ANALYSIS OF MARKETING CHANNELS, INPUTS AND FARMER CHARACTERISTICS ON TECHNICAL EFFICIENCY OF ORANGE FLESHED SWEET POTATO PRODUCTION IN MIGORI COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for an award in diploma or conferment of a degree in this or any other University.

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Recommendation

This thesis has been examined, passed and submitted with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my beloved parents, Mr Moses Jabuya Nyamuche and Mrs Hellen Odeny Jabuya; my lovely sister, Jackline Achieng' Jabuya, among other siblings; my colleagues and friends.

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ABSTRACT

Sweet potato (*Ipomea batatas* L.), particularly the orange fleshed, has gained prominence due to its ability to adapt to wide production ecologies and yield response to minimal inputs. Orange fleshed sweet potatoes (OFSPs) can produce up to 50 tonnes per hectare, improving household income and nutrition in Kenya. However, production in Kenya remains low, with smallholder OFSP farmers producing an average yield of 14 tonnes per hectare. The influence of inputs, farmer characteristics and marketing channel factors on OFSP production by smallholder farmers in Western Kenya has not been fully studied. This research was carried out to assess the technical efficiency of orange fleshed sweet potato smallholder farmers through analysis of inputs, farmer characteristics and marketing channels in Suna East and Kuria West Sub-Counties of Migori County. A descriptive study design was adopted and a cluster random sampling technique was used to select 225 respondents from approximately 6500 OFSP farmers. A semi-structured questionnaire was used to collect primary data on input factors, smallholder farmers' credit access and marketing channel variables. The key informants of the study were OFSP farmers with the assistance of the County government officials from Migori County. The data was entered into SPSS 28 software and analyzed using Stata 15 software. The Multivariate probit model was used to analyze the factors affecting the choices of smallholder OFSP farmers' marketing channels. The results showed that the distance to markets, grading, farmer age, education levels, storage capacity, market assurance, extension visits, group membership and cost of packaging materials influence the smallholder farmers' marketing channel choice decision. The stochastic frontier model was used to analyze the effect of inputs, farmer characteristics, and marketing channels on technical efficiency. The land set aside for OFSP production, planting vines, fertilizer, manure and family labour were the major inputs in the efficiency of OFSP production, according to the model parameters computed using the maximum likelihood method. The technical efficiency of OFSP production among smallholder farmers varied, with the least efficient producing at 36.98 % and the most efficient producing at 99.93 %. Smallholder farmers estimated mean technical efficiency was 78.07%, indicating a need to improve OFSP production by 21.93%. The technical efficiency of smallholder OFSP production was highly influenced by the inefficiency variables like years of farming experience, gender, extension visits, market distance, size of the household, and access to training. Smallholder OFSP farmers produced 8.453 tonnes per hectare with available farm inputs. Farmers can significantly increase the existing level of OFSP technical efficiency of production in the region by concentrating on better use land, use of clean planting materials and hiring labour. Smallholder farmers should be advised to seek services from extension agents and attend training frequently to reduce production inefficiencies. In addition, interventions are required to strengthen the marketing and production capacities of smallholder OFSP farmers.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASDSP	Agriculture Sector Development Support Programme
CV	Coefficient of variation
DEA	Data envelopment analysis
FAOSTAT	Food and Agriculture Organization Statistics database
KNBS	Kenya national bureau of statistics
MLE	Maximum likelihood estimation
NARIG	National agriculture and rural inclusive growth project
OFSP	Orange fleshed sweet potato
OLS	Ordinary least square
SDG	Sustainable development goals
SFM	Stochastic Frontier model
TE	Technical efficiency
WFSP	White fleshed sweet potato

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

After rice, maize, wheat, cassava, and Irish potato, sweet potato is the sixth most important food crop in the world (Krochmal *et al.,* 2020). Sweet potato requires fewer resources and effort than other food crops, such as maize and can tolerate adverse growing conditions (Gitore *et al.,*2021). Since it is mainly farmed by most resource-constrained groups in communities, especially women-headed families, sweet potatoes are praised as a "poor man's" crop (Mwangi *et al.,* 2020a).

The global production of sweet potatoes stands at 88.74 million metric tonnes on about 7.4 million hectares of land, with an average estimated yield of 12.04 tonnes per hectare (FAOSTAT, 2020). The statistics also show that Asia is the leading sweet potato producer, constituting 55.78 metric tonnes of global production. With a total average output of 49.04 tonnes and a yield of 21.81 tonnes per hectare, China dominates the global sweet potato production. Africa is the world's second-largest producer of sweet potatoes after Asia, producing 28.63 metric tonnes (FAOSTAT, 2020). Kenya specifically accounts for about 0.686 million metric tonnes, a significant amount of sweet potatoes produced worldwide (FAOSTAT, 2020).

There exist various varieties of sweet potatoes depending on flesh and skin colour. The colours of the skin and flesh vary from white to yellow to orange to deep purple (Githunguri and Njiru, 2021). In rain-fed environments, OFSP have short growth seasons and large yields. In terms of nutritional content and profitability, OFSPs are the most valued of all root crops (Malavi *et al.,* 2018). Orange fleshed sweet potatoes, like other root crops, have the potential to provide food security, nutrition and cash income to households in Kenya (Ondiek *et al.,* 2020). It may be transformed into food items, including primary, intermediate and secondary products. It is often consumed in its raw, unprocessed state, such as steamed, boiled, grilled, or processed (Malavi *et al.,* 2021).

Orange fleshed sweet potato has Beta-carotene content, a component of Vitamin A, which is essential for human health (Malavi *et al.,* 2021; Ojwang *et al.,* 2021). The OFSPs are high in non-digestible dietary fibre, which prevents colon cancer. It also

contains essential and particular minerals, vitamins, and antioxidants (Ojwang *et al.*, 2021). The high antioxidant contents in OFSP prevent the body from inflammatory conditions such as asthma and arthritis. Owade *et al.* (2018) and Dinu *et al.* (2021) found that OFSP helps control blood sugar levels, prevent disorders like insulin resistance and is a good source of carbohydrates. It is also beneficial to expectant women attempting to conceive since it is high in folate, which is necessary for the healthy development of every cell and tissue (Dinu *et al.*,2021).

Smallholder farmers have the capacity and potential to produce up to 50 tonnes of OFSP per hectare, although they produce only 13.96 tonnes per hectare on average (Owade *et al.*, 2018; Korir *et al.*, 2020). This wide gap between actual and potential output levels is attributed to production, human effects and marketing, among other factors. According to Makini *et al.* (2018), technical efficiency is an essential aspect of productivity increase in farming systems, frequently characterized by inadequate resources and a low possibility of developing and implementing enhanced innovation. Okello (2019) and Munene (2020) reiterated that resources should be utilized more efficiently for farmers to be productive, with an emphasis on maximizing profits and attaining production targets without wasting any. The significance of increasing technical efficiency, particularly as a possible complement, is to enhance OFSP output and resource management.

Inputs and routine management operations such as planting, weeding, pest and disease management, and harvesting are essential in OFSP production that demand farmers' attention. Farmers will likely be deterred from growing OFSP in future seasons if these efforts do not generate comparable returns (Gitore *et al.*, 2021). As a result, their production levels are greatly affected, hence low technical efficiency. Given the current production level, it is critical to understand how efficiently OFSP farmers combine inputs, including OFSP clean recommended planting materials, labour, land and agrochemicals, to maximize outputs and earnings. According to Okello (2019) and Tiruneh *et al.* (2017), farmers apply their best input efforts, although they do not always succeed, which is attributed to smallholder farmers not utilizing these inputs more efficiently.

Farmer characteristics greatly impact the size and scope of production enterprise; credit markets influence farmers' success in producing OFSP (Ndegwa *et al.,* 2020). Credit limitation affects production, which means credit-constrained farms have low productivity. Micro and small farms have more access to microcredit, whereas medium and large ones have more access to bank credit (Okeyo *et al.*, 2020). In Kenya, there is minimal evidence of the influence of farmer characteristics on OFSP technical efficiency. The variables considered in this case were smallholder farmer's age, education level, experience in farming, gender, land tenure and group membership.

Choices of marketing channels for OFSP smallholder farmers who rely on local and regional markets range from direct, intermediaries and dual selling within Migori County (Malavi *et al.,* 2018). Smallholder farmers lack a basic understanding of how to finance and market their produce through a better choice of marketing channels (Okello, 2019). The available marketing channels are characterized by intermediaries who disadvantage farmers regarding prices and other benefits (Okello *et al.,* 2018b). Intermediaries take advantage of farmers by buying their crops at a low price since they harvest in bulky quantities, which might affect their level of production (Malavi *et al.,* 2018; Okello *et al.*, 2018a; Okello, 2019). The variables studied in this study included distance to the market, market information, market assurance, training, mode of transportation, group membership, and extension services that affect the choice of marketing channels.

There is limited documentation on the areas and aspects needed to improve OFSP output more technically and efficiently. The effects of input variables, farmer characteristics, and marketing channel choice on the technical efficiency of OFSP production in Migori County, Kenya, need to be examined and documented. The technical inefficiency of OFSP production in Suna East and Kuria West Sub-Counties of Migori County is determined by measuring the level and effects of input factors on technical efficiency among the OFSP smallholder farmers, analyzing the effects of farmer characteristics on the technical inefficiency of OFSP production, and determining how the available choices of marketing channels contribute to the technical inefficiency level of OFSP production.

1.2 Statement of the Problem

Even though the potential exists, there is low production of OFSP in Suna East and Kuria West Sub-Counties, Migori County. The smallholder farmers produce an average yield of 13.96 tonnes per hectare compared to the potential of up to 50 tonnes of OFSP yield per hectare. The wide yield gap is attributed to technical inefficiencies regarding input utilization and low income from available marketing channels. However, the actual level of technical inefficiency has not been documented, nor will the smallholder farmers' production capacity and profits improve if they are bridged. There is also limited information on farmer characteristics, favourable choice of marketing channels, and how they influence technical efficiency in OFSP production. The study, therefore, sought to find out how inputs, farmer characteristics and choice of marketing channels affect OFSP technical efficiency. The results of this study will contribute to increased OFSP production.

1.3 Objectives of the Study

1.3.1 Broad Objective

To contribute to improved production among smallholder orange fleshed sweet potato farmers by analyzing inputs, farmer characteristics and marketing channels in Kenya.

1.3.2 Specific Objectives

i. To determine the level of technical efficiency on orange fleshed sweet potato production in Suna East and Kuria West Sub-Counties of Migori County.
ii. To determine the effects of inputs on the technical efficiency of the orange fleshed sweet potato farmers in Suna East and Kuria West Sub-Counties of Migori County.
iii. To analyze the effect of farmer characteristics on the technical efficiency of orange fleshed sweet potato farmers in Suna East and Kuria West Sub-Counties of Migori County.
iv. To analyze the effect of choice of marketing channels on orange-fleshed sweet potato technical efficiency in Suna East and Kuria West Sub-Counties of Migori County.

1.4 Research Questions

i. What is the level of technical efficiency on orange fleshed sweet potato yield in Suna East and Kuria West Sub-Counties of Migori County?
ii. What are the effects of inputs on the technical efficiency of the orange-fleshed sweet potato farmers in Suna East and Kuria West Sub-Counties of Migori County?
iii. What are the effects of farmer characteristics on the technical efficiency of orange fleshed sweet potato farmers in Suna East and Kuria West Sub-Counties of Migori County?
iv. What are the effects of choice of marketing channels on orange-fleshed sweet potato technical efficiency in Suna East and Kuria West Sub-Counties of Migori County?

1.5 Significance of the Study

This research finding might benefit various stakeholders in Migori County, Kenya. Smallholder farmers stand to gain significantly from the study examining the technical efficiency of OFSP production. By optimizing resources, farmers can achieve higher productivity, leading to increased income and improved livelihoods. Additionally, the study investigates marketing channels that can further increase revenue by improving product sales.

The government, especially in Migori County, is also expected to gain from the study findings. This study is in line with Vision 2030, Kenya's development plan, which focuses on improving OFSP production efficiency. This helps achieve a number of Sustainable Development Goals (SDGs), including SDG 8 (Decent Work and Economic Growth), SDG 1 (Eradication of Poverty), and SDG 2 (Zero Hunger). It also supports SDG 12 (Responsible Consumption and Production) by supporting sustainable agricultural practices. Extension officers will find the study's recommendations invaluable in providing effective guidance to smallholder farmers.

1.6 Scope of the Study

The study was conducted in April 2022 in Suna East and Kuria West Sub-Counties of Migori County, where OFSPs are produced and marketed locally and regionally. The

study concentrated on inputs, farmer characteristics and the choices of marketing channels factors on OFSP technical efficiency. The study focused on smallholder OFSP farmers for the production year 2021 to 2022.

1.7 Limitations of the Study

The respondent's dishonesty limited the study to giving responses and their low precision to memory recall given the poor record keeping. Farmers who anticipated gains from the research exhibited deliberate bias. These were resolved by assuring respondents that their responses would remain confidential and anonymous.

1.8 Assumptions of the Study

This study assumed that the participants would answer freely and provide truthful information to the research tool. Over the last two years, farmers have not modified the technique used in the production of OFSP. The study further assumed that the ongoing establishment of a mega processing plant at Kuria West Sub-County in the region likely led to an increase in OFSP production.

1.9 Operationalization of Terms

Choice of marketing channel: - Decision of OFSP farmer to sell produce to the market by direct selling, intermediaries or Dual to get income.

Farmer Characteristics: - Refers to the inherent characteristics, attributes, and qualities that describe individuals involved in agricultural activities. These characteristics can vary significantly between farmers.

Household: - A household is a basic social unit consisting of individuals who have lived together for at least six months in a common residence, sharing living conditions and resources. Households can vary in size and composition but generally consist of family members or individuals who cooperate in managing daily life, sharing responsibilities, and pooling resources to meet common needs.

Smallholder farmer: Smallholder farmers for this study were individuals or households engaged in agricultural production on a relatively small scale, ranging from 0.125 to 10 acres, typically cultivating a small plot of land and relying on limited resources.

Technical efficiency: The ratio between the actual and potential output levels for OFSP.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of Orange Fleshed Sweet Potato Production

Low *et al.* (2020) noted that orange-fleshed sweet potatoes are a biofortified kind of sweet potato that has high levels of beta-carotene. Several foods and plants contain the organic pigment beta-carotene, which has a reddish-orange colour. The orange nature of OFSP comes from beta-carotene, which is transformed into Vitamin A in the body after consumption, providing extra nutritional advantages (Krochmal *et al.,* 2020; Dinu *et al.,* 2021). With the help of conventional plant breeding, agronomic techniques, or biotechnology, biofortification increases the concentration of vitamins and minerals in common food crops, enhancing their nutritional value. Provitamin A Carotenoids, zinc, and iron are a few of the vitamins and minerals that can be increased through biofortification, according to Okello *et al.* (2018a).

The health benefits of provitamin A found in OFSP are now used in processed sweet potato products such as pre-cut, cubed, mashed, or pureed sweet potatoes (Dinu *et al.,* 2021). Some schools in the United States have introduced sweet potato puree to their lunch menus to improve the nutritional value of those meals (Schweinberger *et al.,* 2020). The need for local, safe, and nutritious meals grows as Africa's population expands, urbanizes, and becomes more affluent, creating chances for OFSP puree developments (Ojwang *et al.,* 2021). Commercializing processed products in Kenya, Malawi, and Rwanda shows how OFSP puree might help decrease the double burden of malnutrition in Africa and the rest of the world. Owade *et al. (*2018) and Mwangi *et al.* (2020) reiterated that OFSP has enabled the development of new products, businesses, and income opportunities for women and young people working in the supply chain, both on and off the farm. The annual demand for OFSP in Kenya is extremely significant. As a result, the crop's market value has increased, prompting more farming families to cultivate and consume it, resulting in a move away from conventional bread for breakfast.

Sweet potatoes are a flexible crop that can grow from sea level to 2400 meters above sea level, but their growth is affected by rainfall, temperature, soil type, and pH (Okoror and Areal, 2020). It is primarily grown in dry agroecological zones at medium to low

altitudes (Owade *et al.,* 2018). According to Mwangi *et al.* (2020), the crop is susceptible to aluminium toxicity and requires light to medium-textured, well-drained soils with a pH range of 4.5 to 7.0 for optimal growth. Furthermore, OFSP thrives in rich, sandy-clay soils. Light intensity and brief days encourage root development (Mwangi *et al.*, 2020). Stem cuttings or adventitious roots known as "slips" that emerge from the tuberous roots during storage are the two main methods used to propagate sweet potatoes. The vines grow quickly and once they set, smother out weeds. Other than first weeding, very little is necessary after following the OFSP growth nature. Orange fleshed sweet potato tuberous roots mature in three to seven months in western Kenya (Owade *et al.,* 2018).

Vitamin A deficiency is a major contributor to Kenya's chronic and rising malnutrition problem, particularly among children (Girard et *al.,* 2021). The deficit causes night blindness and a high infant fatality rate. The body utilizes beta-carotene, which is found in OFSPs, to produce vitamin A (Mulongo *et al.,* 2021). This approach promotes supplementation and consumption, which are out of reach for many individuals, especially in rural regions where most people cannot meet the high cost of other vitamin A sources (Owade *et al.,* 2018; Mwangi *et al.,* 2020). The improved OFSP varieties with moderate consumer acceptance have not reached many farmers because of minimal documentation on their importance and production.

FAOSTAT (2020) data shows that the country's sweet potato output, yield and production area have greatly decreased since 2015, as indicated in Table 1. The OFSP is extensively suited to Kenya's varied agroecological zones and has enormous food production potential, but it has not been completely acknowledged or utilized. Orange fleshed sweet potato, like other crops, is underused in the country's development. The table indicates that OFSP smallholder farmers are producing less than the potential of up to 50 tonnes per hectare by producing an average yield of 13.96 tonnes per hectare.

Table 1: Kenya Sweet Potato Production Statistics

Year	Yield tonnes/Ha	Area Harvested (Ha)	Production (Tonnes)
2015	17.0773	72162	1232332
2016	14.7797	47184	697364
2017	12.0977	63598	769389
2018	13.5458	64301	871010
2019	13.5458	65973	893656
2020	12.6963	54007	685687

Source: (FAOSTAT, 2020)

2.2 Challenges Facing Orange Fleshed Sweet Potato Production in Kenya

One crop that has been farmed for subsistence for a long time is sweet potatoes, though it was previously classified as an "orphan crop" or a "resource-constrained" man's crop (Echodu *et al.,* 2019). The crop has drawn new interest at the county, national, continental, and international levels as a result of its many applications (Pillay *et al.,* 2018). But not much has been done to include it in policy narratives to get the relevant government agencies around to your point of view. The challenges range from the global to individual household levels regarding the production of OFSP (Sakala *et al.,* 2018).

Orange fleshed sweet potatoes have been perceived as a woman's crop for many years in most western regions of Kenya (Owade *et al.,* 2018). It has been reported that sweet potatoes are mostly grown on small pieces of land by women in Kenya (Wayua *et al.,* 2020; Mulongo *et al.,* 2021). Women prefer to save most of their sweet potato production outcomes for home use because they are usually responsible for providing sufficient food for their families. Wainaina *et al.* (2018) and Sakala *et al.* (2018) stated that even if women sell a portion of their OFSP produce to obtain income, men tend to make most key household choices and exert control over their family's land and this greatly undermines OFSP production among many farmers.

Smallholder OFSP farmers usually get low-quality sweet potato planting materials from their fellow farmers (Okello *et al.,* 2018b; Truong *et al.,* 2018). Pests and pathogens from the previous crop frequently infect the planting material locally acquired. Farmers use them instead of sourcing clean planting material from the recommended sources (Truong *et al.,* 2018). Okello *et al.* (2018a) state that the sweet potato seed system largely depends on farmers, with just a small amount of private-sector engagement.

This means that locally acquired and low-quality planting materials are used by many farmers due to unavailability or lack of capital. Equally, the vines are not packaged in units that allow farmers to estimate how much land they can plant (Sakala *et al.,* 2018). Farmers may end up exploited by their fellows through these unstandardized measurement volumes.

Orange fleshed sweet potato tubers can be preserved for up to five months in a controlled environment; the practice, however, is not possible in real life due to technical constraints (Okello, 2019). Orange fleshed sweet potato tubers can only be preserved briefly before wrinkling and decaying. When sweet potato roots are left in the field after they have reached maturity, weevil infection increases within a month (Dang and Kawasaki, 2017). Researchers and breeders are aware of the difficulties in storing fresh roots, but the need to retain beta-carotene stability makes it more difficult to identify methods for keeping them fresh for longer (Jogo *et al.,* 2021). The necessity for long-term storage of fresh roots can be partially alleviated by stimulating OFSP processing and commercialization on a large scale as opposed to preserving fresh roots in regulated circumstances (Kiprop *et al.,* 2020).

2.3 Technical Efficiency in Crop Production

Technical Efficiency can be achieved by increasing production from a small pool of resources or reducing the quantity needed to produce a particular result (Adelodun *et al.,* 2021). Technical efficiency in economics refers to the difference between actual and prospective output. While allocative efficiency refers to a farmer's ability to use resources best given present prices and production technologies, the capability to maximize output under resource constraints (Aheisibwe *et al.,* 2018). So, if an enterprise is technically and allocatively efficient, it is said to be economically efficient.

According to Hamidah *et al.* (2021), an inefficient farmer operates above or below the production frontier curve, while an efficient farmer operates along it. This concept relates to production efficiency and has to do with producing at the lowest point on the short-run average cost curve. According to Aheisibwe *et al.* (2018), a producer is considered technically efficient if the actual production meets the optimum output, and inefficient if the actual output falls short of the frontier output. Allocative efficiency,

defined as an output level at which the price equals the marginal cost of production, is contingent upon technical efficiency as well (Alulu, 2020).

Kenya's government has contributed to providing and disseminating agriculture practices with the aid of developing nations partners. These include high-yielding varieties like OFSP, among others, to small-scale farmers (Hamidah *et al.*, 2021). However, Nyoro and Jayne's (2019) research revealed that overall production has decreased or stagnated. As a result, more research is needed to establish the reason for the decreased production tendency despite innovative technologies. This research will attempt to document the reasons for such shortcomings of low productivity of OFSP in the face of improved technologies in agriculture.

2.4 Factors Affecting Technical Efficiency in Orange Fleshed Sweet Potato Production

Socioeconomic, institutional, technological, and environmental factors impact farmers' technical efficiency. All these are likely to influence most farm households' technical efficiency (Bocher *et al.*, 2017). Production variability is a result of differences in operation scales and efficiency. Smallholder farmers may be affected by many regional and farm-specific socioeconomic factors (Krochmal-Marczak *et al.*, 2020). The frameworks of the institutional systems will involve mainly the impacts of credit access and the extensional services within the farmer's reach. Input characteristics may range from access to agrochemicals, clean planting materials, labour and land, among many others (Bocher *et al.*, 2017). This study will focus on the input factors affecting technical efficiency, credit access, demographic features and marketing channels as the inefficiency factors.

2.5 Input Factors on Technical Efficiency of Orange Fleshed Sweet Potato Production

Okoror and Areal (2020) suggest that efficient usage of existing input aspects should be employed. When farmers use existing technologies more effectively, doing so will cost less in the short run than implementing a new technology. Increasing productivity is directly tied to greater technical efficiency; it is critical to assist farmers in reducing technical inefficiencies (Oladimeji,2017). This can be accomplished by looking into the

nature of resource productivity and efficiency in farming. The input factors of concern in this study in determining the effects on technical efficiency level were as follows:

Land use and accessibility are essential to the growth of agriculture. Farmers have historically utilized land ownership as an asset to access financial services, which is a good predictor of a farmer's wealth (Bocher *et al.*, 2017). In Kenya, the majority of farmers do not own the land they cultivate (Makini *et al.*, 2018). This research looked at the impact of agricultural productivity and the amount of land used to produce OFSP. The research found this variable to be quite interesting in assessing the technical efficiency of OFSP production.

One of the most crucial components of production is labour, which has a direct influence on the output of OFSP. High labour costs for preparing the ground, building the ridge, planting, weeding, and harvesting are major production bottlenecks (Makini *et al.,* 2018). For the orange fleshed sweet potato to thrive, expand, and be easier to harvest, labour intensive deep, friable soils and thorough plowing are necessary. Furthermore, farming is difficult to mechanize because OFSPs are planted on limited acreages. Machine availability is a constraint to mechanization due to reliance on the available human labour to operate land under production (Oladimeji, 2017). Otherwise, land preparation may be delayed, resulting in late planting and, thus, lower yields than expected.

The output of sweet potatoes is adversely affected by the lack of sufficient enhanced and disease-free planting materials. As a result, farmers frequently grow vines infested with pests and diseases, which might contribute to low yields (Makini *et al.*,2018). Some farmers source planting vines from neighbours that are of poor quality, type, or variation. Kenyan sweet potato farmers bother not to source certified seeds from recommended dealers. According to Makini *et al.* (2018), vegetatively propagated seed material dealers are not reachable within production areas and the crop's bulkiness increases transport costs. Further, since sweet potatoes are clonally propagated, farmers find no need to use certified seed and choose to use locally available sources.

Agrochemicals are agricultural chemicals that boost the quality and quantity of farm output. Agrochemicals, such as fertilizers, insecticides, and fungicides, are compounds used to control an agricultural ecosystem or a community of organisms in a farming establishment (Nwakile *et al.,* 2020). Because they lower labour costs and boost agricultural yield and quality, agrochemicals are economical (Adelodun *et al.,* 2021). Different pesticides have been sprayed on crops during the last few decades in an effort to reduce insect damage and boost agricultural output. In the past 40 years, these agrochemicals have improved soil fertility, insect management, and crop yields (Novotny *et al.*, 2020). The study sought to determine how agrochemical use affects technical efficiency in OFSP production.

2.6 Farmer Characteristics on Technical Efficiency of OFSP Production

Age greatly affects technical efficiency level; old and young age might influence the OFSP smallholder farmers' technical efficiency. According to research by Mogaka *et al.* (2021), a farmer's technical inefficiency in the production of sugarcane rises with age. Age may be detrimental since it indicates that older farmers are incapable of engaging in productive production due to physical or mental limitations and are hesitant to accept new technologies. According to research by Pello *et al.* (2021), younger farmers are more technically proficient than older ones since they have more education. This study explored the effect of OFSP smallholder farmer's age on the technical efficiency level.

Female farmers are more involved with activities and practices of agricultural relations than their male counterparts (Bocher *et al.,* 2021). This might be because women have historically been significantly associated with agricultural output. Therefore, it was anticipated that female farmers would comprise most of the farmers' group. According to Kogo *et al.* (2020), female farmers are likelier to engage in group activities and innovative production than male farmers. Women tend to form more social bonds than males, which motivates them to participate in group marketing efforts for crop commodities (Taiti, 2020).

A significant association exists between technical efficiency and farming experience for most farmers (Ambetsa *et al.*, 2020). Farming expertise is linked to enhanced proficiency in farm production operations and, as a result, increased productivity. The education degree is also beneficial and significant, as a rise in educational attainment might somewhat affect technical efficiency. Ambetsa *et al.* (2020) found that efficiency and education among small-scale sugarcane growers were positively correlated. According to research by Beyene *et al.* (2020) on enhanced input adoption in Ethiopia, highly educated farmers produce more at the production frontier and pick up new technologies faster.

Household size has a significant impact on the technical efficiency of OFSP production among smallholder farmers. Households with many members often have an advantage in terms of labor availability because more family members participate in various agricultural activities. This increase in labor will make agricultural operations from planting to harvest more efficient, ultimately leading to an increase in his OFSP yield. However, the effect of household size is disadvantageous because it also affects the distribution of resources within the household. Larger households may have access to more land and resources, but these assets are often divided among many families, which can limit investment in improved agricultural practices (Jogo *et al.*, 2021). Therefore, maximizing technological efficiency in OFSP production requires a tailored strategy that considers the advantages and drawbacks of smallholder farmer family size.

One crucial aspect of farming that has a big impact on the technical efficiency of OFSP production is land ownership. Farmers who own the land on which they farm often have more secure access to resources and greater incentives to invest in sustainable farming practices, resulting in higher OFSP yields (Jogo *et al.*, 2021). On the other hand, individuals who own leased property or have uncertain land ownership could be hesitant to commit to long-term expenditures, which might hinder the uptake of effective agricultural technology (Beyene *et al.*, 2020). A farmer with a bigger piece of land may allocate a greater area for growing OFSP, potentially leading to economies of scale and increased yields. Thus, protecting and enhancing land tenure may enhance the OFSP production's technical efficiency and, in turn, support smallholder farmers' financial stability and ability to produce food.

Educational level is an important characteristic of farmers that significantly influences the technical efficiency of OFSP production. Farmers with higher levels of education often have easier access to information, resources, and modern farming practices. They are more likely to use innovative techniques, participate effectively in pest and disease control, and make informed decisions regarding OFSP planting, harvesting, and marketing (Ambetsa *et al.,* 2020). Farmers with lower levels of education may face barriers to accessing and understanding agricultural knowledge, hindering the adoption of efficient practices (Jogo *et al.*, 2021). Therefore, promoting education and providing training opportunities to smallholder farmers can lead to increased technical efficiency in OFSP production and ultimately improve crop yields and income levels.

Inefficiencies in OFSP production are significantly impacted by farmers' financing availability. The research aims to investigate if agricultural loan availability lowers production inefficiencies associated with OFSP. According to Omondi *et al.* (2020), access to credit affects the productivity of a farmer. Access to credit enables farmers to acquire the financial means to get relevant technologies to reduce production and storage losses (Mwololo *et al.,* 2019). Similarly, the land tenure system of the smallholder OFSP farmers has a big impact on reducing inefficiency, which has a direct impact on credit access as well. Demographic characteristics of OFSP smallholder farmer also translates to the inefficiencies of production.

2.7 Choice of Marketing Channels on Technical Efficiency of OFSP Production

There is a clear relationship between technical efficiency and market involvement. Market performance helps to increase technical efficiency. As a result, anytime farmers encounter market-related issues, questions about their production and marketing efficiency arise (Kihiu *et al.*, 2021). The most effective and economical method of getting a product into the hands of a customer is through the distribution channel. Numerous organizations that support transactions and in-person exchanges make up the channel (Ntakyo *et al.*, 2019).

Many rural smallholder OFSP farmers have difficulty finding marketplaces to sell their products due to long distances. According to Kiprop *et al.* (2020), farmers are hampered by their remote locations, which can give them the bargaining leverage they need to

interact on an equal footing with other market intermediaries. The distance is expressed in kilometers from an agricultural area to the primary market where he or she sells in a district, urban, or other markets (Kibetu *et al.,* 2021). Due to the high cost of shipping, the rise in production costs as a result of the large distance to the main market, and the profits realized by the farmers, fewer farmers are entering the market. Longer distances result in higher transportation costs. From market impact farmers' selling habits to monopolistic local marketing channels (Kihiu *et al.,* 2021).

Storage facilities are a major factor in marketing channel selection and, therefore, in the technical efficiency of OFSP production. Farmers who have access to suitable storage facilities, such as warehouses and cold storage facilities, have more flexibility in choosing their distribution channels (Mwembe *et al.,* 2021). They can choose a channel that offers a higher price but may require longer storage as they have a means of storing the product. Farmers without adequate storage facilities may be forced to choose distribution channels that emphasize quick sales, perhaps at lower prices (Ngenoh *et al.,* 2020). Ownership of the storage facility also plays an important role. Farmers with their storage facilities have greater control over their produce, allowing them to make strategic decisions about when and how to sell, optimizing profitability and technical efficiency in OFSP production.

Grading influences, the selection of marketing channels and, in turn, the technical efficiency of OFSP production. Farmers often face different classification requirements depending on different marketing channels. Some channels require strict adherence to specific quality and evaluation criteria, while others are more lenient. Channel selection depends on the farmer's ability to meet these classification criteria. According to Ngenoh *et al.* (2020), farmers who can consistently produce OFSPs that meet higher quality standards may choose channels that offer premium prices. At the same time, those who cannot meet stringent evaluation requirements may choose lower-quality channels, such as local markets or processors. Effective evaluation practices and adherence to market standards are critical to ensuring OFSP products reach the most appropriate markets. This optimizes price realization, reduces potential product waste and increases technical efficiency (Mhagama *et al.,* 2021).

Group membership affects the technical efficiency of OFSP production by being a major factor in the choice of marketing channels. Smallholder farmers often organize into cooperatives or farmer groups to develop markets together and negotiate better terms. These groups provide a platform for collective use of agricultural products, improving bargaining power and providing access to higher-value markets that may be difficult for individual farmers (Mhagama *et al.,* 2021). Whether or not the farmer belongs to such a group determines the marketing channel that is selected. Group members will have access to markets with higher prices, lower transaction costs and better market information, contributing to increased technical efficiency. Conversely, independently operating farmers can choose different channels with different levels of risk and return (Kihiu *et al.,* 2021). Therefore, group membership affects not only market choice but also the overall efficiency and profitability of OFSP production.

The technical efficiency of OFSP production and the choice of marketing channels are significantly influenced by access to training. Farmers trained in agricultural practices, post-harvest handling, and market linkages can make informed decisions about marketing channel selection. They have a higher propensity to choose channels that align with their production capacity and market potential, as well as to implement effective marketing tactics. Training improves farmers' understanding of market dynamics, quality standards, and buyer preferences, allowing them to more effectively navigate the complexities of different channels of marketing (Kiprop *et al.,* 2020). In contrast, farmers with limited access to training may choose channels that are more familiar but potentially less efficient, impacting the overall technical efficiency of OFSP production. Improving smallholder farmers' access to training can, therefore, contribute to more informed marketing decisions and ultimately increase the efficiency of their OFSP production systems, which the study sought to find out.

The farmer's selection about the marketing channel to use and the revenue from the sale is influenced by the available method of transportation (Kihiu *et al.,* 2021). While farmers who live far from the market sometimes create marketing groups to promote their goods together, this practice is not widespread (Mbembe, 2020). How OFSP reaches the market greatly influences the type of channel the farmer takes. The availability of these modes is also critical while considering the channel type. The

purpose of the research was to ascertain how the method of transportation affected the OFSP farmers in Migori County's technical efficiency as well as their choice of selling channel and revenue.

Market assurance encourages strong production and marketing engagement. As production increases, farmers who have excess are more likely to sell through the official market channel (Anthony *et al.,* 2020). Smallholder farmers are incentivized to enhance output and participate in cooperative organizations to market their goods (Mhagama *et al.,* 2021). Farmers need a guaranteed market and better facilities for their produce through a specific channel to avoid losses and unnecessary expenses. This study explored whether market assurance influences OFSP smallholder farmers' choice of marketing channel and affects technical efficiency.

The number of visits the extension service performs to the sampled houses each year is how the extension is measured (Kiprop *et al.*, 2020). Extension services assist in disseminating knowledge about technological advancements and marketing opportunities, which boosts output. Mhagama *et al.* (2021) stated that a significant influence on the marketing choice is the frequency of extension interactions. Hence, it affects the amount of OFSP sold and the likelihood of better income earned from better sales.

2.8 Theoretical Framework

2.8.1 Production Theory

The study was based on production theories that support agricultural economics in orange-fleshed sweet potato production. Production is converting inputs into outputs to create value through transformation. The goal is to get the most feasible profits (outputs) from a limited set of resources. A model that assesses the relationship between input and output is called the production function (Bond *et al.*, 2021). Mathematically, this function may be expressed as:

$$\mathrm{Y} = \mathrm{f}(\mathrm{X}_1, \mathrm{X}_2, \mathrm{X}_3, \mathrm{X}_4, \mathrm{X}_5, , , \mathrm{X}_\mathrm{n}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

where;

Y= quantity of output

X_1 = Number of hours that the family labour works on the farm,

X_2 = Acreage allocated to OFSP (m2),

X_3 = Number of planting vines used in the production of OFSP (kg),

X_4 = Fertilizer amount used OFSP production (kg),

X_5 Other agrochemicals used in OFSP production (Litres/M2).

X_n= Other inefficiency factors of production

The production function indicates the highest yield that may be achieved using different combinations of inputs. Farm producers attempt to optimize production at a set cost level or lower the cost of producing a given amount of output; it expresses the functional relationship between resource amounts and outputs. The factor-product relationship guides the basic production decision of how much to produce (Bond *et al.*, 2021). The Cobb-Douglas model is used to estimate the stochastic frontier production function. Due to its ability to meet econometric, statistical, and economic requirements, the Cobb-Douglas production function is often used (Erkoc, 2014). The use of this function requires that the elasticities of production are constant. A mathematical formula for production indicates the highest output that may be produced given a certain set of inputs (Musyoka, 2020). The Cobb-Douglas production function looks like this:

$$Y = AK^{\alpha}L^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Whereby;

Y represents total production output, K is capital input, L is the labour input factor, and A represents the productivity or elasticity factor. The output elasticities of capital and labour are represented by α and β, respectively.

The research applied this theory with the output-oriented technique wherein in an output-oriented approach, an inefficient unit is made efficient by raising its outputs proportionately while maintaining the input proportions fixed. This results from the scarcity of productive resources for production. This approach might ensure proper

utilization of the available resources for efficient production to be realized by the smallholder farmers.

2.8.2 Measures of Technical Efficiency

Parametric and nonparametric methods are the two main approaches to measuring technological efficiency. Data envelope analysis (DEA), a non-parametric or mathematical programming approach, is used to assess unit productivity by accounting for a range of inputs and outputs. Many other agricultural researchers have used it to assess technological efficiency. The best output that can be produced given a set of inputs or the ideal mix of inputs to obtain a specific level of output is known as technical efficiency, or output orientation (Adom and Adams, 2020).

The stochastic frontier production function used in the parametric technique is determined in two stages. It is necessary to specify the stochastic frontier production function before determining the technical efficiency indicators. Second, the indicators are regressed on independent variables that indicate the farm's unique characteristics using the ordinary least square (OLS) approach (Chandio *et al.,* 2019). In agricultural economics, the stochastic frontier technique is the most favoured (Ntakyo *et al.,* 2019).

2.9 Conceptual Framework

Several variables impact technical efficiency, some of which are the study's elements: the choice of marketing channels, farmer characteristics, and inputs. The technical proficiency and OFSP production of the farmers may be impacted by these variables either directly or indirectly. Orange fleshed sweet potato input factors involved aspects directly attributed to producing quality and high yields. The input aspects of the study included the following: farm size, availability of planting materials, access to agrochemicals and availability of labour in OFSP production. The variables quantity utilized were compared to the total output or yield of OFSP generated in order to ascertain the impact of input factors on OFSP production.

Farmer characteristics factors affecting technical efficiency of OFSP production include age, gender, education level, land tenure, household size, credit access and the experience of the farmer. Studies have shown that many farmers' technical efficiency

is influenced by their ability to get credits among other farmer characteristics. The study's marketing channel section looks at the possibilities of farmers selling OFSP output and determines which marketing channel produced the most profit, which in turn encouraged and raised production levels. Some factors of interest in this study included distance to the market, market assurance, grading, group membership, mode of transport to market, access to extension services, storage capacity and training. Uncontrollable environmental conditions are among the intervening variables that influence the degree of technological efficiency. Figure 1 clearly illustrates how all these variables impact the technical efficiency of smallholder farmers' produce.

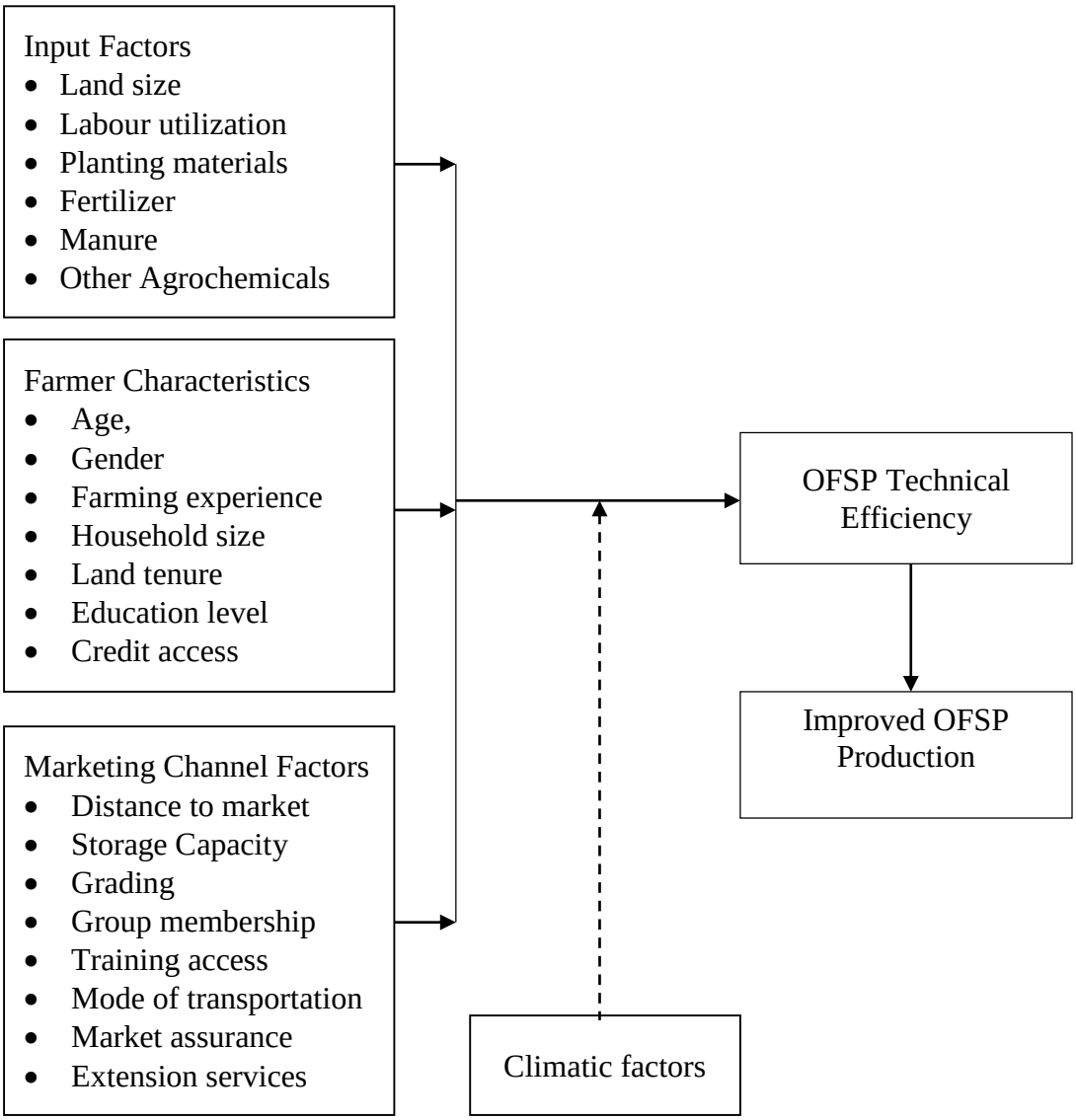

Figure 1: Conceptual Framework

Source: Author's conceptualization

CHAPTER THREE
METHODOLOGY

3.1 Study Area

The study was conducted in April 2022 in Migori County, which lies in southwestern Kenya, bordering Homa Bay, Kisii County, Narok Counties, Tanzania, and Lake Victoria. Migori County is one of the most producing OFSP counties in the western region. The County has a total area of 2613.5 km^2. The study sites were the Suna East and Kuria West Sub-Counties of Migori County (Figure 2). Suna East Sub County has a total area of 205.1 Km^2, a population density of 598/Km^2 and a population of 122,674 (KNBS 2019). The sampling was conducted in Suna Central, God Jope, Kakrao and Kwa Wards in Suna East. Kuria West Sub County has a total area of 395.7 km^2, a population density of 527 per Km^2 and a population of 208,513 (KNBS 2019). Kuria West Sub-County sampling was conducted in Tagare, Isebania, Bukira East and Bukira Central Wards. The rainfall pattern in the two Sub-Counties is bimodal, ranging from 700 mm to 2,200 mm. The socio-economic activities in the region include mining, fishing, and agriculture, among others. The land tenure system is mainly freehold tenure, and each landowner can get title documents for their land parcels.

3.2 Research Design

The research used a cross-sectional descriptive design, it was possible to estimate the prevalence of each attribute. The design entailed collecting data on inputs, farmer characteristics and marketing channel factors simultaneously, making it rapid, simple, and useful for answering the research questions (Siedlecki, 2020).

3.3 Target Population

This study concentrated on smallholder OFSP farmers in Suna East and Kuria West Sub-Counties, Migori County. The targeted population was about 6500 OFSP farmers in Suna East and Kuria West Sub-counties (Kiome *et al.,* 2019).

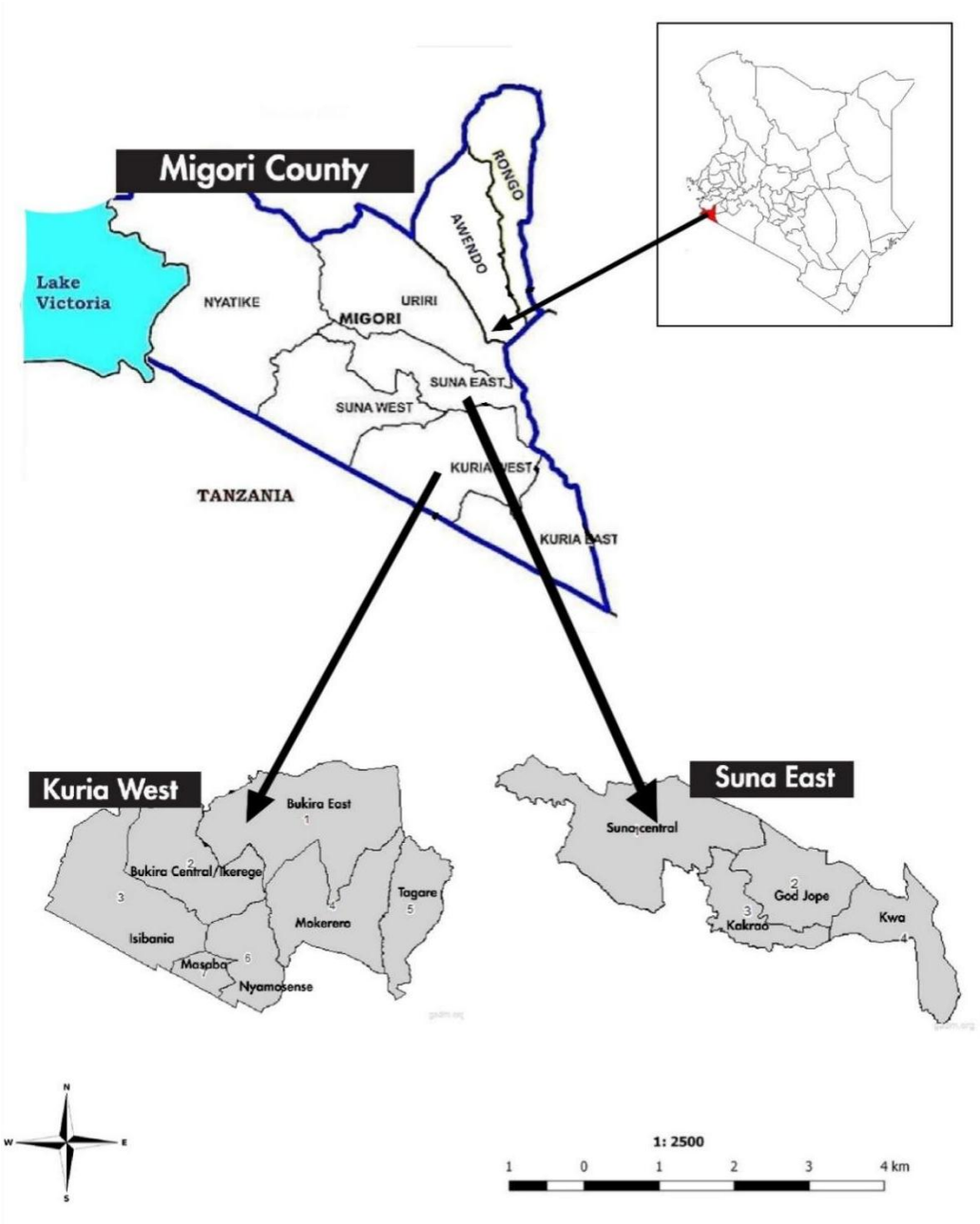

Figure 2: Migori County; Kuria West and Suna East Study Areas

Source: Adapted from Geocurrent Maps

3.4 Sample Determination and Sample Size

Using the (Nassiuma 2000) formula, the research sample size of smallholder OFSP farmers was determined, employing an acceptable coefficient of variation of thirty percent.

$n_o = \frac{NC^2}{C^2+(N-1)(e^2)} = \frac{6500\ (0.3^2)}{0.3^2+(6500-1)(0.02^2)}$= 225.03=226 Orange fleshed sweet potato farmers

where;

n_o= Required sample size

N= OFSP farmers' population size

C= Coefficient of variation (CV) at thirty percent

e = Standard error.

The research used 226 smallholder OFSP farmers in the Sub-counties of Migori County as its sample size, assuming a 30% CV and a 2% standard error. A 30% coefficient of variation signifies relatively high variability within the population, necessitating a larger sample size to ensure the sample accurately represents this variation.

3.5 Sampling Procedures

The study utilized a cluster random sampling procedure to interview smallholder OFSP farmers of Suna East and Kuria West Sub-Counties. A sampling frame was used to divide the OFSP farmers within the two Sub-counties. In Suna East Sub County, the following Wards were sampled: Kwa, Godjope, Kakrao and Suna Central. Tagare, Bukira East, Bukira Central and Masaba Wards in Kuria West Sub County were sampled. A random sampling of OFSP smallholder farmers from the sample Wards was then used. The individual cluster samples were combined to form the overall sample of OFSP respondents. This procedure was effectively used by Anarah *et al.* (2021).

Sample frame $= \frac{\text{Targetpopulation}}{\text{Totalpopultion}} \times$ Sample size

Table 2: Sample Frame Distribution for OFSP Smallholder Farmers in Suna East and Kuria West, Migori County

Selected Sub-Counties	Specific Wards	Target population per ward	Sample Size per Ward
Suna East	Kwa	590	21
	God Jope	350	12
	Kakrao	400	14
	Suna Central	600	21
Kuria West	Tagare	1200	42
	Masaba	1400	49
	Bukira East	1010	35
	Bukira Central	950	32
	Total	6500	226

Source: (Kiome *et al.*, 2019)

3.6 Research Tool

The responses from the respondents were gathered using a semi-structured questionnaire that included both closed- and open-ended questions. This allowed respondents to respond to the study instrument qualitatively and quantitatively freely. The enumerators filled out the questionnaire directly from the respondents of OFSP farmers.

3.7 Pilot study

A pilot study was conducted one and a half weeks before the actual study at Kabondo East and Kabondo East Ward in Homabay County, Kenya, targeting smallholder OFSP farmers. The area was suitable for OFSP farming. According to Connelly (2008), the pilot research had a sample of 23, which constituted 10% of the study's intended sample size. The purpose of the pilot survey was to ascertain the respondents' reactions to the tool and the range of replies that they provided. The pilot study also identified some challenges of the questionnaire and identified some essential wording in the questions as well as ambiguities of the questionnaire to adjust them. This was essential to identify the potential challenges during the actual study, shortcomings in the research methodology and the logistics for the entire process.

3.7.1 Validity

The research instrument was assessed using a judgmental method, which included extensive follow-ups and literature reviews with expert evaluations in the same field of study. In order to verify that the questionnaire was readable, understandable, and comprehensive, as well as that the results accurately reflected the construct questions, the expert team comprised the two university supervisors, specialists from the Department of AGEC, AGBM, and AGED, as well as representatives from the county government ministry of Agriculture and Fisheries of Migori County.

3.7.2 Reliability

The Cronbach Alpha test enhanced the effectiveness and adaptability of the questionnaire tool. Cronbach's alpha measures the degree of connectivity between a set of test items. In this study, an alpha coefficient of 0.70 or higher for a reliability coefficient was acceptable. The study’s Cronbach alpha coefficient was found to be

0.74, which proved the efficiency of the questionnaire tool according to Mensah & Onyancha (2022) reported that if $\alpha < 0.5$ = unacceptable, $\alpha = 0.5$ =poor, $\alpha = 0.6$ - questionable, $\alpha > 0.7$- acceptable, $\alpha > 0.8$ - good, and $\alpha > 0.9$ - excellent.

3.8 Data Collection

A semi-structured questionnaire was used in April 2022 to collect both quantitative and qualitative data. OFSP farmers were the study's primary informants, officials from the State Department of Agriculture in Migori County, and the relevant NGO officials. Data collected were on land size, labour, planting vines and agrochemicals for the inputs' objective. Farmer characteristics data included credit acquisition, farmers' age, gender, education, land tenure, household size and farming experience. The marketing channel variables were chosen based on the distance to the market, grading, storage capacity, mode of transport, group membership, training, market assurance and access to extension services as described in Appendix I.

3.9 Data Analysis

The respondent questionnaire data was transcribed, and thematic content analysis was used for analysis. This allowed the researcher to gain fresh concepts and ideas from the data. Following the survey, data was processed, categorized, and tallied. Programs SPSS 28 and Stata 15 were used to input the data and conduct the analysis. The themes were produced by analyzing the tabular data. Coded data were analyzed using techniques such as measures of dispersion (standard deviation, variance, range and coefficient of variation), measures of central tendency (median, mode, and mean), and measures of association and correlation (correlation, regression). The main econometric models were stochastic frontier and multivariate probit models on Stata 15 used to analyze OFSP technical efficiency.

3.9.1 To Determine the Level and Analyze Marketing Channel, Inputs and Famer Characteristics Factors on Technical Efficiency of the OFSP in Suna East and Kuria Sub-Counties of Migori County

The data were analyzed using the stochastic frontier production function model. The main characteristic of the model is its capacity to take into consideration external factors outside the producer's control and provide a measure that is more in line with potential productivity under normal working circumstances (Aigner *et al.,* 1977). The production

frontier model is the default for the frontier functions in the STATA statistical software, which is made to fit stochastic production frontier models. Based on the theoretical presumption that individual inefficiencies are represented as deviations from the ideal "frontier," which no economic actor may cross, the SFM was developed (Greene, 1980). The stochastic frontier production function, which has the following definition, is used to assess whether OFSP farmers are technically inefficient:

$$Y = f(X_{\alpha} ; \beta)\mathcal{E} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3)$$

Where,

X_α = A vector of input values, β = A vector of parameters, E = Stochastic disturbance term made up of two independent components, u and v, and Y = the amount of the OFSP output

$$\mathcal{E} = U + V \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. (4)$$

V, this takes into account factors like governmental regulations and environmental restrictions that are beyond the farmer's control. U is a symbol of technical inefficiency. Combining (1) and (2) gives the farm's frontier;

$$Y = f(X_{\alpha} ; \beta) * \mathcal{E}(U + V) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

Two important functions for determining the connection between inputs and outcomes are the Cobb-Douglas function and the stochastic frontier (translog) function. The translog function suffers from multi-collinearity because of the huge number of variables, but its functional form is versatile and there are less constraints on input variable substitutions (Skevas, 2019). In addition to its linearity in parameters and the simplicity of estimating through ordinary least squares, the Cobb-Douglas estimator also works well when just a small number of input parameters need to be evaluated. The production elasticity is the percentage change in output that results from a 1% change in the amount of input, ceteris peribus, and is described in terms of regression coefficients because of their convenience and computational viability. Furthermore, it permits declining marginal returns to take place without sacrificing too many options.

This empirical stochastic frontier production function will be used for data analysis:

$$\log Y_i = \beta_\circ \sum_{i=1}^{n} \beta_i \log X_i + \mathcal{E}_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (6)$$

$$\text{Log Y} = \beta_\circ + \beta_1 \text{logLabourdays} + \beta_2 \text{logLand} + \beta_3 \text{logPlanmterl} + \beta_4 \text{logplantfertb} + \beta_6 log\text{pmanqtyb} + \beta_6 \text{logAgrochem} + V_i - U \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where:

U = represents the degree of inefficiency brought about by socioeconomic variables that have an impact on production; log is the input's logarithm, and I is the farmer's observation.

$$\text{Ui} = \delta_\circ + \delta_1 X_1 + \delta_1 X_2 + \delta_1 X_3 + \delta_1 X_4 + \delta_1 X_5 + \delta_1 X_6 \ldots X_n + \omega. \ldots\ldots\ldots\ldots\ldots. (8)$$

Where:

ω_i Represents a random, normally distributed error term, X represents the inefficiency variable and Ui = Technical inefficiency of the ith farmer,

Table 3: Technical Efficiency Variables Used and Their Measurement

Variables	Description	Measurement
logLand	Logarithm of land	Number of acres under OFSP
Age	Age of the farming decision-maker	Number of years
Gender	Gender of the farming decision-maker	Categorical variable (1=male, 0=female)
Yrsedu	Education level	Years of schooling
Yrsofsp	Farming experience	Years of OFSP farming experience
Hhsize	Household size	Number of Members
Mrktdist	Distance to the market	Kilometers
Mktassurance	Market Assurance	0=No, 1=Yes
Acctrainm	Access to training	0=No, 1=Yes
Credtofsp	Access to credit	0=No, 1=Yes
Conextveg	Contact with the extension officer	Number of visits
Groupfun	Group membership	0=No, 1=Yes
Landtit	Land title deed	0=No, 1=Yes
logAgrochem	Logarithm of other agrochemicals	Litres
LogLabourdays	Logarithm of labour	Man-days
logPlanmterl	Logarithm of planting materials	Kilograms
Logpmanqtyb	Logarithm of manure	Kilograms
Logplantfertb	Logarithm of fertilizer	Kilograms

3.9.2 To Analyze the Effect of Marketing Channels on OFSP Technical Efficiency in the Suna East and Kuria West Sub-Counties Migori County

Since there are more than two potential channels of distribution, the researchers used a multivariate probit model (Mugenzi, 2021). Computing multivariate probit results on the multiple choices of marketing channels, for this research, Stata software version 15 was used. Multivariate Probit modeling approaches will be suitable for resolving biases caused by correlation across choices since they enable simultaneous correlation across available options (Mussida and Zanin, 2020). Since the unobserved (error terms) are allowed to freely correlate with one another, a multivariate probit econometric technique will be used in this study to model the impact of a set of independent factors on each of the numerous marketing strategy decision-making processes (Degaga and Alamerie 2020). This multivariate probit model followed the below representation.

$$Y *_{m} = \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_m X_m + \mathcal{E}_m \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(7)$$

Where,

M represents the different marketing channel choices for the OFSP farmers in the Suna East and Kuria West Sub Counties of Migori County.

$$Y_m = 1 \text{ if } Y *_{m} > 0 \text{ and} Y_m = 0 \text{ if otherwise } \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(8)$$

That is,

$$Y_1 = \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + \mathcal{E}_n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(9)$$

$$\vdots\vdots \qquad \vdots \qquad \dots \vdots\vdots$$

$$Y_m = \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_{nm} X_{nm} + \mathcal{E}_{nm} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(10)$$

Where,

$Y_1 \dots Y_m$=1 If OFSP farmers sell his or her produce through direct selling or otherwise, sells through intermediaries or otherwise, and sells through dual marketing channel or otherwise.

$\mathcal{E}_{n} \dots \mathcal{E}_{nm}$ Are the errors normally distributed in multivariate probit? Each has a mean of zero. The Y_m It is a binary unitary outcome of the choice of marketing channel. X_mRepresent the variables independently, as shown in Table 5.

Table 4: Choice of Marketing Channel Variables

Variables	Description	Measurement
Age	Farming decision-maker's age	Number of years
Gender	Farming decision-maker gender	Categorical variable (1=male, 0=female)
Yrsedu	Education level	Years of schooling
Yrsofsp	Farming experience	Years of OFSP farming experience
Mrktdist	Distance to the market	Kilometers
Mktassurance	Market Assurance	0=No, 1=Yes
Conextveg	Contact with the extension officer	Number of visits
Groupfun	Group membership	0=No, 1=Yes
Logcaostcost	Logarithm of harvesting materials cost	Monetary value (Kes)
Storey	Storage capacity	0=No, 1=Yes
Grading	Grading of OFSP	0=No, 1=Yes

3.10 Ethical Consideration

A research introductory letter verified by the Migori County State Department of Agriculture informing participants on the purpose and scope of the research was used to ensure the privacy and confidentiality of respondents' information. The Chuka University Ethics Review Committee granted formal conformance clearance (Appendix II). Appendix III includes the research clearance from the National Commission for Science, Technology, and Innovation (NACOSTI). Before farm visits for survey and data collection, farmers' permission and consent were sought. During the questionnaire administration process, farmers were given the assurance that their information would be kept secret and utilized only for this research.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Questionnaire Response Rate in Suna East and Kuria West Sub-Counties Migori County

The total number of questionnaires distributed and completed by the OFSP survey respondents is shown in Table 5. The result gave a 99.54% response rate (225) from 226 issued questionnaires. This high and efficient response rate was achieved through face-to-face administration technique.

Table 5: Response Rate of the OFSP Respondents from Suna East and Kuria West Sub-Counties in Migori County

Specific Wards	Attained Sample	Target Population	Sample Size	Percentage
Kwa	25	590	21	11.06
Suna Central	18	600	21	7.96
Kakrao	12	400	14	5.31
Godjope	9	350	12	3.98
Tagare	33	1200	42	14.6
Bukira Cast	34	1010	35	15.04
Bukira Central	30	950	32	13.27
Masaba	64	1400	49	28.32
Total	225	6500	226	99.54

4.2 Description of Demographic Characteristics of OFSP Smallholder Farmers in Suna East and Kuria West Sub-Counties in Migori County

4.2.1 Smallholders' Age, Years of Schooling, Household Size, and Farming Experience

The study showed that the average age of the household farming decision-makers was 56 years (Table 6). This could influence the OFSP production as youngest and energetic people were left out. This finding was in line with Mogaka *et al.* (2021), they found that among farmers in Western Kenya, age was a socioeconomic factor impacting the use of climate-smart soil techniques. The study further showed that OFSP production was practiced mainly by smallholder farmers with few years of schooling. The average years of schooling were nine (9) among the main decision makers within the study areas (Table 6). This finding contradicted that of Makini *et al.* (2018), whose research revealed that the degree of education attained by the head of the family affected the potential for innovation in Kenyan sweet potato production. Perhaps this contrast resulted from differences in the type of enterprise.

The average individual household size was seven (7) with at least 2 dependents aged between 6 and 18 years (Table 6). The number of dependents is key to the agricultural labour provision, contributing to OFSP production in the study area. These findings agreed with Bryceson (2019), who reported that household size affects gender and generational patterns of African agriculture in smallholder peasant household farming. The average years of experience in OFSP production were nine (9). The least experienced farmer had two, and the most experienced had 30 (Table 6). Farming experience affected the farmer's production level; most experienced farmers tended to be more efficient than the least experienced. This study was in line with that of Mairura *et al.* (2021), who reported that in the Central Highlands of Kenya, experience had a significant role in influencing farmers' perspectives of climatic variability, mitigation, and adaption techniques for increased productivity.

Table 6: OFSP Farmers Household Demographic Characteristics in Suna East and Kuria West Sub-Counties in Migori County

Variable	Observation	Mean	Std. Dev.	Min	Max
Years of schooling	225	9.21	2.87	0	18
Household size	225	7.39	2.82	2	21
Age of household decision-maker	225	56.28	9.28	29	77
Age of the respondent	225	48.84	13.09	18	74
Years of Experience in OFSP	225	10.74	5.31	2	30
Dependents ov18	225	4.88	2.51	0	15
Children between 6 and 18 of age	225	2.28	1.35	0	6

Key: Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max-Maximum

4.2.2 Gender and Marital Status of OFSP Household Decision Maker

Most household farming decision-makers were male at 78.67%, whereas female decision-makers were 21.33% (Table 7). Production of OFSP is mainly associated with the female gender compared to the male, with results obtained from gender greatly affecting OFSP farming decisions in the region. This study agreed with Jogo *et al.* (2021), whose findings indicated a negative rate of male farmers' adoption and retention decisions of orange-fleshed sweet potato biofortified food crops in Mozambique. The study further observed the marital status of the household decision makers: married were 77.78%, 16.44% were widowed, 3.11% were polygamous, and 2.67% had separated (Table 7). This would translate that household heads were the key

decision-makers influencing OFSP production. The finding corresponded with Ehiakpor *et al.* (2021) report, showing that marital status affects the adoption of sustainable farming methods by Ghanaian smallholder farmers.

Table 7: Gender and Marital Status of OFSP Household Decision Makers in Suna East and Kuria West Sub-Counties in Migori County

Gender and Marital Status of OFSP Decision Maker	Frequency	Percentage
Female	48	21.33
Male	177	78.67
Total	225	100
Marital Status		
Married	175	77.78
Separated	6	2.67
Widowed	37	16.44
Polygamous	7	3.11
Total	225	100

4.2.3 Occupation of the Household Decision Maker

Given the few years of schooling, most household decision-makers were engaged in farming activities 75.11%, while self-employed was 11.56%, as observed from the study. Other occupations for the household decision makers included public sector employment 9.33%, casual workers 2.67%, private sector 0.89% and those unemployed constituted 0.44% (Table 8). The results corresponded with Mairura *et al.* (2021) and Mogaka *et al.* (2021), results that indicated how farmers in Kenya's Central Highlands perceived climate variability, mitigation, and adaptation strategies depended critically on their line of work.

Table 8: Occupation of the Household Decision Maker in Suna East and Kuria West Sub-Counties in Migori County

The decision-maker's main occupation	Frequency	Percentage
Farming	169	75.11
Self-employed	26	11.56
Public sector employment	21	9.33
Casual worker	6	2.67
Private sector employment	2	0.89
Unemployed	1	0.44
Total	225	100

4.3 Farm Characteristic Descriptions in Migori County

4.3.1 Land Ownership

Those with no entitlement to land were 51.11%, while 48.89% were entitled to land (Table 9). The low ownership of land could contribute to the inefficiency in OFSP production among the smallholder farmers. This resulted in a lack of total authority, a sense of security and failure to provide necessary resources, such as access to credit for improved production. Kinuthia *et al.* (2018) had similar findings, which showed that land ownership affected agricultural productivity and farming choices and undermined production in Narok East Sub-County, Kenya.

Table 9: Land Entitlement in Suna East and Kuria West Sub-Counties in Migori County

Land Entitlement	Frequency	Percentage
Not entitled	115	51.11
Entitled	110	48.89
Total	225	100

4.3.2 Gender and Land Ownership

The study observed that gender and land ownership were not proportional; of the 21.33% female-headed households, only 4.89% had title deeds for parcels of land owned. Contrarily, among the 78.67 % of male-headed households, 44% had title deeds, whereas 34.67% did not (Table 10). These results corresponded with Mairura *et al.* (2021) and Njuguna- Mungai *et al.* (2022), who showed that females had limited influence and access to land resources, affecting their agricultural production contribution. Traditionally, OFSP is portrayed as a female crop; hence, low entitlement might contribute to regional production inefficiency.

Table 10: Gender and Land Ownership for OFSP in Suna East and Kuria West Sub-Counties in Migori County

Gender	Land Entitlement					
	No	Percentage	Yes	Percentage	Total	Percentage
Female	37	16.44	11	4.89	48	21.33
Male	78	34.67	99	44	177	78.67
Total	115	51.11	110	48.89	225	100

4.3.3 Area of Land Operated

The study observed that, on average, farmers owned 8.2 acres of land, of which 7.05 were used for agricultural purposes. Crop production utilized 5.99 acres, most preferred crop 3.17, livestock production 1.01, trees area 0.57 and OFSP production 1.32 acres of land (Table 11). Based on these statistics, farmers gave little attention to OFSP production as compared to the most preferred crop in the region. This finding was in line with Makini *et al.* (2018), who reiterated that the sweet potato crop faced stiff competition from other crops, such as maize and sugarcane, in Western Kenya.

Table 11: Land Sizes in Acres Occupied by Different Enterprises in Suna East and Kuria West Sub-Counties in Migori County

Land Allocation	Obs	Mean	Std. Dev.	Min	Max
The total area of land owned	225	8.20	3.20	2	20
The area used for agricultural production	225	7.05	2.50	2	20
The area under crops	225	5.99	2.21	2	15
The area used for the preferred crop	225	3.17	1.27	1	7
The area used for livestock production	225	1.01	0.73	0	4
The area used for tree plants	225	0.57	0.53	0	2
The area allotted for OFSP crop	225	1.32	0.89	0.25	5

Key: Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max-Maximum

4.3.4 Preferred Crops in Migori County

The study observed that most smallholder farmers prefer growing maize, 70.22%, as the region's staple crop. Sugarcane is the second most preferred crop, mainly in Suna East; it is the main cash crop in the area and constitutes 17.78%. Sweet potato was third at 8% popularity in the region, followed by millet, sorghum, cassava and yams, each accounting for 0.089% and finally, vegetables at 0.44% (Table 12). It further showed that Kuria West and Suna East farmers prefer maize at 53.78% and 16.44%, respectively, as the main staple food crop. Suna East registered 11.56% more sugarcane farmers than Kuria West, 6.22%, which could be attributed to a sugarcane factory nearby compared to the latter Sub-County (Table 12). This finding conformed with Makini *et al.* (2018), who opined that maize and sugarcane in Western Kenya are the most preferred crops for food and income.

Table 12: Preferred Crop in Suna East and Kuria West Migori County

Preferred Crop	Sub-County					
	Kuria West		Suna East			
	Frequency	Percent	Frequency	Percent	Total	Percent
Maize	121	53.78	37	16.44	158	70.22
Millet	2	0.01	0	0	2	0.88
Sorghum	2	0.01	0	0	2	0.88
Sweet potato	18	8.00	0	0	18	8.00
Cassava	2	0.88	0	0	2	0.88
Vegetables	1	0.44	0	0	1	0.44
Sugar cane	14	6.22	26	11.56	40	17.78
Yams	1	0.44	1	0.44	2	0.88
Total	161		64		225	100

4.3.5 Land Utilization for Orange Fleshed Sweet potatoes

The study findings showed that 75.56% of farmers mono-cropped OFSP, whereas 24.44% intercropped it with other crops (Table 13). The reasons were small land holdings, lack of full control over land and the preferred crop influence. This finding was consistent with Low *et al.* (2020), who reported that cropping systems affect output and understanding management practices for sustainable production in sub-Saharan Africa.

Table 13: Cropping System for Orange Fleshed Sweet Potatoes in Suna East and Kuria West Sub-Counties in Migori County

Cropping for OFSP production	Frequency.	Percentage
Monocropping	170	75.56
Mixed/Intercropping	55	24.44
Total	225	100

4.4 Land Acquisition, Land Size and Methods of Land Preparation for OFSP Production in Migori County

4.4.1 Land Size and Methods of Land Preparation

The study observed that most households prepared their land using animal-drawn equipment 96.44% owing to small land sizes allocated for OFSP crop production. Respondents also cited a lack of cash to hire tractors for tilling land; only 10.22% of the farmers could access tractors. 5.33% of the smallholder farmers prepared their land manually using jembe and hoes (Table 14). Land operations for OFSP planting involved primary, secondary and ridging. They used animal-drawn implements to make ridges that tractors could not do (Plate 1). Smallholder OFSP farmers who used tractors to

prepare their land owned an average of 3 acres. The smallholder farmers who owned up to an average of 1.35 acres of land used the animal-drawn implement. Finally, farmers who adopted manual methods owned small land with an average of 0.375 acres (Table 14). This study agreed with the results of Nyoro and Jayne (2019) on the trends in regional agricultural productivity in Kenya that most smallholder farmers mainly use manual or animal-drawn implements for land preparation.

Table 14: Land Size and Methods of Land Preparation for OFSP in Suna East and Kuria West Sub-Counties in Migori County

Size and methods of land preparation	Obs	Mean	Std. Dev.	Min	Max
Size of land prepared using the tractor	22	2.98	1.09	1	5
Size of land prepared using animal-drawn	217	1.35	0.87	0.25	5
Size of land prepared manually	12	0.38	0.12	0.25	0.5

Key: Obs-Number of observations Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum

4.4.2 Land Rent Costs

The study revealed that the total amount spent on OFSP-rented land was Kes 55,349. The minimum and maximum amount spent to rent land was Ksh. 7,500, and Ksh. 150,000, respectively. Likewise, smallholder farmers rented out land at Kes 35,000 with a minimum of Kes 15,000 and a maximum of Kes 72,000 (Table 15). This study conformed with Beyene *et al.* (2020) results showing that land is a crucial component of production and that the cost of land affects the adoption of better agricultural inputs and the output of Ethiopian haricot bean growers in the Hadiya area.

Table 15: Land Renting in and Land Renting Out Costs for OFSP Production in Suna East and Kuria West Sub-Counties in Migori County

Land Rent Costs	Obs	Mean	Std. Dev.	Min	Max
Total cost of renting in land	63	55349.21	34614.54	7500	150000
Revenue from land rented out	13	35000	17574.84	15000	72000

Key: Obs- *Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.5 Orange Fleshed Sweet Potato Planting Materials and the Involved Costs in Migori County

4.5.1 Certified Planting Materials and the Cost

The study findings showed that 59.56% of the smallholder farmers did not use certified planting materials as recommended (Table 16). This could have resulted from poor distribution and spread of planting vines, resulting in the use of low-quality second-generation vines from neighbouring farmers by smallholder farmers. The effect of uncertified planting vines distribution was that production was comparatively reduced compared to those who used certified clean planting primary vines from research stations. The finding collaborated with the findings of Jogo *et al.* (2021), suggesting that one of the main causes of the poor acceptance and optimal production of biofortified orange-fleshed sweet potatoes in Mozambique was the shortage and high cost of approved planting materials.

Table 16: Planting Materials and the Cost of OFSP Vines in Suna East and Kuria West Sub-Counties in Migori County

Do you use certified OFSP planting materials?	Frequency	Percentage
No Certified vines	134	59.56
Certified vines	91	40.44
Total	225	100

4.5.2 Quantity and Cost of Certified Vines

Smallholder OFSP farmers used an average quantity of 1805.58, with a minimum of 300 and a maximum of 5000 kilograms of certified vines for planting (Table 17). The findings also revealed that the smallholder farmers spend heavily in meeting the cost of planting materials, which was Ksh. 17748 for the kilograms purchased (Table 17). This high cost of certified vines discouraged many smallholder farmers from using them, resulting in the use of second-generation planting materials. This was in line with research by Hamidah *et al.* (2021) which demonstrated the significance of certified vines in the Lamongan regency's sweet potato farming's economic analysis. Mwangi *et al.* (2022) also compared Kenyan farmers' desire and capacity to multiply sweet potato vines in research that had a similar finding.

Table 17: Quantity and Cost of Certified OFSP Vines in Suna East and Kuria West Sub-Counties in Migori County

Quantity and Cost of Certified Vines	Obs	Mean	Std. Dev.	Min	Max
Quantity of certified vines	91	1805.58	1076.7	300	5000
Total cost of certified vines	91	17748.13	11286.86	3000	60000

Key: Obs-*Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.5.3 Times of Use, Quantity and Cost of Second-Generation Vines and Total Quantity Used.

On average, smallholder farmers could use OFSP second-generation planting vines 3 times subsequently for production (Table 18). Smallholder OFSP farmers used an average total quantity of 2921, 77 minimum and a maximum of 10000 kilograms of secondary planting materials. The results further indicated that a total of Kes 14633 was used in the purchase of these second-generation vines from their neighbours (Table 18). This finding showed that the planting materials cost farmers significant money that might contribute to the overall level of OFSP production. The study was consistent with Kamenya *et al.* (2021), which reported that breeding and genetics for climatic change in Kenya's orphan crops are significantly influenced by the amount and cost of planting inputs.

The survey results also showed that smallholder farmers could use 3561 kilograms of OFSP planting vines (Table 18). The least quantity of planting vines was 77 Kilograms, while the maximum was 10,000 kilograms of OFSP planting vines in the study areas. On average, an individual farmer would spend about Ksh. 21,811, a minimum of Ksh. 385 and a maximum of Ksh. 85000 to purchase OFSP planting vines (Table 18). This finding suggests that most farmers could not afford the high cost of planting materials, leading to a low level of OFSP production. The finding corresponds with Mulongo *et al.* (2021), which indicated that planting materials and other factors constrain and challenge the farmers, preventing them from scaling up OFSP production in Sub-Sahara Africa.

Table 18: Times of Use, Quantity and Cost of Second-Generation OFSP Vines for Planting in Suna East and Kuria West Sub-Counties in Migori County

Second-generation Vines	Obs	Mean	Std. Dev.	Min	Max
Times of 2nd generation vine use	225	2.828	1.00333	0	6
Quantity 2nd generation vines	225	2921.69	2003.09	77	10000
2nd generation cost	225	14633.25	10004.26	385	50000
Total Quantity and Cost of Vines					
Total quantity of planting materials	225	3651.951	2851.126	77	10000
Total cost of planting materials	225	21811.39	19179.99	385	85000

Key: Obs-*Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.6 Labour in OFSP Production in Migori County

The study observed that labour in OFSP production was derived from the family's members and hired labour measured in labour days. On average, the smallholder OFSP farmer utilized family and hired labour for 21 and 10 days, respectively (Table 19). Labour was preferred for establishing OFSP due to the crop's nature and bulkiness. The labour was also dependent on the number of household members, making family labour very reliable within Suna East and Kuria West. This result concurred with Onyalo (2019), who conducted a study about women and agriculture in rural Kenya and reported that women were mainly used in farm manual labour due to their low hiring labour charges and availability in the rural setups.

Table 19: Labour Days in Production of OFSP in Suna East and Kuria West Sub-Counties in Migori County

Variable	Obs	Mean	Std. Dev.	Min	Max
Family Labour Days	225	21.2667	11.7074	0	73
Hired Labour Days	225	10.08	11.3087	0	71

Key: Obs-*Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.7 Other Inputs Used for OFSP Production in Migori County

4.7.1 Fertilizer and Manure used in OFSP Production

The study findings showed that 96.44% of the smallholder farmers applied manure for OFSP nutrition purposes compared to inorganic fertilizers (5.33%) (Table 20). This could be attributed to the high cost of inorganic fertilizers compared to the organic manure types, including the farmers' perception that the crop's nature does not require much nutrition. Although smallholder farmers applied manure, the types of manure

used varied greatly. The variation in the type of manure was due to the costs involved in the preparation and acquisition. Further, the availability and the farmers' belief in the traditional way of producing sweet potatoes were among the reasons for the variations. Most farmers reasoned that OFSP, like traditional sweet potatoes, does not require any form of fertilizer or manure during production. They also reasoned that manure application would negatively affect the tuber's size, resulting in low yields. Therefore, smallholder farmers used plant remains from previous crops 56.22% at the expense of farmyard manures 48.39% (Table 20). These results concurred with the findings of Makini *et al.* (2018), which similarly reported a low application of inorganic fertilizer as an innovation strategy in sweet potato production in Kenya. In both studies, farmers felt that inorganic fertilizer application negatively affected production. Similarly, another study conducted by Hlisnikovský *et al.* (2021) reiterated the effect of mineral fertilizers and farmyard manure on potato yield and chemical parameters of the soil.

Table 20: Fertilizer and Manure used for OFSP Production in Suna East and Kuria West Sub-Counties in Migori County

Fertilizer Type	Frequency	Percentage of responses	Percentage of cases
Planting fertilizer	12	5.24	5.33
Manure	217	94.76	96.44
Total	229	100	101.78
Manure Type			
Compost	2	0.87	0.92
Animal	105	45.85	48.39
Plant remains, manure	122	53.28	56.22
Total	229	100	105.53

4.7.2 Other Agrochemicals and Costs Involved

The survey result showed that a few smallholder farmers in OFSP farms used an average of 11.6 litres of fungicides and herbicides. It further indicated that the cost of purchasing fungicides and herbicides by the smallholder farmers was Kes. 6205 (Table 21). This finding was consistent with Okeyo *et al.* (2020), which indicated low usage of farm agrochemicals among the smallholder farmers for crop production in the Western parts of Kenya, mainly due to perceptions and low levels of education. The result, however, contradicted the study by Mairura *et al.* (2021), research that showed how the use of agrochemicals raised farmers' views of climatic variability and tactics

for adaptation in Kenya's Central Highlands, while agrochemicals also decreased farmers' production costs.

Most smallholder farmers harvested OFSP after five (5) months. This was because most of them were using second-generation planting materials other than the certified seeds, causing the delay in maturity. In addition, the smallholder farmers did not know indicators to confirm when the OFSP was ready for harvesting, contributing to the delayed harvesting, deterioration and infestation by pests while the crops were in the field. This finding was contrary to Girard *et al.* (2021), who cited OFSP farming as a strategy for achieving health and food security at a timely scale of three months to harvesting in Sub-Saharan Africa.

Table 21: Use of Other Agrochemicals in OFSP Production in Suna East and Kuria West Sub-Counties in Migori County

Use of Agrochemicals	Obs	Mean	Std. Dev.	Min	Max
Quantity of agrochemicals	22	11.682	6.275	2	30
Cost of agrochemicals	22	6204.545	3365.296	2000	15000
Period till harvesting					
Period till harvesting	225	0.446	0.073	0.25	1

Key: Obs-*Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.8 Orange Fleshed Sweet Potatoes Marketing in Migori County

4.8.1 Choices of Marketing Channels, Buyers, Market Place and Mode of Transport

The study showed that 65.78% of smallholder farmers chose to sell their produce through intermediaries, which was the main choice of marketing channel (Table 22). Factors cited for this marketing choice included lack of efficient storage facilities for quantity produced, distance to market, market assurance, immediate cash payment, less costly, competition from other sweet potato varieties, and the concentration of the producers within the study areas. Smallholder farmers also used the dual marketing channel (25.33%) to dispose of the rejected oversized produce by the intermediaries who mainly preferred only medium-sized. There was also 10.48% direct selling, common with the farmers who produced OFSP in very small pieces of land (Table 22). This finding is consistent with Mugenzi (2021), study in the Rwandan districts of Musanze and Nyabihu, assessing the variables influencing the market outlets chosen by

smallholder potato growers. The author found that farmers used various marketing outlets to sell their produce, given different tastes and preferences.

The main buyers of the OFSP produced through these marketing channels were the middlemen, 90.67%, consumers 33.78% and traders/other buyers constituted about 3.56% of the market (Table 22). This was due to farmers' marketing constraints and the region's choices and preferences. The study also observed that 91.11% sold OFSP output at farm gates, local markets at 32.44%, urban markets at 13.33%, schools at 6.67% and the research institute at 0.44%. The preferred marketing channel choice was attributed to the farmer's inefficiencies in transportation modes, distance to the market, and the costs involved in transporting the produce. It further showed that the modes of transportation used by the OFSP farmers to deliver the produce to the market places were mostly through motorcycles at 66.67%, on foot at 12%, cars or vans and pick-ups at 1.78%, buyers' mode of transport at 19.11% and other transport modes at 5.57%. From this study findings, place of marketing, buyers and mode of transport affect the choice of marketing channel. These results were consistent with those of Ngenoh *et al.* (2020), who reported that marketing strategies among cassava microenterprises in Kenya depend on factors ranging from market awareness, distance, market participants and the cost of transportation.

Table 22: Choices of Marketing Channels, Buyers, Market Place and Mode of Transport for OFSP in Suna East and Kuria West Sub-Counties in Migori County

Marketing Channel	Frequency	Percentage of responses	Percentage of cases
Direct selling	24	10.48	10.67
Intermediaries	148	64.63	65.78
Dual selling	57	24.89	25.33
Total	229	100	101.78
The Buyers			
Middlemen	204	70.83	90.67
Wholesaler/traders	2	0.69	0.89
Other buyers	6	2.08	2.67
Consumer	76	26.39	33.78
Total	288	100	128
Market Place			
Farm gate	205	63.27	91.11
Local/open-air market	73	22.53	32.44
Urban market	30	9.26	13.33
Schools	15	4.63	6.67
Research institutions	1	0.31	0.44
Total	324	100	144
Transport Mode			
On foot	27	11.39	12
motorcycle	150	63.29	66.67
car, pick-up or van	4	1.69	1.78
buyer transports	43	18.14	19.11
Other, please specify	13	5.49	5.78
Total	237	100	105.33

4.8.2 Distance and Number of Trips to the Market

The average distance to the urban market from the farms was 15.59 kilometers, the closest was two (2) kilometers and the furthest was 32 kilometers away (Table 23). The long distances to the markets affected the ease of access by the smallholder OFSP farmers, which resulted in using available marketing channels, thus attracting low profits. With this aspect in mind, it can be deduced that farmers suffered exploitation, which could have reduced motivation for continued OFSP production. The number of visits to the market by an individual smallholder farmer was six times per season, affecting their marketing channel choice. This finding is consistent with Demisse *et al.* (2022), who reported market distance as a significant factor while analyzing market participation for potatoes, market outlet choice and small farm households in Lemo Southern Ethiopia.

Table 23: Trips and Distance to the Market for OFSP Sale in Suna East and Kuria West Sub-Counties in Migori County

Distance and Visits to Market	Obs	Mean	Std. Dev.	Min	Max
Market distance from the farm	225	15.59	9.33	2	32
Times of visits to the markets	225	6.009	1.83	1	7

Key: Obs-*Number of observations, Mean- Average mean, Std. Dev-Standard Deviation, Min- Minimum and Max- Maximum*

4.8.3 Market Assurance for OFSP Produce

Most smallholder OFSP farmers, 88%, had no assurance for their OFSP product marketing (Table 24). Lack of assurance of efficient and constant markets can result in low production, discouraging producers. These findings agreed with the report of Anthony *et al.* (2020), who found out that market assurance determines the smallholder maize farmers' decision on the selling point to avoid production losses in Kwanza District, Trans-Nzoia County, Kenya.

Table 24: Market Assurance for OFSP Produce in Suna East and Kuria West Sub-Counties in Migori County

Market Assurance	Frequency	Percentage
No	198	88
Yes	27	12
Total	225	100

4.8.4 Farmer Access to OFSP Training Services

The proportion of farmers with access to training was 27.11% compared to those with no access, who were the majority at 72.89% (Table 25). Smallholder farmers who accessed training had better knowledge of OFSP production and value addition, thereby minimizing losses incurred during the production and turning the produce into other valuable forms like; flour for making *chapatis, mandazis* (local pastries), doughnuts, crips and chips. Low training access resulted in inefficient marketing channel choice because untrained farmers did not know how to add value to OFSP produce. This was consistent with the findings by Mbembe (2020), who found that access to proper training determined market participation for the soy bean smallholder farmers in Kakamega County, Kenya.

Table 25: Access to Training Services for OFSP Farmers in Suna East and Kuria West Sub-Counties in Migori County

Training in the last five year	Frequency.	Percentage
No	164	72.89
Yes	61	27.11
Total	225	100

4.8.5 Access to Extension Services by OFSP Farmers

The smallholder OFSP farmers had no proper access to extension services; this was evident from their main reliance on other fellow farmers for information 58.84%, agricultural officers 36.54%, field days 1.15%, local agro vets 0.77% and other channels 2.69% (Table 26). Improper extension access translates to low production and poor marketing of the OFSP produce.

In ideal scenarios, extension agents can connect farmers to the existing valuable marketing information, which was not the case in the current study results. The results of this research were in line with those of McEwan *et al.* (2022), who found that dryland African sweet potato farmers may get planting material more easily by having access to extension services.

Table 26: Access to Extension Services by OFSP Farmers in Suna East and Kuria West Sub-Counties in Migori County

Where access Extension services	Frequency	Percentage of responses	Percentage of cases
Agricultural officer	95	36.54	42.22
Other farmer(s)	153	58.84	68.00
Local agro vet	2	0.77	0.89
Field day	3	1.15	1.33
Others	7	2.69	3.11
Total	260	100	115.56

4.8.6 Credit Access, Purpose and Group Opportunities

The study observed that most OFSP smallholder farmers had no access to credit (90.67%) and farmers with access to credit were few (9.33%) (Table 27). This was attributed to a lack of information, low extension services and a lack of title deeds to act as the security to facilitate credit access. Of smallholder farmers who received

credits, only 61.9% used it for OFSP production purposes, and 38.1% used the acquired credit for other purposes.

A similar study by Onwusiribe et al. (2021) reported that access to credit affects the commercialization of OFSP and food security of the producing household in Benue State, Nigeria, consistent with this current study. The study also showed that the smallholders aware of the group funding opportunities were 24.44%, while those unaware were 75.56%. This low awareness of group funding opportunities might have affected the credit access level.

Therefore, most smallholder farmers could not meet their farms' financial needs, leading to low production levels and poor choice of marketing channels. The findings of this research are consistent with those of Okello (2019), who discovered that one of the main obstacles to an enlarged and sustainable orange fleshed sweet potato value chain in Kenya was credit availability.

Table 27: Credit Access, Purpose and Group Opportunities for OFSP Farmers in Suna East and Kuria West Sub-Counties in Migori County

Access to Credit	Frequency	Percentage
No Access to credit	204	90.67
Access credit	21	9.33
Total	225	100
Credit on OFSP Purposes		
Used for other purposes	8	38.1
Used for OFSP production	13	61.9
Total	21	100
Awareness of Group Funding Opportunities		
Not Aware	170	75.56
Aware	55	24.44
Total	225	100

4.9 Econometric Results on the Technical Efficiency of OFSP in Migori County

The study employed the two-step method to derive maximum likelihood estimates using STATA version 15. The inefficiency and stochastic frontier model parameters were computed concurrently to avoid biased estimations.

4.9.1 Diagnostic Test Statistics Results

The maximum likelihood estimate approach was first used to execute the stochastic production model with the aid of the frontier computer program (Appendix V). Before estimating the model, the underlying assumptions of the stochastic frontier technique were verified. The variance inflation factor (VIF) and contingency coefficient (CC) were used to test for multicollinearity between the continuous and categorical explanatory variables. Just like Abate *et al*. (2019), the values of the VIF and CC for every variable included in this model were below 10 and 0.75, respectively, indicating no substantial problem with multicollinearity among the explanatory variables.

Secondly, the assumption that Cobb-Douglas is rigid, whereas Translog is flexible based on the maximum likelihood ratio test led to identifying a suitable functional form between the Translog and Cobb-Douglas production functions (Mwalupaso *et al.*, 2019). The null hypothesis (H0) was that not all interaction and square terms are larger than zero, and the alternative hypothesis (H1) was that the coefficients are bigger than zero, in order to choose between the two possible alternative functional forms that may reflect the collected data. The likelihood ratio statistic was calculated using the following formula;

$$\mathrm{LR} = -2[\mathrm{L(H0)} - \mathrm{L(H1)}] = -2\{-145.660 - (-110.535)\} = 70.25 \ldots\ldots\ldots (11)$$

Thirdly, the distribution was predicted with a 95% confidence level, and the crucial chi-square value was 2.705. (Appendix V; from Kodde and Palm, 1986). The null hypothesis could not be accepted as the calculated likelihood ratio value of (70.25) was less than the crucial threshold (Appendix V). There is evidence to show that the data on smallholder OFSP farmers who lacked technical efficiency was accurately reflected by the Translog production function.

The fourth test looked for technical inefficiency after establishing the proper production function. The null hypothesis stated there was no room for efficiency improvement among smallholder OFSP producers (H0=γ=0). The alternative hypothesis was that the research area's smallholder OFSP farmers lacked efficiency (H1= γ>0). The gamma parameter, $\gamma = \partial u^2 / (\partial u^2 + \partial v^2)$, ranges from 0 to 1.

If gamma equals zero, errors account for the discrepancy between observed farmer productivity and projected maximum production. Inefficiency, however, considerably impacts the production system if the value is close to one (Hung *et al.,* 2019). This investigation did not accept the null hypothesis since the gamma value was more than zero (0.0056>0) (Table 28). As a result, there was technical inefficiency in the production of OFSP in Migori County. Frontier sigma squared was calculated to be 0.9944, and gamma (γ) was determined to be 0.0056. The estimated values differed significantly from zero, showing that the assumptions for the composite error term were correct (Benedetti *et al.,* 2019).

While examining the impact of land fragmentation on maize farmers' technical efficiency, according to Mwalupaso *et al.* (2019), the gamma and sigma squared values showed consistent findings. Furthermore, they pointed out that the flexibility of the Translog functional form for multiple input models and its capacity to control multicollinearity and correlation made it superior to the Cobb-Douglas functional form.

Table 28: Frontier Stochastic for Technical Efficiency Level on OFSP Production in Suna East and Kuria West Sub-Counties Migori County

logY Frontier	Coefficient.	Standard error	P>z-Statistics
Log of Land	0.479***	0.069	0.000
Log of other Agrochemicals	0.055	0.047	0.243
Log of Planting materials	0.065*	0.037	0.074
Log of Fertilizer	0.038	0.025	0.138
Log of Manure	0.015	0.020	0.472
Log of Family labour days	0.009	0.038	0.813
Log of Hired labour days	0.074**	0.035	0.037
_cons	2.581	0.316	0.000
Inefficiency			
Gender	0.274***	0.092	0.003
Years farming experience	-0.03***	0.007	0.000
Years of education	0.004	0.013	0.760
Household size	-0.029**	0.015	0.047
Land title deed	0.111	0.070	0.110
Market distance	0.011***	0.004	0.002
Market assurance	0.135	0.119	0.255
Access training	-0.347*	0.191	0.068
Group membership	-0.091	0.110	0.409
Credit access	-0.076	0.373	0.839
Contacts to Extension service	-0.092*	0.054	0.085
_cons	0.400	0.178	0.025
Usigma			
_cons	-7.333	3.856	0.057
Vsigma			
_cons	-1.853	0.095	0.000
sigma_u	0.026	0.049	0.604
sigma_v	0.396	0.019	0.000
Lambda	0.066	0.054	0.232

**** Represents levels of significance at 1% ** Represents levels of significance at 5%* Represents levels of significance at 10%, Coef. -coefficient, Std. Err. - standard error, z- Z-statistics*

Log likelihood = -110.535Number of Observation = 225

Wald chi2(6) = 250.50Prob > chi2 = 0.0000

4.9.2 Determining the Level of Technical Efficiency on Orange fleshed Sweet Potato Production in Suna East and Kuria West Sub-Counties of Migori County

Based on the mean technical efficiency of OFSP farmers, which was found to be 78.07 %, there is still an opportunity to increase the output of OFSP by 21.93 %, given a specific level of input application (Table 29). The lowest efficiency score was 36.98 %, and the highest efficiency value was 99.93%. The maximum-likelihood estimate of the

frontier model from Belete (2020) in a prior study conducted in the Guji zone of Ethiopia revealed that, on average, maize farmers were 69% technically efficient. This suggests that 31% of maize production was not realized, supporting the evidence that the current model was adequate. As a result, it has been discovered that the current study's results corresponded to other studies in other areas showing the level of technical efficiency on crop production.

Table 29: Level of Technical Efficiency in OFSP Production in Suna East and Kuria West Sub-Counties Migori County

Variable	Obs	Mean	Std. Dev.	Min	Max
Technical Efficiency Level	225	0.7807	0.1921	0.360	0.9993

The study observed that many smallholder farmers exhibited efficiency in their production of OFSP. It was noted that most farmers operated at or above (70%) efficiency, while 40.89% of the sampled households had an efficiency level below 70% yet were still considered relatively efficient on average (Table 30). This indicates room for improvement for those operating below efficiency levels, either by increasing their productivity or reducing input costs while maintaining the production level. To achieve this, policy strategies should promote efficient utilization of existing inputs and technologies and provide support and resources to enhance farmers' capacity to utilize these inputs efficiently.

The study results further showed the quantities of OFSP harvested at each level of technical efficiency with an average production of 20.9 tonnes per acre, translating to about 8.453 tonnes per hectare (Table 30). This was in line with the findings of Owade *et al.* (2018), who found that the output of OFSP farmers falls short of their potential in their investigation on the production, application, and health advantages of pureed OFSP.

Table 30: Distribution of Technical Efficiency Level in Suna East and Kuria West Sub-Counties in Migori County

TE Distribution	Frequency	Percentage	Mean Quantity Harvested T/Acre	Mean Quantity Harvested T/Ha
0.300	1.000	0.440	6.000	2.428
0.400	14.000	6.220	14.214	5.751
0.500	42.000	18.670	13.595	5.500
0.600	35.000	15.560	19.200	7.768
0.700	27.000	12.000	19.352	7.830
0.800	17.000	7.560	24.941	10.091
0.900	89.000	39.560	42.944	17.375
	225	100.000	20.900 (Av)	8.453(Av)

Key: TE-Technical efficiency, Av-Average, T/Acre- Tonnes per acre, T/Ha- Tonnes per Hectare

4.9.3 Determining the Effects of Inputs on the Technical Efficiency of OFSP Farmers in Suna East and Kuria West Sub-Counties of Migori County

The model computed seven input variables, out of which land size, planting materials and hired labour had a significant effect on the production of OFSP at 10%, 5% and 1% levels of significance (p-value= 0.000<0.01) land, (p-value=0.074<0.1) planting materials and hired labour (p-value =0.037<0.05) (Table 31). All the coefficients for land, planting materials and hired labour variables were positive. The area of land used for OFSP production was used as the unit of measurement. Production would be increased by a factor of 0.479 for every unit increase in the area of land allotted to OFSP farming. This suggests that if farmers increased the quantity of the land planted with the OFSP, production would most likely increase. Belete's (2020) findings regarding the importance and beneficial effect of land area on the output of maize and production were consistent with the current study on OFSP production in Migori County.

The planting material variable on OFSP production was highly significant for this study, with a positive coefficient of 0.0652. This implies that the production of OFSP increases by 0.0652-fold when the usage of clean certified vines is increased. This result is in line with that of Asfaw *et al.* (2019), who discovered that a significant improvement in wheat productivity was achieved by using more certified seeds from the Kenya Seeds Company. Using certified and clean vines increases OFSP performance and improves yield. A farmer using clean, high-quality vines will get more yields from improved, pest-free, disease-free, and fast-growing OFSPs.

The number of man-days engaged in the production process and the productivity of the OFSP were directly correlated, as shown by the positive coefficient and significance of hired labor at the 5% significance level. Given the coefficient of the number of plots used for OFSP cultivation, a one-unit increase in the number of hired man days dedicated to the OFSP production process would generate a 0.0737 increase in the OFSP yield produced. An increase in labour translates to an increase in the farm's productivity and therefore, smallholder OFSP farmers who had access to hired labour were more technically efficient. This could be attributed to the fact that such farmers could conduct the management practices in time without hindrances.

The current results agree with those of Siagian *et al.* (2021), who found a positive correlation between the labour input factor and the production of corn in Banten province. However, the use of other agrochemicals, family labour, fertilizer and manure had an insignificant impact on the production of OFSP. One method to express the stochastic production frontier is as follows:

Table 31: Frontier Stochastic Parameter Model Estimates for OFSP Production in Suna East and Kuria West Sub-Counties in Migori County

logY	Coefficient	Standard error	P>z-Statistics
Frontier			
Log of Land	0.479***	0.069	0.000
Log of other Agrochemicals	0.055	0.047	0.243
Log of Planting materials	0.065*	0.037	0.074
Log of Fertilizer	0.038	0.025	0.138
Log of Manure	0.015	0.020	0.472
Log of Family labour days	0.009	0.038	0.813
Log of Hired labour days	0.074**	0.035	0.037
_cons	2.581	0.316	0.000

**** Represents levels of significance at 1% ** Represents levels of significance at 5%* Represents levels of significance at 10%, Coef. -coefficient, Std. Err. - standard error, z- Z-statistics*

4.9.4 Analyzing the Effect of Farmer Characteristics and Marketing Channel Factors on the Technical Efficiency of OFSP Farmers in Suna East and Kuria West Sub-Counties of Migori County

This study intended to determine whether farmer characteristics and marketing channel factors contribute to the technical efficiency of OFSP production in the Suna East and Kuria West Migori County. Five variables were continuous, while the other six were

categorical variables (Table 32). Finding the technical inefficiency sources for OFSP production helps create interventions and policies to boost present levels of OFSP output. Technical inefficiency falls and technical efficiency levels rise as the independent variable rises, according to a parameter coefficient with a negative sign. A positive parameter coefficient indicates that technical efficiency will decrease when the independent variable increases and technical inefficiency will increase. Therefore, the technical efficiency level of the farms rose with every negative coefficient, and the contrary was also true.

Gender, farming experience, household size, distance to the market, access to training and extension agent visits were significant at the 1%, 5% and 10% significance levels. The p-values of gender, farming experience, household size, distance to the market, access to training and extension visits were p-value= 0.003 <0.01, p-value= 0.000<0.01, p-value= 0.047<0.05, p-value= 0.002<0.01, p-value= 0.068 <0.1 and p-value= 0.085, respectively. The significant exploratory variables (gender, farming experience, household size, distance to the market, access to training and extension visits.

The model output showed that the gender variable had a positive sign, indicating that male farmers place little emphasis on and have a negative impression of OFSP farming. Smallholder male farmers, who make most of the agricultural decisions, did not allocate enough land for the production of OFSP. Male farmers naturally had stronger physical strength than female farmers, but if they had a favourable attitude toward the production of OFSP, more labour might have been generated to increase technical efficiency. According to Francis *et al.* (2020), gender had an adverse effect on the technical efficiency level of sugarcane production in Western Kenya which corresponded with this study.

The farming experience variable was negative and significant at a 5% level. Therefore, more years of farming experience in rural areas where agriculture is the main means of livelihood can signify technical efficiency. The negative coefficient showed that more years of experience reduced the inefficiency of OFSP production. From the result of the study, a unit increase in the farming experience led to a 0.03 increase in the technical efficiency of the OFSP farmers. The current result is similar to the study by Kimaru *et*

al. (2020), which reported a positive effect on farming productivity according to the years of experience in utilizing and adopting Zai pits in drier upper Eastern Kenya. The institutional elements influencing technical efficiency were determined by considering smallholder OFSP farmers' accessibility to extension services. According to the study's inefficiency model, extension services positively impacted OFSP production with a negative sign coefficient.

This study's findings are consistent with those made by Mwangi *et al.* (2020b), who found that tomato farmers in Kirinyaga County, Kenya, benefited greatly from extension services and exhibited technical efficiency. This shows that smallholder OFSP farmers who used extension services were technically efficient and that the more frequently an OFSP farmer visited a provider, the more proficient their production was. The extension agents encourage the OFSP farmers to adopt better technology, value additions, marketing and management methods by employing demonstrations and hands-on learning opportunities. Farmers with access to extension services can consult about the challenges they face during the production of OFSP, which helps them use their inputs more effectively and develop their management and marketing abilities.

The market distance variable was positive, indicating that distance to the market had a negative effect on technical efficiency. A unit increase in the distance to urban markets causes a resulting 0.011 increase in technical inefficiency, leading to low OFSP production. Agriculture in the rural setting is mainly characterized by poor and impassable roads, leading to the high cost of OFSP transport to the market. This study agreed with that of Jindo *et al.* (2020), who opined that distance to the market reduces the morale of farmers in the sustainable intensification of agricultural systems in Western Kenya. Thus, farmers tended to produce crops in small plots of land because they were not near the available markets.

The household size variable significantly affected OFSP technical inefficiency negatively at a 5% significance level. Thus, the variable positively impacted the level of technical efficiency. An increase in the household size by one unit resulted in a relative drop in the technical inefficiency of OFSP production by 0.0291 units, thus increasing the level of technical efficiency. This was attributable to the fact that

increasing the size of the households would positively influence the labour availability for OFSP production, resulting in efficiency and productivity. A study comparable to the current one was reported by Chandio *et al.* (2019) while analyzing the stochastic production frontier approach, where the authors established a positive correlation between household size and technical efficiency in Sindh, Pakistan.

Table 32: Maximum Likelihood Estimates of the Inefficiency Model for OFSP Production in Suna East and Kuria West Sub-Counties in Migori County

	Coefficient	Standard error	P>z-Statistics
Inefficiency			
Gender	0.274***	0.092	0.003
Years of farming experience	-0.03***	0.007	0.000
Years of education	0.004	0.013	0.760
Household size	-0.029**	0.015	0.047
Land title deed	0.111	0.070	0.110
Market distance	0.011***	0.004	0.002
Market assurance	0.135	0.119	0.255
Access to training	-0.347*	0.191	0.068
Group membership	-0.091	0.110	0.409
Credit access	-0.076	0.373	0.839
Contact the extension service	-0.092*	0.054	0.085
_cons	0.400	0.178	0.025

**** Represents levels of significance at 1% ** Represents levels of significance at 5%* Represents levels of significance at 10%, Coef. -coefficient, Std. Err. - standard error, z- Z-statistics*

4.9.5 Factors Influencing the Choices of Marketing Channel for OFSP Yield

Smallholder farmers' various options for marketing outlets to sell their OFSP crops were examined using a multivariate probit model. It was feasible to determine the factors that influenced the marketing channels used for OFSP produce by using the multivariate probit (MVP) model. The multivariate probit model is regarded by statisticians and econometricians as an extension of the model that is used to estimate several associated binary outcomes simultaneously (Mugenzi, 2021). Typically, by adding equations, a multivariate model can be expanded to include more than two outcome variables.

The model results were efficient given the negative likelihood value of -213.73668, likelihood ratio test (rho) of 0 and a Prob > chi2 = 0.0000 (Table 33). The choices of marketing channels identified by the study included direct, selling through intermediaries, and dual marketing. Farmers were more likely to combine various channels to sell their OFSP produce. Several factors can influence OFSP farmers' choice through a given marketing channel.

The characteristics influencing the smallholder OFSP farmers' choice of marketing channel were determined by this research using multivariate probit analysis. There were three dependent variables in the model. The model had fourteen explanatory variables, eight of which were continuous and six of which were dummy. The years of schooling showed a significant positive relationship with OFSP farmers' decision to sell through intermediaries and was insignificant in other marketing channels. This means that farmers with more years of schooling would sell more OFSP produce through intermediaries than other channels to help reduce losses associated with spoilage and lack of storage facilities. According to this finding, farmers are more aware of the advantages of selecting the quickest and most efficient form of marketing channel for OFSP if they have a higher level of education. Educated farmers had good timing with the market demands, which positively influenced their choice of marketing channel. These findings were in line with those of Ehiakpor *et al.* (2021), who discovered that among Ghanaian smallholder farmers, education had a significant role in their adoption of interconnected sustainable agricultural methods.

The insufficient storage facility significantly influenced the choice to sell through intermediaries while influencing dual marketing negatively, whereas it was insignificant to direct marketing choice. This means that inefficient storage facilities stimulated the smallholder farmers' decision to choose intermediaries as they lacked space to store their OFSP produce. On the other hand, farmers who owned storage facilities could also sell through other channels in case of remains to capture more earnings from the sale of OFSP produce. The study result was consistent with Bhanot *et al.* (2021), who inferred that storage facility relieves farmers' distress about marketing challenges in India as they can easily search for better markets with their produce safely in the store.

The OFSP product grading negatively affected smallholders' choice to sell the produce directly to the market, while it was insignificant in the other marketing channel choices. This means that with proper grading of the produce, farmers would not opt for direct selling. Well-graded products attract better market prices and increase farmers' chances of earning more profits. Grading comprises cleaning, sorting and washing, making OFSP produce to attract far markets, making direct marketing channels inappropriate. This research supported the findings of Melese *et al.* (2018), who found that smallholder onion growers in Ethiopia's Amhara Region's Fogera area choose their outlets based in large part on grade.

Market distance negatively affected smallholders' choice of selling directly and dual marketing, while it favored using intermediaries. This means that an increase in the distance to the market discourages smallholder farmers' choice of selling directly or even using dual marketing channels but chooses to sell through the intermediaries. Long market distances characterized by high transport costs and produce deterioration, such as breakages during transportation, lead to low prices for the commodity. The findings correspond to Mbembe (2020), who showed distance as a determinant of soybean farmers market choice in Kakamega County, Kenya.Group membership showed a positive significant impact on the dual marketing channel choice.

Further, group membership was insignificant in the direct selling and intermediary channels of marketing OFSP produce in the study areas. This means that group membership or awareness influences the OFSP smallholder farmers' decision to sell their produce through dual marketing channels other than through intermediaries. This was attributed to the fact that through groups, smallholder farmers acquire more information about other available and better channels to market their produce and access funds to facilitate their marketing capabilities.

The results are consistent with Anthony *et al.* (2021), who suggested that in Kwanza District, Trans-Nzoia County, Kenya, smallholder maize farmers' choice of selling point was significantly influenced by group participation and awareness. Extension visits positively and significantly affected smallholder farmers' choice of selling through dual marketing and impacted selling through intermediaries negatively and

insignificantly for the direct marketing channels. This means that the more the smallholder farmers visit the extension agent, the more they choose to sell their produce through a dual marketing channel. The more farmers visit the extension agents, the more they avoid selling their OFSP through intermediary marketing channels.

These results were attributed to the fact that training from extension agents to carry out value additions of the produce (chapatis, mandazis, among other products) can help capture higher income than the intermediaries' type of marketing. This helps mitigate risks associated with a lack of market or low prices from one marketing channel. The present results are in contrast to the research of Mbembe (2020), which found no link between smallholder soybean farmers in Kenya's Kakamega County's market participation and their access to extension services. The cost of harvesting equipment was positive and significant only with the choice to use dual marketing channels; other marketing channels were insignificant.

The increase in expenses on harvesting equipment influenced the smallholder OFSP farmers to choose to sell through dual marketing channels. The choice of marketing channels for farmers in India was strongly and favorably influenced by relevant marketing costs, which involved purchasing packaging materials, following Oehrtman and Schnake's (2021) study, which corresponded with this study. The age of the decision maker had a significant and positive impact on the dual marketing channel choice. The age also negatively affected the choice to sell through the intermediaries, but it was insignificant for direct marketing channel choice.

Age is a priori of farming experience; therefore, an increase in the age of the OFSP farmer translates to farming experience. An increase in the age of the decision maker increases the chances of farmers using mixed marketing channels. This was attributed to the experience gained not to rely on a single form of marketing channel to avoid losses from rejected sizes by the middlemen. The nature of the brokers and middlemen within the study area was a preference for the medium sizes packaged in 120 kg bags, leaving behind the small and large sized products with the farmers. Experience and age seemed to have enlightened the smallholder farmers to use dual channels to avoid such losses.

The findings correspond to Anthony *et al.* (2021), who indicated that experience and awareness were significant factors affecting the smallholder maize farmers' selling point choice in Trans-Nzoia County, Kenya.

The market assurance variable was only significant for the intermediaries' channel and was insignificant in other marketing choices. This means that marketing assurance increases a farmer's choice to use an intermediary form of marketing. This was because many intermediaries were involved in the marketing channel with means to transport the OFSP product efficiently. This impacted the assurance of most farmers to use the intermediary's choice to curb the inefficiencies associated with produce marketing. The current results agreed with Oehrtman and Schnake (2021), who reported that other costs and risks strongly and favorably influenced the choice of marketing channels for farmers in India in production.

Table 33: Multivariate Probit Model Output Showing Factors Affecting the Choices of Marketing Channel for OFSP Produce in Suna East and Kuria West Migori County

	Direct Selling		Intermediaries Selling		Dual Selling	
Covariate	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Gender	-0.521	0.390	0.168	0.276	0.010	0.274
Age_decmaker	0.028	0.024	-0.029*	0.015	0.028*	0.016
Yrsofsp	0.021	0.031	-0.016	0.021	-0.004	0.020
Yrsedu	0.011	0.080	0.084*	0.050	-0.072	0.050
Logcaostcost	-0.139**	0.055	0.030	0.048	0.145***	0.049
Storage	0.069	0.434	1.001***	0.268	-1.203***	0.281
Grading	-0.727*	0.400	0.169	0.291	0.316	0.294
Ofspwashing	-0.474	2.123	-0.554	1.944	0.000	0.958
Marketdistance	-0.078***	0.020	0.083***	0.013	-0.054***	0.013
Mktassurance	-0.700	0.533	0.571*	0.331	0.009	0.319
Conextveg	0.051	0.139	-0.284**	0.124	0.208**	0.100
Groupfun	-0.707	0.565	-0.495	0.330	0.614**	0.308
_cons	-0.078	2.658	0.459	2.211	-2.066	1.479

**** Represents levels of significance at 1% ** Represents levels of significance at 5%* Represents levels of significance at 10%, Coef. -coefficient, Std. Err. - standard error, Conextveg-contact to extension, Groupfun-group membership, Yrsedu-years of education, Yrsofsp-Years of farming experience, Logcaostcost-log of harvesting materials cost*

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

This research examined the influence of farm inputs, farmer characteristics, and marketing channels on the technical efficiency of OFSP production in the Kuria West and Suna East Sub Counties of Migori County, Kenya. The study used a descriptive research approach to collect cross-sectional data. The design appropriately described the agricultural inputs, institutional settings and farmer characteristics of the OFSP smallholder farmers. A cluster random sampling approach was utilized to choose 225 smallholder OFSP farmers, and a questionnaire instrument was employed to gather data from them. Using a translog production functional form under the stochastic frontier model, data was examined in two steps. From the result, there was a 78.07% level of technical efficiency of OFSP production in Suna East and Kuria West Sub Counties, Migori County, which translates to an inefficiency level of 21.93%.

Orange fleshed sweet potato smallholder farmers in Suna East and Kuria West Sub Counties were mainly household male decision-makers who seemed to have paid little attention to this crop, which could affect the level of OFSP technical efficiency of production. Smallholder farmers also viewed the crop as a female-oriented crop, which also caused a negative effect on production. The smallholder farmers mainly used manure input such as crop residues, which did not markedly improve production levels. Inputs such as land, hired labour and recommended clean planting materials also significantly affected the technical efficiency as more of these inputs improved OFSP production levels. Therefore, using the land allocated for OFSP effectively, use of clean planting materials and hiring labour could result in increased OFSP production. This answered the research question about the effects of inputs on the technical efficiency of the smallholder OFSP farmers in the Suna East and Kuria West Sub-Counties of Migori County.

Farmer characteristics are attributable to weak institutions for information sourcing among the OFSP smallholder farmers, as well as low levels of schooling and lack of land ownership through title deeds. Years of experience in farming and increasing household size of the smallholder farmers positively affected technical efficiency as

these variables led to decreased inefficiency of the OFSP production. This was mostly through a better understanding of farming practices, market choices, and the provision of cheaper labour from the family unit. This answered the third research question on the effects of farmer characteristics on the technical efficiency of OFSP farmers in the Suna East and Kuria West Sub-Counties of Migori County.

Marketing-related factors also influenced the level of technical efficiency. For instance, distance to the markets increased the level of inefficiencies, hence affecting the technical efficiency level. Acquisition of training and extension services, directly connected to marketing, positively affected the smallholder OFSP farmers' technical efficiency by reducing production inefficiencies. Factors that impacted the smallholder decisions to choose a given marketing channel were years of schooling, presence of storage facilities, grading of the produce, distance to the markets, age of decision maker, market assurance, extension visits, group membership and cost of the harvesting equipment. Years of schooling positively affected selling through dual channels and negatively impacted intermediary marketing. The lack of storage facilities also impacted the farmers' decision to sell through intermediaries and negatively on the dual marketing channel. Grading of the produce negatively impacted direct selling and was insignificant to other marketing choices. Smallholder visits to the extension agent significantly impacted both dual and direct marketing channels positively and negatively. Distance to the markets encouraged farmers to sell through intermediaries and significantly discouraged dual and direct marketing channels. Group membership and marketing assurance were significant to the dual and intermediaries' marketing channels, respectively. The decision maker's age significantly affected dual and intermediary marketing channels but was insignificant to direct marketing channels. These answered the research question about the effects of choice of marketing channels on orange-fleshed sweet potato technical efficiency in the Suna East and Kuria West Sub-Counties of Migori County.

5.2 Conclusions of the Study

The following conclusions were reached in light of the study's findings:

i. The overall level of technical efficiency of OFSP production in Suna East and Kuria West Sub counties was found to be 78.07 %; this would translate to about 23.93 % level of inefficiency based on the findings of this study.

ii. A high level of technical efficiency on OFSP production can be realized by increasing the acres of the land under production, hiring and using more labour in the farms as well as using more certified and quality vines as these were the significant input factors.

iii. Farmer characteristics factors contribute immensely to the technical efficiency level of OFSP smallholder farmers. Gender, years of experience and household were found to be significant in this study.

iv. The choice of OFSP marketing channel used by the smallholder farmer was influenced by years of schooling, storage facilities, grading, distance to the markets, age of decision maker, market assurance, extension visits, group membership and cost of the harvesting materials. Marketing channel factors like market distance, access to training and contact to extension service significantly affected the level of smallholder OFSP farmer's technical efficiency.

5.3 Recommendations

i. Orange fleshed sweet potato Smallholder farmers are encouraged to employ more of the inputs such as land, clean planting vines and hired labour to increase OFSP production.

ii. Orange fleshed sweet potato farmers should contact the extension agents to increase production and acquire training and knowledge on OFSP marketing for more returns on the venture.

iii. Policymakers within the county and national levels should develop policies to encourage the use of certified planting vines for the OFSP to increase production and to produce more viable and faster-growing OFSP planting vines.

iv. Orange fleshed sweet potato farmers are encouraged to form farmer groups to increase productivity, information or knowledge sharing and access group credits to improve marketing and production.

5.4 Suggestions for Further Research

i. This study focused on analyzing marketing channels, inputs and credit access on the technical efficiency of OFSP production. However, given that the level of technical efficiency was slightly above the optimum level of (75%), there is a need to understand the effect of OFSP value chain analysis to reveal opportunities for increased income and role as a food security crop in Kenya.

ii. Based on the current actual OFSP output, there is a need to analyze how the use of technology can impact smallholder farmers' ability for potential output of OFSP production.

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APPENDICES

Appendix I: Survey Questionnaire

Serial Number ☐

Date of Interview……

Part A. Geographic Location Information

1 County……

2 Sub County ……

3 Ward……...

4 Place residence 1= Urban [ ] 2= Peri-Urban [ ] 3= Rural [ ]

Part B. Demographic Information

5. Are you the household head?1= Yes [ ] 2= No [ ]
6. Relationship with the household head?……...
7. Who makes the household farming decisions?……...
8. Gender of household decision maker 1= Male [ ] 2= Female [ ]
9. Age of the main decision maker?……...
10. Marital Status of the respondent
    a) = Married [ ]
    b) = Single [ ]
    c) = Separated [ ]
    d) = Widowed [ ]
11. Number of household dependent ……...
12. What is the Education level of the respondent?
    a) = No formal education [ ]
    b) = Incomplete primary education [ ]
    c) = Complete primary education [ ]
    d) = Incomplete secondary education [ ]
    e) = Complete secondary education [ ]
    f) = University / College [ ]
    g) = Adult education [ ]
    h) = Others (specify)
13. Years in education……...

14. Main occupation of the decision maker?
    a) Student
    b) Self-employed
    c) Private sector employment
    d) Public sector employment
    e) Casual worker
    f) Farming
    g) Unemployed
    h) Others specify……...

15. How many people have lived in your household for at least six months during the last 12 months?……...

16. Of these people, how many earn an income?……...

17. In your household, how many dependents are over 18 years old?……..

18. In your household, how many children fall between 6 to 18 years old?……

Part C. Input Factors

A. Land

19. Total land owned [ ] acres

20. What is the form of ownership?
    a) 1= Own/Bought [ ]
    b) 2= Leased [ ]
    c) 3= Inherited[ ]
    d) 4= Others [ ]

21. Do you have a title deed for any parcel of land? 1= Yes [ ] 2= No [ ]

What is the size of total land owned by households?……

What is the total area of all the land used for OFSP purposes?……

What is the total area allotted for other crop production?……

22. Total land size rented in [ ] Rented out[] None [ ]

23. Do you grow OFSP? 1= Yes [ ] 2= No [ ]

24. If yes, how many years have you been in OFSP production? [ ] Years

25. Land under OFSP [ ]acres

B. Planting materials

26. What quantity of planting materials do you use? In (Kgs) ……

27. Where do you source them from?

    a) Neighboring farmer [ ]
    b) Ministry of Agriculture [ ]
    c) Donations from research institutions [ ]
    d) Other (specify) .....

    Reason(s) for the answers above?.....

28. How do you rate the quality of these planting materials

    a) 1=Poor [ ]
    b) 2= Fair[ ]
    c) 3=Good[ ]
    d) 4= very Good[ ]
    e) 5= excellent[ ]

29. Are the sources listed above reliable?.....

30. How are these OFSP planting materials packaged while sourcing them?.....

31. How much do you use to buy a kilo of OFSP planting materials?.....

C. Labour

32. Total number of labourers in the farm [ ]

33. Number of labour in OFSP production [ ]

34. Of these labourers, how many are males?

35. Of these labourers, how many are females?

36. What is the labour source for OFSP production on your farm?

    a) 1=Family labour
    b) 2= Temporary/hired
    c) 3= Permanent
    d) 4= Others specify……

    Give reason?.....

37. How many labours do you employ for land preparation in OFSP production?……

38. How many labours do you employ for routine management practices in OFSP production?……

39. How many labours do you employ forlabour in OFSP harvesting?……

40. Number of working hours……

41. Labour frequency of payment

a) 1=Hourly [ ]

b) 2= Daily [ ]

c) 3=Weekly [ ]

d) 4= Monthly [ ]

42. Labour rate of payment per hour (Ksh.)……

43. What is the total labour cost for OFSP production?……

D. Agrochemicals

44. Do you use agrochemicals? 1= Yes [ ] 2= No [ ]

If yes, which type of agrochemical?

a) 1= Fertilizer [ ]

b) 2= Pesticides [ ]

c) 3= Herbicides [ ]

If no, why……..

45. Sources of agrochemicals used

a) 1=Local shops/agro vets [ ]

b) 2=Ministry of agriculture [ ]

c) 3=Others(specify) ……

46. Quantity of fertilizers used(kgs)/acre ……

47. Cost of fertilizer per kg (Ksh)……

48. Quantity of Pesticides/herbicides used (Litres)/acre ……

49. Cost of Pesticides/herbicides per Litres (Ksh.)……

50. Please provide the TOTAL estimated yield for the last season		
Sweet Potatoes	AREA	YIELD
OFSP……	……	……

Part D. Credit Access

51. Do you have access to credit from the credit institution? 1=yes [ ]2 = No[ ]

a) If yes, have you accessed credit for the past two years? 1= Yes [ ] 2= No [ ]

b) If not, why? ……

52. Where did you acquire the loan?

a) 1=Table banking [ ]

b) 2=Micro finance [ ]

c) 3= Banks [ ]

d) 3=NGOs [ ]

53. What purpose does the loan serve?

a) 1= OFSP production [ ]

b) 2= Others specify……

54. Do you belong to any farming or marketing group?……

Part E. Marketing Channels

55. Do you sell OFSPs? 1= yes 0= no

56. What share of OFSP output do you sell?

a) Sell everything [ ]

b) More than half [ ]

c) Half [ ]

d) Less than half [ ]

e) Do not sell [ ]

f) Others specify……

57. Where do you sell your OFSP produce?

a) 1= farm gate [ ]

b) 2 =local market/Open Air Market [ ]

c) 3=Urban markets [ ]

d) 4= Processing factory[ ]

e) 5= Others Specify.....

Please provide reason?.....

58. What marketing channel do you use while selling your produce?

a) Direct selling to consumers

b) Intermediaries

c) Dual/mix marketing channel

d) Others specify.....

59. What is the distance to the market? (Kms) ……

60. How often do you take OFSP produce to the market?

a) 1=Daily [ ]

b) 2=Twice a week [ ]

c) 3=Weekly [ ]

d) 4=Monthly [ ]

e) 5=Others (specify) ……

61. Main means of transport

a) 1= On foot [ ]

b) 2= Bicycle [ ]

c) 3= Motorcycle [ ]

d) 4= Motor vehicle [ ]

e) 7= Others(specify) ……..…..

62. Transport fee per trip (Ksh) …….

63. Mode of payment (days) 1= Cash [ ], 2= Credit[ ], 3= Bartering[ ]

64. Time to receive the payment (days) …….

65. Do you get any service from extension service providers?

1= Yes [ ] 2= No[ ] 3= Not sure[ ]

66. What type of service do you receive from extension officers?

a) 1 = Price and Market location [ ]

b) 2= Buyers/brokers [ ]

c) 3=Production services [ ]

d) 5=others (specify) ……

67. How else do you acquire marketing information?

a) 1= Other Farmers [ ]

b) 2= Radio/Television [ ]

c) 3= Mobile phone [ ]

d) 4= Personal visit and Brokers [ ]

e) 7= Others (Specify) ……

68. Please provide a reason for the above response……

69. Do you always find a market for all your OFSPs?

1= Yes [ ] 2= No[ ] 3= Not sure[ ]

70. What are your area's major challenges in accessing OFSP markets?

a) 1 = Lack of Transportation mode [ ]

b) 2= Impassable roads [ ]

c) 3= Middlemen interference [ ]

d) 4= Low market price [ ]

e) 4= Low market price [ ]

f) 6= Lack of Market assurance [ ]

g) 7= Inadequate market information [ ]

h) 8= Others (specify) …….

71. Do you think the government authorities have a role in addressing these challenges?

1= Yes [ ] 2= No [ ]

a) If yes, how? …….

Thank You for Your Time

END

Appendix II: Chuka University Ethics Letter

CHUKA UNIVERSITY

Knowledge is Wealth *(Sapientia divitia est)* Akili ni Mali
CHUKA UNIVERSITY INSTITUTION ETHICS COMMITTEE
Telephones: 0612304004 P.O. Box 109 - 60400
Fax line: 020 2310302 Chuka

31st MARCH 2022

REF: **CUIERC/ NACOSTI 257**
TO: **Jabuya Lawrence Otieno**

Dear Sir/madam

RE: Analysis of Marketing Channels, Inputs, and Credit Access on Technical Efficiency of Orange Fleshed Sweet Potato Production in Migori County, Kenya.

This is to inform you that *Chuka University IERC* ***has*** reviewed and approved your above research proposal. Your application approval number is *NACOSTI/NBC/AC-0812.* The approval period is from 31st March 2022 to 31st March 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 *Chuka University IERC.*
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 *Chuka University IERC* within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected the safety or welfare of study participants and others or affect the integrity of the research must be reported to *Chuka University IERC* within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to the 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 *Chuka University IERC.*

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

Yours sincerely

Dr.Benjamin Kanga

SECRETARY

INSTITUTIONAL ETHICS REVIEW COMMITTEE
31 MAR 2022
P. O. Box 109-60400 CHUKA
CHUKA UNIVERSITY

Appendix III: The NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **655718**

Date of Issue: **04/May/2022**

RESEARCH LICENSE

This is to Certify that Mr.. Lawrence Otieno Jabuya of Chuka University, has been licensed to conduct research in Migori on the topic: ANALYSIS OF MARKETING CHANNELS, INPUTS, AND CREDIT ACCESS ON TECHNICAL EFFICIENCY OF ORANGE FLESHED SWEET POTATO PRODUCTION IN MIGORI COUNTY, KENYA for the period ending : 04/May/2023.

License No: **NACOSTI/P/22/17130**

655718

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Appendix IV: Stata Outputs

Stoc. frontier normal/tnormal model

Number of obs = 225
Wald chi2(7) = 250.50
Prob > chi2 = 0.0000

Log likelihood = -110.5354

logY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
logLand	.4790138	.0692212	6.92	0.000	.3433427	.6146849
logAgrochem	.0549288	.047085	1.17	0.243	-.0373562	.1472137
logPlanmterl	.0652393	.0365447	1.79	0.074	-.0063869	.1368655
logplantfertb	.0375794	.0253578	1.48	0.138	-.012121	.0872798
logpmanqtyb	.0146071	.0203171	0.72	0.472	-.0252136	.0544279
logFamlabourdays	.0089691	.0379112	0.24	0.813	-.0653356	.0832738
logHiredlabourdays	.0737008	.0354188	2.08	0.037	.0042812	.1431204
_cons	2.580525	.316076	8.16	0.000	1.961027	3.200023
Mu						
gender	.2737072	.0918846	2.98	0.003	.0936167	.4537976
yrsofsp	-.0276616	.006634	-4.17	0.000	-.0406641	-.0146592
yrsedu	.0041161	.0134721	0.31	0.760	-.0222888	.0305209
hhsize	-.0291049	.014623	-1.99	0.047	-.0577656	-.0004443
landtit	.1114393	.0697933	1.60	0.110	-.0253531	.2482317
Mrktdist	.0111433	.0035168	3.17	0.002	.0042504	.0180362
mktassurance	.1350656	.1185627	1.14	0.255	-.0973131	.3674443
acctrainm	-.3473857	.1905551	-1.82	0.068	-.7208669	.0260955
groupfun	-.0909352	.1100488	-0.83	0.409	-.3066268	.1247565
credtofsp	-.0756449	.373087	-0.20	0.839	-.8068819	.6555922
conextveg	-.0923372	.053681	-1.72	0.085	-.1975501	.0128757
_cons	.3998288	.1777963	2.25	0.025	.0513545	.7483031
Usigma						
_cons	-7.332689	3.85561	-1.90	0.057	-14.88954	.2241675
Vsigma						
_cons	-1.853043	.0951081	-19.48	0.000	-2.039452	-1.666635
sigma_u	.0255698	.0492935	0.52	0.604	.0005845	1.118607
sigma_v	.3959285	.018828	21.03	0.000	.3606938	.4346052
lambda	.0645818	.0540829	1.19	0.232	-.0414187	.1705823

```
. predict te, jlms

.
. sum te
```

Variable	Obs	Mean	Std. Dev.	Min	Max
te	225	.7807104	.1920486	.3597885	.9993195

```
. glm logY logLand logAgrochem logPlanmterl logplantfertb logpmanqtyb logFamlabourdays logHiredlabourdays

Iteration 0:   log likelihood = -145.66022

Generalized linear models                         No. of obs      =        225
Optimization     : ML                             Residual df     =        217
                                                  Scale parameter =   .2215922
Deviance         =   48.0855079                   (1/df) Deviance =   .2215922
Pearson          =   48.0855079                   (1/df) Pearson  =   .2215922

Variance function: V(u) = 1                       [Gaussian]
Link function    : g(u) = u                       [Identity]

                                                  AIC             =   1.365869
Log likelihood   = -145.6602193                   BIC             =  -1127.208
```

logY	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
logLand	.5361946	.0805516	6.66	0.000	.3783165	.6940728
logAgrochem	.1299551	.054057	2.40	0.016	.0240053	.2359048
logPlanmterl	.09686	.0419768	2.31	0.021	.0145869	.179133
logplantfertb	.0404057	.0298683	1.35	0.176	-.0181351	.0989464
logpmanqtyb	.0223191	.0232926	0.96	0.338	-.0233335	.0679717
logFamlabourdays	.0362884	.0431208	0.84	0.400	-.0482268	.1208037
logHiredlabourdays	.0875639	.0411817	2.13	0.033	.0068492	.1682785
_cons	1.924561	.3513364	5.48	0.000	1.235954	2.613168

respectively with one degree of freedom representing the imposed restriction. Critical values for the mixed distribution are obtained from Kodde and Palm (1986).

. sf_xitable, dof(1)

critical values of the mixed chi-square distribution

	significance level					
dof	0.25	0.1	0.05	0.025	0.01	0.005
1	0.455	1.642	2.705	3.841	5.412	6.635

source: Table 1, Kodde and Palm (1986, Econometrica).

Multivariate Probit Model

```
. mvprobit( marketing_channel1= gender age_decmaker yrsofsp yrsedu logcaostcost storey grading ofspwashing Mrktdist mktassur
> ance conextveg groupfun)( marketing_channel2= gender age_decmaker yrsofsp yrsedu logcaostcost storey grading ofspwashing M
> rktdist mktassurance conextveg groupfun)( marketing_channel3= gender age_decmaker yrsofsp yrsedu logcaostcost storey gradi
> ng ofspwashing Mrktdist mktassurance conextveg groupfun), iterate(00)
Iteration 0:   log likelihood = -213.13047
convergence not achieved

Multivariate probit (SML, # draws = 5)            Number of obs   =        225
                                                  Wald chi2(36)   =     166.29
Log likelihood = -213.13047                       Prob > chi2     =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
marketing_channel1						
gender	-.5207842	.3895299	-1.34	0.181	-1.284249	.2426803
age_decmaker	.0275222	.024318	1.13	0.258	-.0201403	.0751847
yrsofsp	.0209309	.0307467	0.68	0.496	-.0393316	.0811934
yrsedu	.010904	.0799312	0.14	0.891	-.1457582	.1675662
logcaostcost	-.1392818	.0547252	-2.55	0.011	-.2465412	-.0320223
storey	.0691923	.4337879	0.16	0.873	-.7810165	.919401
grading	-.72741	.4001759	-1.82	0.069	-1.51174	.0569204
ofspwashing	-.4741985	2.122884	-0.22	0.823	-4.634974	3.686577
Mrktdist	-.0782362	.020314	-3.85	0.000	-.118051	-.0384215
mktassurance	-.7001607	.5327427	-1.31	0.189	-1.744317	.3439957
conextveg	.0511455	.1385376	0.37	0.712	-.2203832	.3226743
groupfun	-.7069732	.5653461	-1.25	0.211	-1.815031	.4010848
_cons	-.0780933	2.657614	-0.03	0.977	-5.28692	5.130734
marketing_channel2						
gender	.1680063	.2761008	0.61	0.543	-.3731413	.7091539
age_decmaker	-.0286666	.0150577	-1.90	0.057	-.0581791	.0008458
yrsofsp	-.0164361	.021449	-0.77	0.444	-.0584753	.0256031
yrsedu	.0843639	.0496149	1.70	0.089	-.0128795	.1816072
logcaostcost	.0295959	.0484272	0.61	0.541	-.0653197	.1245114
storey	1.001041	.2676146	3.74	0.000	.4765261	1.525556
grading	.1690675	.2906023	0.58	0.561	-.4005025	.7386375
ofspwashing	-.5539066	1.944423	-0.28	0.776	-4.364906	3.257093
Mrktdist	.0829444	.0133576	6.21	0.000	.0567639	.1091249
mktassurance	.5713696	.3310641	1.73	0.084	-.0775042	1.220243
conextveg	-.2837084	.124014	-2.29	0.022	-.5267714	-.0406454
groupfun	-.4949544	.3295986	-1.50	0.133	-1.140956	.1510469
_cons	.4592387	2.210508	0.21	0.835	-3.873277	4.791754
marketing_channel3						
gender	.0099501	.2744385	0.04	0.971	-.5279394	.5478396
age_decmaker	.0277249	.0157285	1.76	0.078	-.0031025	.0585522
yrsofsp	-.0038646	.0203915	-0.19	0.850	-.0438313	.0361021
yrsedu	-.0720462	.0497208	-1.45	0.147	-.1694972	.0254047
logcaostcost	.1448062	.048966	2.96	0.003	.0488346	.2407778
storey	-1.202849	.2809545	-4.28	0.000	-1.753509	-.6521878
grading	.3160665	.293877	1.08	0.282	-.2599218	.8920548
ofspwashing	0	.9578481	0.00	1.000	-1.877348	1.877348
Mrktdist	-.0534811	.0134682	-3.97	0.000	-.0798783	-.0270838
mktassurance	.0087486	.3192964	0.03	0.978	-.6170608	.634558
conextveg	.2083066	.0997772	2.09	0.037	.0127469	.4038663
groupfun	.6139114	.3078033	1.99	0.046	.0106279	1.217195
_cons	-2.066217	1.478673	-1.40	0.162	-4.964363	.8319294
/atrho21	0	.1965726	0.00	1.000	-.3852751	.3852751
/atrho31	0	.2223948	0.00	1.000	-.4358859	.4358859
/atrho32	0	.1239519	0.00	1.000	-.2429413	.2429413
rho21	0	.1965726	0.00	1.000	-.3672798	.3672798
rho31	0	.2223948	0.00	1.000	-.4102285	.4102285
rho32	0	.1239519	0.00	1.000	-.238272	.238272

Likelihood ratio test of rho21 = rho31 = rho32 = 0:
chi2(3) = 1.66205 Prob > chi2 = 0.6454

Appendix V: Field Photos

Plate 1: Land prepared (Ridged)

Plate 2: With an individual Farmer on the farm during the survey

Plate 3: An Individual Farm nearing harvest

Plate 4: Brokers collecting OFSP produce using 120Kg bags and Getonganya OFSP Processing Factory (Was to be Launched)