# EFFECTIVENESS OF SELECTED QUASI-PUBLIC EXTENSION SERVICES AND FIELD PRACTICES IN REDUCING POST-HARVEST SUGARCANE LOSS AMONG SMALLHOLDER FARMERS IN AWENDO SUB-COUNTY, KENYA

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## DECLARATION AND RECOMMENDATION

### Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

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### Recommendation

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## DEDICATION

I dedicate this thesis to my blessed children Allince Imani, Arnson James and Lovette Albright for according me time to concentrate on it. Also, my parents the late Edward Sagege and Margaret Atieno as well as brother Dickens Omondi for their encouragement.

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**ABSTRACT**

Farmers globally experience post-harvest sugarcane losses that reduces their income. Sony Sugar Company in Kenya instituted field practices in 2011 to reduce this post-harvest loss. Such practices included trailer loading limit and proper gleaning. Farmers are trained on gleaning and sensitised to supervise sugarcane loading. However, a gap exists on effectiveness of these selected field practices and quasi-public extension services. As a result, this study sought to examine effectiveness of the selected quasi-public extension services and field practices in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County. This study employed a descriptive survey design, guided by the Theory of Change. Target and accessible populations were 3,123 and 2,403 contracted smallholder farmers respectively distributed proportionately across the four wards, namely; North-East, Central, South and West Sakwa. Additionally, all other 67 accessible stakeholders responsible for sugarcane harvesting and transport were purposively included. Supervisors checked the questionnaires for face and content validity. The questionnaire was pilot tested using 30 smallholder farmers from Suna East Sub-County. Data was collected using valid and reliable questionnaires. Cronbach's Alpha reliability coefficients of 0.749 and 0.711 for smallholder farmers' and other stakeholders' questionnaires were established. Only 132 smallholder farmers' questionnaires were valid giving 89.8% response rate. Descriptive statistics and spearman's correlation were used to analyse data using SPSS version 21. Post-harvest sugarcane loss had positive relationships with training farmers on sugarcane gleaning ($r$ (130) = .142, $p > .05$.), sugarcane gleaning during loading ($r$ (130) = .199, $p < .05$.) and trailer loading limit ($r$ (130) = .129, $p > .05$.) Sensitisation of farmers on supervision of cane loading had statistically insignificant relationship, r (130) = -.027, $p > .05$. with post-harvest sugarcane loss. Thus, while training farmers on sugarcane gleaning did not effectively reduce post-harvest sugarcane loss, sensitisation of farmers on supervision of sugarcane loading, gleaning during loading and trailer loading limit effectively reduced post-harvest loss. This study recommends that Sony Sugar Company should enhance its quasi-public extension service of training of farmers on sugarcane gleaning during loading to prevent spillage. Farmers or their agents should be present during loading, glean the sugarcane being scattered by grabbers despite the myriad challenges as benefits outweigh the challenges. Sony Sugar Company through her field staff should ensure trailer load limit is maintained to reduce post-harvest sugarcane loss.

## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AEFS** | Agricultural Extension Field Supervisors |
| **AEFA** | Agricultural Extension Field Assistants |
| **AES** | Agricultural Extension Services |
| **AFA** | Agriculture and Food Authority |
| **AMS** | Agriculture Management System |
| **AMT** | Annual Metric Tonnes |
| **Ha** | Hectares |
| **HoAD** | Head of Agriculture Department |
| **INR** | Indian Rupee |
| **KESREF** | Kenya Sugar Research Foundation |
| **KNASFO** | Kenya National Alliance of Sugarcane Farmers Organizations |
| **KNBS** | Kenya National Bureau of Standards |
| **Kshs** | Kenyan Shillings |
| **MMT** | Million Metric Tonnes |
| **NACOSTI** | National Commission for Science, Technology and Innovation |
| **PC** | Plant Crop |
| **PHSL** | Post-harvest Sugarcane Loss |
| **QPE** | Quasi-public Extension |
| **QPEO** | Quasi-Public Extension Officers |
| **R1** | Ratoon 1 |
| **R2** | Ratoon 2 |
| **SCGA** | Swaziland Cane Growers Association |
| **SDG** | Sustainable Development Goals |
| **SISTR** | Sugar Industry Stakeholders Taskforce Report |
| **Sony Sugar** | South Nyanza Sugar |
| **SPSS** | Statistical Package for Social Sciences |
| **SRI** | Sugar Research Institute |
| **TCH** | Tonnes of cane per hectare |
| **t/ha** | Tonnes Per Hectare |
| **ToC** | Theory of Change |

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background of the Study

Sugarcane is a crop grown commercially worldwide in over 115 countries (Kabeyi & Olanrewaju, 2023), where the largest producers include Brazil, India, China, Thailand, and Pakistan (Molin et al., 2024). Sugarcane is important and strategically positioned worldwide due to its various nutritional and economic uses both at home and in industries (Ahmad et al., 2018; Zulu et al., 2019). It is used for production of sugar and ethanol (Formann et al., 2020) Sugarcane production provides livelihoods for millions of people (Ali et al., 2018). For example, in India it provides direct employment to over 45 million farmers and indirect employment to other skilled and unskilled workers engaged in the value chain (Ahmad et al., 2018). Sugarcane remains the main source of income for about 20 million farmers in China (Luo et al., 2022).

In Sub-Saharan Africa, most sugarcane milling companies produce sugarcane in their nucleus estates and incorporate surrounding producers as outgrowers where the latter dominates. South Africa and Kenya lead in sugarcane production, where they produce about 19.84 and 5.51 million tonnes annually, respectively (Mabeta & Smutka, 2023). In South Africa, sugarcane production is predominantly small-scale, where the industry creates job opportunities and provides a reliable source of income to the smallholder farmers (Zulu et al., 2019).

Sugarcane growing was introduced in Kenya in the early 1900s by Indian labourers constructing the Uganda Railway (Sugar Research Institute (SRI), 2018). Sugarcane production remains the main economic activity in the Nyanza, Western, part of Rift Valley, and Coastal regions (Thuo et al., 2023). About 300,000 farmers contract and supply in part over 94% of cane to the 16 factories in Kenya. These Kenyans draw their livelihoods directly from sugarcane production (Ministry of Agriculture and Livestock Development, State Department for Crop Development (MoALD-SDCD), 2023). The sector supports over 8 million people in Kenya directly (Duncan, 2021).

According to Farooq et al. (2020), farmers cultivate sugarcane to earn income for improved livelihood. However, in the production process, they experience post-harvest sugarcane loss (PHSL) that reduces their income and results in huge economic losses (Khan et al., 2020; Misra et al., 2022). Post-harvest sugarcane loss refers to both quality and quantity losses that occur in the field after harvest (Ambler et al., 2018; Pera & Caixeta-Filho, 2018).

Qualitative losses are in terms of losses in sucrose content (Ali et al., 2018; Datir & Joshi, 2015). A significant percentage of sucrose is lost when millers leave harvested canes in the fields for several days. The cane deteriorates, and sucrose content reduces. For example, sugarcane milled after 72 hours loses about 2% sucrose (Misra et al., 2022). However, quantitative losses remain the greatest concern to farmers as they are paid in terms of quantity of sugarcane delivered to the mills (Duncan, 2021).

According to Nanjala (2022), post-harvest sugarcane quantity losses in the form of spillage make farmers suffer huge losses. Post-harvest sugarcane quantity losses are greatly caused by spillage (A. Singh, 2020; Nanjala, 2022; Sugar Industry Stakeholders Taskforce Report (SISTR), 2019). Other causes include non-collection of all canes from the field (Josphat, 2020) and delayed cut-to-mill time (Afsharnia et al., 2018). Delayed cut-to-mill time leads to both quantity and quality losses in terms of reduction in cane weight and loss of sucrose, respectively (Misra et al., 2022). In certain instances, sugarcane spills from trailers and remains in the field after transport. As a result, PHSL due to spillage is alarming since it reduces sugarcane tonnage delivered to the factory that consequently adversely affects farmers, cane cutters, and millers economically (Duncan, 2021).

Post-harvest sugarcane loss has pulled in far-flung attention as one of the alarming problems of the sugar industry (Kashyap & Kumar, 2018). In quantity losses, a whole stalk of sugarcane loses about 0.42 to 1.5% of its weight per day after harvest when left in an open field. This can be exacerbated by delayed cut-to-mill time, resulting in increased moisture loss through evaporation. Cane weight loss occurs substantially in higher temperatures compared to lower temperatures. This has a direct influence on cane tonnage reaching the factory and affects farmers' income, especially in countries where they are paid on a tonnage basis (Misra et al., 2022). In recent years, post-harvest quality losses have attracted widespread attention that has seen some actions taken to mitigate them. Such actions include minimizing cut-to-mill time. This not only mitigates sucrose losses but also reduces moisture loss, which affects cane weight (Misra et al., 2022). Post-harvest sugarcane loss in the form of field spillage in Awendo Sub-County in 2018, 2019, 2020, and 2021 was 5.48, 5.23, 6.58, and 5.76 tonnes of cane per hectare (TCH), respectively (Agriculture Department, 2021).

Sugarcane field spillage occurs when trailers are carelessly packed and overloaded by cane grabbers. In some instances, gleaned sugarcane and part of the harvested sugarcane in stacks remain in the field unloaded (Duncan, 2021). Consequently, sugarcane millers employ multiple field practices to reduce PHSL (Rai, 2020). Field practices that check sugarcane spillage as the greatest contributor of PHSL include gleaning and trailer loading limit (Zhao et al., 2019). Other strategies employed to reduce field spillage include proper supervision during cane loading into tractors, securing stacks by chaining to avoid spillage, use of properly designed trailers for carrying cane, signing Job Completion Certificates (J.C.C.) in the field, discouraging cane transport at night, adhering to maximum tonnage for each tractor, and contractors hiring workers to glean cane scattered by the loader Kenya Sugar Research Foundation (2006).

Sugar Research Institute (2018) opines that certain agricultural extension services have a bearing on reducing PHSL. Such agricultural extension services include training on gleaning and supervision of loading of harvested sugarcane. These practices notably vary by region. In China, for instance, a fully loaded single bucket trailer carries about seven (7) tonnes of cane to the mills (Zhao et al., 2019). However, information on the effectiveness of these strategies remains scanty.

In Migori County, three sugarcane milling companies source their raw materials: South Nyanza Sugar, Transmara Sugar, and Sukari Industries. South Nyanza Sugar Company (Sony Sugar Company), a Kenyan quasi-public organization established in 1979, is the oldest (MoALD-SDCD, 2023). Farmers in Awendo Sub-county in Migori have commercialized sugarcane production since the inception of Sony Sugar Company (Bundeh, 2018). Contracted sugarcane farmers receive agricultural extension services embedded in the agricultural department of the company (Blum, 2020). As a result, these extension services are hereby termed as quasi-public extension (QPE) services. Consequently, Sony Sugar Company's agricultural extension field supervisors (AEFS) link it with her contracted farmers. They guide in the maintenance of the crop for optimum yields (Oliveira, 2018).

Sony Sugar Company further instituted multiple field practices in 2011 to cushion contracted farmers and herself from PHSL resulting from field spillage. The field practices include but are not limited to proper cane standard stack sizing, proper gleaning during stacking and cane loading, and proper loading and trailer loading limits for both single and double bucket trailers. Besides, the company management installed the Agriculture Management System (AMS) in 2013 to monitor harvesting and transport operations (Harvesting and Transport Division (H&TD), 2017). According to the 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. Acceptable PHSL should be less than one percent of total tonnes delivered to the mill.

Data was limited to spot assessments of 2012, 2013, and 2014. Percentage infield losses in 2012, 2013, and 2014 were 0.07%, 0.20%, and 3.67%, respectively. These actual percentages of PHSL in 2012 and 2013 were within the acceptable threshold. All were attributed to proper gleaning. In 2014, the actual percentage of PHSL was above the acceptable limits (Research and Development Division (R&DD), 2014). Thus, gleaning as an instituted infield practice effectively reduced PHSL in 2012 and 2013. In 2014 the infield practices were ineffective in reducing PHSL. Sampled infield assessments in 2018 reveal that outgrowers lose an average of 4.52 tonnes of cane per acre. However, there is no clear information on the effectiveness of the quasi-public extension services and instituted field practices in reducing post-harvest sugarcane loss.

## 1.2 Statement of the Problem

Sugarcane production provides reliable income to smallholder farmers who invest their limited resources in it. However, in the production process, farmers experience post-harvest sugarcane loss (PHSL). The loss is estimated at an average of 4.52 tonnes per acre per harvest season. Out of 4.52 tonnes, 2.89 tonnes result from infield spillage. The rest are due to poor harvesting. Infield spillage of harvested sugarcane greatly contributes to PHSL. Reduction in sugarcane tonnage due to spillage negatively impacts the income of smallholder farmers. These farmers are paid based on tonnes of cane successfully delivered to the mill. Consequently, Sony Sugar Company Limited instituted infield practices in 2011 to reduce infield PHSL. Acceptable PHSL is less than or equal to one percent of total tonnes delivered to the factory. Some selected infield practices that check PHSL due to infield spillage include trailer loading limit and gleaning. However, information on their effectiveness is scanty. Moreover, the effectiveness of quasi-public extension (QPE) services such as training of farmers on gleaning and their sensitization on supervising sugarcane loading in reducing PHSL was not clearly outlined. As a result, this study sought to examine the effectiveness of selected quasi-public extension services and field practices in reducing PHSL among smallholder farmers in Awendo Sub-County, Kenya.

## 1.3 Purpose of the Study

The purpose of the study was to examine the effectiveness of selected quasi-public extension services and infield practices in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya.

## 1.4 Objectives of the Study

The specific objectives of the study were to:

i. Establish the effectiveness of training farmers on sugarcane gleaning in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya.

ii. Determine the effectiveness of farmer sensitization on supervision of cane loading in reducing post-harvest sugarcane loss among smallholder sugarcane farmers in Awendo Sub-County, Kenya.

iii. Establish the effectiveness of sugarcane gleaning during loading in reducing post-harvest sugarcane loss among smallholder sugarcane farmers in Awendo Sub-County, Kenya.

iv. Determine the effectiveness of the trailer loading limit in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya.

## 1.5 Research Questions of the Study

The study sought to answer the following research questions.

i. How effective was the training of farmers on sugarcane gleaning in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub- County, Kenya?

ii. How effective was farmer sensitization on supervision of cane loading in reducing post-harvest sugarcane loss among smallholder sugarcane farmers in Awendo Sub-County, Kenya?

iii. How effective was sugarcane gleaning during loading in reducing post-harvest sugarcane loss among smallholder sugarcane farmers in Awendo Sub-County, Kenya?

iv. How effective was the trailer loading limit in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya?

## 1.6 Significance of the Study

This study was designed to examine the effectiveness of selected quasi-public extension services and infield practices in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya. The study findings would be useful to the smallholder sugarcane farmers, millers, and other stakeholders. Farmers would use the information obtained to improve their participation accordingly in reducing PHSL. The end result is increased income through sugarcane proceeds. Sony Sugar Company can also get feedback and learn about their standards guiding field practices for adjusting or improving current standards and future interventions. The study findings can also inform the decisions of county and national governments in sound policy formulations on PHSL reduction strategies. This can help in improving farmers' income and livelihood, thereby contributing in part to poverty eradication envisioned as a Sustainable Development Goal (SDG).

## 1.7 Scope of the Study

This study focused on examining the effectiveness of selected quasi-public extension services and infield practices in reducing PHSL among smallholder farmers between 2018 and 2021 in Awendo Sub-County, Kenya. This was the period with missing information on the effectiveness of selected QPE services and infield practices in reducing PHSL. The sub-county had the highest number of farmers (3,123) who supplied sugarcane to Sony Sugar Company and experienced PHSL in the process. Whereas there are a number of infield practices instituted by Sony Sugar to mitigate PHSL, the study only covered selected infield practices that check sugarcane spillage, as the greatest contributor of PHSL. Thus, data was collected on trailer loading limit, proper loading, and gleaning. The effectiveness of training of farmers on gleaning and their sensitization on supervising loading of harvested sugarcane by QPE by 14 Sony Sugar Company's AEFS in reducing PHSL was also studied.

## 1.8 Assumptions of the Study

The study was guided by the assumptions that;

i. Respondents were aware of the post-harvest sugarcane loss. The researcher helped to explain the purpose of the study for clarity.
ii. All the respondents were cooperative and gave honest responses on the required data. Respondents were asked to feel free to either participate or not to participate in the study.

## 1.9 Limitations of the Study

The following were the limitations of the study.

i. All 3,123 smallholder farmers did not participate in the study, but nonetheless, probability sampling gave them an equal chance to be among the sample.
ii. A survey questionnaire was used in data collection. The questionnaire items were developed in the English language. As a result, the researcher or AEFS on behalf interpreted for respondents who were not conversant with the language. This minimized misunderstanding or misinterpretation by respondents not conversant with English.

## 1.10 Definitions of Terms

The following terms were conventionally and operationally defined to aid this study:

**Agricultural extension:** service that assists farmers through educational procedures in improving their farming methods and techniques, increasing production efficiency and income, as well as improving their standards of living and lifting their social and educational standards (Onyenkazi & Gana, 2021). In this study, agricultural extension referred to support services rendered by Sony Sugar Company's AEFS that enabled sugarcane farmers to obtain information and skills to manage post-harvest sugarcane quantity losses.

**Effectiveness:** how well something works towards the intended results or the extent to which planned goals or objectives are achieved as a result of a strategy or an intervention (Zidane & Olsson, 2017). In this study, effectiveness was the capability of selected QPE services and field practices to produce the intended objective of reducing PHSL among smallholder farmers. Effectiveness was measured by smallholder farmers ranking each selected QPE service and field practice in reducing PHSL 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 rankings produced an estimate of effective level. This was confirmed by the success of selected QPE services and field practices in reducing infield PHSL to $\leq$ 1% of the total tonnes of sugarcane delivered to the mill. Estimated tonnes of cane left in the field were computed as percentages of the tonnes delivered to the factory. The result was compared with South Nyanza Sugar Company's set objective of $\leq$ 1% infield PHSL. Values within the set limit made selected QPE services and infield practices be considered effective, while values beyond made them be considered ineffective. Besides, Spearman's correlation was used to measure the strength of the relationship between the selected QPE services and field practices and PHSL.

**Gleaning:** collecting of food left in farm fields that is not economically or logistically feasible for the farmer to harvest (Lott et al., 2020). In this study, gleaning meant gathering spilled sugarcane during cane loading in the field.

**Field practices:** multiple managerial standards and measures employed by sugar mills in the farm to minimize the risk of infield post-harvest loss (Rai, 2020). In this study, selected infield practices were the standards set out by Sony Sugar Company to guide the management of harvested cane at the farm level to reduce PHSL, such as trailer loading limit and gleaning.

**Nucleus estate:** cane plots owned by sugar factories (SISTR, 2019). In this study, nucleus estate referred to the cane plots owned by South Nyanza Sugar Company.

**Outgrowers:** farmers contracted by millers to produce sugarcane for the manufacture of sugar (SISTR, 2019). In this study, outgrowers were farmers in Awendo Sub-County who were contracted by Sony Sugar Company to grow cane under its conditions and expected the company to harvest and transport as well as help them reduce PHSL.

**Post-harvest sugarcane loss:** measurable loss in quality (sucrose content) or quantity (physical sugarcane or its stalk weight) after harvest that occurs between the farm and the mill (Caixeta-Filho & Miyashita, 2018). In this study, PHSL referred to the quantity of harvested sugarcane (in tonnes) left in the field after transport due to spillage.

**Quasi-public extension Services:** agricultural services provided by a quasi-public organization dealing in a specific commodity, for example sugarcane, to support its contracted farmers in order to secure sufficient quantity and quality of sugarcane (Blum, 2020). In this study, quasi-public extension services referred to agricultural services such as training and sensitization provided by Sony Sugar Company, a quasi-public organization, to support its contracted sugarcane farmers in order to secure sufficient quantity and quality of sugarcane and reduce PHSL.

**Reducing post-harvest sugarcane loss:** reducing the level of measurable loss in quantity after harvest that occur between the farm and the mill (Caixeta-Filho & Miyashita, 2018) or reducing sugarcane spillage both in the field and in transit (H&TD, 2017). In this study, reducing PHSL referred to reducing the amount (tonnes) of sugarcane left spilled in the field to less than or equal to one percent ($\leq 1\%$) of total cane delivered to the mill.

**Smallholder sugarcane farmers:** sugarcane farmers with small landholding of about two acres (0.8 Ha) (Mati & Thomas, 2019). In this study, smallholder sugarcane farmers were farmers with five (2.0 ha) or fewer acres of land and depended on the company for harvesting and transport of cane.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.1 Introduction

This chapter presents literature on sugarcane production overview and economic value, the global magnitude of post-harvest sugarcane loss and economic implications, quasi-public extension services in sugarcane production, Sony Sugar Company's infield post-harvest sugarcane loss reduction practices, the effectiveness of Sony Sugar's post-harvest sugarcane loss reduction practices, and the theoretical and conceptual frameworks.

## 2.2 Sugarcane Production Overview and Economic Value

Sugarcane crop (*Saccharum officinarium*) is grown commercially worldwide in around 120 countries (Voora et al., 2023) both in tropical and subtropical regions (Formann et al., 2020). Globally, the largest producers of sugarcane include Brazil, India, China, Thailand, and Pakistan (Molin et al., 2024). Sugarcane is important and strategically positioned worldwide due to its various nutritional and economic uses both at home and in industries (Ahmad et al., 2018; Zulu et al., 2019). It is used for the production of sugar and ethanol (Formann et al., 2020), where it accounts for more than 80% of sugar produced globally and is the second largest bioenergy crop. The milling process releases valuable by-products such as molasses and fibre known as bagasse, which is used for generating electricity (Luo et al., 2022). Sugarcane production contributes substantially to the economy. In India, it provides direct employment to over 45 million farmers and indirect employment to other skilled and unskilled workers engaged in the value chain (Ahmad et al., 2018). In China, sugarcane remains the main source of income for many regional communities where it provides direct employment to about 20 million farmers (Luo et al., 2022) Brazil has remained the largest producer since 1970 (Makina & Oundo, 2020).

In Africa, sugarcane milling companies produce sugarcane in their nucleus estates and incorporate surrounding producers as outgrowers. Outgrowers dominate milling companies in South Africa and Kenya. They supply a larger proportion of sugarcane than nucleus estates to the milling companies (Mabeta & Smutka, 2023). Sub-Saharan Africa contributes 5% of global sugarcane production. South Africa, Kenya, and Eswatini lead in sugarcane production in Sub-Saharan Africa. South Africa produces about 18 million metric tonnes. Kenya and Eswatini produce slightly above 5 million metric tonnes each. (Mabeta & Smutka, 2023). Sugarcane production in South Africa is predominantly small-scale, where the industry creates job opportunities, provides a source of income and develops transport and communication networks (Zulu et al., 2019)

Sugarcane growing was introduced in Kenya in the early 1900s by Indian labourers constructing the Uganda Railway (SRI, 2018). Sugarcane production remains the main economic activity in the Nyanza, Western, part of Rift Valley, and Coastal regions (Thuo et al., 2023). This is spread in some counties such as Migori, Homabay, Kisii, Narok, Kericho, Kisumu, Kakamega, Bungoma, Busia, and Kwale, where sugarcane production is largely under contract farming (Ambetsa, 2020). About 300,000 farmers contract and supply in part over 94% of cane to the 16 factories in Kenya. These Kenyans draw their livelihoods directly from sugarcane production (MoALD-SDCD, 2023). This implies that sugar millers cannot survive without outgrowers (Makina & Oundo, 2020).

Sugarcane production provides employment opportunities either directly or indirectly at the farm and industry levels (Afghan et al., 2023). More than 100 million people globally draw their livelihood from the sugarcane industry. The Brazilian sugarcane sector directly employs about 773,000 people. The Indian and Thai sugarcane sectors support about 6 million and 300,000 smallholder farmers, respectively (Voora et al., 2023). In Pakistan, the sector employs about 4 million people, where almost 980,000 are farmers (Afghan et al., 2023). Farmers cultivate sugarcane to earn income for improved livelihood (Farooq et al., 2020). Approximately one million South Africans depend on the sugar industry for a living. The industry improves the rural and deep rural economies described as job-starved areas (Zulu et al., 2019).

In Kenya, the sugarcane industry plays a pivotal role in socio-economic development. Besides, it supports the livelihood of over eight million Kenyans. About 300,000 outgrower farmers, the majority being smallholders, directly draw their livelihoods from the industry (MoALD-SDCD, 2023). Moreover, the government of Kenya considers the sugar sector a reliable source of income (Nasiche et al., 2020). Nanjala (2022) equally asserts that sugarcane is the main source of revenue for various countries and is one of the industrial crops in Kenya. Measures of sugarcane production yield include agricultural practices, harvesting technologies, and haulage methods (Muteshi & Bolo, 2017). Sulaiman et al. (2019) further assert that sugarcane production is measured in tonnes of cane per planting season per hectare. In this regard, farmers maintain the crop with the aim of obtaining high crop yields in the cane plant cycle and small decreases in the subsequent ratoon cycles. Moreover, farmers consult sugar mills on suitable cane varieties for their location (Oliveira, 2018).

## 2.3 Post-Harvest Sugarcane Loss and Economic Implications

Sugarcane farmers experience post-harvest sugarcane loss in the production process that reduces their income from cane proceeds. Post-harvest loss constitutes both quantitative and qualitative losses (Pera & Caixeta-Filho, 2018) that occur after harvest through the value chain (Ambler et al., 2018). Qualitative losses are in terms of sucrose content. Published reports regarding sucrose loss began to appear towards the end of the 19th century. Early workers emphasized the importance of time lag between harvesting and milling as well as storage conditions (Solomon, 2009). The main cause of post-harvest quality (sucrose) losses is delayed cut-to-mill time (Ali et al., 2018; Datir & Joshi, 2015; Solomon, 2009). This results from inversion by biochemical and microbial processes in harvested cane that is delayed before being milled (Solomon, 2009). According to Ali et al. (2018), delayed transportation with unfavourable environmental conditions causes a loss of sucrose approximated at 20–30% of total synthesized. Other studies indicate that sugarcane milled at 72 hours after harvest loses 1.5 percent sucrose per day (Solomon, 2009) or about 2.0 percent for cane milled at 96 hours (Datir & Joshi, 2015). These studies only favour millers who depend on sucrose content.

Sugarcane farmers are paid in terms of tonnes of sugarcane harvested and successfully delivered to the mills. Thus, quantitative losses remain their greatest concern (Duncan, 2021). Sugarcane spillage, among other things, majorly causes post-harvest sugarcane quantity losses (A. Singh, 2020). Other causes include non-collection of all canes from the field (Josphat, 2020) and delayed cut-to-mill time (Ali et al., 2018). Delayed cut-to-mill time leads to reduction in cane weight (Afsharnia et al., 2018). Ali et al. (2018) studied harvested sugarcane kept in the open and the one covered with trash. The one kept in the open loses a maximum of 27.8% of cane weight after 10 days of storage. Sugarcane covered with trash loses a maximum of 27.8% and 15.7% of cane weight, respectively, after 10 days of storage.

Other studies indicate that weight loss ranges between 7 and 10 percent under subtropical conditions within 72 hours after harvest (Solomon, 2009) or 7.4 and 17.0 percent within 96 hours (Datir & Joshi, 2015). Caixeta-Filho and Miyashita (2018) observed that in a standard system field 0.094 tonnes out of 1.0 tonne of harvested cane remain in the field, while only 0.824 tonnes reach the mill. Most of these studies have quantified PHSL resulting from delayed cut-to-mill time yet sugarcane spillage is equally alarming. This is witnessed when trailers are carelessly packed and overloaded by cane grabbers (Duncan, 2021).

Sony Sugar Company’s research and development division undertakes infield loss assessment in its Nucleus Estate (NE). Sampled plots in the NE in the years 2012, 2013, and 2014 indicate about 0.07%, 0.20%, and 3.67%, respectively, of cane left in the field against the target of less than or equal to one percent of total cane delivered to the factory. Gleaning was effectively done in 2012 and 2013 as opposed to 2014 (R&DD, 2014). A similar assessment is done in outgrowers' farms following farmers' complaints. In this regard, a farmer in Awendo Sub-County on 8th November, 2018, lost about 4.52 tonnes of cane, translating to about Ksh. 19,511.37. The breakdown indicates that 2.64 tonnes were lost due to poor harvesting, while 1.89 tonnes remained spilled in the field due to poor loading (R&DD, 2018). However, inadequate information is available on infield loss assessment on other outgrower farmers' fields. Sugar Industry Stakeholders Taskforce Report (2019) observes that infield cane spillage greatly contributes to PHSL. However, no study clearly indicated the specific or actual infield PHSL in both Sony Sugar's nucleus estate and outgrowers in Awendo Sub-County between 2018 and 2021.

Sugarcane farmers are paid per tonne of harvested and successfully delivered cane to the mill (Duncan, 2021; Kikulwe et al., 2018). Thus, PHSL resulting from reduced tonnage due to sugarcane spillage not only adversely affects sugarcane farmers' returns but also those of cane cutters and millers (Duncan, 2021). Consequently, these parties incur significant economic losses (Khan et al., 2020; Solomon, 2009) despite their desire for improved livelihoods for themselves and their future generations Kenya National Alliance of Sugarcane Farmers Organizations (KNASFO), 2019). An initial study in North India indicates that sugarcane farmers lose about US$ 2 per tonne of cane in delayed delivery of harvested cane at 72 hours, whereas the sugar industry loses around US$ 6000 per day. The loss may escalate in further delay (Solomon, 2009). Later studies in the same country in 2017 reveal that 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).

In Awendo Sub-County, a farmer with an infield loss of about 4.52 tonnes of cane in 2018 lost about Ksh. 19,511.37 (R&DD, 2018). Part of this 4.52 tonnes that is, 1.89 tonnes was due to sugarcane spillage. Post-harvest sugarcane loss in the form of field spillage in the years 2018, 2019, 2020, and 2021 was 5.48, 5.23, 6.58, and 5.76 tonnes of cane per hectare, respectively (Agriculture Department, 2021).

## 2.4 Quasi-Public Extension Services on Sugarcane Production

Agricultural extension serves as an essential mechanism for delivering knowledge, information, and advice to a large majority of farmers (Dlamini, 2018). Such agricultural extension services play an essential role in agricultural development and add to improving the welfare of farmers (SRI, 2017). Agricultural extension services may be defined as the whole set of organizations that sponsor and help farmers to solve problems and obtain skills, knowledge, and technologies to improve their livelihoods (SRI, 2017). Quasi-public extension has become part of the pluralistic approach to agricultural extension under the fully commercialized model. In this model, quasi-public organizations mainly dealing in specific commodities such as sugar provide extension services (Blum, 2020). Kaur and Kaur (2018) observe that quasi-public extension (QPE) is delivered through contract farming involving a forward contract in which growers commit to provide an agricultural commodity of a certain type at a certain time and price in a specified quantity to a known buyer.

As reported by Jensen et al. (2019), smallholder farmers have an incentive to follow advice in order to access inputs, credits, and markets from contracting firms. The firms have an incentive to invest in extension in order to secure sufficient quantity and quality of produce. This is very evident in the sugar industry, as sugar millers cannot survive without outgrowers (Makina & Oundo, 2020). According to SRI (2018), 33.7% of sugarcane farmers receive extension services provided by the millers. Outgrower schemes and the Ministry of Agriculture provide extension services to 33.3% and 18.2% of farmers, respectively.

Sugarcane yield determines the farmers' gross revenue (Muteshi & Bolo, 2017). Thus, farmer education and training is essential (Nasiche et al., 2020) to increase income (Singh et al., 2019). Consequently, agricultural extension services (AES) not only play a pivotal role in the supply of sugarcane to the factory but also increase per-acre tonnage (Muteshi & Bolo, 2017). Miller's agricultural extension officers introduce and train farmers on new improvements and techniques of cane production. Some of the global specific objectives of extension in the sugar industry include, but are not limited to, securing adequate sugarcane delivery, teaching farmers how the industry functions, and distributing industry information to users (Dlamini, 2018). Dlamini (2018) observes that QPE facilitates improved performance of smallholder sugarcane growers, especially in countries where outgrowers supply a large amount of cane.

In Pakistan quasi-public extension officers (QPEO) work with sugarcane growers to improve their per-acre yield. Quasi-public extension officers work with farmers through different extension techniques to increase sugarcane production (Farooq et al., 2020). They motivate farmers to use improved agricultural implements and adopt modern agricultural practices according to their socio-economic status. They also link farmers to research organizations (Raza et al., 2020). As for Swaziland, outgrowers receive QPE from the sugar industry institution model. In this model, the departments of technical services coordinate QPE through the Swaziland Cane Growers Association (SCGA). QPEO advice on all aspects of sugarcane husbandry, identifying sugarcane production problems, and conducting projects to overcome special problems (Dlamini, 2018). However, information on the effectiveness of training farmers on cane gleaning and their sensitization to supervise cane loading in reducing PHSL was inadequate.

Kenyan sugarcane farmers obtain QPE services usually embedded in millers' agricultural services (Blum, 2020). The millers, through their AEFS, identify and train farmers on modern farming methods to meet their sugarcane demand (Nasiche et al., 2020). Blum (2020) highlights methods of agricultural extension in this model to include face-to-face extension, on-farm demonstration, shows, field days, film shows, and adaptive on-farm trials. In Awendo Sub-County, QPE domiciles in South Nyanza Sugar Company's outgrowers extension services division. As part of its extension role, the division organizes education and training for contracted farmers, among others, such as farmer recruitment, input supply, and educating farmers on sugarcane maintenance (Outgrowers Extension Service Division (OESD), 2017).

Various extension services offered in the sugar industry ultimately aim at increasing farmers' productivity and income generation for enhanced livelihood. Farmers' training as an extension approach empowers sugarcane farmers with knowledge and skills to make them experts in sugarcane farming (SRI 2017). Sugar Research Institute (2017) recommends that millers, through their AEFS, should sensitize farmers on the need to supervise loading of cane during lifting. However, little information is available on the effectiveness of training farmers on gleaning as well as their sensitization to supervise loading of cane during lifting to reduce post-harvest sugarcane loss among smallholder farmers.

## 2.5 Sony Sugar Company's Field Post-Harvest Sugarcane Loss Reduction Practices

Post-harvest management implies the whole of processes and measures that contribute to the flow of harvested sugarcane to the mill (Gogh et al., 2017). Ideally, sugarcane should be transported immediately after harvesting. Leading sugarcane-producing counties like Cuba and Brazil transport their harvested sugarcane from the field to the mill by both road and railway. In Kenya, road transport remains the sole mode for tractors, trucks, trailers, and grabbers. Most sugar mills do not compensate the farmers for sugarcane spillages on the roads (Duncan, 2021). However, Sony Sugar Company compensates her farmers who complain in writing for the loss after infield assessment by the company's research and development division (R&DD, 2018).

Post-harvest sugarcane loss not only results in economic losses to the farmers but also to sugarcane harvesters and mills as well (Khan et al., 2020). Duncan (2021) avers that efficient and effective transport of harvested sugarcane prevents sugarcane spillage, loss of sucrose content, and drying up of the cane while still on the farm. As a result, sugar mills employ multiple managerial standards and measures to reduce such PHSL (Rai, 2020). Sony Sugar Company, for example, instituted standards in 2011 that guide infield practices in order to reduce PHSL occasioned by sugarcane spillages. The infield practices include stacking harvested cane at a standard stack size of 4.9 x 3.7 x 2.1 m, approximated to be 4 to 6 tonnes, a cut-to-mill time of within 36 and 48 hours for burnt and green cane, respectively, proper gleaning during stacking and cane loading and trailer loading limit. All these instituted infield practices are intended to achieve the company's objectives to reduce infield and transit losses to less than 1% and 0.5%, respectively, of cane delivered to the mill. Besides, the company management installed the Agriculture Management System (AMS) in 2013 to automate monitoring (H&TD, 2017).

Collection of all harvested cane from the field and proper loading of transporting lorries or tractors reduce post-harvest sugarcane quantity losses resulting from spillage (Josphat, 2020). Sugar Research Institute (2017) recommends that millers should embrace the use of closed double bucket trailers to reduce spillage as county government uses the cess money for road maintenance. Therefore, trailer loading limit and gleaning during loading check sugarcane spillage which contributes greatly to PHSL hence attract much attention (SISTR, 2019). In China for example, a fully loaded single bucket trailer carries about seven (7) tonnes of cane to the mills. In Thailand, the loading limit is 21 tonnes per 10-wheel truck and 10 tonnes per 6-wheel truck (Zhao et al., 2019). Sony Sugar Company recommends a trailer loading limit of approximately 8 to 12 tonnes of cane on a single bucket trailer and 12 to 18 tonnes of cane on a double bucket trailer (H&TD, 2017). However, the effectiveness of trailer loading limit in reducing PHSL resulting from spillage was unknown for the period 2018 to 2021.

In Western Kenya, Butali and Western Kenya sugar companies load their harvested cane manually on tracks, thus reducing sugarcane spillage on transit. In this regard, farmers get the worth of their efforts (Duncan, 2021). Other strategies employed to reduce field spillage include proper supervision during cane loading into tractors, securing stacks by chaining to avoid spillage, use of properly designed trailers for carrying cane, signing Job Completion Certificates (J.C.C.) in the field, discouraging cane transport at night, adhering to maximum tonnage for each tractor, and contractors hiring workers to glean cane scattered by the loader (Kenya Sugar Research Foundation, 2006).

Sony Sugar Company loads its harvested sugarcane mechanically by use of cane grabbers (bells) that scatter sugarcane in the field depending on the operator's skill (H&TD,

2017). Farmers do not like to see their products they put their time and money into go to waste (Lott et al., 2020). Consequently, Sony Sugar Company recommends proper sugarcane gleaning during loading (R&DD, 2014). The company staff properly glean all leftover sugarcane in its nucleus estate to reduce PHSL caused by spillage. They gleaned 0.36 tonnes in 2012, 0.33 tonnes in 2013, and 0.18 tonnes in 2014, where the percentage of infield postharvest sugarcane losses were 0.07%, 0.20%, and 3.67%, respectively (R&DD, 2014). Despite this importance of gleaning, little literature is available on how smallholder farmers use it to effectively reduce PHSL they experience since its institution in 2011.

## 2.6 Effectiveness of Sony Sugar’s Post-Harvest Sugarcane Loss Reduction Practices

Effectiveness of something is how well it works towards the intended results. It can also be defined as the extent to which planned goals or objectives are achieved as a result of a strategy or intervention under ordinary circumstances. To be effective is when results accomplish their purposes, thus giving an effective outcome (Zidane & Olsson, 2017). Sony Sugar Company has infield PHSL assessment reports for its nucleus estate. In the nucleus estate, the assessments reveal that infield practices effectively reduced PHSL between 2012 and 2013. In each of these years, the percentage of infield loss was 0.07% (2012) and 0.20% (2013) compared to the set target of less than or equal to 1% of total cane delivered to the mill. In 2014 the infield practices were ineffective in reducing PHSL since the percentage of actual loss was 3.67% greater than the set target of 1% (R&DD, 2014). Similar information on infield PHSL assessment is scanty on outgrowers fields between 2012 and 2014. Further, little information was available on the effectiveness of the selected infield practices (trailer loading limit and gleaning) in reducing PHSL between 2018 and 2021.

Additionally, the effectiveness of agricultural extension, such as QPE services, can be judged from the successful implementation of extension programmes using various extension methods. The effects of such programmes must be seen in the lives of sugarcane farmers. Effective agricultural extension can also be viewed by its ability to help farmers learn about change and the ends achieved (Onyenkazi & Gana, 2021). Training of farmers on proper sugarcane gleaning during loading and sensitizing them to supervise loading can reasonably reduce PHSL to the set objective (SRI, 2017). This study, therefore, sought to evaluate the effectiveness of selected quasi-public extension services and infield practices in reducing post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County, Kenya.

## 2.7 Theoretical Framework

The study was guided by the Theory of Change (ToC) (Dhillon & Vaca, 2018). Theory of Change was proposed by Carol H. Weiss in 1995. Carol Weiss emphasized the need to look at the mini-steps if a long-term outcome is to be attained and that evaluation should be a learning process to help in decision-making (Msila & Setlhako, 2013). Since the 1990s, the more common concept of the Theory of Change has been introduced to the field of evaluation (Dhillon & Vaca, 2018). Literature reveals that the Theory of Change has no universal definition. According to Dhillon and Vaca (2018), ToC is the hypothesis about the way an intervention brings about its effects. It helps describe the need to be addressed (problem), changes to be made (outcomes), and what to be done (activities/strategies) (Harries et al., 2014). In this study, the problem addressed was post-harvest sugar loss due to field spillage. The desired outcome was reducing PHSL while the strategies employed were selected QPE services and infield practices instituted by Sony Sugar Company.

ToC is essentially the logic behind an intervention (Dhillon & Vaca, 2018) and explains how the intervention works. It helps to design more realistic goals and strategies to be used to achieve the goals (Rogers, 2014). ToC makes organizations more effective by enabling one to identify where strategies are not contributing to intended goals and take action. Besides, ToC provides information needed to monitor performance (Harries et al., 2014). In this regard, the study was to provide information on the effectiveness of the selected QPE services and field practices in reducing PHSL. This can help identify activities that do not contribute to the intended goal of reducing PHSL. Harries et al. (2014) opine that ToC enables teams to work together to achieve a shared understanding of established mitigation strategies. Consequently, farmers, Sony Sugar Company, and other stakeholders can learn from the study findings and take necessary actions.

## 2.8 Conceptual Framework

Sony Sugar Company's selected quasi-public extension services and infield practices determine the level of reduction of post-harvest sugarcane loss due to spillage among smallholder farmers in Awendo Sub-County, Kenya. The independent variables of this research were selected quasi-public extension services and infield practices that determined the extent to which post-harvest sugarcane loss was reduced. Selected quasi-public extension services included training of farmers on proper sugarcane gleaning and farmer sensitization on supervision of cane loading. Selected field practices included trailer loading limit and gleaning. These independent variables, if fully implemented, were expected to reduce the level of PHSL due to spillage to Sony Sugar's set target of ≤ (less than or equal to) one percent (1%) of total tonnes of sugarcane delivered to the factory. However, partial implementation of or failure to implement the aforementioned selected quasi-public extension services and field practices would make smallholder farmers continue experiencing PHSL.

The dependent variable was reducing post-harvest sugarcane loss (PHSL). Reducing PHSL was measured by estimated tonnes of sugarcane left spilled in the field. However, a farmer's age and main source of income would strengthen or diminish the effectiveness of independent variables on dependent variables. For example, young farmers would participate more in gleaning than older farmers. Besides, farmers whose main source of income was sugarcane farming would participate more in gleaning and supervising sugarcane loading as compared to their counterparts with other main sources of income. These became moderating variables in this study. Random sampling of participants controlled their influence on the study variables.

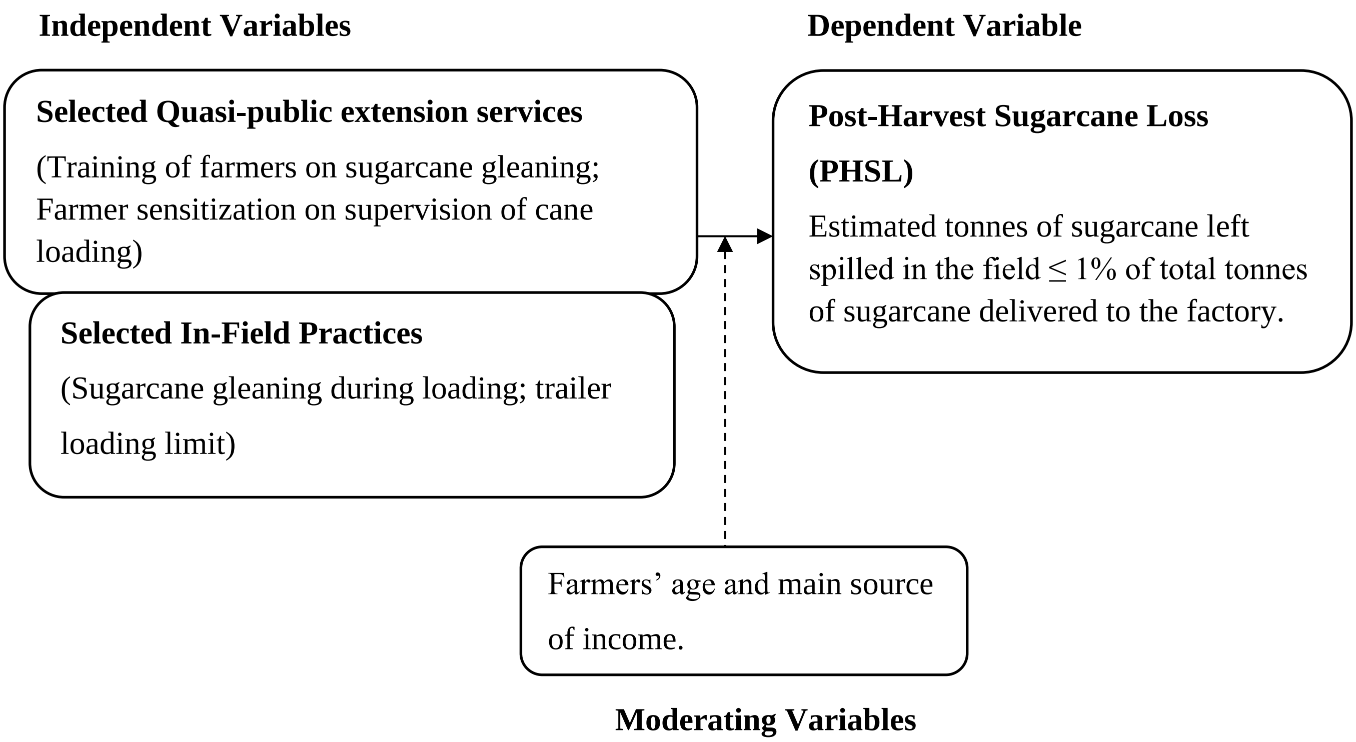


**Figure 1:** Conceptual Framework Demonstrating Interaction of Study Variables

# CHAPTER THREE
# RESEARCH METHODOLOGY

## 3.1 Introduction

The chapter contains the research procedure that was used to achieve the study objectives. It covers research design, location of the study, target population, sampling procedure and sample size, instrumentation, data collection, data analysis, and ethical issues.

## 3.2 Research Design

The researcher used descriptive survey design for this study. Descriptive survey design aims to accurately and systematically describe a situation or phenomenon. It answers questions such as how, what, where, and when but not why. Descriptive survey design was chosen because it could enable the researcher to investigate the variables of study without manipulating any of them but only observing and measuring them (McCombes, 2019). Besides, the researcher was able to study variables using the large sample size that was selected in a relatively short time by face-to-face administration of the questionnaire (Asenahabi, 2019).

## 3.3 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 km$^2$ (Kenya National Bureau of Statistics (KNBS), 2019). It borders Rongo, Uriri, Gucha, Transmara, Homa-Bay, Ndhiwa and Rangwe sub-counties. In this sub-county, sugarcane remains the main cash and industrial crop, while maize is the main staple food (Okoth, 2018). Awendo Sub-County was purposively selected on the basis of the high number of farmers (3,123) among the nine Sony Sugar Company's cane catchment sub-counties where sugarcane was harvested between 2018 and 2021. This equally was the period within which the effectiveness of selected QPE services and infield practices in reducing PHSL was unknown. Other sub-counties with their farmers in parentheses 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). The company was purposively selected because it had commercialized sugarcane production since 1979. This served the longest period compared to Transmara and Sukari Sugar Companies, which were established in 2011 and 2012, respectively. Besides, Sony Sugar Company instituted infield practices in 2011 to minimize PHSL. It is a quasi-public organization run by the National Government of Kenya that significantly benefits from its sugar (Okoth, 2018).

### 3.4 Population of the Study

The target population for this study was 3,123 contracted smallholder farmers, each having less than or equal to two hectares under cane with a total of 1,432.84 hectares. The accessible population was 2,759 smallholder farmers whose cane was harvested between 2018 and 2020, according to what was available in Sony Sugar's AMS as of October 2021. However, about 356 farmers harvested cane in more than one crop cycle (Agriculture Department, 2021). In this study, each farmer had only one entry in the sampling frame to give an equal chance of probability of being selected in the sample (Bartlett et al., 2001). Thus, the accessible population became 2,403 (2,759 – 356) with 1,083.16 ha. These farmers produced sugarcane under the conditions of Sony Sugar Company with expectations to obtain consistent income to sustain their livelihoods. They equally depended on the company's instituted infield practices to reduce PHSL (Agriculture Department, 2021; H&TD, 2017; OESD, 2017, 2019). Besides, 67 other stakeholders in sugarcane maintenance, harvesting, and transport were also part of the accessible population. They included agricultural extension field supervisors and their assistants, harvesting and transport supervisors and their field assistants, harvesting contractors, transport contractors, tractor drivers, grabber operators, winch operators, and cane cutters. Table 1 shows a 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 | 4 |
| Agricultural extension field assistants | 4 | 3 |
| Harvesting and transport supervisors | 6 | 5 |
| Harvesting and transport field assistants | 10 | 4 |
| 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 |
| Total | 3,830 | 2,477 |

Source: Agriculture Department (2021)

### 3.5 Sampling Procedures and Sample size

Both probability and non-probability sampling techniques were used to select samples (Rahi, 2017) for smallholder farmers and other stakeholders. Nassiuma's formula was chosen for calculating the sample size due to its suitability for studies involving large populations (2,403) and its ability to provide a representative sample while minimizing sampling errors. Nassiuma (2000) formula contends that a coefficient of variance in the range of $21\% \leq c \leq 30\%$ and a standard error in the range of $2\% \leq e \leq 5\%$ 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). The lower value for the coefficient of variance was chosen since it was acceptable for many studies, balancing precision and practicality. The chosen lower value for standard error indicated a more precise estimate of population parameters, often achieved with large sample sizes. A higher coefficient of variance or standard error may necessitate increasing the sample size to maintain precision. 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 were 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 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.

$$n_i = \frac{N_i \text{ x } n}{N}$$

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.

In this study, $N_i$ was 600 for Central Sakwa, 505 for North-East Sakwa, 667 for South Sakwa and 631 for West Sakwa; n was 147; and N was 2,403. Table 2 shows the summary of sampling frame and sample size of respondents from each Ward calculated using Cochran (1997) 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.

### 3.6 Instrumentation

Bartlett et al. (2001) assert that using an adequate sample along with high-quality data collection efforts results in a more reliable, valid, and generalizable result as well as resource saving. In this regard, the researcher developed and administered two questionnaires (Appendices A and B) to address each specific objective in consultation with the university supervisors. The questionnaire was chosen on the basis that it is commonly used in social sciences to gather large data sets easily, inexpensively, and within a short time. Besides, it gives respondents the opportunity to report their opinions as the researcher determines their factual knowledge about something (Young, 2015). The first questionnaire for farming households had two sections. Section A captured farmers' demographic characteristics. Section B examined the effectiveness of selected quasi-public extension services and infield practices in reducing PHSL. The second questionnaire was for other stakeholders. This questionnaire generally corroborated information on selected quasi-public extension services and infield practices in reducing PHSL among farmers in Awendo Sub-County, Kenya.

A document review guide was also developed by the researcher to collect secondary data related to the study variables. Document analysis (Appendix C) involved systematic reviews of both printed and electronic materials with the aim of collecting secondary data. The documents were internal or external to the organization, and they included reports, performance ratings, meeting minutes, newsletters, installed agriculture management systems, letters, procedure manuals, journals, and survey data. Document review was chosen as it was used in combination with other methods as a means of triangulation (Bowen, 2009).

### 3.6.1 Validity

Validity is the extent to which an instrument measures what it is designed to measure (Mohajan, 2017). It is the degree of accuracy achieved by the instruments used within a study (Gates et al., 2018) as well as truthfulness of the results (Mohajan, 2017). As a result, the researcher sought opinion of supervisors on face and content validity. The supervisors scrutinized the questionnaire and objectives for face validity. Researcher used their comments to improve the face validity of the questionnaire. This ensured that the questionnaire items were clear, concise, complete, well organized and unambiguous before being used in the field. The supervisors further scrutinized the questionnaire for content validity. This helped determine that the data collected realistically and fully reflected the indicators or content of concepts relevant to the study. Subsequently, the researcher in consultation with supervisors checked the suitability and complexity of the items and reframed where necessary (Mohajan, 2017).

### 3.6.2 Reliability

Farming household survey questionnaire was pre-tested using 30 smallholder farmers obtained by systematic random sampling from Suna East Sub-County in Migori County. Questionnaire for other stakeholders was equally pre-tested using 30 respective respondents within same sub-county. Researcher used a sample of 30, as recommended, to calculate Cronbach's alpha and assess the internal consistency of the reliability measures (Memon et al., 2017). Suna East Sub- County had similar characteristics to those of the study location. The researcher used debriefing method during this study. This involved careful observation of the respondents as they filled out the questionnaire then researcher asked them to reveal any problems with the questions. This helped the researcher to eliminate ambiguity in the questions so that the respondents understand the questions the way they were designed and intended

(Memon et al., 2017). Subsequently, the reliability of the instrument was estimated using Cronbach's Alpha Coefficient which is the most common measure of internal consistency. Reliability co-efficient of at least 0.70 was acceptable for this research study. Findings of the pilot testing exercise were used to adjust the questionnaires until reliability co-efficient of $\alpha$ = 0.749 and 0.711 were achieved for smallholder famers and other stakeholders' questionnaires before data collection. These were above the recommended minimum reliability co-efficient of $\alpha = 0.70$ and above. Better reliability implied more accurate results which increases the chances of making correct generalization in this study (Mohajan, 2017).

### 3.7 Data Collection Procedure

Researcher sought 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 South Nyanza Sugar Company to contact and book appointments with the Head of Agriculture Department (HoAD). Head of Agriculture Department was informed on the intention to collect data. The AEFS and harvesting and transport (H&T) supervisors through referral by HoAD were also informed and appointments made for office visits during which questionnaires were administered. AEFS helped identify the selected smallholder sugarcane farmers and agricultural extension field assistants. Harvesting and transport supervisors helped identify H&T field assistants, contractors, tractor drivers, grabber/bell operators and cane cutters. Other referred stakeholders were contacted at their convenience while smallholder farmers were contacted and appointments made for farm visits. The researcher verbally sought for respondents' consent to participate in the research. They freely choose either to participate or not to participate in the study. Data from respondents was collected through administration of the questionnaires. The researcher relied on a translator or relevant AEFS to do the interpretation in case of language barrier.

Document review guide was used to collect secondary data. 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. Reports on stakeholders in the sugarcane post-harvest value chain were also reviewed. Reviewed documents for secondary data were recorded alongside information sought from each. This process continued until all accessible documents containing information related to post-harvest sugarcane loss in Awendo Sub-County were exhaustively reviewed. Information on trends of PHSL as well as the effectiveness of selected quasi-public extension services and field practices in reducing PHSL among smallholder farmers in Awendo Sub-County were also reviewed for the period between year 2018 and 2021.

### 3.8 Data Analysis

Data in the questionnaire was coded and entered in the computer for processing using Statistical Package for Social Sciences (SPSS) version 21. Based on the objectives of the study, quantitative data were analysed 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 selected QPE services and field practices 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 selected QPE services and field practices in reducing PHSL was also used to determine their effectiveness.

Further, Spearman's rank correlation was used to test the strength and direction of relationship between QPE services and infield practices and PHSL. Spearman's rank correlation was chosen to investigate the linear relations between the two variables of the study. It was chosen since it is a non-parametric test and the data that was to be collected on independent variable was ordinal and monotonically related to the dependent variable. Besides, it would give the most reliable results at 5% significant level regardless of sample size and distribution shape (Temizhan et al., 2022). The relationship would be either negative or positive on one hand, and weak or strong on the other hand. The correlation coefficient values ($r_s$ values) would range from -1 to 1. A -1 meant a strong negative monotonic relationship that was statistically significant, thus, both variables increase or decrease together. A +1 meant a strong positive monotonic relationship that was statistically insignificant, thus, one variable increases while the other decreases. A zero (0) means there is no monotonic relationship hence none of the variables of study would increase or decrease the other. Correlation coefficient values closer to ± 1 indicate strong relationship while those closer to zero indicate weak relationships. Spearman coefficient of ranks correlation was given by the following formula (Ali Abd AlHameed, 2022):

$$r_s = \frac{1 - 6\sum d^2}{n\,(n^2 - 1)}$$

Where $r_s$ is the correlation coefficient; $d$ is the differences between the two ranks and $n$ is the number of ordered pairs.

**Table 3**

*Summary of Data Analysis*

| Research Objective | Independent Variable | Dependent Variable | Statistical Tests |
|---|---|---|---|
| **Ro1**: 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). | Frequencies, Percentages and Mean; Spearman's Rank Correlation. |
| **Ro2**: To determine the effectiveness of farmer sensitization on supervision of cane loading in reducing PHSL among smallholder farmers | Farmers' sensitization on supervision of sugarcane loading. | Post-harvest sugarcane loss (PHSL). | Frequencies, Percentages and Mean; Spearman's Rank Correlation. |
| **Ro3**: To establish the effectiveness of sugarcane gleaning during loading in reducing PHSL among smallholder farmers | Sugarcane gleaning during loading. | Post-harvest sugarcane loss (PHSL). | Frequencies, Percentages and Mean; Spearman's Rank Correlation. |
| **Ro4**: To determine the effectiveness of trailer loading limit in reducing PHSL among smallholder farmers in Awendo Sub-County, Kenya. | Trailer loading limit. | Post-harvest sugarcane loss (PHSL). | Frequencies, Percentages and Mean; Spearman's Rank Correlation. |

## 3.9 Ethical Considerations

The researcher explained the purpose of the study and procedures to be used to the participants. Researcher assured participants that the data collected 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 questionnaires voluntarily. They were informed that they could withdraw from responding to the questionnaires 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.

# CHAPTER FOUR
# RESULTS AND DISCUSSIONS

## 4.1 Introduction

This chapter presents the results of the study. This is done in light of the selected quasi-public extension services and field practices adopted by South Nyanza Sugar Company to reduce post-harvest sugarcane experienced by smallholder farmers in Awendo Sub-County, Kenya and their effectiveness in the same respect. The section begins with the results on respondents Bio-data and trend of post-harvest sugarcane loss in Awendo Sub-County between 2018 and 2021. The section further progresses to results and discussions based on the study objectives.

## 4.2 Respondents Demographic Characteristics

Respondents' demographic characteristics was captured as distribution of smallholder farmers and other stakeholders by ward, farm acreage contracted for sugarcane production between 2017 and 2020, smallholder farmer's source of land and sugarcane crop cycle harvested between 2018 and 2021.

### 4.2.1 Distribution of Smallholder Farmers and Other Stakeholders by Ward

Results in Table 4 show that 28.0% of smallholder farmers in the study were from South Sakwa while the least number (21.0%) were from North-East Sakwa based on sample distribution. Fifty-eight-point two percent of other stakeholders such as AEFS, harvesting and transport contractors operated in more than one ward.

**Table 4**

*Distribution of Respondents by Ward*

| Ward | Smallholder farmers (n=132) | | Other stakeholders (n=67) | |
|---|---|---|---|---|
| | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| Central Sakwa | 33 | 25.0 | 6 | 9.0 |
| North-East Sakwa | 28 | 21.2 | 3 | 4.5 |
| South Sakwa | 37 | 28.0 | 11 | 16.4 |
| West Sakwa | 34 | 25.8 | 8 | 11.9 |
| More than One Ward | | | 39 | 58.2 |
| Total | 132 | 100 | 67 | 100 |

#### 4.2.2 Farm Acreage Contracted for Sugarcane Production Between 2017 and 2020

Results in Table 5 show that out of 118.1 hectares, the farm acreage contracted for sugarcane production was 72.4 hectares, with an average of 0.55 hectares per farm. Notably, 45.5% of farmers had land acreage between 0.1 and 0.5 hectares., totalling 22.2 hectares, of which 18.9 hectares (85.13%) were dedicated to sugarcane production.

**Table 5**

*Farm Acreage Contracted for Sugarcane Production (n=132)*

| Acreage range in Hectares (Ha) | Total farm acreage (Ha.) | Acreage contracted for sugarcane production (Ha.) | Smallholder farmers | |
|---|---|---|---|---|
| | | | Frequency | Percentage |
| 0.1 – 0.5 | 22.0 | 18.9 | 60 | 45.5 |
| 0.6 – 1.0 | 23.5 | 16.2 | 30 | 22.7 |
| 1.1 – 1.5 | 15.0 | 12.6 | 12 | 9.1 |
| 1.6 – 2.0 | 57.6 | 24.7 | 30 | 22.7 |
| Total | 118.1 | 72.4 | 132 | 100 |

This implies that the smallholder farmers grew sugarcane in about 61.3% of their total land. Thus, PHSL beyond the set limit would have reaching implications to their farming income. However, effective reduction of PHSL would lead to increase in income through sugarcane proceeds.

#### 4.2.3 Smallholder Farmer's Source of Land

Figure 2 indicates that most (56.8%) of the smallholder farmers grew contracted sugarcane on their own lands, 41.7% leased land while few (1.5%) produced on gifted land.

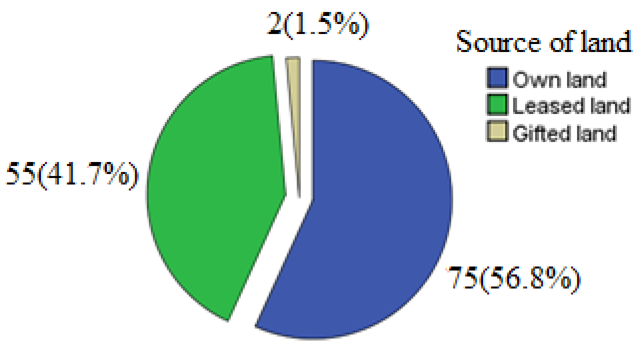


**Figure 2:** Smallholder Farmers' Source of Land

Farmers who leased land (41.7%) had increased cost of production compared to their counterparts who grew sugarcane on own and leased land. They incurred extra costs to lease land and those who experienced PHSL above expected level of ≤ 1% of tonnes of cane delivered to the factory greatly lost income. Farmers who leased land and experienced PHSL below the expected limit had similar income outcomes just like their counterparts who grew sugarcane on their own land and those who leased land and experienced PHSL below the limit.

#### 4.2.4 Sugarcane Crop Cycle Harvested Between 2018 and 2021

Figure 3 shows that most plant crops (PC) compared to other crop cycles were harvested in 2018 (89.3%, 25 plots), 2019 (68.8%, 22 plots) and 2020 PC (65.4%, 17 plots). In 2021, the number of PC and Ratoon 1 (R1) crop plots harvested were the same at (39.1%, 18 plots each). Ratoon 2 (R2) plots harvested were lowest between 2018 and 2021 with the least in 2020 (3.8%, 1 plot).

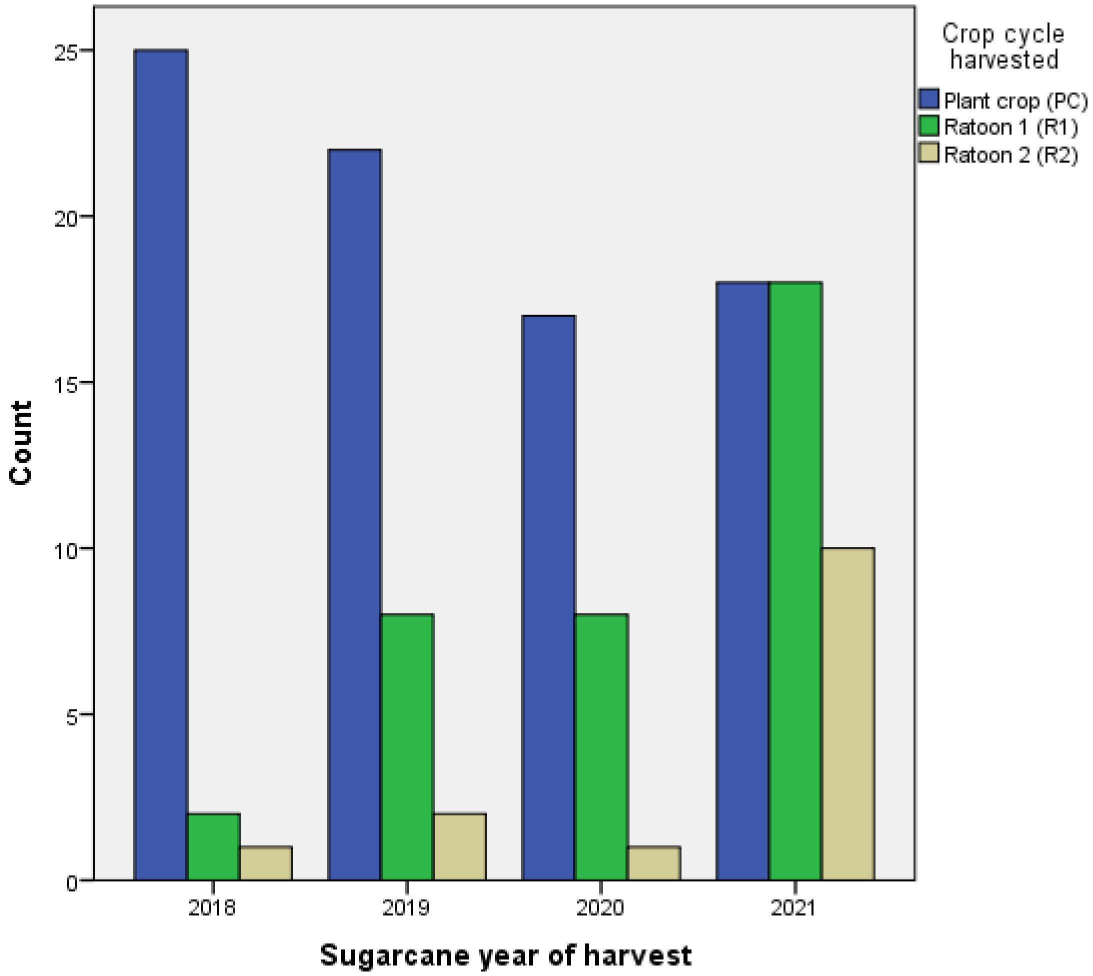


**Figure 3:** Sugarcane Crop Cycles Harvested Per Year

Farmers incur more expenses in plant crops than ratoon crops since the former takes longer to mature. This implies that farmers whose plant crop were harvested in 2018, 2019 and 2021 and experienced PHSL above expected level of ≤ 1% of tonnes of cane delivered to the factory greatly lost income as compared to their counterparts who harvested ratoon crops. Similar losses would be experienced in 2021 by farmers whose plant crops were harvested despite their number being equal to those whose ratoon 1 crops were harvested. Smallholder farmers who harvested plant crops and experienced PHSL below the expected limit likely saw similar income benefits to those whose harvested ratoon crops were harvested with PHSL below the limit.

## 4.3 Post-Harvest Sugarcane Loss in Awendo Sub-County Between 2018 and 2021

Results on post-harvest sugarcane loss in Awendo Sub-County between 2018 and 2021 has been presented in terms of its trend, causes, effects on stakeholders' incomes and mitigation strategies.

### 4.3.1 Trend of Post-Harvest Sugarcane Loss Between 2018 and 2021

The results in Figure 4 show that mean PHSL in form of infield spillage in Awendo sub-county was high in the Year 2020 at 6.58 tonnes per hectare (TCH) and lowest in 2019 (5.23 TCH).

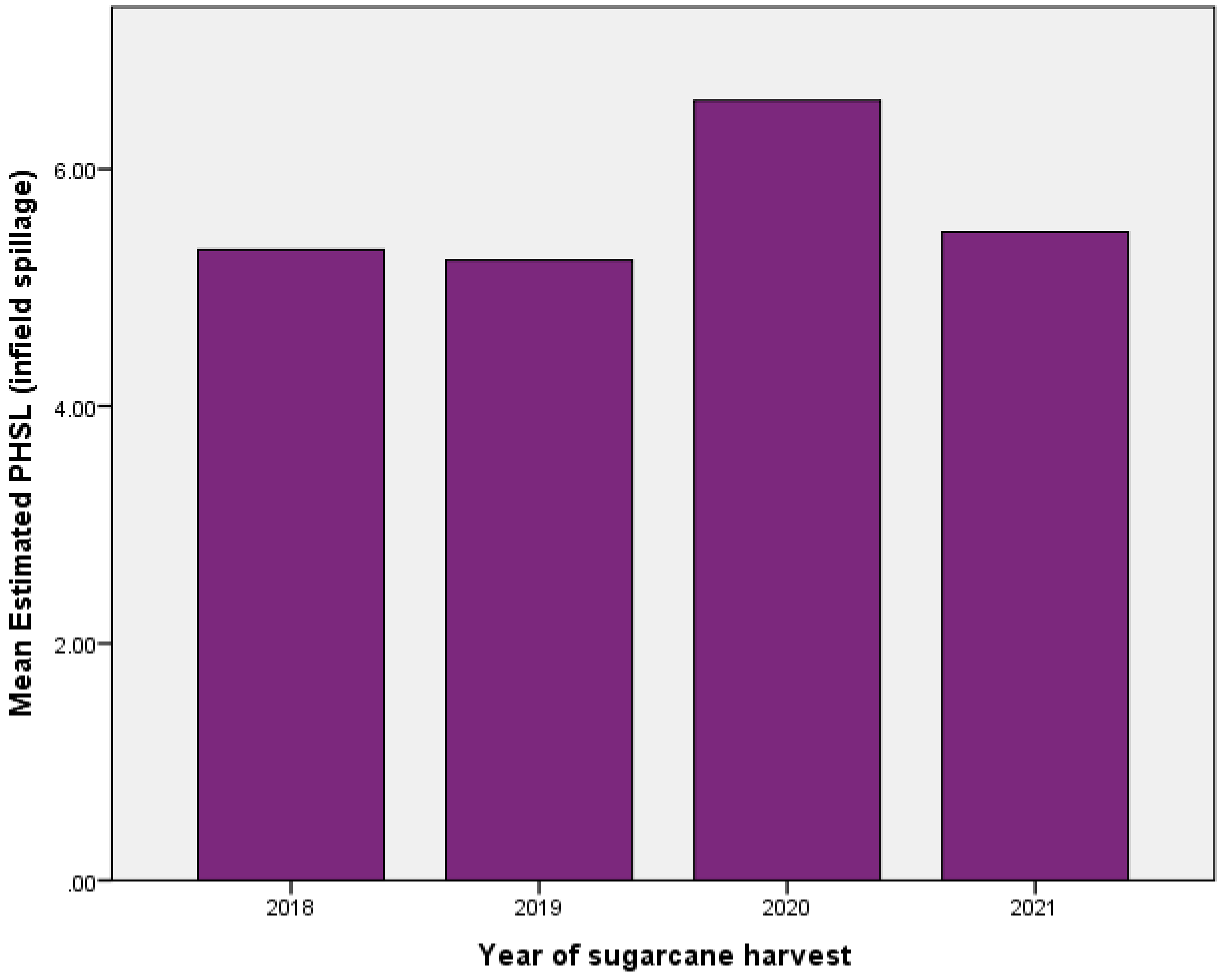


**Figure 4:** Trend of Post-Harvest Sugarcane Loss between 2018 and 2020 (Std. Deviation – 6.5)

Smallholder farmers whose sugarcane were harvested in 2020 experienced the highest average PHSL which greatly affected their income from sugarcane proceeds compared to 2021, 2018 and 2021. It also implied that some or all selected quasi-public extension services and field practices did not reduce PHSL to expected set level of ≤ 1% of tonnes of cane delivered to the factory.

Results in Table 6 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 6**

*Estimated Percentage Field Loss (n=132)*

| Estimated percentage field 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 |
| Total | 132 | 100 |

South Nyanza Sugar company pays her farmers based on tonnes of sugarcane successfully delivered to the factory. Thus, majority of these smallholder farmers (83.3%) who experienced estimated percentage field PHSL above the set level of less than 1% of total cane delivered to the factory, lost substantial income from sugarcane cane proceeds. This could be attributed to ineffectiveness of selected quasi-public extension services and field practices in reducing PHSL. However, their counterparts (16.7) who experienced estimated percentage field PHSL below the set level of less than 1% of total cane delivered to the factory, gained and got best returns from their limited resources they invested in the production process.

### 4.3.2 Causes of Post-Harvest Sugarcane Loss Between 2018 and 2021

Figure 5 shows how sugarcane post-harvest value chain relationship was conceptualised as per document review guide. It highlights stakeholders responsible for various activities in sugarcane post-harvest value chain in Awendo Sub-County such as farmer or their agents and other stakeholders.

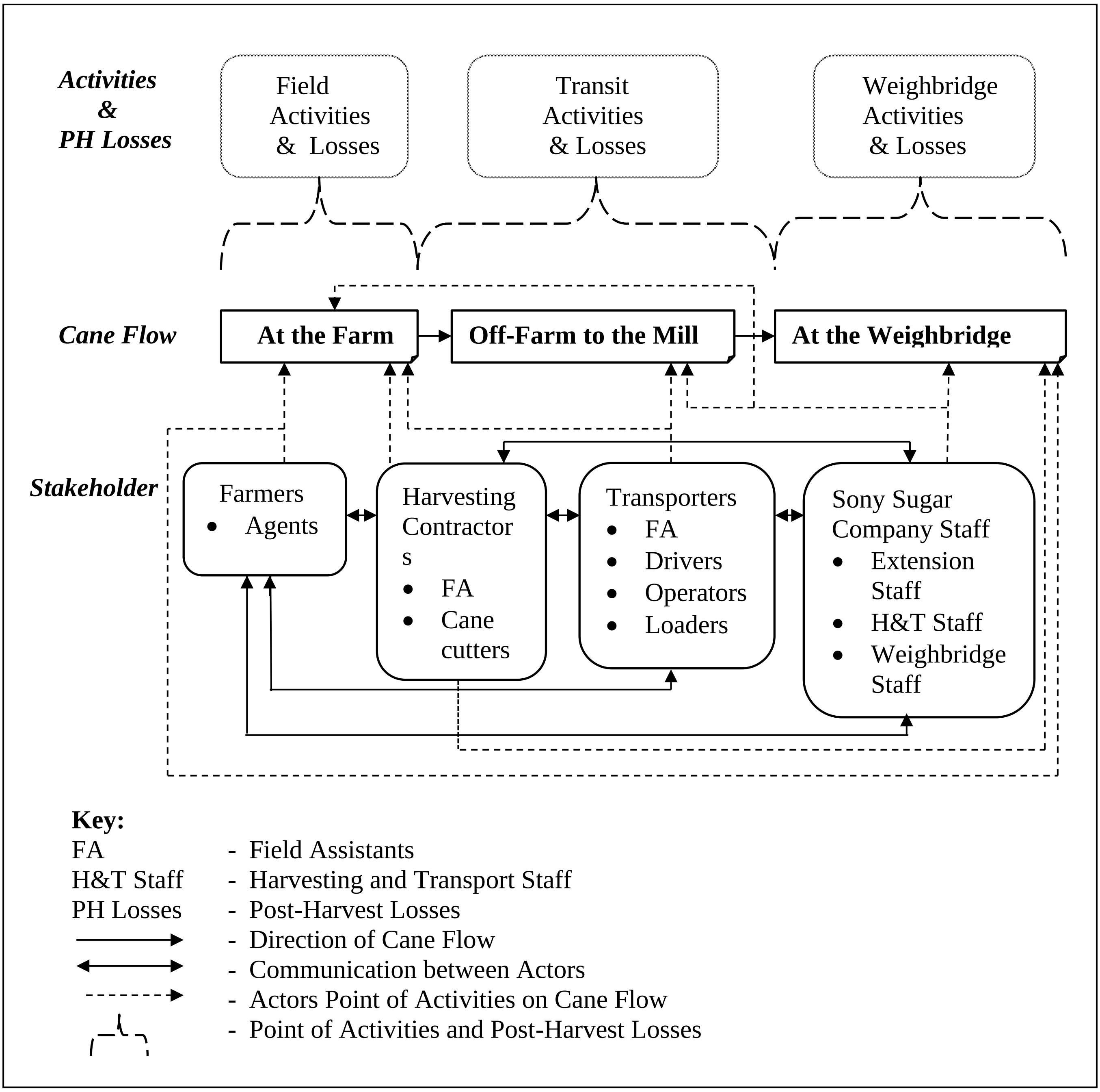


**Figure 5**: Sugar Cane Post-Harvest Value Chain Relationships

In Awendo Sub- County, sugar cane post-harvest value chain of interest to the smallholder farmer flowed from the Farm and ended at the Weighbridge. The actors included the farmers as the owners of the cane or their agents and other stakeholders such as Company staff, transporters and their staff as well as harvesting contractors and their teams. Sugar cane flowed from the farm to the mill as indicated in Figure 5 which shows how sugarcane post-harvest value chain relationship was conceptualised.

At the farm, farmers grew cane, supervised loading of harvested sugarcane and gleaned those that would be scattered by cane grabbers during loading. These farmers would leave their agents to undertake similar activities in their absence. Sony Sugar Company extension staff comprising supervisors and field assistants trained farmers or their agents on proper sugarcane gleaning and sensitized them to supervise sugarcane loading during transport. Harvesting contractors through their agents and cane cutters were responsible for harvesting can according to set standards. Harvesting standards include cutting sugarcane at 2.5cm above the ground, arranging them in clean windrows then heaping them to form a standard stack size of 3.7m x 4.9m x 1.8m which approximately weighs 6 tonnes. Transporters through their teams such as field assistants, tractor drivers, winch and bell operators had the obligation to transport harvested cane according to standards. Transport standards include proper collection of sugarcane in windrows and loading a maximum of two and three stacks per single-bucket and double-bucket trailers respectively. Failure by any of these actors to perform expected activities caused field losses. Sony Sugar Company's harvesting and transport staff would supervise to ensure harvesting and transport contractors adhered to set standards.

Transit losses occurred when sugarcane spilled out from loaded tractors hauling harvested sugarcane from the farm to the weighbridge. These were due to overloading, improper tying of loaded cane with cane wires and when tractors got accidents and overturned. Transporters and Sony Sugar Company's harvesting and transport staff had the task of ensuring no such losses occurred. Weighbridge losses resulted from swapping cane weighment slips and improper weighment caused by Sony Sugar company's weighbridge staff. Thus, actors through their various activities contribute to post-harvest losses in the value chain. At the end, smallholder sugar cane farmers were paid only for the sugarcane cane successfully delivered and weighed at the factory weighbridge (SISTR, 2019).

Results in Table 7 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 7**

*Farmers' Observations on Greatest Contributors of Field PHSL (n=132)*

| Greatest contributors of field 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 | 4.6 |
| 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 |
| Total | 132 | 100 |

These findings imply that farmers who experience field PHSL normally fail to glean when grabbers scatter sugarcane during loading. Little PHSL are occasioned by poor terrain that make loading difficult. As a result, PHSL would be substantially reduced if farmers properly gleaned during loading and grabber operators picked both stacked and scattered sugarcane properly. None of the contributors of field PHSL were to be ignored to realize the overall goal of reducing PHSL to set level of less than 1% of total cane delivered to the factory.

### 4.3.3 Effect of Post-Harvest Sugarcane Loss on Stakeholders' Income

Results in Table 8 indicate that PHSL affects the income of all farmers and 70.1% of other stakeholders, while 29.9% of other stakeholder's income remains unaffected.

**Table 8**

*Effect of PHSL on Income of Stakeholders*

| Effect of PHSL on Income | Stakeholder | | | |
|---|---|---|---|---|
| | Smallholder Farmers (n=132) | | Others (n=67) | |
| | Frequency | Percentage | Frequency | Percentage |
| Yes | 132 | 100.0 | 47 | 70.1 |
| No | 0 | 0.0 | 20 | 29.9 |
| Total | 132 | 100 | 67 | 100 |

Smallholder farmers concur that PHSL affect their income as they are paid based on tonnes of sugarcane successfully delivered to the factory. Some other stakeholders such as cane cutters, tractor drivers, harvesting and transport contractors were equally paid based on tonnes of cane received at the factory. In this regard, when some harvested sugarcanes do not reach the factory, all farmers and some of the other stakeholders aforementioned receive less income than they expected.

### 4.3.4 Post-Harvest Sugarcane Loss Mitigation Strategies

Sony Sugar Company's roles in mitigating PHSL in Awendo Sub-County were highlighted in the documents that were reviewed. The reviewed documents included reports, quality management procedure manuals, quality management documented information and electronic information on Agriculture management system (AMS). The information that was being looked for during the review process include the company's quasi-public extension services, set field standards guiding sugarcane harvesting and transport and transport field assessment reports both in the Nucleus estate and outgrowers. Finally, stable secondary data were obtained to complement the primary data collected from stakeholders, including Sony Sugar Company's harvesting and transport staff, as well as contractors involved in the same operations, through a questionnaire.

The review findings revealed that Sony Sugar Company is a quasi-public organization under the Kenyan national government hence its extension services offered to farmers are hereby referred to as quasi-public extension services. The company further instituted multiple managerial standards and measures in 2011 to reduce PHSL occasioned by field spillage to less than one percent (1.0%) of total cane delivered from a farmer's plot to the factory (H&TD, 2017). The set standards regulate both quasi-public extension services and field practices to mitigate this alarming problem of PHSL (H&TD, 2017; OESD,2017).

Quasi-public extension services such as training on sugarcane gleaning and sensitization of farmers to supervise cane loading were considered among others. The field practices included cutting sugarcane at the right age (18 months for PC and 16 months for ratoons), height (≤ 2.5 cm above the ground) and top (self-snapping point), laying harvested cane in clean windrows before forming stacks, forming standard stack measuring 3.7m x 4.9m x 1.8m (approximately 6 tonnes), cut to mill time (within 48 and 36 hours for green and burnt cane respectively) and loading a maximum of two standard stacks (approximately 6 to 12 tonnes) per single bucket trailer and a maximum of three (approximately 12 to 18 tonnes) per double bucket trailer. Sony Sugar Company installed Agriculture Management System (AMS) in 2013 to monitor sugarcane production in both its nucleus estate and outgrowers. Besides, the company signs legal renewable contracts with harvesting and transport contractors based on performance.

Sony Sugar Company's harvesting and transport staff, as well as contracted staff for these operations, were engaged on their awareness about this Company's objective of reducing PHSL to less than 1% of tonnes of sugarcane delivered to the factory. Majority (83.8 per cent) of them indicated that they were informed on the company's PHSL mitigation strategies.

### 4.4 Effectiveness of Training Farmers on Sugarcane Gleaning in Reducing Post-Harvest Sugarcane Loss

The first objective was to establish the effectiveness of training farmers on sugarcane gleaning in reducing PHSL. The objective was anchored on quasi-public extension service aimed at reducing PHSL in Migori County. In this study, effectiveness refers to the capability of training of farmers on sugarcane gleaning in reducing PHSL to less than one percent (1.0%) of total cane delivered from a farmer's plot to the factory. To achieve this objective, 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. Besides, Spearman's correlation was used to measure the strength of the relationship between training on sugarcane gleaning and PHSL.

Table 9 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 method of extension delivery was farm field visits (75.8%). However, 3.0% of farmers are never contacted.

**Table 9**

*Main Method by Which AEFS and AEFA Contact Smallholder Farmers (n=132)*

| 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 |
| Total | 132 | 100 |

Results in Table 10 reveal that during such contacts, majority (57.5%) of smallholder farmers were never trained on sugarcane gleaning during loading to reduce PHSL.

**Table 10**

*Level of Farmer's Training on Sugarcane Gleaning (n=132)*

| Level of farmers' training on sugarcane gleaning | Frequency | Percentage |
|---|---|---|
| Very often | 1 | 0.8 |
| Often | 35 | 26.5 |
| Occasionally | 10 | 7.6 |
| Rarely | 10 | 7.6 |
| Never | 76 | 57.5 |
| Total | 132 | 100 |

Smallholder farmers who were never trained on sugarcane gleaning cited reasons for missing such training. Results in Table 11 reveal that majority (61.8%) of the farmers took it as self-initiative to reduce loss having learnt from fellow farmers while (13.3%) of them were unaware of such trainings. This group of smallholder farmers who were never trained, however stated that they benefited from their trained counterparts through social interactions.

**Table 11**

*Main Reason for Farmers Never Being Trained by AEFS on Sugarcane Gleaning (n=76)*

| Reason for having never been trained on sugarcane gleaning | Frequency | Percentage |
|---|---|---|
| AEFS has never been reaching farmers | 1 | 1.3 |
| Farmer’s busy schedule | 14 | 18.4 |
| Unaware | 10 | 13.3 |
| Inherited the training from fathers | 2 | 2.6 |
| No individualized training | 1 | 1.3 |
| Farmer’s self-initiative to reduce loss | 47 | 61.8 |
| Trained by harvesting contractor | 1 | 1.3 |
| Total | 76 | 100 |

The study found out that 51 out of 56 farmers, constituting 91.1% who were trained on sugarcane gleaning, gleaned during loading. All these 51 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 (74.5%) of them ranked the effectiveness level of training of farmers on sugarcane gleaning in reducing PHSL as effective. 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 as shown in Table 6. 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%). However, 57.6% of the 132 respondent farmers ranked the effectiveness of training on sugarcane gleaning in reducing PHSL as ineffective. These 76 farmers were equally not trained on sugarcane gleaning. Table 12 indicates ranking of effectiveness of training on sugarcane gleaning in reducing PHSL.

**Table 12**

*Ranking of Effectiveness of Training on Sugarcane Gleaning in Reducing PHSL*

| Ranking level of effectiveness of training on sugarcane gleaning in reducing PHSL | By Smallholder farmers | | | | By AEFS and AEFA (n=7) | |
|---|---|---|---|---|---|---|
| | Frequency | | Percentage | | Frequency | Percentage |
| | n=51 | n=132 | n=51 | n=132 | | |
| 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 | | |
| Total | 51 | 132 | 100 | 100 | 7 | 100 |

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 13 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 13**

*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 |

The result revealed a weak positive relationship as correlation coefficient was closer to zero. The positive correlation meant that if more farmers were trained on sugarcane gleaning and farmers practiced the same, the level of PHSL would be greatly reduced. The inverse would also be true. However, smallholder farmers who were never trained on sugarcane gleaning ranked it ineffective since they had no knowledge or skill to apply. They only relied on social interactions with their fellow trained farmers.

According to Nasiche et al.(2020), 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 Muzaffargarh 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 (2017) 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 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 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 ($\chi^2$ 12.844, $df=1$, p=0.000).

## 4.5 Effectiveness of Sensitisation of Farmers on Supervision of Loading in Reducing Post-Harvest Sugarcane Loss

The second objective was to determine the effectiveness of sensitisation on supervision of loading in reducing PHSL. In this study, effectiveness refers to the success of sensitisation of farmers on supervision of cane loading in reducing PHSL to less than one percent (1.0%) of total cane delivered from a farmer's plot to the factory. To achieve this objective, effectiveness of supervision of cane loading 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 level. 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 sensitisation on supervision of loading is effective in reducing PHSL while above 1.0% means it is not effective. Besides, Spearman's correlation was used to measure the strength of the relationship between sensitization on supervision of loading and PHSL.

Results in Table 14 show that majority (74.2 %) of smallholder farmers were sensitised to supervise loading of their harvested sugarcane. Only 25.8% of smallholder farmers were never sensitized. Smallholder farmers cited reasons for this sensitization such as to monitor loading operations to avoid loss, prepare for gleaning and record registration numbers of tractors that haul cane to the factory for purposes of signing JSCC and follow up in case of anomaly.

**Table 14**

*Sensitization Level of Smallholder Farmers to Supervise Loading of Harvested Sugarcane (n=132)*

| Level of farmers' sensitisation on supervision of loading of harvested sugarcane | Frequency | Percentage |
|---|---|---|
| Very often | 4 | 3.0 |
| Often | 70 | 53.0 |
| Occasionally | 17 | 12.9 |
| Rarely | 7 | 5.3 |
| Never | 34 | 25.8 |
| Total | 132 | 100 |

The study further established that 96.9% of 98 respondents sensitized on supervision of loading harvested sugarcane supervised the operation. They formed part of the 93.18% of 132 smallholder farmers who supervised loading of their harvested cane. Figure 6 presents the results of farmers' supervision of sugarcane loading.

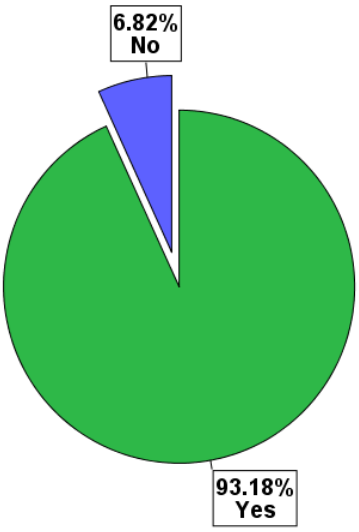


**Figure 6:** Smallholder Farmers' Supervision of Sugarcane Loading

Smallholder farmers who were present and supervised sugarcane loading however noted that their absence would have led to PHSL. This would arise due to a lot of sugarcane remaining infield, collusion between other naughty farmers and transporters to swop cane stack identification slips in their favour, collusion between bell operator and jaggery people to scatter cane and cover some with trash, poor loading and missing transport tractors. However, others smallholder farmers exuded confidence in Sony Sugar's operations thus stated that no problem would arise in their absence. 6.82 percent of farmers who were absent during transport and did not supervise loading cited being away due to reasons such as busy schedule, being in church, sickness, not given prior information and transport operation were done at night.

Smallholder farmers were not sensitised on supervision of loading harvested sugarcane cited reasons such as their busy schedules. Some were just unaware of such sensitisation. However, 82.4% of 34 smallholder farmers who were not sensitised still supervised loading of their harvested cane due to their self-initiative or just bumping on tractors. 4.5% of the 132 respondents who were never sensitised on supervision of cane loading and were never present to supervise the operation experienced average PHSL of 7.88 TCH between 2018 and 2021. Moreover, they all never gleaned and experienced percentage infield PHSL of between 3.3% and 15.8% compared to set target of less than 1.0% of total tonnes of cane delivered to the factory.

This study further found out that 100% of 95 smallholder farmers who were sensitised on supervision of cane loading and supervised the operation stated that the sensitisation was effective in reducing PHSL experienced by smallholder farmers in Awendo Sub-County. Majority of them ranked the effectiveness level as effective (73.7%). Table 15 shows respondent's ranking of effectiveness of sensitization on supervision of sugarcane loading in reducing PHSL. Results of the percentage PHSL they experienced in their cane fields confirmed their rankings since they formed the majority (72.7%) 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. They lost an average of 0.08 TCH.

However, some 83.3% of smallholder farmers who were present and supervised loading lost more than the set target of less than 1.0% of total tonnes of cane delivered to the factory. They experienced an average PHSL of 6.47 TCH between 2018 and 2021 with the highest losing 36.36 TCH. These smallholder farmers indicated greatest contributors of this higher PHSL as scattered cane by grabbers, faster grabber loading speed than the gleaning speed and failure to glean. Results in Table 15 indicates that 75% of all the respondents also confirmed that sensitisation on supervision of sugarcane loading was effective in reducing PHSL experienced by farmers in Awendo Sub-County. 100% of AEFS and AEFA who sensitised smallholder farmers on supervision of cane loading equally asserted that this their QPES effectively reduced PHSL. They ranked it at very effective (50.0%) and excellently effective (50.0%).

In certain instances, smallholder farmers stated effectiveness of sensitization on supervision of cane loading was enhanced by certain factors such as some company field staff created good rapport with farmers, farmers were present during loading to monitor and raise concerns of any anomalies and block leaders were used to inform them on scheduled transport on site. Other stakeholders similarly observed that some farmers were present not only during loading but during harvesting as well. In this way the smallholder farmers were able to give safe way to their cane plots, monitor harvesting and transport operations. They further stated that other farmers equally attended seminars organized by the company where such sensitizations were done.

**Table 15**

*Respondent's Ranking of Effectiveness of Sensitization on Supervision of Sugarcane Loading in Reducing PHSL*

| Ranking level of effectiveness of sensitization on supervision of sugarcane loading in reducing PHSL | By Smallholder farmers | | | | By AEFS and AEFA (n=4) | |
|---|---|---|---|---|---|---|
| | Frequency | | Percentage | | Frequency | Percentage |
| | n=95 | n=132 | n=95 | n=132 | | |
| Excellently effective | 4 | 4 | 4.2 | 3.0 | 2 | 50.0 |
| Very effective | 13 | 13 | 13.7 | 9.8 | 2 | 50.0 |
| Effective | 70 | 73 | 73.7 | 55.3 | | |
| Slightly effective | 8 | 9 | 8.4 | 6.8 | | |
| Not effective | | 33 | | 25.0 | | |
| Total | 95 | 132 | 100 | 100 | 4 | 100 |

However, the Spearman's test results in Table 16 reveal that the relationship between sensitization on supervision of sugarcane loading and post-harvest sugarcane loss was negative. The relationship between the two variables was not statistically significant, $r$ (130) = -.027, $p$ > .05.

**Table 16**

*Relationship Between Sensitization on Supervision of Sugarcane Loading and PHSL*

| **Scale** | | Post-harvest sugarcane loss |
|---|---|---|
| Sensitization on supervision of sugarcane loading | Correlation coefficient | -.027 |
| | P-value | .755 |
| | N | 132 |

The result indicated a weak negative relationship since the correlation coefficient value was closer to zero. This negative correlation meant that decrease in level of farmer's sensitisation on supervision of loading of harvested sugarcane would increase the level of PHSL. Sensitisation is believed to be an effective extension technique that increases farmers awareness and inculcate in them basic knowledge about technology or an innovation and its application. Agricultural extension agents link the farmers to research thus ensures farmers are sensitized. Besides, the agents provide knowledge and skill development support to farmers in order to improve their livelihoods (Mariappan et al., 2012).

The results are in line with studies by Dlamini (2018) who found out that smallholder farmers in the developing world required up to date information for increased agricultural production. As a result, agricultural extension officers played an important role in disseminating such information as they were crucial connectors between farmers and other actors. Mariappan et al. (2012) affirm that informing farmers on new improved farm practices remains the major key to the success of the farming sector. Regarding smallholder farmers' complaints of cane transport at night, a study by SRI (2018) equally found out that most transport operations were carried at night thus caused massive spillage resulting to PHSL.

The results are also consistent with findings on study by Adewole at al. (2022) that evaluated the effects of sensitisation in rural community on conflict resolution between herdsmen and crop farmers in Ogbomosho North Local Government Area of Oyo State, Nigeria. The study found out that about 91% of crop farmers and 53.38% of herdsmen participated in the sensitisation. About 84% of crop farmers and 44.50% of herdsmen resolved conflicts thus, participation in sensitization was effective. Mariappan et al. (2012) study in India, also found that sensitization workshops had significantly contributed to the increase in awareness levels of fishery extension officers on Pacific white shrimp farming.

## 4.6 Effectiveness of Proper Gleaning in Reducing Post-Harvest Sugarcane Loss in Awendo Sub-County

The third objective was to establish the effectiveness of proper gleaning in reducing PHSL. In this study, effectiveness refers to the capability of proper gleaning during loading in reducing PHSL to less than one percent (1.0%) of total cane delivered from a farmer's plot to the factory. To achieve this objective, effectiveness of proper gleaning during loading 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 level. Besides, the ratings were confirmed by estimated percentage PHSL 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 proper gleaning during loading is effective in reducing PHSL while above 1.0% means it is not effective. Besides, Spearman's correlation was used to measure the strength of the relationship between proper gleaning during loading and PHSL.

Results in Table 17 revealed that most (84.8%) of smallholder farmers properly gleaned their harvested sugarcane during loading to reduce PHSL. This was in bid to increase their tonnage received after factory weighment. They further stated that they would not wish to see their sugarcane they greatly invested in remaining in the field and going into waste. However, 15.2% of smallholder farmers never gleaned citing reasons such as being away in church, their busy schedules and sickness. Others stated lack of money to pay gleaners while others cited lack of prior information on programmed transport. Some farmers resorted to leave them for later sale to jaggery people at low costs citing factory's delayed payment of delivered cane.

**Table 17**

*Smallholder Farmers' Participation on Sugarcane Gleaning During Loading (n=132)*

| Farmer's participation on sugarcane gleaning during loading | Frequency | Percentage |
|---|---|---|
| Yes | 112 | 84.8 |
| No | 20 | 15.2 |
| Total | 132 | 100 |

Results in Table 18 indicate that 99.1% of the 112 smallholder farmers who gleaned properly during loading stated that proper gleaning is effective in reducing PHSL experienced by smallholder farmers in Awendo Sub-County. Majority ranked the effectiveness level of proper gleaning in reducing PHSL as very effective (45.5%). Results of the percentage PHSL they experienced confirmed their statements since they experienced percentage infield PHSL of between zero (0) and 0.7%. They lost an average of 0.09 TCH.

**Table 18**

*Smallholder Farmer's Ranking of Effectiveness of Proper Gleaning in Reducing PHSL*

| **Ranking level** | **Smallholder farmers who gleaned during loading** | | **All smallholder farmers who participated in the study** | |
|---|---|---|---|---|
| | **Frequency (n=112)** | **Percentage (n=112)** | **Frequency (n=132)** | **Percentage (n=132)** |
| Excellently effective | 13 | 11.6 | 13 | 9.8 |
| Very effective | 51 | 45.5 | 51 | 38.6 |
| Effective | 41 | 36.6 | 41 | 31.1 |
| Slightly effective | 6 | 5.4 | 6 | 4.6 |
| Not effective | 1 | 0.9 | 21 | 15.9 |
| Total | 112 | 100 | 132 | 100 |

Smallholder farmers who did not glean during loading had percentage PHSL in the range of 1.7% and 29.4%. They experienced an average PHSL of 6.50 TCH between 2018 and 2021. The Spearman's test results in Table 19 reveal that the relationship between proper sugarcane gleaning and post-harvest sugarcane loss was positive. The relationship between the two variables was statistically significant, $r$ (130) = .199, $p < .05$.

**Table 19**

*Relationship Between Proper Sugarcane Gleaning and PHSL*

| **Scale** | | Post-harvest sugarcane loss |
|---|---|---|
| Proper sugarcane gleaning | Correlation coefficient | .199* |
| | P-value | .022 |
| | N | 132 |

The result revealed a negligible positive relationship as correlation coefficient was closer to zero. The positive correlation meant that PHSL would be effectively reduced if more smallholder sugarcane farmers gleaned sugarcane during loading.

However, this study also found out that certain challenges made some farmers who gleaned unable to achieve the set target of less than 1.0% of total cane delivered. They still experienced PHSL ranging between 1.1% to 66.8% with an average of 6.75 TCH between 2018 and 2021. Overall, these farmers who gleaned lost an average of 7.4% of tonnes of cane delivered to the factory representing 5.44 TCH. Table 20 shows results on challenges smallholder farmers experienced during gleaning. The top three challenges included paying gleaners at own cost (23.5% of respondents), gleaning speed not matching grabber's' collection and loading speed (18.9% of respondents) and labour-intensive nature of gleaning (16.7% of respondents).

**Table 20**

*Challenges Smallholder Farmers Experience During Gleaning (n=132)*

| Gleaning challenges | Frequency | Percentage |
|---|---|---|
| Gleaning speed could not match grabber's collection and loading speed | 25 | 18.9 |
| Graber operator not willing to load gleaned cane | 12 | 9.0 |
| Graber operator demanding payment to load gleaned cane | 11 | 8.3 |
| Injury and accidents | 2 | 1.5 |
| Labour intensive | 22 | 16.7 |
| Paying gleaners at own cost | 31 | 23.5 |
| Not applicable | 15 | 11.4 |
| Destruction of cane by grabbers | 7 | 5.3 |
| Agent does not glean in order to sell to others who book by paying | 1 | 0.8 |
| Rains making cane stick in the mud | 2 | 1.5 |
| Cane covered with trash | 1 | 0.8 |
| No challenge | 2 | 1.5 |
| Not all gleaned cane is picked | 1 | 0.8 |
| Total | 132 | 100 |

In respect to this objective, some other stakeholders responsible for facilitating easy gleaning process were equally engaged. These actors cited certain challenges they faced that compromised expected standards and in turn affected effectiveness of gleaning as an infield practice in reducing PHSL. They stated that gleaning was hampered right from harvesting all through to the point of loading.

Sugarcane cutters stated that they faced challenges such as poorly maintained cane plots by farmers due to lack of weeding. This made sugarcane scattered thus hindered collection and formation of standard stacks. Some plots were stony interfering with harvesting height. Some cutter got injuries from thorns while others suffered bee stings and snake bites endangering their lives. 71.4% of cutters agreed that they negotiated with farmers for payment to harvest poorly maintained cane plots and also transfer cane from wet areas to safe areas for loading.

Harvesting contractors cited similar challenges since they supervised cutters to ensure that sugarcane cutting and stacking standards were met.

Grabber operators were responsible for loading harvested and gleaned sugarcane within expected limit. They equally cited challenges they faced such as rains that made movement in muddy plots and cane collection difficult. The end result is scattered cane that equally arose from poor stacks and sugarcane left in windrows. Muddy plots made them run grabbers on harvested sugarcane to obtain grips at the wheels. This made gleaning cumbersome as was stated by the farmers. Transport contractors and their field assistants supervised loading to ensure harvested and gleaned cane are loaded within limit and transported within expected time. They cited challenges they faced as insufficient fleet availability, inadequate mobility for field inspection, rains during loading making cane collection by grabber and movement of tractors difficult. They also sought shelter unaware of ongoing loading operations. Thus, some gleaned cane remained uncollected.

The study also established that harvesting and transport supervisors supervised their respective operations to ensure harvesting and transport standards were met. They cited challenges they faced such as lack of mobility to check supervise harvesting and loading standards, heavy rains affecting loading and timely transport, poor terrains making cane grabbers scatter cane during loading and few cane haulage units that may lead to overloading. However, they indicated that they did not negotiate with farmers to pay for their work.

In respect to farmer's complaints on compromised harvesting and transport standards, results in Table 21 reveal that 73.1% of other stakeholders were disciplined for non-compliant to the set standards on the roles they play. The study established that the disciplinary actions were varied based on gravity of the mistake. 40.3% of other stake holders who were non-compliant on their roles were disciplined by way of show cause, 23.8% verbal warning and 6.0% surcharge. 3.0% were disciplined by other means such as suspension. However, they stated that they could avoid poor workmanship if farmers or their agents properly maintained their cane plots and were available during harvesting and transport. In their opinion, cane plot maintenance through weeding would have facilitated easy harvesting and proper stacking. They mentioned that farmers needed to monitor harvesting standards and raise complaints to the harvesting contractor on site. Besides, they stated that farmers should have continued to glean during loading and the Company should have engaged gleaners to assist where possible.

**Table 21**

*Disciplinary Action for Non-compliance to Set Standards (n=67)*

| Level of disciplinary action | Frequency | Percentage | Nature of Disciplinary action | Frequency | Percentage |
|---|---|---|---|---|---|
| Never | 18 | 26.9 | None | 18 | 26.9 |
| Rarely | 40 | 59.7 | Verbal warming | 16 | 23.8 |
| Occasionally | 7 | 10.4 | Sow cause | 27 | 40.3 |
| Very often | 2 | 3.0 | Surcharge | 4 | 6.0 |
| | | | Others | 2 | 3.0 |
| Total | 67 | 100 | | 67 | 100 |

The study found out that smallholder farmers believed that effectiveness of proper gleaning in reducing PHSL can still be improved. They suggested a raft of measures on this issue. Such measures include cutters to harvest according to expected standards and form standard stacks to minimize scattering of cane during loading, can to be transported during the day, transporters to give farmers ample time to glean during loading, company to engage bell turn boys to help in gleaning, re-turn transport for gleaned as in the case in nucleus estate, grabber operators to be trained, keen on cane collection and load gleaned cane without asking for any bribes, prompt payment to enable them engage gleaners on credit, synchronizing harvesting with favourable weather to evade cumbersome work during rainy season and use of manual loaders. They further suggested that disciplinary actions be taken to other stakeholders who are reported to have contravened set standards.

The results are similar with the report of Food and Agriculture Organization (FAO) (2019), that efforts to reduce post-harvest food loss and waste involve costs that actors will only be willing to bear as long as the benefits in return outweighs such costs. Thus, processors and farmers devote more time and money to reduce PHL on food products that fetch higher prices as opposed to those that fetch lower prices. Stakeholders may not take up full rational decision to reduce food loss in the event that they lack information on how much food they lose (FAO, 2019). According to finding by Stevenson (2022), gleaning reduces much more post-harvest loss besides food wastage and environmental pollution. The study found out that gleaning made farming financially viable as the farmer collected whatever was left in the field for sale. Picking whatever is left in the field made good use of it than being ploughed back into the field.

These results are consistent with the study by Lott et al. (2020) on gleaner-farmer relationships in Vermont, a state in North-eastern United States. The study equally found out that farmers participated in gleaning because they did not like to see their products, they put their time and money into go into waste. They wished to sell everything they grew. The study further revealed that gleaning programmes in Vermont exist to address challenges of food loss on farms and to alleviate widespread food insecurity. Gleaners in this context were in different categories such as paid full-time staff of Vermont non-profits dedicated to food security and/or sustainable farming and volunteers. Gleaners observed that farmers were motivated to allow them glean their farms due to the desire to improve community food security and reduce on-farm food loss.

The results also go along with study findings of Harvey et al. (2022) in Greater Kansas City metro region, United States of America. They studied farmer attitudes and perceptions toward gleaning programs and the donation of excess produce to food rescue organizations. Their study findings revealed that farmers donated their farms to volunteer gleaners with the primary objectives of reducing waste, putting unharvested produce to good use and for tax incentives offered to farmers for food donation. Their decision to participate in gleaning was informed by word of mouth from other participating farmers and information through direct mailers from volunteer gleaners. They further found out that farmers believed that without the gleaning programme, much produce would have been left in the field. On the flipside, farmers who did not participate in gleaning stated that they were extremely busy coupled with short window of time to glean specialty crops with few gleaners showing up.

Similar findings were obtained by SISTR (2019). The study observed that capacity building on sugarcane harvesting, improving infrastructure (road network and harvesting equipment), modifying transport units, synchronizing milling requirements with cane harvesting and eliminating unethical practices in harvesting and transport greatly reduce PHSL. Moodley (2010) avers that training is an essential component to enhance loading operations. Harvesting method, creation of windrows or cane stacks prior to the loading as well as topography had a marked impact on loading. Duncan (2021) equally stated that transportation should be carefully planned and coordinated to avoid the wastage of harvested sugarcane.

## 4.7 Effectiveness of Trailer Loading Limit in Reducing Post-Harvest Sugarcane Loss

The fourth and last but not least objective was to determine the effectiveness of trailer loading limit in reducing PHSL. In this study, effectiveness refers to the capability of trailer loading limit in reducing PHSL to less than one percent (1.0%) of total cane delivered from a farmer's plot to the factory. To achieve this objective, effectiveness of trailer loading limit 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 level. 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 trailer loading limit is effective in reducing PHSL while above 1.0% means it is not effective. Besides, Spearman's correlation was used to measure the strength of the relationship between trailer loading limit and PHSL.

The study found out that other stakeholders are key players in the loading exercise such as grabber operators, tractor drivers, winch operators, transport supervisors, transporters and their field assistants. Grabber operator loads both harvested and gleaned sugarcane within the expected limit. According to Sony Sugar (2017), the recommended limit is 2 standard stacks or between 6 to 12 tonnes per single bucket trailer and 3 standard stacks or between 12 to 18 tonnes per double bucket trailer. Tractor drivers work within this provision and transport harvested green and burnt sugarcane within the expected time. Winch operator tows tractors into difficult plots for loading and out with loaded sugarcane. At times, they stated that they tow cane grabbers when stuck in wet plots. Transport supervisors and field assistants as well as transporters supervise these grabber and winch operators and tractors to ensure they adhere to set transport standards.

Results in Table 22 indicate that most (62.1%) of smallholder farmers had their harvested sugarcane transported by both single and double bucket trailers. The least number (7.6%) of smallholders had theirs transported by double bucket trailers. Documented records in Sony Sugar's AMS were reviewed in line with this objective. The study established in the results in Table 20 that a single bucket trailer carried the lowest average load of 9.07 tonnes of cane per trip to the factory while a double bucket trailer carried the highest of 14.42 tonnes per trip. Double bucket trailers contributed to the highest average percentage PHSL of 9.7% of total tonnes of cane delivered to the mill.

**Table 22**

*Average Trailer Load and Percentage PHSL (n=132)*

| Trailer type | Frequency | Percentage | Average load in tonnes | Average % Infield PHSL |
|---|---|---|---|---|
| Single bucket trailers | 40 | 30.3 | 9.07 | 8.5 |
| Double bucket trailers | 10 | 7.6 | 14.42 | 9.7 |
| Both single and double bucket trailers | 82 | 62.1 | 9.96 | 6.9 |
| Total | 132 | 100 | 33.44 | 25.1 |

Results in Table 23 indicate that most (78.0%) of smallholder farmers observed that most trailers did not spill sugarcane as they left their farms to the road. This was attributed to proper loading as stated by 95.1% of 103 smallholder farmers who did not experience spillage from tractors. They further mentioned that the cane was properly tied, loaders were keen and grabber operators pressed loaded cane on tractors. However, 22% of respondents observed that most trailers spilled sugarcane as they left their farms to the road. They attributed this to three top most factors such as improper loading (89.7%), bad weather that made tractor movement within the plot difficult (6.9%) and poor terrains of farm plots that made tractors shake (3.4%).

**Table 23**

*Smallholders' Observation on Loaded Trailers Leaving Cane Farms (n=132)*

| Observation | Frequency | Percentage |
|---|---|---|
| Most trailers did not spill sugarcane as they left the farm | 103 | 78.0 |
| Most trailers spilled sugarcane as they left the farm | 29 | 22.0 |
| Total | 132 | 100 |

Considering effectiveness of trailer loading limit, the results in Table 24 indicate that 69.7% of smallholder farmers ranked it as effective in reducing PHSL whereas 5.3% ranked it as never effective. Precisely, majority (94.7%) of smallholder farmers stated that trailer loading limit was effective in reducing PHSL between 2018 and 2021. Majority ranked it as effective (69.7%). The trailer average load for single bucket trailer (9.07 tonnes) and double bucket trailer (14.42 tonnes) confirmed this ranking since the set standards were between 6 to 12 tonnes for single bucket trailer and 12 to 18 tonnes for double bucket trailer. 87.1% of other stakeholders also ranked their roles on effectiveness of trailer loading limit to be effective in reducing PHSL. Majority of these other stakeholders ranked their roles as slightly effective and very effective (29.0% each).

**Table 24**

*Respondents' Ranking of Effectiveness of Trailer Loading Limit in Reducing PHSL*

| | By smallholder farmers (n=132) | | By other stakeholders in the transport operation (n=31) | |
|---|---|---|---|---|
| **Respondent's ranking** | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| Excellently effective | 1 | 0.8 | 4 | 12.9 |
| Very effective | 7 | 5.3 | 5 | 16.2 |
| Effective | 92 | 69.7 | 9 | 29.0 |
| Slightly effective | 25 | 18.9 | 9 | 29.0 |
| Not effective | 7 | 5.3 | 4 | 12.9 |
| Total | 132 | 100 | 31 | 100 |

Small holder farmers suggested that effectiveness of loading limit can be improved to minimize PHSL in form of infield spillage. Such suggestions included re-introduction of side loaders, use of mobile weighbridge to weigh cane at the farm, company to give enough cane hauling units based on harvested cane and avoid late night transport, bell operators to be trained to load according to expected standards and use of closed bucket trailers.

This study found out that certain actions by other stakeholders responsible for loading harvested sugarcane compromised set loading standards. These lead to overloading resulting in substantive PHSL in form of infield spillage experienced by certain farmers. Grabber operators for example colluded with tractor drivers to load more cane in order to earn more. This was because majority (83.3%) of tractor drivers were paid based on tonnes of cane delivered to the factory. Transport supervisors, transport field assistants and transporters cited the challenge of few cane haulage units. Transporters also demanded higher delivery per trip leading to overloading. As a result, 74.2% of these levels of field staff have been disciplined for flouting set standards with majority (78.3%) getting show cause. They however, suggested that effectiveness of loading limit in reducing PHSL may be maintained and/or improved by addition of haulage units and strict supervision of grabber operators and tractor drivers to adhere to set standards.

Further, the Spearman's test results in Table 200 reveal that the relationship between trailer loading limit and post-harvest sugarcane loss was positive. The relation between the two variables was statistically significant, $r$ (130) = .129, $p$ > .05.

**Table 25**

*Relationship Between Trailer Loading Limit and PHSL*

| Scale | | Post-harvest sugarcane loss |
|---|---|---|
| Trailer loading limit | Correlation coefficient | .129 |
| | P-value | .139 |
| | N | 132 |

The result revealed a negligible positive relationship as correlation coefficient was closer to zero. The positive correlation meant that PHSL would be effectively reduced if more trailers were loaded within the expected limit.

The results are consistent with findings of Zhao et al. (2019) who reported similar outcomes. The study found out that in China where a fully loaded single bucket trailer carried about seven (7) tonnes of cane to the mills. This was in view to effectively reduce PHSL in form of spillage. Similar study by SRI (2017) agrees with this finding in that it observed that sugarcane spillage during loading and transport was reduced by increasing transport fleet to avoid late night operations and use of closed bucket trailers. The study further agrees in its findings in Narok County for example, that Transmara Sugar Company use side loaders that ensure recommended loading technique. Moreover, the findings are consistent with this study on the fact that millers need to train loaders on recommended loading techniques. Moodley (2010) equally observed that topography has an impact on loading.

Results of this study are equally consistent with the study by Duncan (2021) on transportation: the un-slayed dragon in sugarcane farming in Western Kenya. The study found out that sugarcane transportation was dominated by tractors, tracks, trailers and grabbers. The study also found out that Mumias and Nzoia sugar companies sub-contracted independent transporters to transport farmers' harvested sugarcane. The harvested sugarcane was carelessly packed and overloaded into tracks by grabbers causing maximum spillage. However, Western Kenya and Butali sugar companies were quickly gaining popularity in Western region since they loaded harvested sugarcane manually on tracks, stacked and carefully tied loaded sugarcane. This minimized spillage and reduced PHSL and farmers got the worth of their efforts. The study further noted that efficient transport was necessary to avoid sugarcane wastage through spillages.

A study by Moodley (2010) on a review of whole-stick sugarcane transfer systems in South Africa also found out that single bucket trailers and double bucket trailers are configured to transport 12 and 25 tonnes of cane respectively. The study further revealed that double trailer-tractors were appropriate when operating infield where significant tonnages need to be transported. The study also found out that training was an essential component to enhance loading operations. This was so as efficient loading required cane to be placed in neat bundles or windrows.

Results of this study concurs with Masakhwe et al. (2017) that found out that tractors are the main form of sugarcane transport in Kenya. The study in Western Kenya also revealed that some tractors were overloaded during transport hence spilled cane in the field and on transit. Besides, some sugarcane transporters were reckless. Cane spillage as an element of PHSL negatively impact on smallholder farmers' income since most of them do not possess tractors and depend on the companies for transport.

Infield transport involved mostly the use of trailers pulled by tractors as they have the ability to move in over more than 80% of the infield roads with reasonable speed. Many sugar estates throughout the world mainly used agricultural tractor with trailers of various forms to haul cane infield. The harvested cane could be loaded onto the tractor-trailers manually by hand loaders or mechanically by grab loaders. Study found out that several tractor-trailers with an average load limit of 7 tonnes per trip were used to haul cane. In case, overloaded in-field or on transit spillage would occur. That not only affected farmers' income but also posed hazard to other road traffic in case of transit spillage. In regard, often uncomplimentary comments were frequently levelled at such sugar factories (Elkaoud & Ahmed, 2017).

Findings of this study are similar to Bhatt et al. (2021) findings in India that smallholder farmers lack the capacity to buy tractors hence depend on company transport. The study found out that tractor trolley transports more than two-thirds of sugarcane produced in the estates to the mill. In Uttarakhand state for example, big and small trailer trolleys carry between 80 and 90 quintals and 40 quintals respectively per a trip. This translates to between 8 and 9 tonnes and 4 tonnes of sugarcane per trip for big and small tractor trolley. The results of this study are also in line with the policy by MoALD-SDCD (2023) which stipulated that sugarcane transport equipment and carriers should be designed to maximize payload and minimize cane spillage.

The study concurs with Moodley (2010) on a review of whole-stick sugarcane transfer systems. An effective system consists of successful loading that reduced losses of cane. This was achieved by considering sugarcane length, density and diameter as well as field conditions. Results revealed that sugarcane was prepared for loading by either being windrowed or bundled. Loading operation by grab-loader was more effective for bundled cane as it resulted in less spillage. Larger bundles were loaded first then smaller ones added to attain payload capacity. Training of loader operator resulted in a more efficient operation in cane handling. Training sensitizes the operator to estimate cane bulk density hence loaded more accurately.

# CHAPTER FIVE
# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter gives a summary, conclusions and recommendations of the study as well as suggestions for further research. Conclusions and recommendations made were based on the findings for possible intervention by various stakeholders in sugarcane industry.

## 5.2 Summary of the Study Findings

The study sought to examine effectiveness of selected quasi-public extension services and infield practices in reducing post-harvest sugarcane loss experienced by smallholder farmers in Awendo Sub-County, Kenya. This was achieved by collecting data on the selected quasi-public extension services and field practices instituted by South Nyanza Sugar Company limited and ranking them in terms of their effectiveness in reducing post-harvest sugarcane loss.

Analysis of the data obtained on the four objectives of the study revealed that:

i. Training of smallholder farmers on sugarcane gleaning in reducing PHSL was ranked by farmers as ≤ 42.4% effective on a 5-point Likert scale. This was evident on farmers who were trained and never participated in the gleaning while their counterparts who gleaned ranked it at ≤ 100% effective. Farmers who were trained and gleaned experienced PHSL of less than the set target of one percent (1.0%) of total tonnes of sugarcane delivered to Sony Sugar factory. Post-harvest sugarcane loss had positive relationships with training farmers on sugarcane gleaning ($r$ (130) = .142, $p > .05$.).

ii. Farmer's sensitization on supervision of cane loading in reducing PHSL was ranked by farmers as ≤ 75.0% effective on a 5-point Likert scale. However, it was ≤ 100% effective to farmers who were sensitised and supervised loading. They lost less than the set target of one percent (1.0%) of total tonnes of sugarcane delivered to Sony Sugar factory. Sensitisation of farmers on supervision of cane loading had statistically insignificant relationship, r (130) = -.027, $p > .05$. with post-harvest sugarcane loss.

iii. Sugarcane gleaning during loading in reducing PHSL was ranked by farmers as ≤ 84.1% effective on a 5-point Likert scale. Most of these farmers applied their self-initiative to glean since they would not wish their cane to remain infield and go into waste. Others went an extra mile to hire gleaners and even induce grabber operators to load their gleaned cane. Post-harvest sugarcane loss had positive relationships with sugarcane gleaning during loading ($r$ (130) = .199, $p$ < .05.).

iv. Trailer loading limit in reducing PHSL was ranked by farmers as ≤ 94.7% effective on a 5-point Likert scale. Trailers loaded within their expected set standards of between 6 to 12 tonnes for single bucket trailer and 12 to 18 tonnes for double bucket trailer. Trailer loading limit had statistically significant relationship, r (130) = -.027, $p$ > .05. with post-harvest sugarcane loss.

## 5.3 Conclusions

Based on the results of this study, the following conclusions were made:

i. Training farmers on sugarcane gleaning as a selected quasi-public extension service did not effectively reduce post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County if farmers do not implement the training.

ii. Sensitisation of farmers on supervision of sugarcane loading as a selected quasi-public extension service effectively reduced post-harvest sugarcane loss among smallholder farmers in Awendo Sub-County.

iii. Sugarcane gleaning during loading as a selected field practice was highly effective in reducing PHSL experienced by smallholder farmers.

iv. Trailer loading limit as a selected field practice was very high effective and substantially reduced post-harvest sugarcane loss experienced by smallholder farmers in Awendo Sub-County.

## 5.4 Recommendations of the Study

Based on the findings of this study, the following recommendations were made:

i. South Nyanza Sugar Company should enhance its quasi-public extension service of training farmers on sugarcane gleaning. Farmers should be available for the training to enable them acquire necessary skills to reduce post-harvest sugarcane loss.

ii. South Nyanza Sugar Company should foster its quasi-public extension service strength in sensitising farmers to supervise cane loading in order to prevent cases of sugarcane spillage. Further, smallholder farmers should be notified on scheduled transport of harvested sugarcane in prior via mobile short messages (SMS) for them to be available.

iii. Farmers or their agents should be present during loading and glean the sugarcane being scattered by grabbers despite the myriad challenges as benefits outweigh the challenges. Where possible, gleaners can be outsourced and engaged on a mutual agreement.

Grabber operators and tractor drivers should give farmers ample time to glean scattered cane for loading. Besides, return transport may be organized for gleaned cane hence effectively reducing post-harvest sugarcane loss to desired limit.

iv. Sony Sugar Company through her field staff should ensure trailer load limit is maintained. Grabber operators should load the tractors while pressing the cane up to the last rim level of the bucket then secure the cane with wire ropes to minimize post-harvest sugarcane loss.

## 5.5 Recommendations for Further Research

Based on the findings of this study and building on existing research, it is hereby recommended that further research be undertaken in the following areas:

i. Effectiveness of selected quasi-public extension services and field practices in reducing post-harvest sugarcane loss experienced by smallholder farmers in other sub-counties where Sony Sugar Company draws its contracted sugarcane.

ii. Compensation policies and procedures put in place by South Nyanza Sugar Company to shield farmers from her cane catchment sub-counties from post-harvest sugarcane loss occasioned by negligence of harvesting and transport staff.

iii. Effectiveness of South Nyanza Sugar Company's set standards in reducing post-harvest loss on transit experienced by contracted smallholder farmers.

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## APPENDICES

### Appendix A: Questionnaire for Farming Household

**Dear respondent,**

My name is Collince Otieno Sagege, a student at Egerton University pursuing a Master of Science in Agricultural Extension in the Department of Agricultural Education and Extension, Faculty of Education and Community Studies. I am conducting research on Effectiveness of Quasi-Public Extension Services and Selected Infield Practices in Reducing Post-Harvest Sugarcane Loss (PHSL) among Smallholder Sugarcane Farmers in Awendo Sub-County, Kenya. You are among the selected farming households to participate in the study. The information you provide will be treated with highest confidentiality and used purely for academic purposes. I request you to kindly respond to the items of this questionnaire voluntarily, objectively and honestly. Your participation will be highly appreciated.

**Section A : Demographic Characteristics**

Please tick [ √ ] where applicable.

1. Total acreage of your farm: (*0.4 Ha. = 1 Acre*) ____________ Hectares (Ha.)
2. Area planted with sugarcane contracted with Sony Sugar Company between 2017 and 2020:_________Hectares (Ha.)
3. Source of land:
   Own land [ ]
   Leased land [ ]
   Gifted land [ ]
4. Location/ward where the contracted sugarcane was:
   Central Sakwa [ ] North-East Sakwa [ ] South Sakwa [ ] West Sakwa [ ]
5. Year when selected sugarcane was harvested: 2018 [ ] 2019 [ ] 2020 [ ] 2021 [ ]
6. Received tonnage after factory weighment: ________________ tonnes.
7. Expected tonnage from factory weighment: ________________ tonnes.
8. Indicate the person or group that harvested your sugarcane. _________________________
   ______________________________________________________________________
9. Indicate the person or group that loaded and transported your harvested sugarcane.
   ______________________________________________________________________
   ______________________________________________________________________

10. Indicate the main role you played during harvesting of sugarcane:

_______________________________________________

_______________________________________________

_______________________________________________

11. Main method of contact with your area Sony Sugar agricultural extension field supervisor.

Farm field visits [ ] Field days [ ]

Field demonstrations [ ] E-extension [ ]

Agricultural training centers [ ] Agricultural information desks [ ]

**Section B : Effectiveness of Selected Quasi-Public Extension Services and Infield Practices**

**in Reducing Post-Harvest Sugarcane Loss**

12. Level by which your area Sony Sugar agricultural extension field supervisor trains you on sugarcane gleaning (*collecting spilled harvested sugarcane during loading on tractors*).

Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

13. Please give a reason for your answer in number 12 above.

_______________________________________________

_______________________________________________

14. Level by which your area Sony Sugar agricultural extension field supervisor sensitizes you to supervise loading of your harvested sugarcane.

Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

15. Please give a reason for your answer in number 14 above.

_______________________________________________

_______________________________________________

16. You or your agent supervised loading of harvested sugarcane in your farm?

Yes [ ] No [ ]

17. If No in number 16 above, please give a reason: (*Indicate N/A if Yes in number 16 above*).

_______________________________________________

_______________________________________________

18. If Yes in number 16, list utmost two (2) things that would have happened if you or your agent did not supervise loading of harvested cane. (*Indicate N/A if No in number 16*).
    1. ____________________________________________
    ____________________________________________
    2. ____________________________________________
    ____________________________________________
19. Farmer's participation level on proper sugarcane gleaning (*collecting spilled cane*) during loading.
    Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]
20. Please give a reason for your answer in number 19 above.
    ____________________________________________
    ____________________________________________
21. Which main challenge did you face when gleaning sugarcane during loading?
    ____________________________________________
    ____________________________________________
22. Trailers used to load your harvested cane:
    Single bucket trailers [ ]
    Double bucket trailers [ ]
    Both single and double bucket trailers[ ]
23. Number of tractors that transported your harvested sugarcane to the factory ______________
24. Observation on loaded tractors leaving your sugarcane plot.
    Most tractors did not spill sugarcane as they left [ ]
    Most tractors spilled sugarcane as they left [ ]
25. Please give a reason for your answer in number 24 above.
    ____________________________________________
    ____________________________________________
26. Estimated tonnes of harvested sugarcane left spilled in the field after transport: ______ tonnes
27. Indicate what greatly contributed to the sugarcane left spilled in the field
    ____________________________________________
    ____________________________________________
    ____________________________________________

28. Give utmost two other suggestions that can help you reduce post-harvest sugarcane loss you experience.

1. ______________________________________________

   ______________________________________________

2. ______________________________________________

   ______________________________________________

29. Rank the effectiveness level of how each of the following selected quasi-public extension services and infield practices help you to reduce post-harvest sugarcane loss (*Please use the criteria provided and tick [ √ ] where applicable* )

| **Selected Quasi-public extension service and Infield practice** | **Farmer's ranking on effectiveness of Quasi-public extension service and Infield practice in reducing post-harvest sugarcane loss** | | | | |
|---|---|---|---|---|---|
| | Not effective | Slightly effective | Effective | Very effective | Excellently effective |
| Training you are given on sugarcane gleaning (*collecting spilled cane*). | | | | | |
| Sensitization you get on supervision of sugarcane loading. | | | | | |
| Your participation on proper sugarcane gleaning during loading. | | | | | |
| Trailer loading limit of your harvested sugarcane. | | | | | |

**Thank you for completing this questionnaire**

## Appendix B: Questionnaire for Other Stakeholders in Sugarcane Maintenance, Harvesting and Transport

**Dear respondent,**

My name is Collince Otieno Sagege, a student at Egerton University pursuing a Master of Science in Agricultural Extension in the Department of Agricultural Education and Extension, Faculty of Education and Community Studies. I am conducting research on Effectiveness of Quasi-public Extension Services and Selected Infield Practices in Reducing Post-Harvest Sugarcane Loss (PHSL) among Smallholder Sugarcane Farmers in Awendo Sub-County, Kenya. You are among the selected participants in the study. The information you provide will be treated with highest confidentiality and used purely for academic purposes. I request you to kindly respond to the items of this Questionnaire voluntarily, objectively and honestly. Your participation will be highly appreciated.

**Please tick [ √ ] where applicable.**

1. Indicate your designation at Sony Nyanza Sugar Company.
   (a) Agricultural Extension Field Supervisor [ ]
   (b) Harvesting and Transport Supervisor [ ]
   (c) Agricultural Extension Field Assistant [ ]
   (d) Harvesting Field Assistant [ ]
   (e) Transport Field Assistant [ ]
   (f) Harvesting Contractor [ ]
   (g) Transport Contractor [ ]
   (h) Cane Cutter [ ]
   (i) Tractor Driver [ ]
   (j) Graber/Bell Operator [ ]
2. Year of employment or signing contract:___________________

3. Location/Ward of operation:

   Central Sakwa [ ] North-East Sakwa [ ] South Sakwa [ ] West Sakwa [ ]

   More than One Ward [ ]

4. Indicate one main role you play as a commitment to South Nyanza Sugar Company to reduce post-harvest sugarcane loss experienced by farmers:

   (a) Cutting sugarcane within the recommended height [ ]

   (b) Stacking harvested sugarcane to required standard [ ]

   (c) Training farmers on sugarcane gleaning [ ]

   (d) Sensitizing farmers to supervise loading of harvested sugarcane [ ]

   (e) Loading gleaned (*collected spilled*) harvested sugarcane during loading [ ]

   (f) Loading harvested sugarcane within the expected limit [ ]

   (g) Transporting harvested green and burnt sugarcane within the expected time [ ]

5. Other than the main role indicated in number 4 above, state other roles you play to reduce post-harvest sugarcane loss experienced by Sony Sugar Company farmers. (*You may pick from the list in number 4 above or mention others not listed*).

   ______________________________________________________________

   ______________________________________________________________

   ______________________________________________________________

   ______________________________________________________________

6. Sony Sugar Company payment basis for the role you play.

   Salary [ ] Wage per tonne of sugarcane delivered to the factory [ ]

7. Level by which your immediate senior stakeholder in sugarcane maintenance, harvesting and transport trains you on the roles you play.

   Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

8. Level to which you negotiate with farmers to pay for the role you play.

   Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

9. Nature of farmers' payment for the role you play.

   None [ ]

   Negotiated Cash [ ]

   Negotiated Material [ ]

10. Farmers' complaint level about the role you play.

Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

11. Disciplinary action level by Sony Sugar Company about the role you play.

Never [ ] Rarely [ ] Occasionally [ ] Often [ ] Very Often [ ]

12. Main challenges faced as you play your roles above to reduce post-harvest sugarcane loss experienced by Sony Sugar Company farmer:

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

13. Rank the effectiveness level of your roles in reducing post-harvest sugarcane loss experienced by Sony Sugar Company farmers. (*Use the criteria provided*).

Not effective [ ]

Slightly effective [ ]

Effective [ ]

Very Effective [ ]

Excellently Effective [ ]

14. Suggest what farmers need to do to ensure standards set by Sony Sugar Company enable them to reduce post-harvest sugarcane loss.

_______________________________________________

_______________________________________________

_______________________________________________

15. Suggest what Sony Sugar Company needs to do to ensure set standards reduce post-harvest sugarcane loss experienced by its farmers.

_______________________________________________

_______________________________________________

16. Does post-harvest sugarcane loss experienced by farmers affect your income?

Yes [ ] No [ ]

17. Please give a reason for your answer in number 16 above _______________________

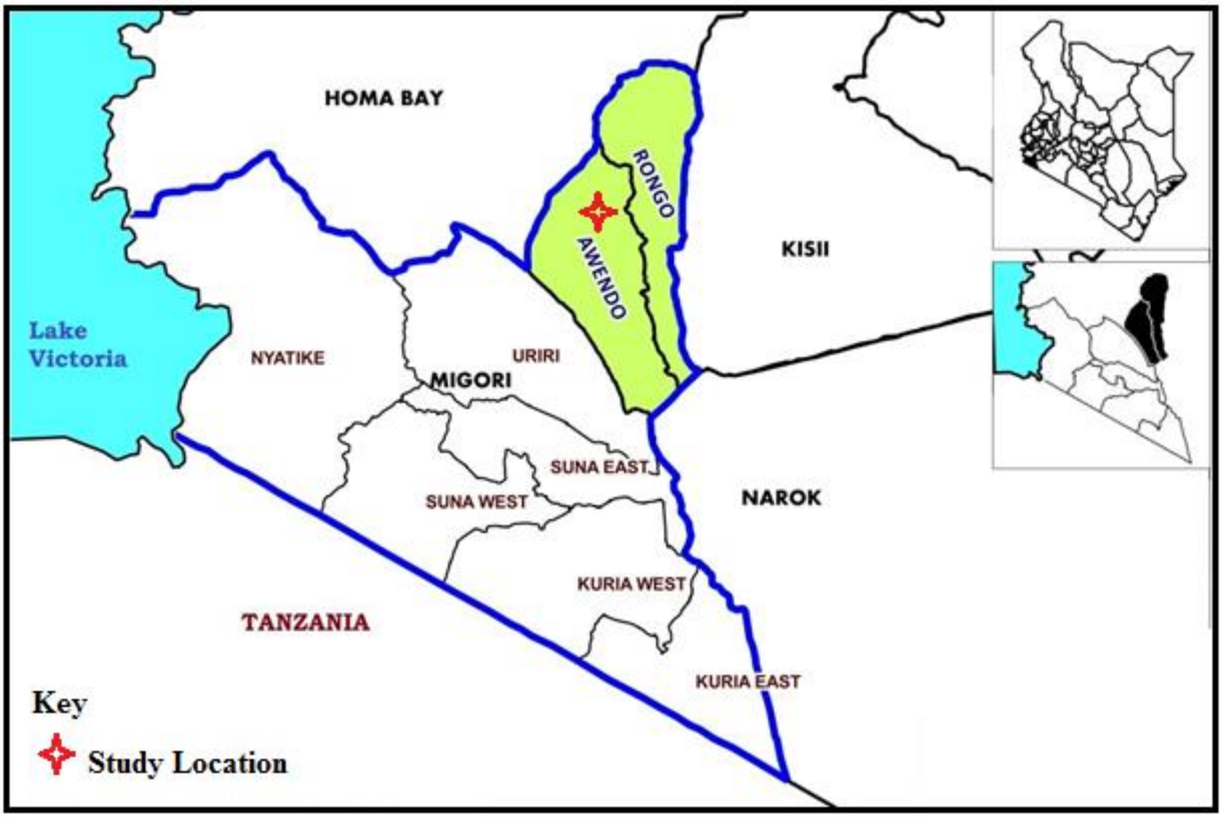
_______________________________________________

**Thank you for completing this questionnaire**

## Appendix C: Document Review Guide

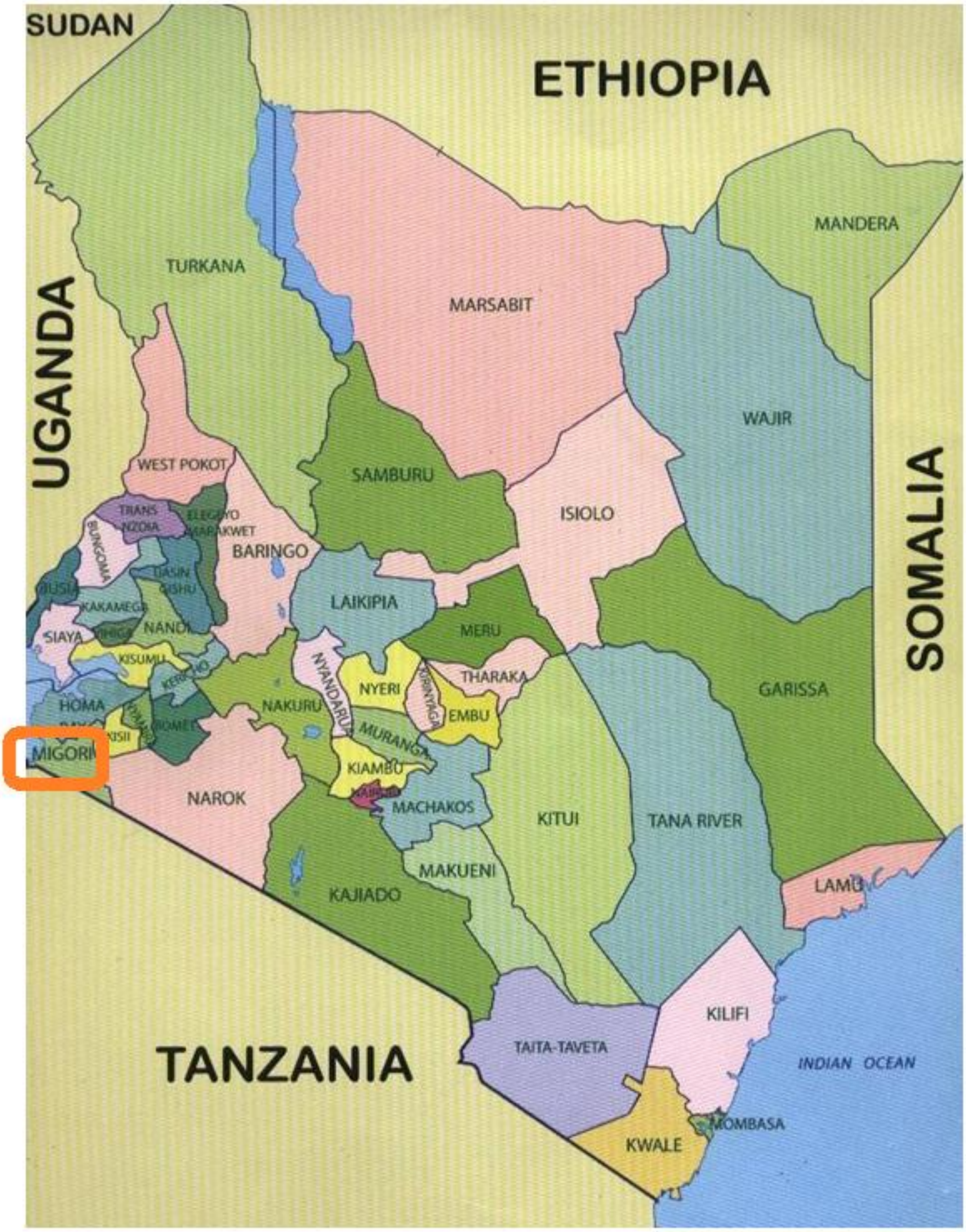
| S/No | Document | Information Looked For |
|---|---|---|
| 1. | Farmers' Perception on Improved Sugarcane Varieties in Western Kenya – SRI 2018 | - Quasi-public extension services |
| 2. | Impact Assessment of Outreach Activities on Uptake of Improved Sugar Cane Production Technologies in Kenya. | - Training of farmers on improved sugarcane production technologies. |
| 3. | Agriculture Management System (AMS) | - Target and accessible populations for smallholder farmers and other stakeholders.<br>- Farmer's tonnes of cane received after factory weighment.<br>- Number of tractors that transported each farmer's harvested cane between 2018 and 2021.<br>- Year each farmer's sugarcane was harvested and transported to the factory. |
| 4. | Sony Sugar Company's Research and Development Division Assessment Reports | - Sampled infield assessment reports both in the Nucleus estate and outgrowers. |
| 5. | Harvesting & Transport Division Quality Management System Procedures Manual | - Harvesting and transport objectives and standards. |
| 6. | Outgrowers Extension Services Division Quality Management System Documented Information – Issue 07, 2017. | - Quasi-public extension services offered to sugarcane farmers. |

## Appendix D: Map of Awendo Sub-County




Source: www.africairs.net/kenya

**Appendix E: Geographical Location of Migori County in Kenya**



## Appendix F: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 106777

Date of Issue: 28/October/2022

**RESEARCH LICENSE**

This is to Certify that Mr.. Collince Otieno Sagege of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev. 2014) in Migori on the topic: EXAMINING EFFECTIVENESS OF SELECTED QUASI-PUBLIC EXTENSION SERVICES AND INFIELD PRACTICES IN REDUCING POST-HARVEST SUGARCANE LOSS AMONG SMALLHOLDER FARMERS IN AWENDO SUB-COUNTY, KENYA for the period ending : 28/October/2023.

License No: NACOSTI/P/22/21353

106777

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

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See overleaf for condition

## Appendix G(i): Ethical Approval (page 1)

**EGERTON** **UNIVERSITY**

TEL: (051) 2217808
FAX: 051-2217942

P. O. BOX 536
EGERTON

**EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE**

**EU/RE/DVC/009**
*Approval No. EUISERC/APP/202/2022* — *12th October*, **2022**

Collince Otieno Sagege,
P.O.Box 308 – 40405
Sare.
Telephone: 0714591969
E-mail: sagegecollince@yahoo.co.uk

Dear Collince,

**RE: ETHICAL APPROVAL: EXAMINING EFFECTIVENESS OF SELECTED QUASI-PUBLIC EXTENSION SERVICES AND IN FIELD PRACTICES IN REDUCING POST-HARVEST SUGARCANE LOSS AMONG SMALLHOLDER FARMERS IN AWENDO SUB-COUNTY, KENYA**

This is to inform you that ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/202/2022.*** The approval period is ***12th October, 2022 –13th October, 2023.***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours.

*"Transforming Lives through Quality Education"*

## Appendix G(ii): Ethical Approval (page 2)

v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to ***Egerton University Institutional Scientific and Ethics Review Committee***.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely.

EGERTON UNIVERSITY
Date. 12/10/2022
RESEARCH ETHICS

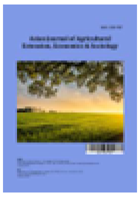
Prof. R. Ngure

**CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE**

*RMN/BK/*

*"Transforming Lives through Quality Education"*

# Appendix H: List of Publication



*Asian Journal of Agricultural Extension, Economics & Sociology*

*Volume 43, Issue 5, Page 24-37, 2025; Article no.AJAEES.134829*
*ISSN: 2320-7027*

# Effectiveness of Training Farmers on Sugarcane Gleaning during Loading in Reducing Post-Harvest Loss among Smallholder Farmers in Awendo Sub-County, Kenya

**Collince Otieno Sagege [a*], Stephen Wambugu Maina [a] and Gilbert O. Obwoyere [b++]**

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*[b] Department of Natural Resources, Egerton University, P.O Box 536 – 20115, Egerton, Njoro, Kenya.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

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***Original Research Article***

***Received: 25/02/2025***
***Accepted: 26/04/2025***
***Published: 28/04/2025***

## 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.

*++Prof. and Dr.rer.nat;*
**Corresponding author: E-mail: sagegecollince@yahoo.co.uk;*

***Cite as:*** *Sagege, Collince Otieno, Stephen Wambugu Maina, and Gilbert O. Obwoyere. 2025. "Effectiveness of Training Farmers on Sugarcane Gleaning During Loading in Reducing Post-Harvest Loss Among Smallholder Farmers in Awendo Sub-County, Kenya". Asian Journal of Agricultural Extension, Economics & Sociology 43 (5):24-37. https://doi.org/10.9734/ajaees/2025/v43i52735.*