sugar productivity targeting to increase farmers’ income: Strategies and prospects. *3 Biotech*, *9*(2), 48. <https://doi.org/10.1007/s13205-019-1568-0>

Solomon, S. (2009). Post-harvest deterioration of sugarcane. *Sugar Tech*, *11*(2), 109–123. <https://doi.org/10.1007/s12355-009-0018-4>

Stathers, T., Holcroft, D., Kitinoja, L., Mvumi, B. M., English, A., Omotilewa, O., Kocher, M., Ault, J., & Torero, M. (2020). A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia. *Nature Sustainability*, *3*(10), 821–835. <https://doi.org/10.1038/s41893-020-00622-1>

Sugar Industry Stakeholders Taskforce Report. (2019). *Report of the national sugar taskforce.*

Sugar Research Institute. (2017). *Impact assessment of outreach activities on uptake of improved sugarcane production technologies*. ISBN:978-9966-9602-4-5

Sugar Research Institute. (2018). *Farmers' perception on improved sugarcane varieties in Western Kenya*. ISBN:978-9966-1512-1-6

Tiwari, I., Shah, K. K., Tripathi, S., Modi, B., Shrestha, J., Pandey, H. P., Bhattarai, B. P., & Rajbhandari, B. P. (2020). Post-harvest practices and loss assessment in tomato (Solanum lycopersicum L.) in Kathmandu, Nepal. *Journal of Agriculture and Natural Resources*, *3*(2), Article 2. <https://doi.org/10.3126/janr.v3i2.32545>

United Nations (2017). Economic and social commission for Asia and the Pacific (ESCAP) monitoring and evaluation policy and guidelines

Zhao, P., Guo, J., Gao, X., Liu, G., Li, Y., Burner, D. M., & Yang, L. (2019). Small-Scale Mechanical Harvesting and Tractor-Caused Soil Compaction Reduce Early Growth in Sugarcane. *Agronomy*, *9*(12), Article 12. <https://doi.org/10.3390/agronomy9120830>