EFFECT OF PADDY SOURCING METHODS ON THE VOLUME OF RICE MILLED BY SMALL AND MEDIUM-SCALE RICE MILLERS IN MWEA CONSTITUENCY, KIRINYAGA COUNTY, KENYA

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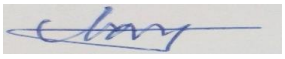
DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been presented in any other University for the award of a degree.

Signature:  Date: 17.11.2023

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Recommendation

This research thesis has been submitted with our approval as University supervisors

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DEDICATION

This thesis is dedicated to my parents, sisters, brothers, friends, and support and to the small and medium-scale rice millers in Kirinyaga County.

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ABSTRACT

Rice plays a critical role in the socio-economic development of the Kenyan economy. Despite this acknowledgment, the capacity of over 256 rice mills in Kenya is underutilized. The main objective of this study was to determine the effect of paddy sourcing methods on the overall volumes of rice milled by small and medium-scale millers. Specifically, it focused on identifying paddy sourcing methods, determining the level of usage of paddy sourcing methods, factors that determine choice of paddy sourcing methods and effects of the sourcing methods on the volume of rice milled by small and medium scale millers. The study adopted a multistage sampling technique and used semi-structured questionnaires to collect qualitative and quantitative data using face-to-face interviews. Data was collected from 90 small and 70 medium-scale rice millers giving a total of 160 millers in Mwea, Kirinyaga county. Descriptive statistics, multivariate probit analysis, and a two-stage Instrumental Variables approach were used in data analysis. Results indicate that the methods used are direct sourcing from individual farmers (88%), individual farmers bringing paddy to the miller (83.9%), buying from traders (76.3%), and sourcing using agents (68.7%). The most frequently used paddy sourcing method is a combination of direct sourcing from farmers and individual farmers bringing paddy to the miller at 51.9%. Factors that influenced the utilization of paddy sourcing methods included the millers' age, ownership of transport means, price of paddy, commission cost, gender, marital status, working experience, transport cost, storage capacity and degree of competition. Approximately 97.8% of rice millers use a combination of paddy sourcing methods while 2.2% use a single paddy sourcing method. Finally, the use of a combination of buying from traders, direct sourcing from individual farmers and individual farmers bringing paddy to the miller ($B_1D_1I_1A_0$) has a significant effect on the volume of paddy sourced and milled. Therefore, the study recommends policy initiatives aimed at improving transport infrastructure and enhancing communication between stakeholders within the paddy supply chain that can promote the efficiency and sustainability of paddy-sourcing methods within the rice-growing regions. Initiatives aimed at promoting transparency in the paddy pricing system can strengthen the relationship between millers and farmers thus fostering a mutually beneficial agricultural system. Disseminating up-to-date market information, can guide rice millers' decision-making and help them adjust their strategies and ensure competitive edge in the industry.

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LIST OF ABBREVIATIONS AND ACRONYMS

ALDEV	African Land Development Unit
ATT	Average Treatment on Treated
ESR	Endogenous Switching Regression Model
JICA	Japan International Cooperation Agency
MESR	Multinomial Endogenous Switching Regression Model
MIS	Mwea Irrigation Scheme
MOA	Ministry of Agriculture
MRGM	Mwea Rice Growers Multipurpose Cooperative
MRM	Mwea Rice Mill Limited
MT	Metric Tonnes (1,000 Kilograms)
MVN	Multivariate Normal Distribution
NCPB	National Cereals and Produce Board
NIB	National Irrigation Authority
PSM	Propensity score matching
RUM	Random Utility Model
WFP	World Food Programme

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Rice is main cereal harvest in Kenya after maize and wheat (Atera *et al.,* 2018). Smallholder farmers in Central (Mwea), Western (Bunyala), Coast (Tana delta, Msambweni) and Nyanza region (Ahero, West Kano, Migori and Kuria) are the major growers of rice for food and money (Vishnu & Mukami, 2020). Interestingly, there has been an increase in the number of rice farmers since the year 2000 (Debonne *et al.*, 2021). Approximately 80% of the rice crop is developed on irrigation systems and 20% under downpour conditions (MOA, 2008). Farm rice yields in Kenya is at present estimated at 4.25 t/ha (Atera *et al.*, 2018). According to KNBS (2018), economic survey, the area under rice production was approximated at 39,095 hectares in 2018. Though the country has a capability of around 540,000 hectares of irrigable land and 1.0 million hectare of rain fed land appropriate for rice cultivation, the Government is committed towards expanding it to 104,000 hectares by 2030 so as to achieve rice self-sufficiency (MOA, 2020).

Rice assumes a significant part in guaranteeing food security, given the country's dependence on maize and wheat. Its production fluctuated substantially in the recent years and tended to increase between 1972 to 2021 period ending at 186,000MT in 2021 (Mano *et al.*, 2021). Over 300,000 rice growers earn their living out of the crops cultivation (Vishnu & Mukami, 2020). Rice consumption in Kenya grows at an annual estimated rate of 11% (Obura *et al*., 2017), which is attributable to a mix of elements; populace development, urbanization, changing purchaser preferences and financial turn of events (Kilimo Trust, 2019). The consumption of rice in Kenya in 2018 stood at 949,000MT against a production level of 150,000 MT. This compelled importation of about 90% of the consumed volumes valued at 26 billion Kenya shillings (KNBS, 2019). This corroborates with Atera *et al.* (2018), findings of rice consumption exceeding production in Kenya making it the most expensive cereal. The improved livelihoods through jobs created and businesses established as a result of rice milling greatly contribute in supporting food security (Mumuni & Oladele, 2016).

Rice milling node has several stage post-farm processes that involves expulsion of husk and bran layers to create a palatable white piece/grain (Bodie *et al.,* 2019). Three different groupings of rice processors exist in Kenya. They include small, medium and large millers. The lack of a standard parameter on which to categorize these mills has prompted researchers to develop independent parameters that they deem necessary for categorizing rice mills.

According to Gitau *et al.* (2010), small scale processors have basic plant (factory without pre-cleaner, husker, de-stoner, grader, pail lifts), gauging scale and a drying yard, Medium scale mill operators on the other hand have essentially rice processing chain or compound rice plant, drying yard, pre-cleaner, husker, de-stoner, grader, container lifts, a gauging scale, and a bundling unit while Large scope mill operators own basically rice processing chain or compound rice plant with extra parts including mechanical dryer and a colour sorter. Githumbi (2017), categorises mills according to the number of sacks milled. The large-scale millers are those that can mill a minimum of 1 tonne of rice per day. Mills are also categorized as simple one step process (single pass), two steps process (either single pass or two pass) and multi stage process (IRRI, 2022). Joshi *et al.* (2020) categorized rice mills based on hourly processing capacity. Large scale rice mills were those with above 3.5MT/hour capacity, between 1.5 to 3.5MT/hour were rated as medium scale and less than 1.5MT/hour as small-scale rice mills. This is what was adopted by the study.

Significant rice millers in Kenya with different milling capacities include Lake Basin Development Authority (LBDA) (3.5 MT/hour), Mwea rice mills (24 MT/day), Western Kenya Rice Millers (3 MT/hour) and Tana Delta (3 MT/hour). Several privately owned small scale one pass mills also exist around the schemes especially in Mwea (Gitau *et al*., 2010), with average capacity of 0.5 tonnes/hour. Currently, large scale mills in Kenya are 16 while small to medium rice processors in Mwea and the remainder of the rice developing regions are more than 256 (Ndirangu & Oyange, 2019). The capacity utilization of large-scale mills ranges from 13.5% to 60% (USAID COMPETE, 2010), while usage of small and medium-scale rice plants is about 20 to 50% (MOA, 2008). The average mill utilisation capacity of the 256 small and medium scale rice mills and 16 large scale mills is 23.6% (Ndirangu & Oyange, 2019).

Private rice plants in Mwea represent a greater part of the absolute volume of the regular rice handled in Kenya (Atera *et al.*, 2018). Irrespective of the size, all the millers access paddy through private traders (including middlemen), agricultural cooperatives, individual farmers who deliver paddy to the millers, direct sourcing from individual farmers and use of village agents (Atera *et al*., 2018; Kunihiro *et al.*, 2014; Muhunyu, 2012; Watanabe *et al.*, 2021). The state controlled National Cereals and Produce Board (NCPB) is also involved in the purchase of raw material (paddy) from producers and mill in the government controlled mills (Atera *et al*., 2018).

The vast majority of the installed capacity of the mills are underutilized chiefly because of absence of paddy and breakdowns. One explanation that could clarify the sagging capacity in large scale public mills is the liberalization of the rice sector which permitted entry of private

mill operators thus exposing them to fierce competition from small scale mill operators (JICA, 2013). Mwea Rice Growers Multipurpose Cooperative (MRGM) handles only 10% of the total volume of paddy produced in the Mwea irrigation scheme which accounts for over 70% of the national total production (Vishnu & Mukami, 2020). These mills experience high overheads which eventually diminishes mill operators and producers' benefits (Wijeesoriya *et al.,* 2020).

The challenges faced by millers trickle down to farmers since mills that are located far from the farmers could deter rice production through significant expense brought about in transportation, high expense of processing could affect farmers recovery of their expenses (Ndirangu & Oyange, 2019). This shows that the limit and productivity of the rice milling industry greatly determines the performance of the overall value chain as well as the revenue received by farmers. The current production limit of rice mills is adequate to adapt to expanding rice production (Moniruzzaman, 2020), however, the significance of further improving and developing the utilization rate of rice mills and post-farm processes need urgent priority to allow full capacity utilization. Improving the sourcing methods of paddy from farming communities by millers and using a combination of appropriate sourcing methods can boost the volume of paddy sourced hence greatly increasing the capacity utilization of the mills. This further lead to reduced cost of production and increased margins at both the miller level and farmer levels. Therefore, this study focused at determining the effects of paddy sourcing methods on the volumes of rice milled by small and medium scale millers.

1.2 Statement of the Problem

Rice millers in Kenya have gradually adopted imported improved milling machines which has transformed the rice milling industry. However, the capacity utilization of small and medium-scale rice mills is still very low. The underutilization of the rice mills is mainly attributable to inadequate paddy volumes supplied by farmers or sourced by millers. This stems from the liberalization of the rice sector allowing entry of private millers which made other millers to face stiff competition. Consequently, this has resulted in widening production costs thus constraining the profit margin realised by millers. Rice millers in Mwea constituency source paddy directly from farmers, through agents, from traders and cooperatives. Literature reveals that research has concentrated on production, marketing and consumption of rice. However, the effect of paddy sourcing methods on the overall volumes of rice milled by small and medium scale millers is unknown. This study seeks to fill this knowledge gap by identifying efficient and cost-effective paddy sourcing methods by determining the effects of paddy sourcing methods on the volumes of rice milled by small and medium-scale millers.

1. 3 Objectives

1.3.1 General Objective

To contribute to improved competitiveness of the rice milling subsector in Kenya by determining the effect of paddy sourcing methods on the volume of rice milled by small and medium-scale rice millers in Mwea, Kirinyaga County.

1.3.2 Specific Objectives

i. To characterize the different paddy sourcing methods currently used by small and medium-scale rice millers.
ii. To determine the level of usage of the different paddy sourcing methods by small and medium-scale rice millers.
iii. To determine the factors influencing the choice of paddy sourcing methods among small and medium-scale rice millers.
iv. To determine the effect of paddy sourcing methods on the volume of rice milled by small and medium-scale rice millers.

1. 4 Research Questions

i. What are the characteristics of the different paddy sourcing methods used by small and medium-scale rice millers?
ii. How often are the different paddy sourcing methods used by small and medium-scale rice millers?
iii. What factors influence the choice of paddy sourcing methods among small and medium-scale rice millers?
iv. What are the effects of the paddy sourcing method and volume of rice milled?

1.5 Justification of the Study

As the third most significant cereal crop after maize and wheat (Oburu *et al.*, 2017), rice plays a critical role in the socio-economic development of the Kenyan economy. This calls for efforts to undertake rice value chain analysis in order to determine the gaps and develop interventions to address them (MOA, 2008). The improved livelihoods through jobs created and businesses established as a result of rice milling greatly contribute in supporting food security. Therefore, it is important to note that the challenges faced by millers directly impact rice producers. Increasing volumes of paddy sourced and milled, reducing production costs at miller level and widening margins requires appropriate but also sustainable and proven paddy sourcing methods or a combination of methods. This not only requires calculated but also maximum competitiveness amidst the stiff competition that exists among millers. To enhance the role of the rice value chain in the socio-economic development of Kenya, initiatives should

focus on factors that undermine the competitiveness of the rice subsector especially low mill utilization which is as a result of low volumes of paddy supplied or sourced.

By determining the effects of paddy sourcing method on the volumes of rice milled by small and medium scale millers, the study fills the knowledge gap required to boost the volumes of paddy sourced by millers, increase the utilization capacity of the mills thus improving the competitiveness of the subsector. The study contributes towards the realisation of Kirinyaga CIDP that seeks to improve the productivity of agricultural value chains and Vision 2030 that seeks to transform Kenya in to an industrialising economy. The study also contributes to SDGs 1,8 and 9 which are no poverty, decent work and economic growth and industry, innovation and infrastructure. The findings of this study provide necessary information to policy and decision makers on the most appropriate and sustainable paddy sourcing method or a combination of methods required to devise more fitting ways to assign resources to this industry and to increase profits from the current investment. This results into enhanced volumes of paddy sourced, increased mill utilization capacity and widened margins for both the millers and the farmers.

1.6 Scope and Limitations of the Study

The study focused on the effects of paddy sourcing methods on the volumes of rice milled by small and medium scale millers in Mwea, Kirinyaga County in Kenya. Mwea was targeted because it accounts for between 70 and 80% of the total national rice production. In addition, Mwea irrigation scheme has about 256 small and medium scale millers providing an assurance for quality data to be collected for the study. The study focused on small and medium-scale rice millers leaving out large-scale miller. Data was collected in 2022.

The informal nature of small-scale millers characterized by limited levels of record keeping and reliance on recall data was expected to constrain the accuracy of the data to be collected. This was mitigated by continuous probing during the administration of the questionnaire in a face-to-face interview coupled with observation as a form of triangulation. The facts decisions regarding paddy sourcing are sometimes made by mangers and not rice mill owners acted as a limitation during data collection. However, constant probing limited the extent to which this incidence would affect the quality of data collected.

1.7 Operational Definitions of Terms

Installed capacity describes the maximum volume of paddy that a rice mill is designed to process per hour/day according to the manufacturers' specifications**.**

Large scale millers refer to millers that own at least rice milling chain with milling capacity of above 3.5MT/hr.

Medium scale millers refer to millers that own milling equipment with milling capacity of between 1.6 - 3.5MT/hr.

Mill capacity utilization rate is the total amount of rice milled divided by the milling capacity of the machine for a given period of time. It refers to how much of the installed capacity is currently being utilized. It also means the percentage ratio of actual production to potential production.

Milled rice refers to rice that is processed with the hull, the bran layers and the germ removed. It is the most common type of rice accessible.

Paddy refers to threshed unmilled rice. It is rice harvested from the field, threshed and has not undergone removal of the hull and polishing.

Small scale millers refer to millers that own milling equipment with milling capacity of below 1.6MT/hr.

Sourcing method includes every activity that revolves around identifying and obtaining paddy for milling.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter presents the literature reviewed in relation to the study. It begins by giving brief information on the evolution of rice milling industry in Kenya, paddy sourcing methods used by rice millers across the world, the concept of consumer behaviour, factors that influence choice of businesses in decision making and effects of such choices on performance. It proceeds to discuss theories upon which the study was based and concludes with a conceptual framework.

2.1 Evolution of Rice Milling Industry in Kenya

Since its introduction in 1907 by the colonial government at the Coast (Onyango, 2014), rice has for some time been viewed as a cash crop for the provincial populace where it is developed (Atera *et al.*, 2018). Its development begun in 1964 under the African Land Development Unit (ALDEV), which started various water system plans, including Mwea, Hola, Perkerra and Yatta. After freedom, these plans were taken over by the Ministry of Agriculture (Ngige, 2004). In December 1993, the Government declared liberalisation of rice marketing as well as that of other staple food crops (Ngige, 2004). Smallholder farmers in Central (Mwea), Western (Bunyala), Coast (Tana delta, Msambweni) and Nyanza provinces (Ahero, West Kano, Migori and Kuria) are the major growers of rice for food and commercialisation (Vishnu & Mukami, 2020). About 80% of the rice crop is developed on irrigation systems and 20% under downpour conditions (MOA, 2008). Average rice yields in Kenya is currently estimated at 4.25 t/ha (Atera *et al.*, 2018). However, MOA (2020), estimates the yield to be 3.5 t/ha. The variations may be attributed to the inconsistencies and overestimation in the data retrieved by FAOSTAT from which Atera *et al.* (2018) sourced their information.

In Kenya, the majority of the rice is handled within the regions where it is cultivated (Watanabe *et al.*, 2021). This is because the rice milling facilities are located in those specific areas where rice is produced. For example, modern rice milling in Mwea irrigation scheme dates back to 1967 when a public rice miller, Mwea Rice Mill Ltd imported milling machines from Germany. This was followed by purchase of a multi-stage milling machine by MRGM, Mwea and 10 other private millers (Mano *et al.*, 2021). Currently, there are 16 large-scale rice mills in Kenya with over 256 other small to medium rice mills in Mwea and the rest of the rice growing areas. Mwea irrigation scheme is a home for over 148 small scale rice millers. Among the large-scale mills that exist, Western Kenya Rice Mills, Lake basin development Company,

Mwea Rice Mills and National Cereals and Produce Board (NCPB) (sagana) are owned by the government (Atera *et al.,* 2018). The number of rice mills in Kenya has increased over years due to the increased production of rice and the increased uptake and adoption of rice as an important part of the diet.

Rice plays an importantly critical role in ensuring food security in Kenya (Atera *et al*., 2018). The milling process transforms paddy into nutritionally utilizable form while generating by-products husks and bran (Bodie *et al*., 2019). Through the constant purchase of paddy from over 300,000 rice farmers in Kenya, millers provide farmers with a source of living out of the crop's cultivation (Vishnu & Mukami, 2020). Rice processing sector directly provides a significant number of jobs to the rural people primarily for women (Paman *et al.*, 2016). A few mill operators give rice farmers credit or loans under the understanding that they will carry their paddy to the mill operators after harvesting (Furuya & Sakurai, 2005). The improved livelihoods through jobs created and businesses established as a result of rice milling greatly contribute in supporting food security.

Medium and large scale rice mills in Kenya have installed capacities ranging between 1 – 22.5 MT/hour, while small scale mills have an average capacity of 0.5 tonnes/hour (Ndirangu & Oyange, 2019). The capacity utilization of large mills ranges from 13.5% to 60% (USAID COMPETE, 2010), while utilization of small and medium-scale rice mills translates to about 20 to 50% (MOA, 2008). Factors responsible for low mill utilization are inadequate and inconsistent supply of paddy and proliferation of rice mills in the rice producing areas (Atera *et al.,* 2018; Oburu *et al.*, 2017). Other factors responsible for low mill utilization include breakdowns of machinery, unavailability of skilled labourers and power interruption, inadequate finance and side selling to traders from other areas (Hutapea *et al*., 2021; Hyderabad & Korbu, 2009).

Mwea irrigation scheme represents more than 70% of the national total rice production. However, millers within the scheme only access 10% of the total production volume (Vishnu & Mukami, 2020). The overall impact of underutilization of capacity on millers is high overheads which ultimately reduces millers and farmers' profits (Twine *et al.,* 2021), poor liquidity position and use of debt capital on account of poor capacity utilization (Hyderabad & Korbu, 2009). It is evident that the amount of rice processed is one of basic determinants of the profitability of rice processing activity (Kunihiro *et al*., 2014). It is generally agreed that higher underutilization leads to higher range of decline in the profits and vice-versa (Hyderabad & Korbu, 2009). Note that, the challenges faced by millers trickle down to farmers. Mills that are located far from the farmers could deter production through significant expense brought about

in transportation, high expense of processing could affect farmers recovery of their expenses (Ndirangu & Oyange, 2019). Therefore, it is evident that improving the milling value chain enhance rice production and food security.

For the rice value chain to meaningfully contribute to the socio-economic development of Kenya, initiatives must be directed towards factors that undermine the competitiveness of the rice subsector especially low mill utilization. Rice millers ought to source adequate amount of raw material (paddy) to mill all year around (Kunihiro *et al.*, 2014). Increasing volumes of paddy sourced and milled, reducing production costs at miller level and widening margins requires appropriate but also sustainable and proven paddy sourcing methods or a combination of methods. By determining the effects of paddy sourcing method on the volumes of rice milled by small and medium scale millers, millers get to understand the most appropriate and cost-effective methods to sustainably source paddy for milling throughout the year.

2.2 Paddy Sourcing Methods

Understanding paddy marketing channels helps to reveal the different ways through which millers access raw materials for milling. Paddy is mainly traded through two different systems (Moniruzzaman, 2020), that is through the public and the private channels (Wijesooriya *et al*., 2020). Paddy procured by the government is either sold to the rice millers or it finally finds its way to the millers through different channels. Different categories of traders such as small village traders, traditional traders, middlemen, large traders and wholesalers collect paddy from various locations and sell directly to the millers.

A study by Wejisooriya *et al.* (2020), found that farmers in Sri Lanka sell paddy to the government which then distributes it to millers with the aim of stabilizing the market. In Bangladesh, government procures paddy and distributes less than 20% of the locally produced rice, while the private sector circulates the rest of the surpluses that enter the market (Moniruzzaman, 2020). Similarly, in India, the government procures surplus paddy from farmers and distributes to millers (WFP, 2017). In Kenya, the state controlled National Cereals and Produce Board (NCPB) is involved in the purchase of paddy from producers and mills in the government-controlled mills. The state-controlled mills procure paddy from producers and mill the same through their rice mills in Ahero, Mwea and Kibos (Atera *et al*., 2018). A study by Muhunyu (2012), found that farmers in Mwea sell about 1% of paddy to NCPB. In the schemes under National Irrigation Authority (NIB), farmers are offered soft loans in form of credit and cash for school fees and farming purposes. They are then expected to convey paddy to NIB who thus deducts the credit and transmits the balance to the farmers (Ngige, 2004). The

relevance of this arrangement on the total volume of rice milled need to be established to accurately measure its effectiveness.

Large, medium, and small-scale millers are the main private actors who purchase the paddy in major growing areas (Moniruzzaman, 2020). They tend to receive paddy from farmers because of the limited purchasing capacity of the government schemes (Wijesooriya *et al.*, 2020). Paddy rice harvested by producers is delivered to rice mills by producers themselves or village collectors or agents sent by rice mills or town merchants (JICA, 2013). According to Kunihiro *et al.* (2014), 70% and 20% of paddy rice for milling in Uganda is brought to the millers by producers and town gatherers/brokers. About 10% of paddy is gathered by millers by going to rice cultivating areas to purchase paddy rice from farmers or sending their representatives to the towns for the procurement. A study by Moniruzzaman (2020), found that farmers sell 17%, 23%, 42%, 8% and 10% of paddy to small village traders, traditional traders, large traders, wholesalers and millers, respectively. Large traders account for the highest volume of paddy received compared to the rest of the actors including millers. Both the scenarios presented are instances where farmers are dealing individually with millers. Instances where the same farmers collectively sell their produce may provide different reasoning, findings and statistics.

Private rice plants in Mwea represent the greater part of the absolute volume of the regular rice handled (Ndirangu & Oyange, 2019). Rice millers' endeavours to gather as much rice for processing as possible compels them to traverse other neighbouring districts and countries (Kunihiro *et al.*, 2014). Middlemen are also involved in the sourcing of paddy, they visit the farmers as soon as they harvest, purchase paddy for cash, and transport it to private rice mills (Watanabe *et al.*, 2021). In some instances, farmers prefer selling paddy directly to the millers, they transport paddy mainly by humans and animals, and sometimes using mechanical power to the mills (Ndirangu & Oyange, 2019). Millers in competitive areas make various arrangements to acquire paddy; they cater for full or half the cost of transporting paddy to the mill, lend money to farmers during peak periods on condition that immediately rice is harvested, it is brought to the mill (Kunihiro *et al.*, 2014). A study by Muhunyu (2012), established that farmers in Mwea Constituency sell about 24% of paddy to farm gate intermediaries, 39% to intermediaries in commercial centres, 35% to the Cooperative Society, and the rest collected by village money lenders. All the paddy sold to the different channels finds its way to the millers. However, paddy sourcing methods keep evolving over time depending on the location and degree of competition, this is not so clear in the case of Mwea irrigation scheme.

2.3 The Concept of Consumer Behaviour

Consumer behaviour is defined as the behaviour that consumers display in searching for, purchasing, using, evaluating, and disposing of products, services and ideas that they expect will satisfy their needs (Hanaysha, 2018). Consumer choices involve internal cohesion of the decision process and action when planning, acquiring, using and disposing of a good or service (Soyer & Ditrich, 2021). This definition emphasizes the fact that the phases of consumption of a given good or service follows logical steps involving searching for information, making decisions, using a commodity and its disposal (Raj *et al.,* 2022). Consumer behaviour is not considered to happen solely at the time of purchase, rather, it includes stages before, during and after the buying experience (Panitapu, 2013).

The use of the product is often the single most aspect used by a marketer to influence how it can be positioned for sale and how its consumption can be influenced (Dwivedi *et al.*, 2021). Andreasen (1965) proposed the first and earliest model of consumer behaviour which emphasized the importance of information in consumer decision making process. The model equally emphasizes the importance of consumer attitudes, and relates the buying behaviour to a judgmental process of feeling satisfied or dissatisfied if a product is judged to be better or not better than the other.

According to Srivastava *et al.* (2021), the Engel Kollat Blackwell model of consumer behaviour asserts that there are four decision making stages involved in purchase of a commodity. Problem recognition as the first step largely depends on the extent to which the decision maker is involved in problem solving behaviour; Information input as the second stage involves a consumer gathering information from marketing and non-marketing sources in order to reach a satisfactory choice; The third stage of information processing consists of exposure, attention, perception, acceptance and retention of incoming information; The variables influencing the decision process in the fourth stage consists of mainly the individual (lifestyle, motives, values, personality) and environmental (financial condition) factors that affect decision making. Religion is also emphasized in this model as one of the factors that influencing buying behaviour of consumers.

There are several factors that influence consumer behaviour. Svecova and Odehnalova (2019) reported that young consumers are largely influenced by personal attitudes and subjective norms while Frydloda and Vostra (2011) assert that the major determinants of consumer behaviour are income of the consumer, price of the good/service, and individual attitude. Contrary to the above, Chaudhury (2010) emphasize that convenience, motive and appeal influence consumer behaviour. The decision to purchase fast moving consumer goods in

Nigeria is determined by reference group, social class, family, and cultural beliefs (Unanam *et al.,* 2019). Age, number of nuclear family members, education level and cooking time were found to influence decision to purchase ready to eat products in France (Sgroi, 2018). Of recent, health consciousness, quality and availability have taken the lead in influencing consumer behaviour (Sarkar *et al.,* 2022). Factors that influence consumers purchase of products in farmers markets were revealed as location of and access to the market, quality and freshness of products, activities at and around the market, availability of a variety of products around the market, volume of produce available and safety of the produce (Adanacioglu, 2021). The real behaviour of business men and women tends to differ basing on the business and level of expertise, the beahviour of rice millers in the paddy market in Mwea irrigation scheme does not have empirical documented evidence.

2.4 Factors that Determine the Utilization of Paddy Sourcing Method by Small and Medium Scale Millers

Much as paddy is traded through two different channels (Moniruzzaman, 2020), millers access paddy through various means stemming from the two channels. A study by Kunihiro *et al.* (2014), found out that due to the relatively competitive rice markets in the Eastern and the Northern Uganda, rice millers there attempted to acquire paddy by visiting towns in and outside their locality of operation. They also noted that the high degree of competition has compelled millers to put forth different attempts to get as much paddy for milling, for instance, to pay farmers or agents the entire or part of the expense for shipping paddy from towns to the mill. The mean collection cost rice in Eastern Uganda from villages costs $1/sack of 100 kg, because of this, millers try to source paddy from areas in the range of around 70 km (JICA, 2013). Understanding the decisions of millers in circumstances where the sourcing cost is much cheaper or expensive can influence the final recommendation basing on the area of study.

A study by Soe *et al.* (2015), employed multinomial logit regression model to analyse the elements affecting marketing channel decision by paddy rice producers in Myanmar. They found out that distance to market, amount of rice sold, transport means, condition of roads, and access to market information were critical elements that impacted farmers' decision of either selling to intermediaries or directly to millers. Siddique *et al*. (2018), used a conjoint analysis to analyse the factors that impacted marketing channel choices of smallholder citrus producers in Pakistan. The study uncovered that selling price, urgency in need for cash, payment for cash advances, method of payment, assurance of payment, delay in payment, number of fruits picked, and harvesting fruits loss were the key factors that impacted marketing channel

decision choices. The decision by the farmers is based on the fact that they cannot independently set or bargain for better prices of paddy. The existence of cooperatives in Mwea which are actively involved in bargaining for better prices can provide a different view on the factors that influence choice of sourcing method.

In Ghana, Martey *et al.* (2012), applied the multinomial logit model to analyse the impact of yam farmers' access to marketing information on their decisions of marketing channel. This study showed that farmer age, gender, educational level, distance to tarmac roads, access to mobile phones, farm size and output price were critical factors that impacted on farmers' decision to pick one channel over others. The biasness of this study towards market information changes the view in which factors that influence decision are viewed. Mmbando *et al*. (2016), used the same model to understand factors influencing decisions of marketing channel used by smallholder maize and pigeon pea farmers in Tanzania. Transaction cost, household wealth, access to credit and extension services, group membership, age and the price of the products affected the farmers' choices of marketing channels. This study considered farmers who produce both maize and pigeon pea. The factors that influence the decision of an actor dealing in a single crop such as paddy can be far different from an actor dealing in multiple crops due to complementary and supplementary relationships.

Tura and Hamo (2018), used multivariate probit model for analysing the tomato farmer's market outlet choices in Ethiopia. Results revealed that transaction costs such as distance to nearest markets, access to credit, family size, age of household head, education status, farming experience and volume of tomato produced significantly influence the market channels choices of tomato farmers. The same model was used by Dlamini *et al.* (2019), to study the factors affecting the choice of marketing outlet selection strategies by smallholder farmers in Swaziland. The study revealed transaction cost, market attributes and institutional variables as the major factors. Wosene *et al.* (2018), used the same model to investigate the factors affecting market outlet choices of pepper in Ethiopia and found out that quantity produced, farming experience, extension contact, bargaining power and market distance had a statistically significant influence on choices of the market outlet. All the three studies focused on horticultural commodities whose marketing decisions largely depend on their perishability unlike rice which can be stored for long.

Most of the literature available focuses on the factors that influence the farmers' choice of selling method. However, no consideration has been given to the factors that influence the buyer or rice millers' choice of sourcing from different rice suppliers or using a given sourcing method to acquire raw materials.

2.5 Effects of Paddy Sourcing Method on the Volume of Rice Milled by Millers

According to Kunihiro *et al*. (2014), around 70% and 20% of paddy rice for processing in Uganda is brought to the mills by farmers and town gatherers/mediators, individually, while 10% is sourced by mill operators from the neighbouring towns. Therefore, farmers bringing paddy to the miller produces the highest volume of paddy sourced and milled in Uganda. In India where government has full control over paddy procurement, the miller has no choice but to source paddy from the government agency/body involved (WFP, 2017). This correlates with the findings from the study conducted by Wijesooriya *et al.* (2020) in Sri Lanka and (Rahaman *et al*., 2021) in Bangladesh where government is engaged in paddy procurement. In Kenya where both government and private channels exist, the impact of each channel on the other and the combined impact on the overall rice milled can be different compared to the studies above.

According to Mmbando *et al*. (2017), maize farmers in Tanzania sell produce to brokers (44%), village traders (36%), to wholesalers (16%) and other traders (10%.) This means that maize millers receive the highest volume of maize from traders who purchase the highest volumes from farmers. Mukaila *et al*. (2021), found that majority (51.2%) of vegetable farmers in Thailand sold vegetables to the collector channel, followed by the farmer cooperative (30%) and lastly direct retailing. This directly results into a processor accessing the highest volume of vegetable for processing from traders followed by farmer cooperatives. Both the studies do not consider contractual arrangements between farmers or farmer groups with the respective buyers. Contracts are a potential determinant of the choice and thus volume of produce sold and sourced.

Majority (59.7%) of the paddy rice farmers in Thailand prefer selling produce directly to millers while 26.8% sell to local collectors (Thamthanakoon, 2018). Therefore, individual farmers bringing paddy to the miller offers the highest volume of paddy for milling. Adu (2018), found that 61.3% of the paddy rice farmers in Ghana offered their paddy to brokers at the farm gate whereas the remaining 38.7% sold their paddy directly to millers. Millers therefore receive the highest volume of paddy for milling from traders who are middlemen. On average, smallholder farmers Prey Veng province in Cambodia sold about 43% and 33% of their paddy products to collectors or traders and millers respectively (Chiv *et al*., 2020). And since collectors also sell to the millers, it is evident that the largest volume of paddy for milling is sourced from collectors or traders. All the three studies do not consider millers as one of the traders. Studying instances where the miller is directly involved in trading paddy can change the orientation of the volumes sourced.

Moniruzzaman (2020), found that the farmers in Sri Lanka sell paddy mainly to large traders (42%), traditional traders (23%) small traders, (17%), millers (10%) and wholesalers (8%). Therefore, millers received the highest volumes of paddy for milling from traders. According to Muhunyu (2012), farmers in Mwea sell paddy to marketplace brokers (39%), cooperative society (35%), farm gate brokers (24%), government body (1%), and the rest collected by money lenders. It is evident the largest volume of paddy received by millers for milling is sourced from traders (brokers at farm gate and market place). The two studies do not consider the agents employed by millers. The volumes that are transferred through millers' representatives in rice producing areas can influence the volumes that goes directly to the miller and that that goes to other actors.

2.6 Theoretical Framework

There are several theories that could explain the relationship between paddy sourcing methods and volume of rice milled by small and medium scale rice millers. Some of the theories include Transaction Cost Economics (TCE) theory, Resource Dependency Theory (RDT) and Random Utility Model (RUM). Although Transaction Cost Economics (TCE) and Resource Dependency Theory (RDT) have been widely used in agro-industry procurement studies, they lack focus on social and political factors. Other factors, such as market conditions, technological change, and social norms, may also influence procurement decisions, and these factors may not be fully captured by Transaction Cost Economics (TCE) and Resource Dependency Theory (RDT).

2.6.1 Theory of Consumer Behaviour

Consumer behaviour is defined as the behaviour that consumers display in searching for, purchasing, using, evaluating, and disposing of products, services and ideas that they expect will satisfy their needs (Hanaysha, 2018). It is worth noting that rice millers are the consumers of paddy in this case. Thus, they are rational, this makes it possible to express the probability of utility gained from using alternative paddy sourcing methods to satisfy their needs. Rice millers compare utility anticipated from using alternative paddy sourcing methods subject to a number of factors. Therefore, a rice miller faces several alternatives that shape his/her decision from a set of choices (Ben-Akiva & Lerman, 2018). Rice millers' choice on the available alternative paddy sourcing methods depends on a number of factors including economic, socio socioeconomic, technical and sourcing cost factors.

Therefore, a rational utility theory was used to understand this concept because it explains and quantifies consumers' preferences based on a finite set of alternatives. This theory is based on the idea which states that an individual derives utility by choosing an alternative

from various options. The theory models an individual's inclinations on choices by drawing a genuine esteemed score on every other option (commonly freely) from a defined circulation, and afterward positioning the options as indicated by scores (Soufiani *et al*., 2012). It is appropriate for modelling discrete choice decisions such as paddy sourcing choices (Tura & Hamo, 2018). The choice of a paddy sourcing method is anchored on the theory of rational choice that assumes millers are rational decision makers and rank alternative sourcing methods for utility maximization. The factors that determine utilization of paddy sourcing were assumed to be based on economic factors, socioeconomic, technical factors and sourcing cost factors. Millers are more likely to choose at least two or more paddy sourcing methods simultaneously assuming the selection of different sourcing methods as well as their simultaneous use depends on miller's willingness to maximize their profit and conditional to economic, socioeconomic, technical and sourcing cost related factors. If the expected utility (profit maximization) from the methods is positive and higher than alternative options, a miller selects these paddy sourcing methods.

Following Balsevich *et al*. (2006), a typical miller, i, is assumed to identify N (5) paddy sourcing methods, for instance, buying from traders, aggregation by cooperatives, collecting from individual farmers, using an agent at village level or individual farmers bringing paddy to the miller. The utility (difference between expected benefits and costs) of the miller using a given paddy sourcing method, j, is represented by U_{ij}. The miller does an expected benefit-marginal cost calculation based on the utilities achieved by a given paddy sourcing method or another. The utility, U_{ij}, for every individual mill operator picking a specific option is determined as a direct capacity of the vector of obtaining technique explicit boundaries, (ßj), and the properties of that other option (X_{ij}) and a stochastic error part (e_{ij}):

$$U_{i(j=k)} = ß_{j=k}X_{ij} + e_{ij} \; \forall j e N \qquad (I)$$

Utilities cannot be observed directly, but the sourcing method chosen by the miller reveals which one provides the greater utility (Greene, 2012). The miller chooses a paddy sourcing method if the expected utility gained by sourcing using a given method is greater than that of all the other methods. The likelihood of picking an option is equivalent to the likelihood that the utility of that specific option is more noteworthy than or equivalent to the utilities of any remaining choices in the decision set. The miller selects a sourcing method j = k if

$$U_{i(j=k)} > U_{i(j\neq k)} \; \forall k \neq j \qquad (2)$$

where U_{ij} indicates a random utility associated with the paddy sourcing method j = k; and $ß_j=kX_{ij}$ is an index function indicating the miller's average utility related with this alternative. The subsequent term, e_{ij}, indicates a random error that is specific to a miller's utility preference.

2.6.2 Rational Choice Theory

The study was equally informed by the rational choice theory which asserts that all complex social phenomena are driven by individual human actions (Homans, 1961). Thus, understanding rational decisions of individual behaviour can reveal the underlying behavioural actions much better. According to Stepnisky and Jeffrey (2014), all actions are oriented towards goals that are likely to enable the decision maker attain their desired objectives. Thus, the choices made by rice millers stem from alternative courses of actions and calculations of the chances or perceptions of probability they have towards achieving their goals. These perceptions are guided by previous experiences and past successes and similarity to the present situation.

This study fits in the theory in that rice millers choose different alternative paddy sourcing methods to increase the volume of paddy sourced and milled basing on their past experiences with the alternatives. According to rational choice theory, while a rice miller assumes alternatives and uses paddy sourcing methods that are most effective towards attaining set goals, most of the decisions maybe monetarily oriented. For example, choosing a paddy sourcing method may involve factors such as cost related effort needed to raise a given volume of paddy in terms of number of workers to carry along and distance to be covered. The non-monetary oriented factors for the use of some paddy sourcing methods may involve culture within a community and willingness of the final consumers to associate with products from the community where it was sourced. The rationality in this case arises when rice millers find a way of comparing different rewards and costs and deciding what course of action is rewarding and least costly to them.

Additionally, some social interactions between the buyers and sellers may involve some unbalanced exchanges (Blau, 1964). This automatically means that one party may benefit more from the interaction than the other party. Therefore, an individual can either benefit or incur huge costs in a rational choice interaction. In other words, this unbalanced exchange can lead to unprofitable situations incase malpractice is a constituent in the interaction. Rice millers may offer low prices for poor quality paddy produced or mixed-up varieties or improperly dried paddy. This may resonate with the fact that some farmers do not have the capacity to meet the quality requirements of the miller, and the millers tend to have markets for milled rice that is not mindful of the quality of milled rice. Rational choice theory equally involves optimization

approach like profit maximization. The application of the theory is relevant in this case since it probes the underlying intentions and non-intention of rice millers to source paddy using a given method. In conclusion, the theory proves that the choice of paddy sourcing method by the rice millers is typically based on a rational thought.

2.7 Conceptual Framework

In this study, paddy sourcing methods used by small and medium scale rice mil owners were assumed to be aggregation under cooperative, aggregation by an agent from the miller, private traders/middlemen, individual farmers bringing paddy to the miller and direct sourcing from individual farmers by the miller. Factors that determine millers' utilization of a given paddy sourcing method were assumed to be influenced by: economic factors, socioeconomic, technical factors and sourcing costs. Under the economic factors, the study mainly focused on aspects such as nature of business, mode of payment, level of financing availability, volume of paddy in a given locality and, contract agreements with farmers; Technical factors focused on aspects such as installed milling capacity, storage capacity available, level of miller's expertise, level of competition; and sourcing cost factor were limited to aspects such as labour costs, price of paddy, transport costs (distance), commission costs, truck hiring & servicing costs. In this case, the study assumed that these factors influence the decision of small and medium scale millers to use either one method or another or a combination of methods. The study also assumed that the sourcing method employed by small and medium scale millers either positively or negatively affect the total volume of rice milled. Therefore, the volume of rice milled was assumed to respond to changes in the sourcing methods which are influenced by technical factors, socioeconomic, economic factors and sourcing costs.

The study also assumed that a millers' utilization of a combination of sourcing methods irrespective of the size receive more volumes of paddy hence higher volumes of paddy milled, high mill utilization capacity, reduced unit cost of production and higher marginal returns compared to millers using a single method of paddy sourcing as shown in Figure 2.1.

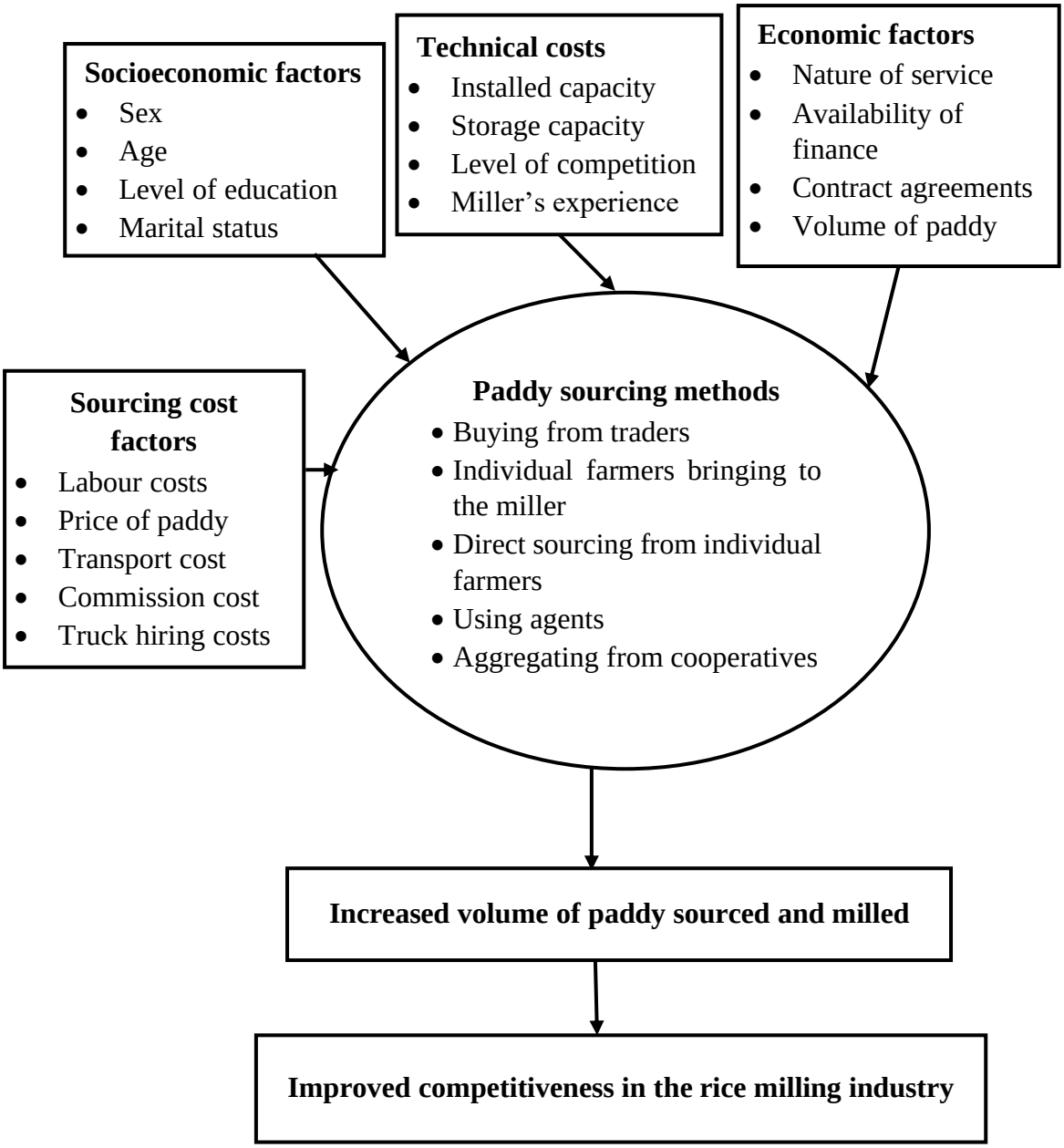

Figure 2.1. The Conceptual Framework

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter presents the study area and methodology used in analysis It presents the study area, sample selection, sampling procedure, data collection and analysis and the analytical framework.

3.1 Study Area

The study was conducted in Mwea Irrigation Scheme (MIS) which is situated in Mwea constituency of Kirinyaga County. The region is on the South-Eastern part of the district, around 100 kilometres North-East of Kenya's capital city, Nairobi (Kadipo *et al.,* 2021). The scheme was laid out in 1954 and at present has around 12,000 ha exclusively under rice development, delivering roughly 80% of the paddy rice produced in Kenya (Ngige, 2004). The Mwea Irrigation Scheme is the largest irrigation zone in Kenya in terms of area (Watanabe *et al*., 2021). The nuclear scheme is divided into 5 sections, namely; Tebere, Mwea, Thiba, Wamumu and Karaba (Nyabonyi, 2016) as shown in Figure 3.1.

Mwea Irrigation Scheme possesses the lower height zone of the region with sweeping low-lying muddy regions, which contains dark cotton soils. The elevation goes from around 1000-2000m above ocean level, with least and greatest temperatures of 15°C and 30°C (Ngige, 2004). It receives an annual mean precipitation of 950 mm, with annual sunshine of 677 2485 h since it lies within latitude 37° 13'E and 37° 30'E and longitude 0°32'S and 0°46'S (Kabutha & Mutero, 2000). There are two rainy seasons, with long rains happening from mid-March to May and short rains in October/November. The main agricultural activity is the rice mono cropping. Rice is grown on irrigated paddies that are flooded for about half of the year (Muhunyu, 2012). Over 70% of all locally grown rice in Kenya is produced in the Mwea Irrigation Scheme, including 95% of all domestically grown basmati. The optimal per unit production under irrigation is 5.5 t/ha for aromatic varieties and 7 t/ha for nonaromatic varieties. Actual yields in Mwea have been lower than the expected yield (Muhunyu, 2012) approximated at 4.25 t/ha (Atera *et al*., 2018).

According to Rice Millers Association of Kenya (2015), there were 130 rice milling factories in Kirinyaga County by 2015 while MOA *et al.* (2017), established the number at 139. The study area was purposively selected because Ndirangu and Oyange (2019), found out that there are over 256 other small to medium rice mills in the rice growing areas with Mwea accounting for over 58% of the millers. Rice processing industrial facilities utilize various sizes

and nature of hardware which results to different production capacities (in volume) and rice quality differences which are classified into small, medium and large (Githumbi, 2012).

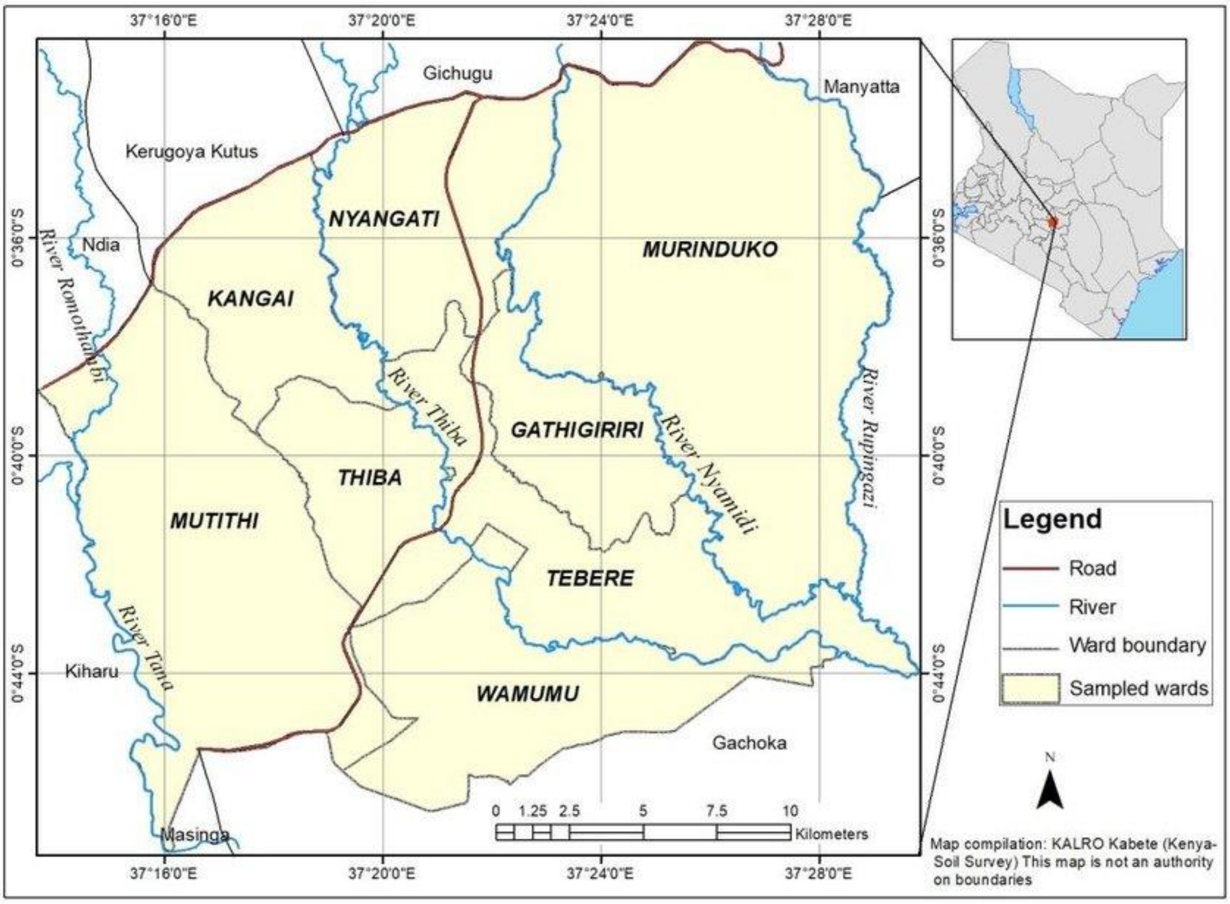

Figure 3.1 Map of Mwea Irrigation Scheme

Source: Nakhungu *et al.* (2019)

3.2 Sample Selection

A sample can be described as a collection derived from the universe to act as the universe's representative (Kothari, 2008). The study consisted of a sample unit of small and medium scale millers who source paddy for milling in Mwea constituency in Kirinyaga County. The rice millers considered are those who actually owned the rice mills and not managers. The sample size was determined following a sampling procedure that was determined by Yamane (1973), and taken up by Israel (1992) and Polonia (2013). The sample size was determined as follows:

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

Where: n = desired sample size; N = number of millers; e = level of significance at 0.05.

Therefore;

$$n = \frac{256}{1+256(0.05)^2} = 156$$

This resulted to a sample size of 156 respondents which was selected according to the proportion of the number of small and medium scale millers in the population. However, during the actual data collection, 160 respondents were considered. This was considered in order to obtain a more precise estimate of population parameters.

3.3. Sampling Procedure

The study adopted a multistage sampling technique to obtain the required sample size. Purposively selecting the Mwea irrigation scheme in Kirinyaga County comprised the first stage because it accounts for 70% of the total rice produced in the country. The second stage involved purposive selection of Tebere, Mwea, Thiba, Wamumu and Karaba divisions which constitute Mwea Irrigation Scheme. The scheme is also known to have around 256 small and medium scale rice millers. From the 256 small and medium-scale millers, a sample size of 156 was considered as shown in Table 3.1. Lastly, systematic sampling was used to select respondents from a list of small and medium scale millers. The first respondent was selected randomly and the others were selected by K^{th} (sampling interval) 1.6 which was determined by dividing the entire population with the desired population (256/160).

$K^{th} = N/n = (256/160) = 1.6$

where K = systematic sampling interval, N = Population size, n = desired sample size

Table 3. 1 Proportionate Distribution of the Sample Size

Category	Population	Proportion	Sample size
Small scale millers	148	148/256	90
Medium scale millers	108	108/256	70
Total	**256**		**160**

3.3 Data Collection and Data Analysis

Primary data was used for this study. Primary data was collected through semi-structured questionnaires (see appendix 1) administered to the small and medium scale millers to collect qualitative and quantitative data for the study. The questionnaires administered had a blend of both open ended and close ended questions. A pilot study was conducted prior to the actual data collection to test the validity and reliability of the questionnaire. Observation was used to provide additional information about the millers, their tasks and other sourcing

methods. Secondary data was collected from accredited publications, relevant websites, books, journals, newspapers, and government records to find out the available information related to the study. The different methods were used to determine the different paddy sourcing methods used by small and medium scale millers, factors that influence the use of the identified methods and effects of the methods on the volume of rice milled by small and medium scale millers. Quantitative techniques were used to analyse the data collected. The data was entered using SPSS and analysed using STATA computer packages.

3.4 Analytical Framework

3.4.1 Objective One: Characteristics of Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers

To establish the different paddy sourcing methods used by small and medium scale rice millers, descriptive statistics such as frequencies, percentages, and means were used. These were used to summarize and describe the characteristics of the small and medium scale rice millers. They equally provided a concise and meaningful summary of the data, which was used to understand the patterns and relationships in the data. The *t*-test was used to compare the characteristics between small and medium scale rice millers.

3.4.2 Objective Two: The Level of Usage of the Different Paddy Sourcing Methods by Small and Medium-Scale Rice Millers

From literature, there are five (5) paddy sourcing methods that small and medium scale rice millers use to access paddy for milling. The different sourcing methods determine the volume of paddy sourced and milled by these millers. To identify the intensity of use of paddy sourcing methods by small and medium-scale rice millers, millers were asked to rank the paddy sourcing methods from 1 to 6 (with 1 showing the least commonly used methods and 6 showing the most commonly used method). The frequencies of the ranks of each paddy sourcing method were calculated, and used to assign positions to each of the paddy sourcing methods. The results for the different sourcing methods identified and the intensity of their use was then visualized using appropriate info-graphics, tabular presentations, and summary statistics.

3.4.3 Objective Three: Factors Influencing the Choice of Paddy Sourcing Methods among Small and Medium-Scale Rice Millers

The factors that determine the utilization of the paddy sourcing method were assumed to be based on economic factors, socioeconomic, technical factors, and sourcing cost factors. Under the economic factors, the study considered the nature of business, level of financing available, contract agreements with cooperatives, and volume of paddy in a given locality. The

technical factors that were considered include installed milling capacity, storage capacity available, level of competition, and level of millers' expertise while the sourcing cost factors considered were the price of paddy, labour cost, transport cost, commission cost, truck hiring or servicing costs. It was assumed that these factors (independent) could explain millers' usage of given sourcing methods (dependent).

The utilization of paddy sourcing methods was measured as a dummy variable. That is 1 if a rice miller uses a given paddy sourcing method and 0, otherwise. In relation to this objective, econometric models such as multivariate probit or logit, multinomial probit or logit, conditional and nested logit have been used to analysis categorical choice dependent variables (Tarekegn *et al.*, 2017). There are a number of studies that have been conducted to identify the factors that influence farmers' choice of marketing channels for different agricultural products. A study by Wijesooriya *et al.* (2020), used logistic regression, Martey *et al.* (2021), Mmbando *et al.* (2016) and Soe *et al.* (2015) used multinomial logit model, Siddique *et al.* (2017), used multivariate decision analysis technique while Dlamini-Mazibuko *et al*. (2019), Tarekegn *et al*. (2017), Tura & Hamo (2018) and Wosene *et al.* (2018) used multivariate probit model.

Multinomial models are appropriate when individuals can choose only one outcome from among the set of mutually exclusive, collectively exhaustive alternatives (Tarekegn *et al*., 2017). However, in this study, the factors that determine the utilization of a given paddy sourcing method are not mutually exclusive, considering the possibility of simultaneous factors and the potential correlations among these factors. Therefore, based on the empirical studies reviewed, multivariate probit model was adopted for this study to estimate several correlated binary outcomes jointly. This is because it simultaneously captures the influence of the set of explanatory variables on each of the different paddy sourcing methods while allowing for the potential correlations between unobserved disturbances, as well as the relationships between the choices of different paddy sourcing methods (Greene, 2012).

The decision of whether or not to choose a sourcing method is underpinned on the general framework of utility or profit maximization (Arinloye *et al*., 2015). It is assumed that given miller i in making a decision considering not exclusive alternatives that constituted the choice set Kth of paddy sourcing methods, the choice sets may differ according to the decision-maker. Consider the *i*th miller (i = 1, 2…...N) facing a decision problem on whether or not to choose available paddy sourcing methods. Let Uk represent the benefit of miller to choose the K^{th} paddy sourcing method: where K denotes buying from traders (Y1), sourcing from cooperatives (Y2), sourcing from individual farmers (Y3), using agents sent by the miller (Y4), and individual farmers bringing paddy to the miller (Y5). The miller decides to choose the K^{th}

paddy sourcing methods if Y*ik = U*k – U_o > 0. The net benefit (Y*ik) that the miller derives from choosing a paddy sourcing method is a latent variable determined by observed explanatory/independent variable (Xi) and the error term (εi):

$$Y^*_{ik} = X'_i \beta_k + \varepsilon_i \qquad (K=1,2,3,4,5) \qquad (2)$$

Hence, the econometric methodology for this study is by utilizing the pointer work; the unseen inclinations in Equation (2) converted into the noticed double result condition for every decision as follows

$$Yik = \begin{cases} 1 \; if \; Yik > 0 \\ 0 \; Otherwise \end{cases} \qquad (K=1,2,3,4,5) \qquad (3)$$

With a possibility of several paddy sourcing methods in a multivariate model, the error terms concertedly follow a multivariate normal distribution (MVN) with zero tentative mean and variance normalized to cohesion (for identification of the parameters) where (μx1, μx2, μx3, μx4, μx5) MVN~(0, Ω) and the symmetric covariance matrix Ω is given by:

$$\boldsymbol{\Omega} = \begin{vmatrix} 1 & P_{x1x2} & P_{x1x3} & P_{x1x4} & P_{x1x5} \\ P_{x2x1} & 1 & P_{x2x3} & P_{x2x4} & P_{x2x5} \\ P_{x3x1} & P_{x3x2} & 1 & P_{x3x4} & P_{x3x5} \\ P_{x4x1} & P_{x4x2} & P_{x4x3} & 1 & P_{x4x1} \\ P_{x5x1} & P_{x5x2} & P_{x5x3} & P_{x5x4} & 1 \end{vmatrix} \qquad (4)$$

The off-inclining components in the covariance grid address the unseen connection among stochastic parts of various upper hand choices (Tarekegn *et al*., 2017). This presumption implies that the above condition produces a multivariate probit model together addressing a choice to acquire an upper hand. This detail with non-zero off-inclining components considers relationship among the error terms of various unseen elements.

The implicit functional form of factors that influences the utilization of a given paddy sourcing method was estimated as;

$$\mathbf{Y_{ik}} = \beta_0 + \beta_1 Age + \beta_2 Gen + \beta_3 Mstat + \beta_4 Educ + \beta_5 Service + \beta_6 Fin + \beta_7 Contct + \beta_8 Paywork + \beta_9 Price + \beta_{10} Tpcost + \beta_{11} Comm + \beta_{12} Tpown + \beta_{13} Insta + \beta_{14} Stoca + \beta_{15} Expert + \beta_{16} Compt + \beta_{17} Dstance + \beta_{18} Ownership + \varepsilon_i$$

where: Y_{ik} (k=1…5): Paddy sourcing methods

β_0 = Constant, β_1 - β_{18} = Coefficients and ε_i = Error term

Table 3. 2 Description and Expected Sign of the Variables to be Used in the Multivariate Probit Model

Variables	Descriptions	Measurement	Expected sign
Dependent			
Paddy sourcing methods			
Yi=1,…,5	Buying from traders	1=yes, 0=otherwise	
	From cooperatives	1=yes, 0=otherwise	
	From individual farmers	1=yes, 0=otherwise	
	Using agents	1=yes, 0=otherwise	
	Individual farmers	1=yes, 0=otherwise	
Independent			
Age	Age (years) of the miller	Number of years	+/-
Gender	Gender of the miller	1 male, 0 female	+/-
Mstat	Marital status	1 Married, 0 Single	+/-
Educ	Level of education	Number of years	+
Service	Nature of business offered	1 Both customized milling and buying for processing and sell, 0 Either customized milling or buying for milling and sale	+/-
Fin	Access to finance	1 Yes, 0 No	+
Contct	Contract agreements	1 Yes, 0 No	+
Paywork	Payment per worker per trip	KES/trip	+/-
Price	Price of paddy	KES/Kg	+/-
Tpcost	Transport cost (KES)	KES/MT	+/-
Comm	Commission cost	KES/Kg	+/-
Tpown	Ownership of a means of transport	1 Yes, 0 No	+/-
Dstance	Distance from the farmer to the mill	Km/trip	+/-
Instca	Installed capacity	MT/hr	+
Stoca	Storage capacity	MT	+
Expert	Level of millers' experience in years	Number of years	+

Compt	Level of competition	Number of millers within the same ward	-
Ownership	Mill ownership	1 Own, 0 Rented	+

3.4.4 Objective Four: Effect of Paddy Sourcing Methods on the Volume of Rice Milled by Small and Medium-Scale Rice Millers

The study assumed that rice millers have five (5) methods through which they source/collect paddy for milling. The sources include buying from traders, aggregation by farmer cooperatives, individual farmers bringing paddy to the miller, using village agents and direct sourcing from individual farmers. It is assumed that each miller uses either one or a combination of the paddy sourcing methods. This objective seeks to determine the effect of using one or a combination of the sourcing methods (independent) on the volume of paddy sourced and milled (dependent) by millers. This can be achieved using Propensity score matching (PSM) and endogenous switching regression model (ESR). However, PSM approach only accounts for the observable factors (Abdulai & Abdulai, 2017), while both the PSM and ESR can only handle two regimes like adopters and non-adopters (Oparinde, 2021). Yet, when millers make a choice of a paddy sourcing method, there may be self-selection, as millers choose their sourcing method based on their perception (unobserved characteristic) of the benefits they get from each sourcing method. This gives rise to endogeneity. Therefore, if the endogeneity that arises in milling decisions and usage of paddy sourcing methods is not taken into account, the true effect on the volumes milled cannot be estimated.

A two-stage instrumental variables approach was used to analyze this objective because it accounts for both the observed and unobserved endogeneity. In the model, R_i indicated usage of a single or combination of paddy sourcing methods by rice millers. However, due to the unobserved nature of usage of combinations of paddy sourcing methods, R_i^* was used to indicate unobserved usage while R_i indicated observed usage. The usage model was expressed as

$$R_i^* = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_i X_i + \varepsilon_i \text{ with } R_i = 1 \; if \; R_i^* > 0 \text{ or } 0 \text{ otherwise} \quad (5)$$

Where X_i is the vector of independent variables that influence participation in paddy sourcing methods while ε_i represents the unobserved factors.

$$Y_{i=} \boldsymbol{\alpha X}_i + \mu_i \quad (6)$$

Y_i represents the outcome variable (volume of rice milled), $\boldsymbol{X}_i$ represents the exogenous variables that affect the volume of rice milled, μ_i is the random disturbances associated with the model. The effect of using combinations of paddy sourcing methods on the outcome variable is measured by the estimates of the parameter in a two-stage simultaneous procedure. The decision to use a combination of paddy sourcing methods may be influenced by unobservable that can affect the outcome variable. If that is the case, then the error terms in Equation (5) and Equation (6) are correlated, leading to biased effects of which is the productivity effect of using a combination of paddy sourcing methods. The self-selection that arises when deciding on the combination of paddy sourcing method to use was tested using the Hausman and Durbin test for endogeneity. The solution was to account for such endogenity using an instrumental regression technique that assumes a joint normal error distribution (Di Falco *et al.,* 2011).

The choice of the instrument requires a variable that is correlated with the use of a combination of paddy sourcing methods but not with the error term of the volume of rice milled equation. The study adopted the choice of instruments as used by Algesheimer *et al.* (2010) which followed two steps. The first step involved specifying a participation model (Equation 5) which linked rice millers' usage of paddy sourcing methods to economic, socioeconomic, sourcing cost factors and technical factors. Thereafter, prediction probabilities obtained from the results of the usage of combinations of paddy sourcing methods model. These probabilities were used as an instrument in Equation (6) to instrument usage of combinations of paddy sourcing methods variable R_i.

$$Y_{i=}\boldsymbol{\alpha X}_i + \gamma \mathrm{R}_i + \mu_i \qquad (7)$$

Y_i represents the outcome variable (volume of rice milled), $\boldsymbol{X}_i$ represents the exogenous variables that affect the volume of rice milled, μ_i is the random disturbances associated with the model and $\gamma \mathrm{R}_i$ represents the predicted probabilities generated in the probit model (Equation 6) which instrumented usage of a combination of paddy sourcing methods. The quality of the instrument was tested using an F-test.

Table 3. 3 Description and Expected Sign of the Variables to be Used in the Instrumental Variables Approach

Variables	Descriptions	Measurement	Expected sign
Dependent			
Volsourc	Volume of paddy sourced	Metric tonnes (MT)	
Independent			
$B_1D_1I_1A_0$ Combination	Buying from traders, Direct sourcing from individual farmers, Individual farmers bringing paddy to the miller	1 Yes, 0 Otherwise	+/-
$B_1D_1I_1A_1$ Combination	Buying from traders, Direct sourcing from individual farmers, Individual farmers bringing paddy to the miller, Using agents	1 Yes, 0 Otherwise	+/-
$B_0D_1I_1A_0$ Combination	Direct sourcing from individual farmers and Individual farmers bringing paddy to the miller	1 Yes, 0 Otherwise	+/-
$B_0D_1I_1A_1$ Combination	Direct sourcing from individual farmers, Individual farmers bringing paddy to the miller, Using agents	1 Yes, 0 Otherwise	+/-
$B_1D_1I_0A_1$ Combination	Buying from traders, Direct sourcing from individual farmers, Using agents	1 Yes, 0 Otherwise	+/-

Note: B- Buying from traders, D- Direct sourcing from individual farmers, I- Individual farmers bringing paddy to the miller, A- Use of Agents

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This section presents the results and discussions of the findings of the study. The specific objectives of the study were to identify the paddy sourcing methods used by small and medium scale rice millers, the intensity of usage of the different sourcing methods, factors that influence utilization of the identified sourcing methods and the effects of sourcing methods on the volume of rice sourced and milled by small and medium scale rice miller. Data was collected using semi-structured questionnaire and a total of 160 rice millers including 90 small-scale and 70 medium scale millers participated in the study. This chapter highlights the descriptive statistics, inferential statistics multivariate probit and multinomial endogenous switching regressions results based on the study objectives.

4.2 Descriptive Statistics of the Respondents

4.2.1 Small and Medium-Scale Rice Mill Owners' Characteristics

The study analysed the socioeconomic background of the owners of small and medium scale rice-mills in Mwea to facilitate an understanding of their social and economic conditions and help to understand their personality patterns to better interpret their problems. The results of age, gender, marital status and education levels of small and medium-scale rice millers are presented in Table 4.1. Age of small and medium rice millers was grouped into five categories namely, below 25 years, between 26 to 35 years, between 36 to 45 years, between 46 to 55 years and above 55 years. Among the small-scale millers, majority (40%) were aged between 46 to 55 years, closely followed by between 36 to 45 years (37.8%), between 26 to 35 years (18.9%) and above 55 years (3.3%). Majority (45.7%) of the medium-scale millers were aged between 36 to 45 years, followed by those aged between 46 to 55 years (25.7%), between 26 to 35 (22.9%) and above 55 years (5.7%). Generally, majority (41.7%) of the rice millers were aged between 36 to 45 years, followed by those aged between 46 to 55 years (32.9%), between 26 to 39 (20.9%) and above 55 years (4.5%). Rice milling business requires huge initial capital to establish and high daily operational costs that requires long term savings for a considerable amount of time. Medagbe *et al.* (2020) indicates that as individuals tend towards 40 years, they spend most of their time on economic activities including farm and non-farm work to raise income that can allow them venture in self-operated income-generating activities.

Table 4. 1 Frequency Distribution of Mill Owners Characteristics

Variable	Small scale-millers (N=90)	Medium scale-millers (N=70)	Total (N=160)
Age (%)			
Between 26 - 35 years	18.9	22.9	20.9
Between 36 - 45 years	37.8	45.7	41.7
Between 46 - 55 years	40.0	25.7	32.9
Above 55 years	3.3	5.7	4.5
Gender (%)			
Male	53.3	58.6	56.0
Female	46.7	41.4	44.0
Marital status (%)			
Single	7.8	12.9	10.3
Married	87.8	82.9	85.3
Widowed	4.4	4.3	4.4
Education level (%)			
Primary education	2.2	4.3	3.3
Secondary education	66.7	48.6	57.6
College education	27.8	40.0	33.9
University education	3.3	7.1	5.2

Overall, male rice millers were the majority (56%) and females were 44%. Among the small-scale rice millers, 53.3% were males and 46.7% were females while 58.6% of the medium scale rice millers were males and 41.4% were females. Thus, majority of the small and medium-scale rice millers are males. This can be attributed to the fact that males have more access to productive resources, access to information and start-up capital to engage in rice milling activities compared to their female counterparts. This is in line with findings from Adejoh *et al.* (2017) who reported that males own most of the productive resources required to engage in rice production and trading.

With regards to marital status of the respondents, majority of the small and medium scale-rice millers were married in proportions of 87.8% and 82.9%, followed by those who are single, 7.8% and 12.9% and the widowed were 4.4% and 4.3% respectively. The high initial and operational costs involved in rice milling business requires combined efforts in terms of

raising income to invest and run the business. This result is consistent with findings from Adu (2018) who found that paddy rice farmers in the northern region of Ghana who were married had access to supply of labour for rice production, and markets as well as financial resources to invest in rice production.

In relation to education level, most (57.6%) of the small and medium-scale rice millers had secondary-level education at 66.7% and 48.6% respectively. College level education (33.9%) closely followed at 27.8% and 40% for, university education (5.2%) at 3.3% and 7.1% and primary level education (3.3%) at 2.2% and 4.3% small and medium scale rice millers respectively. Generally, more than 95% of the rice millers have secondary level education and above. This makes them able to read, interpret and understand the operational manuals that come along with the rice milling equipment which are largely imported from China (62.2%), Germany (12.5%), India and Brazil (25.3%) (Mano *et al.*, 2021). Better educated rice millers are likely to be highly innovative and creative in running and operating the rice milling machines (Ouma *et al.,* 2020).

Table 4. 2 Technical Characteristics

Variable	Small scale-millers (N=90)	Medium scale-millers (N=70)	Total (N=160)
Ownership (%)			
Mill is owned	48.9	64.3	56.6
Mill is rented	51.1	35.7	43.4
Storage facility (%)			
Yes	73.3	97.1	85.2
No	26.7	2.9	14.8
Service offered (%)			
Customized milling	2.2	0.0	1.1
Buying paddy for milling and selling only	4.4	20.0	12.2
Both services	93.4	80.0	86.7

The technical related characteristics of the respondents in terms of ownership of the rice mills, storage facility availability, and nature of service offered by the miller are presented in Table 4.2. In relation to ownership of rice mills, majority of the small-scale millers (51.1%) rented the rice mills while 48.9% owned the rice mills. Contrary to the small-scale millers, majority of medium-scale millers (64.3%) owned the rice mills and only 35.7% rented the rice

mills. Generally, 56.6% of the rice millers owned rice mills and 43.4% rented the rice mills. The high initial costs of buying and establishing rice milling facility can justify the fact that majority of small-scale millers rent rice mills. The need to control the set up and functioning of the mills and the major decisions related with the rice milling facility prompts medium scale millers to own rather than rent mills. Rice milling facilities are characterized with regular breakdowns and frequent adjustments which may result into delays in case the user of the facility is not the actual owner to guarantee permission for adjustments. According to Otsuka *et al.* (2023), mill owners are more likely to invest in quality improving technologies in order to attract more customers, improve on their capacity utilization and earn more profits.

Services offered by the millers were categorized as customized milling (offering milling services only), buying paddy and milling for sale only and pursuing both services. Majority (86.7%) of the millers offer both services with 93.4% small scale millers and 80% medium scale millers. Buying paddy for milling and selling only was majorly done by medium scale millers (20%). A few (2.2%) small scale millers also offer the customized milling services. Majority of the millers offer both services in order to increase their income streams and reduce the period that the milling facility lies idle when the millers do not have their own paddy. Mano *et al.* (2021) reported that offering customized milling contributes to approximately 2% of the total income earned by millers per year while sale of milled rice contributes 96%.

Table 4. 3 Means of Rice Millers Experience, Storage and Installed Capacities

Variable	Small scale-millers (N=90)		Medium scale-millers (N=70)		All millers (N=160)		*t*-test
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev	
Experience (Years)	9.3	4.197	10.8	6.046	9.9	5.126	-1.8*
Storage capacity (MT)	15.7	21.201	394.1	315.965	181.2	281.147	-11.2***
Installed capacity (MT/hour)	1.0	0.337	2.8	0.763	1.7	1.0564	-19.9***

* and *** = significant at 10% and 1% level, respectively

The mean differences of rice millers' experiences, storage capacity and installed capacity are presented in Table 4.3. Concerning the experience of the two groups, small-scale millers had a mean experience of 9.3 years while medium-scale millers had a mean experience

of 10.8 years. The association between rice milling and age was statistically different at 10%. The variation in mean age between the two groups could be explained by the fact that competitive management of medium scale rice mills requires competent, qualified and experienced management which plays a crucial role in oversight and providing significant guidance in running the milling business. Generally, the mean years of experience of the small and medium rice millers is 9.9 years. This is close to the results from Kapalata and Sakurai (2020) who found that over 70% of rice millers in Morogoro in Tanzania had a mean rice milling experience of 9 years.

Additionally, small scale and medium-scale millers have a mean storage capacity of 15.7 MT and 394.1MT respectively. The overall mean storage capacity for small and medium scale rice millers is 181.1MT. The association between rice milling and storage capacity was statistically different at 1%. Majority of the medium scale rice millers own the milling facilities and therefore can make adjustments to improvise for storage facility unlike the small-scale millers who mainly rent the facilities. A storage facility allows millers to stock adequate raw material/paddy to allow the milling process to continue during the off-season period. According to Atera *et al.* (2018), offering free storage and space for sale of rice has since been adopted by all medium and large mills in Mwea Constituency.

The study considered small scale milers as those whose installed milling capacity ranged from 0.1MT/hour to 1.5MT/hour and 1.6MT/hour to 3.5MT/hour for medium scale millers. Small scale millers have a mean installed capacity of 1MT/hour and 2.8MT/hour for medium scale millers. This is consistent with the study conducted by Twine *et al.* (2021) who reported an average installed capacity of 10MT/day for small scale millers in Uganda. However, this is contrary to the study conducted by Mano *et al.* (2021) who reported an average installed milling capacity of 0.86MT/hour for small scale millers in Mwea. Their study fully focused on small scale-millers with traditional type of rice mills which could explain the variation. The overall installed milling capacity for all the small and medium scale millers in the study was 1.8MT/hour.

4.3 Characteristics of Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers.

In relation to objective one of the study, Figure 4.1 presents the paddy sourcing methods used by small and medium-scale rice millers. Majority of the small-scale millers depend on individual farmers bringing paddy to the mills (87.8%), followed by buying from individual traders (81.1%), direct sourcing from individual farmers (78.9%) and sourcing using agents

(54.4%). All small-scale millers who participated in the study participate actively in farming and majority combine farming and trading activities. Due to the lower installed capacities and high commission costs, the use of agents is limited among small scale millers. Medium-scale millers largely use direct sourcing from individual farmers (97.1%) followed by sourcing using agents (82.9%), individual farmers bringing paddy to the miller (80%) and buying from traders (71.4%). Buying from traders is the least commonly used method among medium scale millers because they all double as paddy traders. Due to the higher installed capacities, direct sourcing of paddy from individual farmers is the most commonly used method since waiting for smallholder farmers to bring paddy to the miller is not consistent and sustainable.

Generally, direct sourcing from individual farmers is the most commonly used paddy sourcing method (88%), closely followed by individual farmers bringing paddy to the miller (83.9%), buying from traders (76.3%) and sourcing using agents (68.7%). The unit price of paddy when sourcing directly from farmers is the lowest compared to the rest of the methods thus its prominence. Over 80% of the rice millers offer both customized milling services to limit on the period that the milling facility remains idle due to absence of paddy. This further explains the reliance of millers on individual farmers bringing paddy to the miller. Agents charge an extra 1KES as commission cost on each kilogram of paddy that they source from individual farmers. This makes it expensive for the millers thus explaining the fact for its limited general usage among millers. Literature shows that sourcing from farmer cooperatives is among the paddy sourcing methods used by millers (Atera *et al.,* 2018; Kunihiro *et al.,* 2014; Muhunyu, 2012; Ndirangu & Oyange, 2019; Watanabe *et al.,* 2021). However, in Mwea, cooperatives have their own mills thus other millers cannot get paddy from any of the cooperatives.

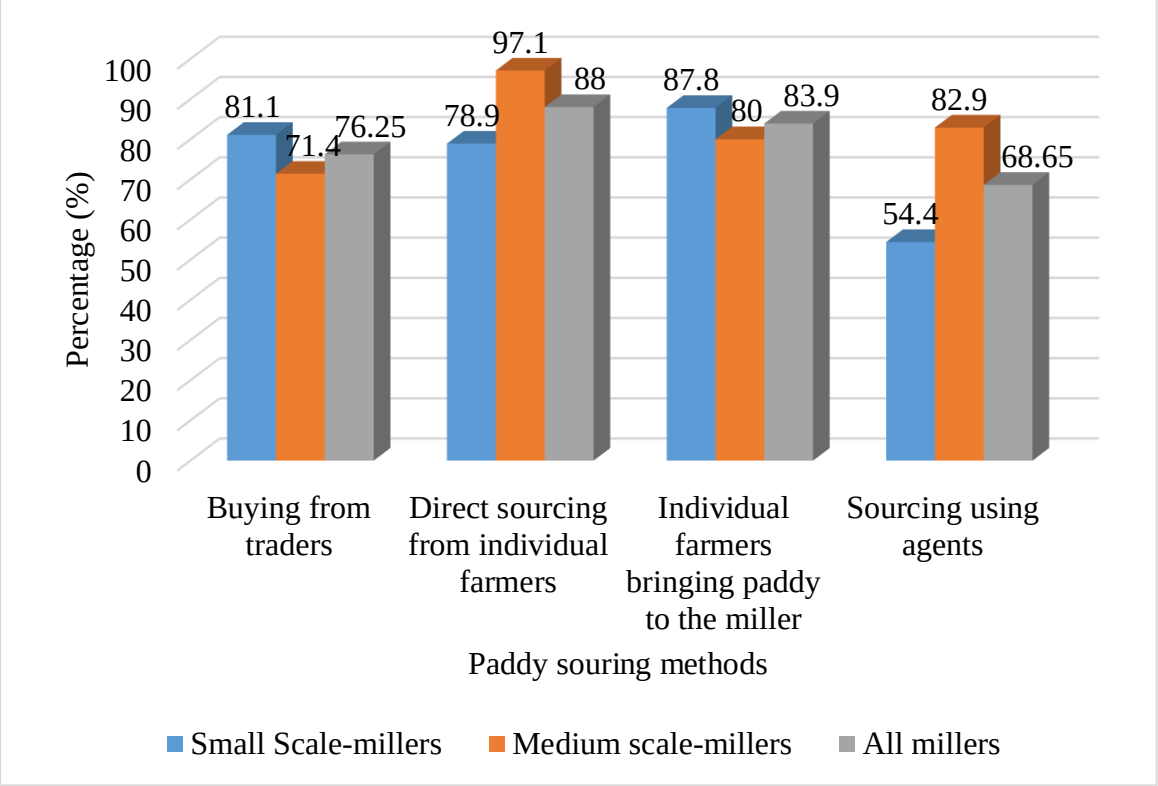

Figure 4.1 Paddy Sourcing Methods Used by Small and Medium Scale Rice Millers

4.3.2 Combination of Paddy Sourcing Methods Used by Small and Medium-Scale Millers

The different combinations of paddy sourcing methods used by small and medium-scale millers are presented in Table 4.4. It indicates that only 2.2% of the millers used a single paddy sourcing method (individual farmers bringing paddy to the miller). The small-scale millers who relied on this method had an installed capacity of 0.1MT/hour and engaged in both farming and trading activities. The rest 97.8% of the millers use a combination of paddy sourcing methods.

Table 4. 4 Combination of Paddy Sourcing Methods Used by Small and Medium-Scale Millers

Paddy sourcing method	Category of miller		
	Small scale-millers (%)	Medium scale-millers (%)	All millers (%)
Individual farmers bringing paddy to the miller ($B_0D_0I_1A_0$)	4.4	0.0	2.2
Buying from traders, direct sourcing from farmers, and individual farmers bringing paddy to the miller ($B_1D_1I_1A_0$)	95.6	54.3	74.9
Buying from traders, direct sourcing from farmers, individual farmers bringing paddy, and using agents ($B_1D_1I_1A_1$)	66.7	82.9	74.8
Direct sourcing from farmers and individual farmers bringing paddy to the miller ($B_0D_1I_1A_0$)	13.3	17.1	15.2
Direct sourcing from individual farmers, using agents and individual farmers bringing paddy to the miller ($B_0D_1I_1A_1$)	17.8	40.0	28.9
Direct sourcing from individual farmers, using agents, and buying from traders ($B_1D_1I_0A_1$)	2.2	5.7	4.0

Majority (95.6%) of the small-scale millers use a combination of buying from traders, direct sourcing from farmers and individual farmers bringing paddy to the miller. Small-scale millers who use all four paddy sourcing methods considered in the study are 66.7%. Direct sourcing from individual farmers, using agents and buying from traders is the least (2.2%) commonly used paddy sourcing combination among small-scale millers. Majority (82.9%) of the medium-scale millers use a combination of all the four paddy sourcing methods considered in the study. Buying from traders, direct sourcing from farmers and individual farmers bringing paddy to the miller is used by 54.3%, direct sourcing from individual farmers, using agents and individual farmers bringing paddy to the miller by 40%, direct sourcing from farmers and individual farmers bringing paddy to the miller by 17.1% and direct sourcing from individual farmers, using agents and buying from traders by 5.7% of the medium-scale millers. This is consistent with finding from Kunihiro *et al.* (2014) millers in Uganda access paddy by directly

buying from individual farmers in production areas, allowing individual farmers to bring to their mills and use of village agents in rice producing areas.

Generally, majority (74%) of the millers use two paddy sourcing combinations almost in equal measure. Buying from traders, direct sourcing from farmers and individual farmers bringing paddy to the miller at 74.9% and all the four paddy sourcing methods used by 74.8% of the millers. This tie is attributed to the major use of a combination involving agents by medium-scale millers and a major use of three main methods that exclude use of agents by small-scale millers. The use of these combinations is also related to the fact that most of the millers offer both customized milling services and buy paddy for milling and selling purposes. This requires a constant supply of paddy throughout the year such that the mills cannot lie idle. Direct sourcing from individual farmers, using agents, and individual farmers bringing paddy to the miller is used by 28.9% and the least commonly used combination is direct sourcing from individual farmers, using agents and buying from traders by 4% of the millers. Individually, buying paddy from traders and using agents are the least commonly used methods because of the high unit price of paddy associated with the two methods. Therefore, a combination of three paddy sourcing methods having these two methods is likely to be least commonly used.

4.4 Level and the Likelihood of Usage of Paddy Sourcing Methods.

4.4.1 Level of Usage of Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers.

In order to answer objective two, level of utilization of paddy sourcing methods among small and medium-scale rice millers was categorized into six different groups. Frequently used (above 71% of volumes of paddy is sourced using this method), usually used (between 51-70% of volumes sourced), occasionally used (between 31-50% of volumes sourced), sometimes used (between 11-30% of volumes sourced), rarely used (less than 10% of paddy volumes sourced) and did not use the sourcing paddy. The most frequently used paddy sourcing methods by small and medium scale rice millers are presented in Table 4.5.

Table 4. 5 Paddy Sourcing Methods Frequently Used by Small and Medium-Scale Rice Millers

Paddy sourcing method	Category of miller		
	Small scale-millers (%)	Medium scale-millers (%)	All millers (%)
Direct sourcing from individual farmers	35.6	20.0	28.8
Individual farmers bringing paddy to the mill	10.0	25.7	16.9
Buying from traders	1.1	0.0	0.6
Direct sourcing from farmers and individual farmers bringing paddy to the miller	52.2	51.4	51.9
None	1.1	2.9	1.9

The most frequently used paddy sourcing method among small and medium-scale millers is a combination of direct sourcing from farmers and individual farmers bringing paddy to the miller at 52.2% and 51.4% respectively. Other frequently used methods by small-scale millers include direct sourcing from individual farmers (35.6%), individual farmers bringing their paddy to the miller (10%), and buying from traders (1.1%). Among the medium-scale millers, 25.7% of the individual farmers take their paddy to the miller while 35.6% directly source from individual farmers. About 1.1% and 2.9% of the small and medium-scale millers do not frequently use any of the paddy sourcing methods. Direct sourcing from individual farmers is associated with the cheapest unit cost of paddy while individual farmers incur transport costs when they bring to the miller. Individual farmers bringing paddy to the miller is dominant due to the informal credit facilities offered by the miller to the farmers during rice production which is paid back in terms of paddy. Sourcing using agents is not frequently used by the millers due to the high commission cost associated with the use of agents. According to Ojwang (2012), maize millers in Kenya position themselves to frequently access raw materials at the cheapest cost possible while minimizing the cost of transportation.

The paddy sourcing methods that are usually, occasionally, sometimes and rarely used are presented in Table 4.6. Majority of the millers 70.6% and 78.8% do not usually and occasionally use the different paddy sourcing methods respectively. Since majority of the millers frequently use a combination of direct sourcing from individual farmers and individual farmers bringing paddy to the miller, the intensity of usage of other sourcing methods largely depends on how much paddy has been sourced. This is consistent with findings from Kunihiro *et al.* (2014) who noted that over 70% of the paddy sourced by the millers in Uganda is brought to the mills by farmers. Contrary to the frequently used methods, sourcing using agents is

sometimes used (18.1%), rarely used (17.5%), occasionally used (8.1%) and usually used (3.8%). Nagalakshmi *et al.* (2013) noted that farmers and other actors in India tend to desist from dealing with commission agents because they frequently cheat them.

Use of agents is common as a supplementary method during off season periods when accessing paddy from individual farmers becomes extra difficult for the millers. Millers also reported that agents own stores where they keep the bulk paddy they buy from farmers during harvesting period. This leaves millers with no choice but to access paddy through agents. Nagalakshmi *et al.* (2013) reports that commission agents usually outline the preferred price of sale and other preferred conditions of the deal and always wait until the conditions are satisfied.

Table 4. 6 Other Levels of Utilisation of Paddy Sourcing Methods

Paddy sourcing method	Category of miller		
	Small scale-millers (%)	Medium scale-millers (%)	All millers (%)
Usually used (%)			
Direct sourcing from individual farmers	4.4	12.9	8.1
Individual farmers bringing paddy to the mill	15.6	11.4	13.8
Buying from traders	1.1	7.1	3.8
Using agents	2.2	5.7	3.8
None	76.7	62.9	70.5
Occasionally used (%)			
Direct sourcing from individual farmers	3.3	11.4	6.9
Individual farmers bringing paddy to the mill	0.0	1.4	0.6
Buying from traders	2.2	10.1	5.6
Using agents	8.9	7.1	8.1
None	85.6	70.0	78.8
Sometimes used (%)			
Direct sourcing from individual farmers	0.0	4.3	1.9
Individual farmers bringing paddy to the mill	20.0	4.3	13.1
Buying from traders	31.1	10.0	21.9
Using agents	11.1	27.1	18.1
None	37.8	54.3	45.0
Rarely used (%)			
Direct sourcing from individual farmers	1.1	7.1	3.8
Individual farmers bringing paddy to the mill	0.0	1.4	0.6

Buying from traders	41.1	38.6	40.0
Using agents	18.9	15.7	17.5
None	38.9	37.2	38.1

Buying from traders is rarely used (40%), sometimes used (21.9%), occasionally used (5.6%), usually used (3.8%). The intensity of usage of buying from traders is low across different categories of usage. Millers reported that unit prices of paddy are highest among traders, millers complained of tampered and adjusted weighing scales used by traders, selling of mixed varieties of rice was associated with traders and the sale of improperly dried paddy. Millers can then access paddy from them without any competition from other suppliers. According to Yankson *et al.* (2016), some farmers in Ghana do not sell their produce to traders because of failure to agree on the price set by the farmers.

4.4.2 Likelihood of Usage of Paddy Sourcing Methods by Small and Medium-Scale Rice Millers in the Next Harvesting Period

Knowing the likelihood of rice millers to use a given paddy sourcing method can provide valuable insights for researchers, policy makers and other stakeholders working with rice millers and help promote sustainable, efficient and profitable decisions. The likelihood of small and medium scale rice millers to use given paddy sourcing methods in the next harvesting period is presented in Table 4.7. Majority of the millers 75% and 61.3% are very likely to source paddy using direct sourcing from individual farmers and individual farmers bringing paddy to the miller respectively. At the same time, 25% and 38.7% of the millers are likely to source paddy directly from farmers and allowing individual farmers to bring paddy to the mill respectively. The likelihood of using these two methods is associated with the stiff competition for paddy among rice millers across the entire Mwea irrigation scheme, the low unit price of paddy when sourcing directly from farmers and the fact that smallholder farmers incur the transport cost when transporting paddy to the millers. This is in line with findings from Kyeremah *et al.* (2019) who reported that over 88% of rice farmers in Ghana are likely to sell their paddy by allowing millers to pick from their homes or directly deliver to the rice mills.

The likelihood of allowing individual farmers to bring paddy to the miller indicates that millers are still willing to offer credit facilities to the farmers during the production periods. This equally indicates the miller's continuation of offering both customized milling services and buying paddy for milling and for sale. Majority (67.1%) of small-scale millers are very likely to source paddy from individual farmers bringing paddy to the miller while majority (85.6%) of medium scale millers are very likely to directly source from individual farmers.

This can also be attributed to the completion of the construction of Thiba dam which indicates an increased supply of water for irrigation purposes and possibility of rice production throughout the year in Mwea irrigation scheme (MOA, 2019).

Buying from traders and using agents are very likely to be used by 3.1% and 4.4% millers and likely to be used by 13.8% and 8.8% of the millers respectively. The likelihood of using these methods is largely associated with the fact that they own storage facilities where they stock cheap paddy that they buy during the harvest period. Since harvest period does not last for long, millers will have limited options of acquiring sufficient volumes of paddy. This makes the millers turn their focus to traders and agents to access paddy. This is consistent with findings from Moniruzzaman (2020) who reported that rice farmers in Bangladesh sell paddy to traders and agents because they lack appropriate storage facilities to accommodate the volumes produced and maintain the quality of paddy to meet the millers requirements.

Table 4. 7 The Likelihood of Using Different Paddy Sourcing Methods

Paddy sourcing method	Category of miller		
	Small scale-millers	Medium scale-millers	All millers
Buying from traders (%)			
Very likely	3.3	2.9	3.1
Likely	17.8	8.6	13.8
Neutral	10.0	7.1	8.8
Unlikely	43.3	24.3	35.0
Very unlikely	25.6	57.1	39.4
Direct sourcing from individual farmers (%)			
Very likely	61.4	85.6	75.0
Likely	38.6	14.4	25.0
Neutral	0.0	0.0	0.0
Unlikely	0.0	0.0	0.0
Very unlikely	0.0	0.0	0.0
Individual farmers bringing paddy to the miller (%)			
Very likely	67.1	56.7	61.3
Likely	32.9	43.3	38.7
Neutral	0.0	0.0	0.0
Unlikely	0.0	0.0	0.0
Very unlikely	0.0	0.0	0.0
Using agents (%)			
Very likely	2.2	7.1	4.4
Likely	6.7	11.4	8.8
Neutral	4.4	4.3	4.4
Unlikely	24.4	12.9	19.4
Very unlikely	62.2	64.3	63.1

Buying from traders and sourcing through agents are very unlikely to be used by 39.4% and 63.1% and unlikely to be used by 35% and 19.4% of the millers respectively. This is due to the high prices of paddy from traders and inclusion of commission costs when using agents. Majority (57.1%) of the medium scale millers are very unlikely to buy paddy from traders because they equally double as paddy traders during the harvesting period. Other reasons for the low likelihood of buying paddy from traders and using agents include use of adjusted or

tampered weighing scales, sale of mixed varieties of paddy, supply of poorly dried paddy and delays in supply of paddy to the agreed miller. Ravikishore *et al.* (2022) posits that agricultural traders and agents incur high transaction costs while buying produce from farmers. They also reported that traders and agents inflate the prices of produce and some go ahead to adulterate produce in order to recover the high costs incurred.

4.5 Factors Influencing Choice of Paddy Sourcing Methods Among Small and Medium-Scale Rice Millers

4.5.1 Multicollinearity Test

Before the actual running of the multivariate probit model, a multicollinearity test was conducted. Multicollinearity diagnostics measure how much regressors are related to the other regressors and how this affects the stability and variance of the regression estimates. Pairwise correlation analysis performed, using the Variance Inflation Factor (VIF) which is a measure of how much the variance of an estimated regression coefficient increases if the explanatory variables are correlated. The Table 4.9 was generated to check for multicollinearity. According to Kennedy (2008) as a rule of thumb, a variable whose average VIF values are greater than 10 may merit further investigation. From the table there was low multicollinearity within the variables with mean VIF of 2.95 hence the mean VIF was less than 10 and thus none of the variables were dropped from multicollinearity problem as shown in table 4.8.

Table 4. 8 Variance Inflation Factor as a Test for Multicollinearity

Variable	VIF	1/VIF
Age	3.582	0.279
Gender	1.742	0.574
Mstat	1.817	0.550
Educ	5.860	0.171
Expert	2.420	0.413
Ownershi	2.129	0.470
Priceave	2.999	0.333
Dstavera	1.914	0.523
Costaver	3.437	0.291
Payavera	1.843	0.543
Instalco	2.521	0.397
Storacap	2.515	0.398
Comptiti	3.154	0.317
Service	4.052	0.247
Contagre	2.689	0.372
Commcost	2.086	0.479
Mean VIF	2.951	.

4.5.2 Results of the Multivariate Probit Model

A Multivariate Probit (MVP) model was used to determine the factors that influence the utilization of paddy sourcing methods by small and medium-scale rice millers as depicted in Table 4.9. The Wald test $\{\chi^2(72) = 103.53, p < 0.0001\}$ implied that multivariate regression is highly significant and the likelihood ratio test $-\chi^2/6 = 21.02, p < 0.0001\}$ of the independence of multiple usage of various paddy sourcing method was strongly rejected. This indicates that multiple usage of different paddy sourcing methods among small and medium-scale rice millers is not mutually independent and multivariate probit specification fits the data. This equally implies that the Multivariate Probit Model had high explanatory power and goodness of fit of the model. The covariance matrix which is denoted by rho21=rho31=rho41=rho32=rho 42= rho43=0, implies that the rho-values are statistically significant at a 95% confidence level.

Older rice millers were more likely to buy paddy from traders and allowing individual farmers to bring paddy to the mill. Older millers have a tendency of building and widening

their business networks in terms of traders and smallholder farmers that they deal with over time. This allows them cut operational costs at the same time meet the growing market demand. Radipere and Dhliwayo (2014) revealed that business performance improves with an increase in the age of the business owner. However, older rice millers were less likely to directly source paddy from individual farmers at 99%. As millers grow older, their physical strength reduces and reaching to individual farmers become tiring and difficult. Also, millers gain considerable experience overtime in terms of reducing on the transport cost incurred when sourcing paddy. Milanovic *et al.* (2013) reported that physical strength reduces by 30% to 50% between the ages of 30 to 80 years. Chisambara (2022) confirmed that as businesses grow, business owners gain experience and focus on cutting costs and improving product quality.

Male rice millers had a 75.25% likelihood of directly sourcing paddy from individual farmers compared to the females (24.75%). Males have more access to productive resources, they are abler to hire or buy transport facilities to ferry paddy from individual farmers and pay employees who will go along with them compared to their female counterparts. Medagbe *et al.* (2020) reported that males own most of the productive resources required to engage in rice production and trading. Directly sourcing from individual farmers involves intense physical work such as loafing and offloading, carrying heavy bags of paddy from rice fields to where trucks park. This requires energy and physical strength which men possess. Bartolemei *et al.* (2021) conducted a study to compare male and female athletes in relative strength and power performances. They found significantly greater physical strength among males as compared to females.

Table 4. 9 Multivariate Probit Results for the Factors Influencing the Choice of Paddy Sourcing Methods among Small and Medium Scale Rice Millers

Variables	Buying from traders			Direct sourcing from individual farmers			Individual farmers bringing paddy to the miller			Using agents		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Age	1.579	0.509	0.002***	-1.053	0.325	0.001***	0.415	0.201	0.038**	-0.489	0.327	0.134
Gender	0.845	0.545	0.121	0.753	0.374	0.044**	0.155	0.267	0.561	-0.751	0.402	0.061*
Marital status	-2.810	0.557	0.035**	2.329	0.368	0.003*	-1.904	0.263	0.468	-0.020	0.285	0.946
Education	-0.344	0.353	0.330	0.345	0.299	0.249	-0.181	0.215	0.400	-0.601	0.430	0.163
Working experience	-0.271	0.087	0.002***	0.079	0. 041	0.055*	-0.057	0.027	0.034**	-0.020	0.047	0.669
Mill ownership	0.706	0.613	0.249	0.643	0.457	0.888	-0.265	0.279	0.342	0.563	0.488	0.263
Price of paddy	0.082	0.031	0.009***	-0.067	0.028	0.015**	0.041	0.015	0.006***	-0.019	0.029	0.511
Distance (Km)	-0.006	0.054	0.913	-0.013	0.043	0.748	-0.032	0.031	0.307	0.003	0.050	0.952
Transport cost	-0.001	0.000	0.013**	-0.000	0.000	0.142	0.000	0.000	0.857	0.000	0.000	0.351
Payment per worker	-0.002	0.001	0.108	0.002	0.001	0.262	0.001	0.001	0.155	0.006	0.005	0.235
Installed capacity	0.436	0.299	0.145	-0.244	0.240	0.311	-0.153	0.161	0.344	0.224	0.295	0.447
Storage capacity	0.001	0.001	0.221	0.002	0.001	0.010**	0.001	0.000	0.005***	-0.002	0.007	0.005***
Level of competition	-1.139	0.069	0.062*	1.033	0.478	0.031**	-0.182	0.273	0.504	-0.024	0.366	0.948
Nature of service	0.996	0.693	0.151	0.594	0.532	0.264	-0.045	0.381	0.907	0.394	0.542	0.467
Contract Agreement	-0.120	0.510	0.695	0.605	0.395	0.125	0.515	0.289	0.075	-0.350	0.399	0.381

Commission cost	0.001	0.001	0.079*	0.005	0.009	0.601	0.001	0.007	0.044**	-0.002	0.027	0.116
Access to finance	0.099	0.523	0.059*	-0.016	0.046	0.728	0.011	0.036	0.765	0.038	0.062	0.540
Constant	-7.928	3.726	0.033	2.855	3.008	0.343	-1.988	2.111	0.346	0.580	4.602	0.731

Number of observations = 160, Wald chi2 (68) = 111.200, Log likelihood = -198.254, Prob> chi2 = 0.000, rho21=rho31=rho41=rho32=rho42=rho43=0.002

The asterisk ***, ** and * Represents 1%, 5%, and 10% significant levels, respectively

On the other hand, male rice millers (75.13%) had a less likelihood of using agents in sourcing paddy compared to their female counterparts. Females often tend to have limited access to information, education and resources compared to men. Thus, dealing with agents can help then not only access information but also market for raw materials (paddy). Akinnagbe and Ayibiowu (2020) reported that male rice farmers in Ogun State in Nigeria directly participated in the sale of their produce because they had more access to market information compared their female counterparts.

Married rice millers were more likely to source paddy directly from individual farmers and less likely to buy from traders. The combined effort and income sources from married millers allow them to access other capital goods such as transport means which makes it possible to reach the distant smallholder farmers and access paddy at cheaper prices. Fry and Cohn (2010) postulate that married businessmen/women have greater economic gains than the unmarried counterparts due to the adjusted household income and higher financial contribution to run household/family businesses.

The more experienced rice millers were more likely to directly source from individual farmers and less likely to buy from traders and individual farmers bringing paddy to the miller. The experience and knowledge gained by the millers help them to become more efficient and productive as they explore mechanisms of increasing volumes of paddy sourced and reducing costs. That expounds on why direct sourcing becomes more critical since it is the cheapest method compared to buying paddy from traders and allowing individual farmers to bring paddy to the miller. Depending on traders and individual farmers to supply raw materials required for constant milling activities to continue may not be sustainable for significant commercial purposes to be conducted. In line with this, Adianto (2020) studied the effect of work experience on employee performance in Indonesia and revealed that work experience had a significant influence on employee performance.

An increase in the unit price of paddy was more likely to influence buying paddy from traders and individual farmers bringing paddy to the mill and less likely to influence direct sourcing from individual farmers. Both traders and individual farmers bringing paddy to the miller incur the cost of transporting paddy to the miller thus helping the miller to cut the cost that would have been incurred. While sourcing directly from the miller, the miller directly incurs the cost of transporting paddy from the different scattered individual farmers in the rice growing areas. Incurring such a high cost while at the same time buying paddy expensively

becomes less economical for the milling business. According to Joshi *et al.* (2020), the Nepalese rice milling industry is less competitive both locally and internationally because of the low profit margins due to the high unit price of paddy in Nepal.

A larger storage capacity was more likely to influence direct sourcing from individual farmers and individual farmers bringing paddy to the miller and less likely to influence using agents. Having a storage facility allows millers to source paddy from individual farmers because they have an assurance of where it can be stored for the continuous operation of the rice mills. While conducting a rice value chain analysis in Tanzania, Nkuba *et al.* (2016) noted that farmers sell paddy to traders at low prices because they lack appropriate storage facilities to accommodate their harvest. They also noted that some farmers sell paddy to local brokers because the rice mills are located far from them thus fearing to incur high transport costs to the rice mills. The main reason for using agents is due to their possession of storage facilities where they store paddy during times of plenty. This explains why an increase in storage capacity among the millers is associated with a reduction in sourcing using agents. Rahman (2019) noted that rice producers in Bangladesh sell their harvest to commission agents because other traders and rice millers do not have established warehouses within the production areas.

A highly competitive rice milling environment was more likely to influence directly sourcing from individual farmers and less likely to influence buy from traders. Direct sourcing from individual farmers over time results in a bond built between the miller and the farmers. This results in millers offering rice farmer services such as training about agronomic practices, credit facilities, and production resources. Thus, in cases where competition is high, the millers cultivate the relationship already established with individual farmers to access paddy. A highly competitive environment is associated with high paddy prices charged by traders. Since millers cannot break even when paddy is bought at higher prices, they opt for other means instead of sourcing from traders. Kunihiro *et al.* (2014) report that in a very competitive paddy market in Eastern Uganda, rice millers are compelled to search for paddy outside their districts of operation.

A higher commission cost was more likely to influence buying paddy from traders and individual farmers bringing paddy to the miller. Agents increasing the cost of commission makes the unit cost of paddy from other sources much cheaper than buying from them. It thus becomes favourable to buy from traders at the current price and allow individual farmers who do not charge any commission. According to Fiamohe *et al.* (2014), the high commission cost

paid by rice millers in Benin is associated with reduced competitiveness of the rice milling industry, increasing prices for consumers and limiting opportunities for producers, traders and rice millers.

Rice mill owners' access to finance had a positive and significant influence on the choice to buy paddy from traders. Accessing additional finance provides the rice millers with an opportunity to buy paddy at the inflated prices from traders who tend to have paddy at all times. Availability of finance allows them to invest in new technologies, purchase transport means and access traders who are scattered within Mwea. According to IFDC (2019), easy access to finance rice millers in Eastern Uganda such as Diners Group Limited allowed them to access cheaper transport facilities and higher volumes of rice milled per season.

4.6. Effect of Utilization of a Combination of Paddy Sourcing Methods on the Volume of Paddy Sourced and Milled

To determine the effect of paddy sourcing methods on the volume of rice milled by small and medium scale rice millers, a two-stage instrumental variable approach was used. The study used installed milling capacity as an instrument and it referred to the maximum volume of paddy that a rice mill is designed to process per hour/day according to the manufacturers' specifications. Commission cost was used as endogenous variable because a variable is said to be endogenous when it is correlated with the error term in the model.

Endogeneity test, validity test of the instrument and test for the strength of the instrument were conducted. Hausman test indicated presented in Appendix 5 indicated that commission cost was endogenous ($p=0.0093$). This finding, therefore, necessitated the use of an instrument in the model. A durbin test score was conducted to supplement the results of the Hausman test and it was $\chi 2=6.77352$ and significant ($p=0.0105$) confirming that indeed commission was endogenous. Therefore, the Durbin test and Hausman tests rejected the null hypothesis (variables are exogenous) at 1% and 5% significant levels respectively. Appendix 5 presents the falsification tests that indicated that installed milling capacity as a valid instrument because it was correlated with commission cost. The F statistic test of the strength of the instrument was $F(1,153) = 19.3619$ $Prob > F = 0.0003$ indicating that installed milling capacity was a strong instrument. Therefore, the Hausman, Durbin and validity tests validated the use of two stage instrumental Variables Approach for this objective.

The results of the two-stage instrumental variable approach are presented in Table 4.10. The Wald Chi-Square was 29.16 and the model was strongly significant at 1% level indicating that at least one of the explanatory variables is not equal to zero. The results indicate that the highest volume of paddy sourced by rice millers is achieved when they utilize a combination of three paddy sourcing methods which are buying from traders, direct sourcing from individual farmers and individual farmers bringing paddy to the miller ($B_1D_1I_1A_0$) by 467.6MT at 5% significant level. This could be attributed to the low unit price of paddy when sourcing directly from farmers, the fact that farmers incur the cost of transporting paddy to the miller when individually bringing paddy to the miller and the huge volumes stocked by traders during the offseason periods which makes paddy still available to the millers. This is consistent with the findings by Kunihiro *et al.* (2014) who reported that about 70% and 20% of paddy milled in Uganda was brought to the millers by farmers and bought from traders respectively.

Table 4.10: Two Stage Instrumental Variables (2SLS) Regression Results

Volume sourced	Coef.	St.Err.	p-value
Commcost	0.010	0.002	0.000
$B_1D_1I_1A_0$	467.564**	589.532	0.028
$B_1D_1I_1A_1$	-420.269	622.034	0.499
$B_0D_1I_1A_0$	195.666*	626.739	0.055
$B_0D_1I_1A_1$	-1026.839	686.775	0.135
$B_1D_1I_0A_1$	-3126.621***	982.900	0.001
_cons	335.000	580.2481	0.564
Wald chi2 (6) = 29.160	Prob > chi2 = 0. 000	R-squared = 0.265	

The asterisk ** *, ** and * Represents 1%, 5%, and 10% significant levels, respectively.
Note: B- Buying from traders, D- Direct sourcing from individual farmers, I- Individual farmers bringing paddy to the miller, A- Use of Agents

Utilization of a combination of direct sourcing from individual farmers and individual farmers bringing paddy to the miller ($B_0D_1I_1A_0$) had a significant and positive effect on the volume of paddy sourced and milled at a 10% significant level. The causal effect of this combination was 195.7MT. As earlier noted, direct sourcing from individual farmers is associated with the cheapest unit cost of paddy while individual farmers incur transport costs when they bring to the miller. Besides, millers have informal credit contract agreements with

individual farmers whose obligation is to pay back the in form of supplying paddy to the millers. Thus, supply of paddy to the miller is likely to be continuous as long as smallholder farmers are bounded in such agreements. According to JICA (2014), rice farmers in Kirinyaga County tend to make their current or future seasons harvest as collateral in order to acquire loans from rice millers. This ensures steady supply of paddy to the rice millers from smallholder farmers with whom loan agreements have been undertaken.

Using buying from traders, direct sourcing from individual farmers and using agents ($B_1D_1I_0A_1$) paddy sourcing combination had a significant and negative effect on the volume of paddy sourced at 1% level. The results indicate that the use of this combination is associated with a decrease in volumes of paddy sourced by 3126.6MT of paddy. One unique feature in this combination is the use of agents who charge exorbitant prices due to a 1 KES commission cost added per kilogram of paddy sold. This has a direct inverse proportion on the volume of paddy that can be purchased with a given amount of money. Additionally, it was noted that the highest average price of paddy was that sold by traders since they include the transport cost, storage cost and preferred profit margin on the overall price of paddy. This indirectly means that this is the most expensive paddy sourcing combination thus the low volume sourced. CASA (2021) notes the agribusinesses tend to shift to smallholder sourcing as a means of bringing down purchasing costs and as a cost reduction strategy.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This section presents the conclusion and recommendations of the study based on the objectives.

5.2 Conclusion of the Study

The following are the key conclusions of the study as per the objectives.

5.2.1. Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers in Mwea, Kirinyaga County

Rice millers pursue different paddy sourcing methods concurrently to raise high volumes of paddy that can keep their mills running throughout the year. The preference for directly sourcing paddy from farmers highlights the dominance of direct relationships between rice millers and farmers.

5.2.2. Level of Usage of Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers in Mwea, Kirinyaga County

The high frequency of utilizing a combination of direct sourcing from farmers and individual farmers bringing paddy to the miller underscores the significance of fostering direct relationships within the agricultural supply chain. The reluctance by rice millers in utilizing agents during paddy sourcing highlights the significant role played by pricing strictures and operational costs in shaping a rice miller's decisions.

5.2.3. Factors that Influence Choice of Paddy Sourcing Methods Used by Small and Medium-Scale Rice Millers in Mwea, Kirinyaga County

The results reveal that factors that influence rice millers' choices of paddy sourcing methods are diverse and multifaceted. The millers' age, ownership of transport means, price of paddy and commission cost, gender, marital status, working experience, cost of transport, storage capacity and degree of competition play a significant role in rice millers decision making. Thus, social, economic, technical and financial factors interact in dynamic ways to influence business decisions.

5.2.4. Effects of Paddy Sourcing Methods on the Volume of Rice Milled by Small and Medium-Scale Rice Millers in Mwea, Kirinyaga County

The use of a combination of paddy sourcing methods has a significant influence on the volume of paddy sourced and milled by rice millers.

5.3 Recommendations

From the findings of the study, the following are some of the policy recommendations that can be derived;

i. Rice millers should continue to invest in building and strengthening relationships with rice farmers through transparent communication and reliable transactions which are not only essential in maintaining relationships but also creating a stable supply chain.

ii. Initiatives aimed at improving transport infrastructure and enhancing communication between stakeholders within the paddy supply chain can promote the efficiency and sustainability of paddy sourcing methods within the rice growing and milling regions. Additionally, initiatives aimed at promoting transparency in paddy pricing system can strengthen the relationship between millers and farmers thus fostering a mutually beneficial agricultural system.

iii. Offering training to younger and less experienced millers can enhance their skills and knowledge to make informed decisions leading to sustainable business practices. Offering subsidies in form of low interest rate loans, grants and activity-specific funding can be impactful in help maintenance and acquisition of transport means for millers who do not own. This will also enable millers to reach farmers and markets easily. Disseminating up to date market information, trends and forecasts can guide rice millers' decision making and help them adjust their strategies and ensure competitive edge in the industry.

iv. Awareness programs to promote utilization of a combination of paddy sourcing methods that raise the highest volumes of paddy. There is need to disseminate information to rice millers about the productivity and contribution of different combinations of sourcing methods to the total volumes of paddy that can be sourced per year.

5.3 Further research

The study focused on the effects of paddy sourcing methods on the volume of paddy sourced and milled by small and medium-scale rice millers in Mwea, Kirinyaga County in Kenya. The study focused on rice mill owners as the respondents yet they may not have full control over the day-to-day decisions of the mills. Further studies focusing on only managers as key decision makers can provide interesting results. The millers were recruited within the same cultural setting with similar attributes towards rice milling. Therefore, the study maybe

generalizable to only the Kenyan situation. Conducting the same study in a different cultural setting or diverse cultural setting could validate these findings. Thirdly, millers within the study area do not source paddy from farmer cooperatives. This was attributed to the fact that these cooperatives had their own rice milling facilities. Conducting a similar study in an area where rice millers source paddy from cooperatives could provide a new insight to the study findings. Lastly, millers were found to engage in informal agreements with smallholder farmers, however, these agreements are not documented anywhere. There is a need to understand the dynamics and operationalization of these agreements, the effectiveness of these informal agreements, and their effects on the overall volume of paddy sourced by the miller.

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APPENDICES

Appendix A: Questionnaire

My name is Apollo Uma, a student at Egerton University pursuing a Master of Science Degree in Agribusiness Management. The purpose of this survey is to determine the **Effects of paddy sourcing methods on the volumes of rice milled by small and medium scale millers in Mwea constituency, Kirinyaga County**. As a rice miller, you have been selected to participate in the study. Your participation in this survey is entirely voluntary and will be treated with the highest level of confidentiality only to be used for research purposes. There is no right, or wrong answer and your responses are completely anonymous. In case the space provided is not enough, kindly attach an extra paper bearing your responses.

Questionnaire identification

Questionnaire Number

…….

Sub-county ……...…….....

Ward…….……

Name of the respondent…….…….……Tel contact….

…..…….

Name of enumerator……...……..…Tel contact

.....……

Date…….……...… Start time……. End time……

Section A: Profile of respondent

Kindly tick (✓) the appropriate box and write where necessary.

A1. Age in years

☐ 25years & below ☐ 26 – 35 years ☐ 36 – 45 years

☐ 46 – 55 years ☐ Above 55 years

A2. Gender

☐ Male ☐ Female

A3. Marital status

☐ Single ☐ Married ☐ Divorced ☐ Widowed

A4. How many years did you spend in school?

☐ No formal education (0 years in school) ☐ Primary level education (1-8years)

☐ Secondary level (9-12 years) ☐ College level education (13-15 years)

☐ University level education (Above 15 years)

A5. Rice milling experience ……. years

A6. Other than rice milling, are there any other milling activities that you are engaged in? If yes, what else do you mill?

……

……

……

A9. List other non-milling economic activities that you are engaged in?

……

……

……

A10. What proportion of household income is from rice milling activities? …..……%

A12. Ownership of the rice milling facility?

☐ Miller is the Owner ☐ Rented ☐ Owned by Government

☐

☐ Owned by the cooperative Others

Section B: The main sourcing method used and intensity

B1. What paddy sourcing methods do you use? (you can tick more than one)

☐ Buying from traders ☐ Sourcing from farmer cooperatives

☐ Direct sourcing from individual farmers ☐ Using agents

☐ Individual farmers bringing paddy to millers ☐ Others (Specify)

B2. How often did you use them during the period of 2020 to 2022?

Please rate ONE the level of frequency by ticking (✓) one of the numbers.

1 = Did not source using this method

2 = Rarely, in less than 10% of paddy sourced

3 = Sometimes, in about 11- 30% of paddy sourced

4 = Occasionally, in about 31 - 50% of paddy sourced

5 = Usually, in about 51 - 70% of paddy sourced

6 = Frequently, in above 71% of paddy sourced

Put (√) only methods you used and use figures (1 – 6) to show the level of frequency	1= Did not use 6= Frequently used

How often did you use them during the period of 2020, 2021, and 2022 season one?

		2020		2021		2022
		Season 1	Season 2	Season 1	Season 2	Season 1
	Buying from traders					
	Sourcing from cooperatives					

	Using agents					
	Direct sourcing from individual farmers					
	Individual farmers bringing paddy to the miller					
	Others					

B3. What was the total quantity of paddy bought per season during the following years?

Year	**Season**	**Quantity**
2020	Season 1	
	Season 2	
2021	Season 1	
	Season 2	
2022	Season 1	

B4. What proportion did you source using each of the sources mentioned?

Method/Source	**Proportion (%)**				
	2020		**2021**		**2022**
Buying from traders					
Sourcing from cooperatives					
Using agents					
Sourcing from individual farmers					
Individual farmers bringing paddy to the miller					
Others					

B5. Please rate ONE level of likelihood of using a given method in the next season by indicating one of the numbers.

1 = Very unlikely 2 = Unlikely 3 = Neutral 4 = Likely 5 = Very likely

Put (√) only methods you intend to use and use figures (1 – 5) to show the level of likelihood of usage	1= Very unlikely 5= Very likely
What paddy sourcing methods do you intend to use during the next season (2022 season 2).	
	2022 (season 2)
Buying from traders	
Sourcing from cooperatives	
Using agents	
Sourcing from individual farmers	
Individual farmers bringing paddy to the miller	
Others	

Section C: Factors determining the utilization of a paddy sourcing method.

Sourcing cost factors

C1. What was the price of paddy from each of the sources?

Method/Source	**Price (Ksh)**				
	2020		**2021**		**2022**
	Season 1	Season 2	Season 1	Season 2	Season 1
Buying from traders					
Sourcing from cooperatives					
Using agents					
Sourcing from individual farmers					
Individual farmers bringing paddy to the miller					
Others					

C2. How far are the sourcing points from the miller?

Sourcing points	**Distance from the miller (Km)**	**Means of transport used**
Buying from traders		
Sourcing from cooperatives		
Using agents		
Sourcing from individual farmers		
Individual farmers bringing paddy to the miller		
Others		

C3. Do you own any of the means of transport mentioned above?

Truck ☐ Yes ☐ No

Motorcycle ☐ Yes ☐ No

Tricycle ☐ Yes ☐ No

Others, specify ☐ Yes ☐ No

C4. Rank the commonly used means through which paddy is transported to the mill?

1=Frequently used (71% and above) 2=Occasionally used (51 -70%)

3=Sometimes used (30 -50%) 4=Rarely used (less than 30%)

Truck ☐ Motorcycle ☐ Tricycle ☐

Others, specify ☐

C5. How much do you incur in transporting paddy using a given means per season?

Means of transport	Costs incurred (Kshs) per day	
	If owned, servicing and fuel costs	If hired, hiring costs
Truck		
Tricycle		
Motorcycle		
Others		

C6. Do you employ people while transporting paddy?

Yes ☐ No ☐

C7. If yes, how many people do you employ per sourcing method used?
How much do you spend on each worker in each method used?

Sourcing method	**People employed**	**Payment per worker (Kshs)**
Buying from traders		
Sourcing from cooperatives		
Using agents		
Sourcing from individual farmers		
Individual farmers bringing paddy to the miller		
Others		

Technical Factors

C8. Which paddy variety/varieties do you source from farmers? Name according to the order of priority from most sourced to least sourced.

1…….

2……

3…….

4……..

C10. In which months do you source paddy? Indicate the months in which the highest volume of paddy is sourced.

……
……
……

C11. For how long have you been engaged in rice milling activities?

Less than 1 year ☐ 1 – 5 years ☐ 6 -10 years ☐

11 – 15 years ☐ 16 – 20 years ☐ Above 20 years ☐

C13. What is the Installed milling capacity of your mill? ……. Tonnes/hr.

C14. How many hours does the mill operate per day? And how many days in a month? How many months per year?

…… hours per day ……... days per month …… months per year

C15. Why does the mill operate for the time that it does as mentioned above?

Hours per day…….

Days per month……..…

Months per year……...…….

C16. What is the estimated volume of paddy milled per day during the previous seasons?

Year	**Volume (Kg) milled per day**	
	Season 1	Season 2

2020		
2021		
2022		

C17. Do you have a paddy storage facility?

Yes ☐ No ☐

C18. If yes, what is the storage capacity available……. Tonnes

C19. Are there any other rice millers within this village?

Yes ☐ No ☐

C20. If yes, how many are they?

Less than 5 ☐ 6 – 10 ☐ 11 -15 ☐

16 – 20 ☐ 21 – 25 ☐ Above 25 ☐

C21. How is the competition for paddy among the millers?

Very high ☐ High ☐

Low ☐ Very low ☐

Economic Factors

C22. Which services do you offer as a miller?

Milling services only ☐

Buying paddy and milling for sale only ☐

Both services ☐

C23. What is the mode of payment for the paddy sourced through different methods?

1=Cash on delivery 2=A week After delivery 3=Two weeks after delivery 4=Other, specify

Sourcing method	**Mode of payment**
Buying from traders	
Sourcing from cooperatives	
Using agents	
Sourcing from individual farmers	
Individual farmers bringing paddy to the miller	
Others	

C24. Which of the methods involves payment of commissions? And how much is paid as commission per person involved?

Sourcing method	**Involves paying commission (1=Yes 2=No)**	**Amount paid as a commission (Per Kg)**
Buying from traders		
Sourcing from cooperatives		
Using agents		
Sourcing from individual farmers		
Individual farmers bringing paddy to the miller		
Others		

C25. Do you have any contract agreements with your suppliers?

Yes ☐ No ☐

C26. If yes, with which suppliers do you have contract agreements?

Traders	Yes	☐	No	☐
Farmer cooperatives	Yes	☐	No	☐
Individual farmers	Yes	☐	No	☐
Agents	Yes	☐	No	☐
Others	Yes	☐	No	☐

C26. Do you access financing for paddy sourcing?

Yes ☐ No ☐

C27. If Yes, what is the source of finance for paddy sourcing?

Banks	☐	Microfinance	☐	Friends	☐
NGOs	☐	Government	☐	Own saving	☐
Traders	☐	Cooperatives	☐	Others	☐

C28. Which are the most common source of finance from the above-mentioned list?

Mostly used (71% and above financing) ……

Occasionally used (51 – 70% financing) ……

Sometimes used (31 – 50% financing) ……..

Rarely used (30% and below) ……

C29. How do you know about the availability of paddy in a given area?

Friends	☐	Radio	☐	Television	☐

NGOs	☐	Government	☐	social media	☐
Traders	☐	Cooperatives	☐	Others	☐

C30. Which methods do you employ in areas where paddy volumes are very high or very low?

1=Used when volumes of paddy are low (Below 5MT) 2=Used when volumes of paddy are high (5 MT and above) 3=Used irrespective of the volume of paddy available

Sourcing method	**When is it used**
Buying from traders	
Sourcing from cooperatives	
Using agents	
Sourcing from individual farmers	
Individual farmers bringing paddy to the miller	
Others	

C31. What are the reasons for using each of the paddy sourcing methods?

Sourcing method	Reasons for using
Buying from traders	
Sourcing from cooperatives	
Using agents	
Sourcing from individual farmers	
Individual farmers bringing paddy to the miller	
Others	

C32. What challenges do you face with each of the paddy sourcing methods?

Sourcing method	**Challenges**

Buying from traders	
Sourcing from cooperatives	
Using agents	
Sourcing from individual farmers	
Individual farmers bringing paddy to the miller	
Others	

Section D: Effects of the methods

D1. What was the total quantity (MT) of rice milled in the previous seasons?

Year	**Season**	**Quantity**
2020	Season 1	
	Season 2	
2021	Season 1	
	Season 2	
2022	Season 1	

D2. In which season did you incur the highest and lowest cost of sourcing paddy?

Highest cost……

Lowest cost…….

D3. According to you, which paddy sourcing method brings in the highest volume of paddy per season? Rank according to the one that brings in the highest to lowest volumes.

1……..……

……

3…….

……

5…….……

…..

THANK YOU VERY MUCH FOR THE INFORMATION PROVIDED

Appendix B: Ethical Clearence

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EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009
Approval No. EUISERC/APP/225/2023 ***10th March*, 2023**

Apollo Uma,
Egerton University,
P.O. Box 536-20115
Egerton
Telephone: +254112435039/ +256704339765
E-mail: umarapollo34@gmail.com

Dear Apollo,

RE: ETHICAL APPROVAL: EFFECTS OF PADDY SOURCING METHODS ON THE VOLUME OF RICE MILLED BY SMALL AND MEDIUM-SCALE RICE MILLERS IN MWEA CONSTITUENCY, KIRINYAGA COUNTY, KENYA

This is to inform you that ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/225/2023.*** The approval period is ***10th March, 2023 –11th March, 2024***

This approval is subject to compliance with the following requirements;

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

Appendix C: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **723241**

Date of Issue: **13/December/2022**

RESEARCH LICENSE

This is to Certify that Mr.. Apollo Uma of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kirinyaga on the topic: EFFECTS OF PADDY SOURCING METHODS ON THE VOLUME OF RICE MILLED BY SMALL AND MEDIUM-SCALE RICE MILLERS IN MWEA CONSTITUENCY, KIRINYAGA COUNTY, KENYA for the period ending : 13/December/2023.

License No: **NACOSTI/P/22/22556**

723241

Applicant Identification Number

Director General
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See overleaf for conditions

Appendix D: Multivariate Probit Regression Results

mvprobit (Buytrade= Age Gender Mstat Educ Expert Ownershi Priceave Dstavera Tpowned Costaver Payavera Instalco Storacap Comptiti Service Contagre Commcost Finances)(Drctsour=Age Gender Mstat Educ Expert Ownershi Priceave Dstavera Tpowned Costaver Payavera Instalco Storacap Comptiti Service Contagre Commcost Finances)(Indvbrin=Age Gender Mstat Educ Expert Ownershi Priceave Dstavera Costaver Payavera Instalco Storacap Comptiti Service Contagre Commcost Finances)(Agents=Age Gender Mstat Educ Expert Ownershi Priceave Dstavera Tpowned Costaver Payavera Instalco Storacap Comptiti Service Contagre Commcost Finances)

Multivariate probit (MSL, # draws = 5) Number of obs = 160
Wald chi2(72) = 103.53
Log likelihood = -193.72057 Prob > chi2 = 0.0088

	Coef.	Std.Err.	z	P>z	[95%Conf.	Interval]
Buytrade						
Age	1.579	0.509	3.1	0.002	0.581	2.576
Gender	0.845	0.545	1.55	0.121	-0.223	1.913
Mstat	-2.810	0.557	-2.58	0.035	-2.53	-0.348
Educ	-0.344	0.353	-0.97	0.33	-1.036	0.349
Expert	-0.271	0.087	-3.12	0.002	-0.441	-0.101
Ownershi	0.707	0.613	1.15	0.249	-0.494	1.907
Priceave	0.082	0.031	2.61	0.009	0.02	0.143
Dstavera	-0.006	0.054	-0.11	0.913	-0.111	0.099
Costaver	-0.001	0	-2.48	0.013	-0.002	0
Payavera	-0.002	0.001	-1.61	0.108	-0.005	0.001
Instalco	0.436	0.299	1.46	0.145	-0.15	1.021
Storacap	0.001	0.001	1.22	0.221	-0.001	0.003
Comptiti	-1.139	0.609	-1.87	0.062	-2.333	0.055
Service	0.996	0.693	1.44	0.151	-0.363	2.355
Contagre	-0.2	0.51	-0.39	0.695	-1.199	0.799
Commcost	0	0	1.76	0.079	0	0
Finances	0.099	0.523	-0.14	0.059	-0.179	0.154
_cons	-7.928	3.726	-2.13	0.033	-15.231	-0.626
Drctsour						
Age	-1.053	0.325	-3.24	0.001	-1.69	-0.415
Gender	0.753	0.374	2.01	0.044	0.019	1.486
Mstat	0.669	0.368	1.82	0.069	-0.053	1.391
Educ	0.345	0.299	1.15	0.249	-0.242	0.931
Expert	0.079	0.041	1.92	0.055	-0.002	0.16
Ownershi	0.064	0.457	0.14	0.888	-0.831	0.959
Priceave	-0.067	0.028	-2.42	0.015	-0.121	-0.013
Dstavera	-0.014	0.043	-0.32	0.748	-0.098	0.071
Costaver	0	0	-1.47	0.142	-0.001	0
Payavera	0.001	0.001	1.12	0.262	-0.001	0.004
Instalco	-0.244	0.24	-1.01	0.311	-0.714	0.227
Storacap	0.002	0.001	2.57	0.01	0.001	0.004
Comptiti	1.033	0.478	2.16	0.031	0.096	1.97
Service	0.594	0.532	1.12	0.264	-0.449	1.638
Contagre	0.605	0.395	1.53	0.125	-0.168	1.378
Commcost	0	0	0.52	0.601	0	0
Finances	-0.016	0.046	-0.35	0.728	-0.105	0.073

_cons	2.855	3.007	0.95	0.343	-3.04	8.749
Indvbrin						
Age	0.415	0.2	2.07	0.038	0.022	0.808
Gender	0.155	0.267	0.58	0.561	-0.368	0.677
Mstat	-0.19	0.263	-0.73	0.468	-0.705	0.324
Educ	-0.181	0.215	-0.84	0.4	-0.602	0.24
Expert	-0.056	0.027	-2.12	0.034	-0.109	-0.004
Ownershi	-0.265	0.279	-0.95	0.342	-0.812	0.282
Priceave	0.041	0.015	2.74	0.006	0.012	0.07
Dstavera	-0.032	0.031	-1.02	0.307	-0.092	0.029
Costaver	0	0	-0.18	0.857	0	0
Payavera	-0.001	0.001	-1.42	0.155	-0.003	0
Instalco	-0.153	0.161	-0.95	0.344	-0.468	0.163
Storacap	-0.001	0	-2.8	0.005	-0.002	0
Comptiti	-0.182	0.273	-0.67	0.504	-0.716	0.352
Service	-0.045	0.381	-0.12	0.907	-0.792	0.702
Contagre	0.515	0.289	1.78	0.075	-0.051	1.081
Commcost	0	0	-2.02	0.044	0	0
Finances	0.011	0.035	0.3	0.765	-0.059	0.08
_cons	-1.988	2.111	-0.94	0.346	-6.125	2.15
Agents						
Age	-0.489	0.327	-1.5	0.134	-1.129	0.151
Gender	-0.751	0.402	-1.87	0.061	-1.538	0.036
Mstat	-0.02	0.285	-0.07	0.943	-0.58	0.539
Educ	-0.601	0.43	-1.4	0.163	-1.444	0.242
Expert	-0.02	0.047	-0.43	0.669	-0.111	0.072
Ownershi	0.546	0.488	1.12	0.263	-0.41	1.503
Priceave	-0.019	0.029	-0.66	0.511	-0.075	0.037
Dstavera	0.003	0.05	0.06	0.952	-0.096	0.102
Costaver	0	0	0.93	0.351	0	0.001
Payavera	0.006	0.005	1.19	0.235	-0.004	0.015
Instalco	0.224	0.295	0.76	0.447	-0.354	0.802
Storacap	-0.002	0.001	-2.8	0.005	-0.003	-0.001
Comptiti	-0.024	0.366	-0.06	0.948	-0.741	0.694
Service	0.394	0.542	0.73	0.467	-0.668	1.455
Contagre	-0.35	0.399	-0.88	0.381	-1.131	0.432
Commcost	0	0	-1.57	0.116	0	0
Finances	0.038	0.061	0.61	0.54	-0.083	0.158
_cons	1.58	4.602	0.34	0.731	-7.44	10.599
/atrho21	-0.601	0.274	-2.19	0.028	-1.138	-0.064
/atrho31	-0.492	0.23	-2.14	0.033	-0.944	-0.04
/atrho41	-0.053	0.235	-0.23	0.82	-0.514	0.407
/atrho32	-0.319	0.227	-1.4	0.161	-0.765	0.127
/atrho42	0.257	0.225	1.14	0.255	-0.185	0.699
/atrho43	-0.118	0.22	-0.53	0.593	-0.55	0.314
rho21	-0.538	0.195	-2.76	0.006	-0.814	-0.064
rho31	-0.456	0.183	-2.5	0.013	-0.737	-0.04
rho41	-0.053	0.234	-0.23	0.82	-0.473	0.386
rho32	-0.309	0.206	-1.5	0.134	-0.644	0.126
rho42	0.251	0.211	1.19	0.234	-0.183	0.604

rho43	-0.117	0.217	-0.54	0.59	-0.5	0.304

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0:

chi2(6) = 21.0172 Prob > chi2 = 0.0018

Appendix E. Two Stage Instrumental Variables Approach Results

```
Instrumental variables (2SLS) regression          Number of obs   =        160
                                                  Wald chi2(6)    =      29.16
                                                  Prob > chi2     =     0.0001
                                                  R-squared       =     0.2647
                                                  Root MSE        =     820.59

------------------------------------------------------------------------------
    Volsourc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    Commcost |  -.0100492   .0020032     5.02   0.000     .0061229    .0139754
         BDI |   467.5645   589.5326     0.79   0.028    -687.8982    1623.027
        BDIA |  -420.2691   622.0346    -0.68   0.499    -1639.435    798.8963
          DI |   195.6667   626.7396     0.31   0.055     -1032.72    1424.054
         DAI |  -1026.839   686.7752    -1.50   0.135    -2372.894    319.2155
         BDA |  -3126.621   982.9006    -3.18   0.001    -5053.071   -1200.171
       _cons |         335   580.2481     0.58   0.564    -802.2653    1472.265
------------------------------------------------------------------------------
Instrumented:  Commcost
Instruments:   BDI BDIA DI DAI BDA Instalco


estat endog

  Tests of endogeneity
  Ho: variables are exogenous

  Durbin (score) chi2(1)          =  6.77352  (p = 0.0093)
  Wu-Hausman F(1,152)             =   6.7193  (p = 0.0105)

. estat firststage

  First-stage regression summary statistics
  ------------------------------------------------------------------------------
               |             Adjusted      Partial
      Variable |   R-sq.       R-sq.        R-sq.      F(1,153)   Prob > F
  -------------+----------------------------------------------------------------
      Commcost |  0.3414      0.3156       0.0839       19.3619    0.0003
  ------------------------------------------------------------------------------


  Minimum eigenvalue statistic = 19.3619

  Critical Values                       # of endogenous regressors:    1
  Ho: Instruments are weak              # of excluded instruments:     1
  ---------------------------------------------------------------------
                                      |    5%     10%     20%     30%
  2SLS relative bias                  |         (not available)
  ------------------------------------+---------------------------------
                                      |   10%     15%     20%     25%
  2SLS Size of nominal 5% Wald test   |  16.38    8.96    6.66    5.53
  LIML Size of nominal 5% Wald test   |  16.38    8.96    6.66    5.53
  ---------------------------------------------------------------------
```

Appendix F: Published Paper

Heliyon 9 (2023) e22901

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Effect of paddy sourcing methods on the volume of rice milled by rice millers in Mwea, Kirinyaga county, Kenya

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ARTICLE INFO

Keywords:
Paddy
Paddy sourcing method
Capacity utilization
Underutilization
Combination of paddy sourcing methods
Small-scale millers
Medium-scale millers

ABSTRACT

Rice millers access paddy through private traders, cooperatives, individual farmers, and village agents. These methods determine the capacity utilization of the mills, costs incurred, and profitability of the rice milling business. This article aimed at determining the effect of paddy sourcing methods on the volume of rice milled by small and medium-scale rice millers in Kenya. Specifically, the study sought to determine the sourcing methods used, combinations of sourcing methods, and effects of these combinations on the volume of rice milled. A multistage sampling technique resulted to a total of 160 millers comprised of 90 and 70 small and medium-scale rice millers respectively. A multinomial endogenous switching regression (MESR) was used to determine the resultant effects of paddy sourcing methods on volume of rice milled. Results: The results show that sourcing paddy directly from individual farmers, individual farmers bringing paddy to the miller, buying from traders and sourcing through agents are the four paddy-sourcing methods used by rice millers. Factors that influence utilization of a combination of sourcing methods are age of the miller, ownership of the miller, unit price of paddy, distance from the mills, ownership of the mills, degree of competition, contract agreements, access to information and finance. The highest volume of paddy sourced was achieved using a combination of three paddy sourcing methods: buying from traders, direct sourcing from individual farmers and individual farmers bringing paddy to the miller ($B_1D_1I_1A_0$). This combination increases volumes sourced by 114.1 %. This underscores the sole vitality of a myriad of factors in determining the choice of utilization of a combination of paddy sourcing methods. This study can influence de-