SOCIO-ECONOMIC ANALYSIS OF INDIGENOUS TECHNICAL KNOWLEDGE USE IN RICEBEAN PRODUCTION AMONG SMALL HOLDER FARMERS IN NYANZA REGION KENYA

Costa Kokwon

A Research Thesis Submitted in Partial Fulfillment for the Requirements of the Doctors of philosophy Degree in Agricultural Extension and Rural Development of Masinde Muliro University of Science and Technology

March, 2025

STATEMENT OF PLAGIARISM

Student Declaration

1. I hereby declare that I understand that this thesis must be my own work.
2. I know that the incorporation of materials from other works or a paraphrase of such material without acknowledgement will be treated as plagiarism according to the rules and regulation of Masinde Muliro University of Science and Technology.
3. I know that plagiarism is an academic dishonesty and that if I commit any act of plagiarism my thesis can be assigned a fail grade 'F'.
4. I further understand that I may be suspended or expelled from the University for Academic Dishonesty.

Signature……………………………**Date**…………………………..

Costa Kokwon ERD/H/01-70209/2020

Supervisors Declaration

I / we hereby approve the examination of this thesis. The thesis has been subjected to plagiarism test and its Similarity Index is not above 20%.

Signature……………………………… **Date**……………………

Prof. Alice Chesambu Ndiema

Signature……………………………… **Date**……………………

Dr. James Bill Ouda

Signature………………………… **Date**…………..……………

Prof. Valary Palapala

DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award

Signature: ………………………………. Date: ………………………………

Costa Kokwon

ERD/H/01-70209/2020

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of Science and Technology a thesis entitled: "S**ocio-economic analysis of indigenous technical knowledge use in ricebean production among small holder farmers in Nyanza Region, Kenya."**

Signature……………………………. Date: ………………………………………

Prof. Alice Chesambu Ndiema

Department of Agribusiness Management and Extension

Masinde Muliro University of Science and Technology

Signature: …..………………………….. Date: ………………

Dr. James Bill Ouda

Department of Educational Psychology

Masinde Muliro University of Science and Technology

Signature………………………………. Date: ………………………………………

Prof. Valary Palapala

School of Science and Technology

United States International University- Africa

ABSTRACT

The promotion of sustainable, climate-smart agricultural practices and crop diversification is essential for addressing food insecurity in Kenya. Despite government efforts to transform agricultural systems, progress remains uncertain, with challenges needing comprehensive solutions to ensure long-term sustainability. Ricebean, a multipurpose but underutilized legume, holds significant potential for improving crop diversity and resilience; however, its adoption is limited due to lack of knowledge and awareness among farmers and extension officers. Farmers possess indigenous technical knowledge (ITK) about ricebean, but the knowledge is neither well-documented nor integrated with scientific advances, hindering the crop's wider adoption. This study aimed to analyze the ITK used by ricebean farmers in Nyanza Region, identifying knowledge gaps and strategies to increase adoption and support sustainable ricebean production. Specific objectives of the study included: identifying farmers' ITK on ricebean production, assessing socioeconomic factors that influence ITK adoption, evaluating farmers' perceptions on integrating ITK in ricebean production, and comparing the prevelance rate of ITK among smallholder farmers in Migori, Siaya, and Kisii counties. Grounded in Social Cognitive Theory, the study used a cross-sectional survey design to collect data from 397 ricebean-farming households through multistage, purposive, propotionate and snowball sampling procedures in the three counties. Data collection methods included semi-structured questionnaires, FGDs guide, interviews, photographs and observations. Analysis was done using SPSS version 20. Results show that most ricebean farmers are women (70.3%) with education level of 57.2% being at primary education and an average age of 44 years. Farming is the main occupation for 88.2% of participants, with more than half earning less than Ksh 35,000 annually. Use of ITK is widespread, particularly in planting timing, land preparation and crop management, with 62% of farmers integrating ITK with scientific practices. Adoption of ITK is influenced by factors such as gender, market access and extension services ($p<0.05$), with men more likely to adopt ITK practices than women. Although farmers value ITK for its affordability and environmental benefits, they believe that it is not effective as its production is relatively low. County-level variations indicate that Siaya has the highest female farmer participation and lowest income levels, while Kisii leads in ricebean income generation. Similarly, ITK practices in ricebean farming vary significantly across Kisii, Migori, and Siaya counties, shaped by factors such as climate, socio-cultural preferences and resource availability. The study concludes that ricebean farming in Kisii, Migori, and Siaya counties is characterized by small-scale, female-dominated operations with significant reliance on Indigenous Technical Knowledge (ITK). However, challenges such as low incomes, limited access to education, markets and extension services hinder productivity. Policymakers should focus on improving access to credit, agricultural support systems and markets, particularly in underserved regions like Migori and Kisii. Strengthening training programs, fostering farming groups, and promoting equitable resource distribution can enhance ITK adoption, boost productivity and improve rural livelihoods.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AIVs	African Indigenous Vegetables
CK	Conventional Knowledge
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
IK	Indigenous Knowledge
ITK	Indigenous Technical Knowledge
KAP	Knowledge, Attitudes and Practices
LK	Local Knowledge
NGO	Non-Governmental Organization
SAT	Sustainable Agricultural Technologies
SCT	Social Cognitive Theory
SDG	Sustainable Development Goals
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
UNEP	United Nations Environmental Programme
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Legumes are essential components of farming systems throughout Sub-Saharan Africa (SSA). They provide a variety of environmental benefits, including the enhancement of soil fertility and the regulation of erosion, in addition to serving as sources of food, livestock feed, fuel, and income. In comparison to cereals, legume seeds have an average protein content that is twice as high, and their nutritional quality is generally high (Yao et al., 2015). Legumes provide a cost-effective protein source for a significant portion of the population in developing countries, such as Kenya, in addition to diversifying human diets (Das et al., 2014). The utilization of underutilized legumes that contain high-quality protein can be a solution to food insecurity (Enujiugha et al., 2014). Additionally, Katoch (2020) observed that the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) emphasized the importance of legumes, particularly the underutilized varieties, in ensuring food security and the right to food. This is due to the high-quality protein, dietary fiber, and essential micronutrients provided by legumes, as well as their associated health benefits.

Ricebean (Vigna umbellata), which is commonly known as "dengu special" in Kenya, is one such underutilized legume. It is a non-traditional legume that is less well-known and is native to South and Southeast Asia. The crop was initially domesticated in the Midland Southeast Asian Monsoon Forest Zone. It was subsequently introduced to Japan and Nepal, where it was cultivated in newly cleared lands alongside significant crops such as tea and mulberry. Furthermore, it was cultivated in regions that were not conducive to the cultivation of other bean varieties (Tomooka, 2020). The Arabs subsequently introduced the crop to Egypt, and it has since been cultivated in Kenya, Tanzania, Congo, Zambia, and Ghana, as well as along the eastern coast of Africa and the Indian Ocean islands (Rajerison & Ohashi, 2006).

Ricebean is cultivated on small plots by subsistence farmers, despite its nutritional value, and is primarily neglected and underutilized. According to Joshi et al. (2008), it is frequently cultivated as an intercrop with maize or along rice bunds and terraces in India, with minimal input from cultivators and a reliance on residual soil fertility.

Nevertheless, it has garnered attention in recent years due to its nutritional advantages. All portions of the Ricebean plant are edible and are employed in a variety of culinary applications, as per Joshi et al. (2016). For example, the desiccated seeds can be boiled and consumed with rice or transformed into a nutritious flour that is suitable for the diets of children. The high lysine content of ricebeans renders them an exceptional addition to cereal-based diets (Joshi et al., 2008). Furthermore, research conducted in Singapore has supported the assertion that Ricebean has a superior nutritional value, particularly in terms of protein content, when contrasted with other legumes from the Vigna family (Katoch, 2020).

In addition to human consumption, Ricebean serves as a significant resource for livestock feed. The vegetative components may be provided fresh or processed into hay, while the seeds function as fodder, contributing to improved livestock productivity and quality across various climatic conditions (Singh & Onte, 2020). Additionally, Ricebean's capacity to function as an intercrop promotes effective land utilization, particularly in regions with constrained arable land. A study conducted in Pakistan demonstrated that intercropping Ricebean with maize led to a significantly greater net income per hectare in comparison to sole cropping systems (Zaman & Malik, 2000). This underscores Ricebean's potential role in subsistence farming, enhancing diets and food security in areas where it is presently cultivated and beyond.

The increasing interest in underutilized legumes in Africa is largely attributed to their drought tolerance and capacity to improve soil nitrogen levels via symbiotic nitrogen fixation (Chivenge et al., 2015). Despite its potential in Kenya, Ricebean is frequently overlooked due to the prioritization of more profitable crops in commercialization efforts. Furthermore, institutional support for the development and promotion of Ricebean is minimal, characterized by limited research and extension services for the crop. Chawe et al. (2019) identify several factors contributing to the uncertain production levels of specific pulses in farming communities, including the absence of high-yielding varieties, limited awareness of the crop's significance for food security and climate resilience, and insufficient farmer involvement in crop selection.

Farmers are essential in the adoption, testing, and integration of new agricultural practices within their local contexts. Their expertise is essential for maintaining agricultural productivity. Harouna et al. (2019) highlight the necessity of evaluating the acceptance of new agricultural technologies by farmers and consumers prior to the initiation of extensive research. This promotes the adoption, continuity, and effective utilization of these technologies, ensuring long-term benefits for farmers. Rising living costs compel smallholder farmers to adopt coping strategies, frequently based on Indigenous Technical Knowledge (ITK), which has been honed over generations and functions as a critical decision-making resource for local agricultural practices.

ITK is integral to the cultural and agricultural heritage of a community. Research conducted in India demonstrates that indigenous knowledge is cost-effective, straightforward to implement, moderately scientific, efficient, and environmentally sustainable (Borthakur et al., 2012; Kalita et al., 2010). A critical analysis of these techniques may improve comprehension of their scientific foundations, facilitating enhancements when combined with contemporary agricultural practices (Naharki & Jaishi, 2020). In Nepal, traditional agricultural knowledge retains significant value at the grassroots level, exhibiting effectiveness that parallels modern agricultural practices. This knowledge has been passed down through generations, promoting self-sufficiency and organic farming (Singh et al., 2018).

ITK serves as a crucial catalyst for advancements in agriculture. Research indicates that indigenous communities apply their knowledge in multiple areas, such as natural resource management, agriculture, medicine, and socioeconomic development (Borthakur et al., 2012). Indigenous knowledge in Africa has enhanced rural enterprises and promoted sustainable food production and resource management (Evalindigenous, 2021).

The utilization of Indigenous Technical Knowledge (ITK) has been documented in multiple agricultural value chains, resulting in favorable economic outcomes. Farmers in Southern Sudan and Zaire have identified that the land surrounding termite mounds exhibits enhanced fertility for the cultivation of sorghum and cowpea. The combined effect of these crops is significant; sorghum aids in loosening and aerating the soil, whereas cowpea enhances soil fertility through nitrogen fixation (Adedipe et al., 2004). Farmers in Tanzania established a multi-storey farming system that integrated fallowing, intercropping, and selective weeding. Weeds were permitted to grow to a specified extent before being cut and retained on the soil as protective mulch. This practice is founded on the premise that weeds inhibit excessive soil desiccation, foster advantageous competition that enhances crop growth, and mitigate soil erosion during precipitation (Bwambale, 2015).

Ugandan farmers have implemented various traditional methods to manage pests and diseases. In cassava farming, clean planting materials are meticulously selected, ensuring that cuttings are undamaged and planted with nodes oriented downward to facilitate successful sprouting and root development (Bwambale, 2015). Farmers engaged in burning practices, positing that the resultant ashes contributed nutrients to the soil and aided in the management of agricultural pests.

In post-harvest management, fresh cassava tubers were buried one foot deep in moist soil, which extended their freshness for a duration of up to seven days. Farmers utilized a crop rotation system, frequently sowing legumes as the second crop by broadcasting seeds prior to ploughing. Natural pesticides, including a solution of ash and dried goat droppings in water, were employed to address pests and diseases. Ash played a significant role in the preservation of beans due to its function as a natural insect repellent (Reddy, 2006).

Research by Reddy (2006) supports the use of various organic materials, including wood ash, cow dung, soap nut leaves, neem leaves, and pungam leaves, which are combined with pulses prior to storage in bins or bags. These substances serve as insect repellents, antifeedants, and oviposition deterrents, thereby minimizing crop losses and promoting long-term preservation.

In Kenya, the application of Indigenous Technical Knowledge is increasingly vital for enhancing food security and agricultural production, especially for the livelihoods of impoverished Kenyans who rely on this knowledge for their agricultural practices

(Ponge, 2011). However, this knowledge has frequently been overlooked in the agricultural and rural development sector.

Despite considerable research on Indigenous Technical Knowledge across various value chains, there is a notable lack of documentation concerning ITK associated with Ricebean cultivation. Given the relative obscurity of Ricebean in Kenya, it is crucial to collect and document farmers' knowledge to inform strategies for the promotion and popularization of the crop. Incorporating indigenous knowledge into the design of development projects is essential, as ineffective policies impede agricultural adaptation to climate change. Formulating effective adaptation strategies necessitates an examination of the socioeconomic factors that shape farmers' perceptions and decision-making processes. Incorporating local perspectives and indigenous knowledge into policy-making may yield cost-effective, inclusive, and sustainable solutions to climate-related agricultural challenges.

Due to the dispersion and inaccessibility of Indigenous Technical Knowledge, effective documentation is essential for facilitating knowledge-sharing among communities and ensuring its long-term applicability (Pradhan et al., 2017). Ohagwu et al. (2024) propose that documenting the traditional knowledge of farming communities is a highly effective strategy for enhancing the production of underutilized legumes. This study aimed to document Indigenous Technical Knowledge regarding Ricebean cultivation in Kenya, establishing a basis for strategies to improve its adoption and utilization.

1.2 Statement of the Problem

The production and utilization of ricebean in Kenya are largely underexplored and underutilized, despite the potential benefits of this multipurpose crop. The absence of adequate and pertinent knowledge and information among agricultural extension officers and farmers is a substantial obstacle to its adoption. Despite the fact that farmers possess valuable Indigenous Technical Knowledge (ITK) regarding ricebean cultivation, this knowledge is still not adequately documented, disseminated, or associated with scientific advancements. Furthermore, ITK is at risk as a result of socioeconomic advancements, including urbanization, globalization, and the expansion of formal education.

The ricebean has been relatively underrepresented in agricultural research and development, as the majority of extant studies have concentrated on other legume crops, including beans, green grams, and cowpeas. Consequently, it is imperative to promptly identify and document the ITK associated with ricebean production among cultivators in the Nyanza region's Siaya, Migori, and Kisii counties. The crop's productivity, sustainability, and resilience can be improved by combining scientific innovations with indigenous knowledge.

In addition to safeguarding ITK as a valuable cultural resource, addressing these voids will also help to popularize ricebean among local farmers. It is anticipated that this integration will lead to enhanced agricultural practices, increased food security, and higher yields, all of which will contribute to the socioeconomic development of the region.

1.3 Overall Objective

To contribute to the popularity of Ricebean crop through documentation of Indigenous Technical Knowledge used for sustainable ricebean production in Kenya.

1.3.1 Specific objectives

1. To identify the Indigenous Technical Knowledge utilized in ricebean production among smallholder farmers in the Nyanza region, Kenya.
2. To evaluate the socio-economic factors influencing the adoption of Indigenous Technical Knowledge in ricebean production among smallholder farmers in Nyanza region, Kenya.
3. To analyze smallholder farmers' perception on the integration of Indigenous Technical Knowledge in ricebean production in Nyanza region, Kenya.
4. To compare the regional utilization of Indigenous Technical Knowledge in ricebean production among smallholder farmers in Siaya, Migori, and Kisii Counties in the Nyanza region, Kenya.

1.3.2 Research questions

i. What specific Indigenous Technical Knowledge is used in ricebean production among smallholder farmers in the Nyanza region?

ii. How do smallholder farmers perceive the integration of Indigenous Technical Knowledge in ricebean production in the Nyanza region?

1.3.3 Hypothesis

i. Socio-economic factors do not significantly influence the adoption of Indigenous Technical Knowledge in ricebean production among smallholder farmers in the Nyanza region.

ii. There are no significant differences in the regional utilization of Indigenous Technical Knowledge in ricebean production among smallholder farmers in Siaya, Migori, and Kisii Counties.

1.4 Justification

The diversification of agriculture is essential for tackling the challenges of food insecurity in Kenya. Ricebean, as a cultivated species, possesses considerable promise in enhancing this diversity. Nevertheless, its potentials are not fully realized owing to an insufficiency of pertinent and comprehensive information regarding the crop. Furthermore, there exists a paucity of documentation and a lack of integration of Indigenous Technical Knowledge (ITK) with contemporary scientific advancements concerning ricebean. This research endeavors to address this gap through the identification, documentation, and analysis of Indigenous Technical Knowledge in ricebean production among smallholder farmers in the Nyanza region, particularly within Siaya, Migori, and Kisii Counties.

The significance of integrating ITK with scientific knowledge cannot be overstated. ITK provides sustainable, economically viable, and regionally tailored agricultural methodologies that can bolster resilience against climate-related disturbances, augment productivity, and mitigate adverse environmental effects. This is in accordance with Kenya's Big Four Agenda concerning food security and the second Sustainable

Development Goal (SDG), which advocates for the attainment of food security, enhancement of nutrition, and the advancement of sustainable agricultural practices. Moreover, Kenya's Vision 2030 underscores the importance of diversifying crops, enhancing rural agricultural markets, fostering agribusiness, and advancing research and extension services.

Confronting the socio-economic difficulties encountered by rural farmers, including the decline of indigenous traditional knowledge, is essential for the enduring viability of agricultural technologies. This research aims to elucidate the effective integration of Indigenous Knowledge Systems with scientific advancements to formulate strategies for climate-smart agriculture. These strategies will prove advantageous for policymakers, government agencies, NGOs, and development practitioners, aiding in the formulation and design of sustainable practices that elevate agricultural productivity and guarantee enduring food security.

The outcomes of this research will not only contribute to the promotion of ricebean among agricultural practitioners but will also exemplify the integration of indigenous technical knowledge with contemporary farming methodologies. This integrative technique is anticipated to be readily adopted by agricultural communities across the region, fostering resilience, sustainability, and enhanced food security.

1.5 Scope of the Study

This research examined the Indigenous Technical Knowledge of farmers and their perceptions related to Ricebean production, while also evaluating the rationale behind their practical applications. The study meticulously delineated and articulated the Indigenous Technical Knowledge possessed by Ricebean farming communities in Kenya, encompassing the sources of information regarding Ricebean production, insights into Ricebean varieties, agronomic practices associated with Ricebean cultivation, post-harvest methodologies, utilization strategies for Ricebean, and processing techniques relevant to Ricebean. Secondly, the research assessed the various elements that affect the adoption of Indigenous Technical Knowledge among Ricebean farmers, including gender, age, educational attainment, marital status, household size, occupation, annual income, sources of income, land tenure, access to production support services, and farming experience. Thirdly, the study assessed farmers' perceptions regarding the integration of Indigenous Technical Knowledge in Ricebean farming. In conclusion, the research examined the application of Indigenous Technical Knowledge in the cultivation of ricebean by smallholder farmers across Siaya, Migori, and Kisii Counties within the Nyanza region. The research was conducted in the Nyanza region of Kenya. The selection of these areas is based on their prominence as the leading regions for Ricebean cultivation in Kenya. The research was conducted across three specifically chosen counties: Migori county, encompassing the Awendo, Rongo, and Uriri constituencies; Siaya county, which includes the Alego Usonga and Ugunja constituencies; and Kisii county, represented by the South Mugirango constituency. The timeframe for the recall encompassed the preceding 12 months of production.

1.6 Limitations of the Study

The limitations of the study included the following; i) The data collected was based on the ability of the respondents, especially farmers to recall the cause and effect of their agricultural activities. This possibly may not accurately represent all the facts. A pilot study was conducted before the actual data collection to test the reliability and validity of the instruments. ii) There is limited research on Ricebean in the context of Kenya. Therefore, most inferences, arguments and conclusions were drawn from studies done on Ricebean in other continents which may not have the same farmer realities as is the case in Kenya.

1.7 Definition of Terms

Adoption- is the process of accepting to use something new or available to the user in the process of producing crops

Climate-smart Agriculture- is the combination of farming technologies that aims at increasing farmers' productivity, enhancing resilience and minimizing environmental degradation in agricultural production.

Conventional Knowledge- these are the accepted practices or beliefs associated with crop farming.

Diversification- the process of varying agricultural activities or enterprises done in the farm to expand spread risks and increase production and enhance sustainability.

Farming systems- The ways by which a farmer organizes the farm and all its enterprises in relation to each other to meet his or her daily needs in a sustainable manner.

Indigenous Technical Knowledge – refers to the body of knowledge, skills, and practices developed and sustained by local communities through experience, adaptation, and interaction with their environment and used to solve their day-to-day problems.

Innovation- it is a new idea that is developed to generates more output in ricebean production

Landrace- a local cultivar or variety that has been improved by traditional farming methods.

Scientific knowledge- the knowledge that is generated after systematic study of famers' experiences and subjected to some guiding principles in relation to crop production.

Sustainability- the ability of the indigenous practices to constantly maintain a process across a long period of time without affecting the future generation.

Underutilized legume - crops that are popular in their home nations because of their economic, cultural, or agronomic merits, but are typically neglected by plant breeders, decision-makers, consumers, agricultural researchers, donors, extension agencies, and technology providers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section presents a detailed review of previous studies in relation to the proposed study. The chapter begins by providing literature on general overview of community characteristics in relation to use of agricultural technologies in farming systems, significance of Indigenous Technical Knowledge and how it can be integrated with scientific knowledge to come up with a climate smart approach of farming systems. Finally, it presents ricebean overview and Indigenous Technical Knowledge relating to ricebean and other value chains. This chapter concludes by defining the gaps in the reviewed literature, presenting theoretical and conceptual frameworks on which the study was based on.

2.2 Factors influencing adoption of Agricultural Technologies

The implementation of sustainable agricultural technologies stands as a pivotal factor in enhancing both the resilience and productivity of agricultural systems. Nonetheless, numerous factors influencing the acceptance of innovative agricultural technologies have been acknowledged and examined by various scholars. The insights derived from indigenous knowledge are essential for the formulation and execution of nature-based solutions, especially concerning indigenous peoples and local communities, who are pivotal participants in these endeavors (United Nations Environment Programme [UNEP], 2021). The significance of incorporating Indigenous Knowledge and Local Knowledge systems in climate change adaptation strategies was acknowledged in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR5) (IPCC, 2014).

The pace of adoption of these technologies is contingent upon their resilience and profitability for the farmer, and is likely to be significantly shaped by a variety of factors. The factors influencing adoption have been demonstrated to be essential in promoting the uptake of technology among farmers. A variety of factors, such as age, gender, the scale of the farming household, acreage size, and the expertise and educational backgrounds of farmers, play significant roles in influencing their decisions regarding the adoption or rejection of agricultural technologies (Annan 2018). Dissanayake et al. (2022), in their comprehensive review of agricultural technology adoption in Sri Lanka, categorized these factors into three distinct groups: Elements associated with the attributes of farmers, such as age, gender, educational attainment, farm size, economic status, previous experience with the technology, labor availability, and resource accessibility; elements pertaining to the characteristics of the technology, including cost-effectiveness, accessibility, compatibility, complexity, trialability, and observability; and institutional elements, encompassing access to extension services, inputs, markets, and credit facilities. He additionally suggested that an examination of how these factors influence technology adoption be conducted. In a similar vein, Waaswa et al. (2021) identified a significant correlation between socioeconomic factors and the implementation of climate-smart agricultural practices among potato cultivators in Kenya.

In this study, the researcher examined analogous factors and their influence on the adoption of Indigenous Technical Knowledge in ricebean farming. The factors were classified into three distinct categories: social factors, economic factors, and factors related to the perception of technology.

2.2.1 Social factors

Agricultural research innovations are primarily utilized by farmers, whose individual preferences concerning the characteristics of new agricultural technologies play a crucial role in their decisions to adopt these advancements. A multitude of social factors can exert either beneficial or detrimental effects on these adoption decisions. For example, research conducted by Wollni & Andersson (2014) in Spanish indicates a positive correlation between age and adoption decisions. The propensity of older farmers to engage in organic farming can be attributed to their generally lower opportunity costs, which allows them to allocate more time to the labor-intensive practices essential for organic cultivation, such as hand weeding. This aligns with research conducted by Mkwanazi et al. (2020) in South Africa regarding the application of indigenous knowledge for tick control in goats. Their findings indicated a positive correlation between age distribution and the utilization of indigenous knowledge, revealing that farmers aged 50 and above employed this knowledge more frequently than other age groups. In a similar vein, Andati et al. (2022) conducted a study examining the adoption of climate-smart technologies in potato farming within Kenya, revealing that older farmers demonstrated a heightened willingness to embrace these innovations compared to their younger peers. It is essential to recognize that age does not invariably correlate with a favorable impact on the adoption of technology. Certain senior farmers might exhibit hesitance in adopting novel agricultural technologies, particularly if they regard them as intricate or alien. In contrast, younger farmers, frequently motivated by advanced educational backgrounds and ambitions for enhanced agricultural livelihoods, tend to embrace contemporary farming innovations, especially when these innovations promise increased profitability and efficiency. Regarding gender, there exists a notable divergence among researchers in their findings pertaining to the relationship between gender and the utilization of indigenous technologies. A research endeavor conducted by Addaney et al. (2021) in Ghana revealed that female farmers have exhibited exceptional resilience in the face of climate change, employing innovative strategies to surmount these obstacles and enhance their productivity. Conversely, a study conducted in South Africa regarding the application of Indigenous Traditional Knowledge (ITK) in the management of ticks in goats revealed a correlation between the utilization of ITK and gender, indicating that males employed it more frequently than females (Ndlela et al., 2021). The results align with the research conducted by Andati et al. (2022) in Kenya, indicating that the gender of the household head positively influences the likelihood of increased demand for CSA practices, as male-headed households demonstrate a greater propensity to adopt CSAs compared to their female-headed counterparts. Nevertheless, the influence of social and cultural norms, along with prevailing values, suggests that gender as a factor in technology adoption within developing nations may be subject to change. This is largely attributable to the discrimination faced in terms of access, control, and ownership of productive resources, including land, where the majority of access and control tends to favor men.

The dimensions of a farming household significantly influence the decision-making dynamics associated with the adoption of innovative agricultural technologies. Nonetheless, its influence may manifest in both beneficial and detrimental ways (Kafle, 2010). The investigation carried out by Muhammed et al. (2019) in Northern Ghana revealed an absence of a significant correlation between household size and the adoption of maize farming technologies. Conversely, research conducted by Mignouna et al. (2011) in Kenya indicated that more extensive farming households might possess a distinct advantage in surmounting labor constraints, which are frequently essential for the adoption of contemporary agricultural innovations. The participation of household members of working age in farming activities is significant, as their involvement in labor-intensive tasks can ultimately affect the process of adopting new technologies (Mignouna*etal*.,2011).

The knowledge and academic qualifications of farmers significantly influence their readiness to embrace innovative agricultural technologies. The study by Wollni and Andersson (2014) in Spain revealed a positive correlation between educational attainment and adoption decisions, indicating that increased education enriches farmers' understanding and capacity to adopt technological innovations. Their research revealed that educational attainment plays a crucial role in the adoption of agricultural innovations, with farmers possessing higher levels of education exhibiting a greater propensity to incorporate and utilize new technologies in their farming methodologies. In a similar vein, Begho et al. (2022) conducted research in Asia that revealed a significant correlation between educational attainment and the adoption of technology, highlighting that farmers with higher levels of education demonstrated a greater willingness to adopt contemporary agricultural practices. In summary, education is deemed crucial for enhancing farmers' technical expertise and literacy or numeracy capabilities, thereby empowering them to adeptly employ emerging technologies. The experience in agriculture significantly affects the adoption of technology, shaping farmers' decisions in both advantageous and disadvantageous manners (Zakaria et al., 2020). With the accumulation of experience, farmers often transition from technologies that yield lower outputs to those that offer the potential for greater returns (Ndeke et al., 2021). Nonetheless, this observation stands in opposition to the findings presented by Otara et al. (2023), who investigated the implementation of regenerative agricultural technologies in Kenya. Their research revealed that farmers possessing considerable farming experience exhibited a lower propensity to embrace minimum tillage practices, implying that prolonged exposure to traditional farming methods may occasionally hinder the adoption of innovative agricultural technologies. The integration of indigenous knowledge is shaped by a multitude of factors, encompassing social, educational, economic, and managerial dimensions, as noted by Hosseini and Zand (2011). Their cross-sectional study on the determinants of IK adoption in agricultural water management in the arid regions of Iran demonstrated that social factors were paramount in influencing farmers' readiness to embrace indigenous agricultural practices.

In a similar vein, research undertaken by Getyengana et al. (2023) explored the elements affecting the amalgamation of Traditional Indigenous Knowledge (TIK) and Conventional Knowledge (CK) in the context of water security for livestock in South Africa. The research revealed a significant correlation between gender and the integration of knowledge, indicating that women exhibited a greater propensity to endorse the incorporation of TIK and CK in comparison to their male counterparts. Furthermore, the integration process was notably affected by age, as adults exhibited a higher level of support compared to their younger counterparts.

Moreover, the employment status of respondents influenced their perspectives, with those who were unemployed demonstrating a greater propensity to support the amalgamation of Indigenous Knowledge and Conventional Knowledge compared to their employed counterparts. The level of educational attainment emerged as a significant influence; those farmers possessing less formal education demonstrated a greater propensity to endorse the amalgamation of indigenous knowledge and conventional knowledge. Ultimately, the socioeconomic standing of farmers played a crucial role in shaping their viewpoints, as those identified as very poor demonstrated a greater inclination towards integration than their counterparts who were deemed less poor or poor (Getyengana et al., 2023).

Although extensive research has been undertaken regarding social determinants that facilitate technology adoption among farmers, particularly concerning modern agricultural technologies, there remains a significant gap in understanding how these factors affect the adoption of Indigenous Technical Knowledge. The present investigation examined not only the societal dimensions and their impact on adoption but also the factors that shape farmers' embrace of indigenous technologies.

2.2.2 Economic factors

The decision made by farmers to embrace agricultural technologies is complex, influenced by various economic factors. The analysis is shaped by a multitude of economic variables, including cost-benefit evaluations, availability of credit, market fluctuations, risk assessment, scale of operations, and governmental assistance. Farmers carefully consider these factors when making decisions regarding the adoption of new practices. The interplay of these factors collectively influences the course of agricultural development, affecting both livelihoods and sustainability. The yearly earnings of farmers significantly impact their choices regarding the adoption of agricultural technologies. A research endeavor conducted by Begho et al. (2022) in Asia indicated that farmers possessing elevated income levels exhibited a greater propensity to adopt agricultural innovations, especially those necessitating considerable financial investment. Their enhanced financial stability empowers them to embrace risks, secure credit, and expand their information sources, thereby fostering the integration of new technologies. In contrast, Ndlela et al. (2021) conducted a study in South Africa examining the application of indigenous knowledge in the management of nematodes in goats. Their findings indicated that low-income farmers, the unemployed, and individuals with limited educational backgrounds demonstrated a greater propensity to depend on IK-based solutions than their wealthier counterparts.

In a similar vein, Getyengana et al. (2023) underscored the economic viability of indigenous agricultural water management practices, rendering them advantageous for farmers with limited resources. Furthermore, research conducted by Waaswa et al. (2021) in Kenya identified a favorable correlation between household annual income and the implementation of climate-smart agricultural practices among potato cultivators. The research identified this trend as a consequence of affluent farmers' capacity to broaden their investments across both agricultural and non-agricultural sectors, leveraging profits from prior farming seasons to support additional innovations. The dimensions of a farm play a crucial role in the adoption of technology. The study undertaken by Hu et al. (2022) in China examined the relationship between farm size and the adoption of agricultural technology, revealing that those with more extensive landholdings exhibited a greater propensity to embrace modern agricultural practices. Nonetheless, this discovery stands in opposition to the work of Massresha et al. (2021) in Ethiopia, which indicated that farm size had a detrimental effect on technology adoption, implying that smaller landholders exhibited a greater receptiveness to innovation. In a comparable vein, research conducted by Andati et al. (2022) regarding the adoption of climate-smart agricultural practices (CSA) in potato farming indicated that farmers possessing larger tracts of land exhibited greater motivation to adopt CSA techniques. This can be ascribed to the capacity of larger landowners to engage in experimentation with various agricultural technologies aimed at enhancing productivity.

A significant relationship exists between land tenure systems and the uptake of agricultural technologies. Comprehending the influence of land ownership on the adoption of agricultural technology is crucial, especially in informing market-driven land reforms in Kenya. A research conducted by Zeng et al. (2018) in Ethiopia demonstrated that cash-renters were as inclined as landowners to adopt enhanced agricultural practices, whereas sharecroppers showed a heightened propensity to embrace these technologies owing to their profitability. Conversely, a study conducted by Oostendorp and Zaal (2012) in Kenya revealed that the presence of secure land rights markedly facilitated the implementation of soil and water conservation practices.

A variety of governmental support services, such as access to credit, management of rainfall and plot-level disturbances, social networks, extension services, and market accessibility, play a vital role in facilitating the adoption of agricultural technology (Teklewold et al., 2013). Similarly, Gbegeh and Akubuilo (2013) discerned that the availability of credit, membership in cooperatives, and access to extension services are pivotal elements that shape farmers' decisions regarding the adoption of technology. Extension services are essential in the transmission of information to farmers, whether through direct engagement with agents or via indirect exchanges among farmers themselves. Research conducted by Wollni & Andersson (2014) in Honduras revealed that farmers who participated in extension training covering various facets of organic agriculture exhibited a greater propensity to embrace organic farming practices. Their research further indicated that agricultural producers situated in isolated regions with limited market accessibility were less inclined to embrace such methodologies. In a similar vein, Singh and Sharma (2019) conducted a study in Nigeria that revealed a significant correlation between the adoption of organic farming and various factors, including training, knowledge, media exposure, education, social participation, and attitude. The results are consistent with the conclusions drawn by Ntshangase et al. (2018), which highlighted the significant role of extension services in advancing no-till conservation practices.

In their 2011 study, Hosseini and Zand highlighted that the perceptions and attitudes of farmers towards Indigenous Technical Knowledge were notably shaped by factors related to extension and education. Their findings indicated that enhanced training and familiarity with indigenous knowledge systems facilitated the adoption of such practices among farmers. Furthermore, the research revealed that the impact of peer influence via farm visits was instrumental in the adoption of indigenous technical knowledge. Furthermore, the backing of policymakers and agricultural leaders was crucial in merging traditional knowledge with contemporary farming practices. Engagement in agricultural organizations constitutes a significant element affecting the adoption of technology. These organizations facilitate farmers' access to information, strengthen their negotiating capabilities, and foster confidence in novel agricultural innovations (Mignouna et al., 2011). Nonetheless, Yusuf and Mustapha (2019) observed that numerous farmers do not engage in such groups owing to an insufficient understanding of their advantages. As a result, they underscored the importance of government-initiated awareness campaigns to encourage participation among farmer groups.

Furthermore, the availability of reasonably priced agricultural credit options profoundly influences the choices made by smallholder farmers regarding the adoption of innovative technologies. Atsriku (2020) noted in Ghana that the presence and ease of access to credit positively influenced the adoption of agricultural technology, as financial limitations frequently deter farmers from embracing new technological risks. In a similar vein, Gichuki et al. (2020) observed that access to credit had a favorable impact on the degree of agricultural technology adoption, as it afforded farmers alternative funding avenues to invest in watershed management practices. Similarly, Masca et al. (2022) in Kenya observed that access to credit substantially motivated smallholder potato farmers to adopt sound agricultural practices. The collective findings of these studies indicate that farmers who possess dependable access to credit are more inclined to embrace contemporary agricultural practices than their counterparts lacking such financial resources.

Moreover, the accessibility of markets is crucial for the integration of agricultural technologies. Astorga's research (2024) in Brazil revealed a constructive correlation between enhanced market infrastructure and the adoption of technology, indicating that improved market access significantly bolsters farmers' capacity to acquire inputs and efficiently market their outputs. In a similar vein, Perosa et al. (2024) identified that essential market determinants exerted a considerable influence on agricultural diversity. In Tanzania, Leerzem (2015) posited that the accessibility of markets enables farmers to surmount barriers related to inputs and marketing, thus promoting the adoption of innovative agricultural technologies.

While considerable investigation has been undertaken regarding the economic ramifications of adopting agricultural technology, the majority of studies have predominantly centered on contemporary farming innovations, with insufficient attention given to indigenous technical practices. This study sought to fill a notable research gap by examining the influence of indigenous knowledge on the adoption of agricultural technologies, particularly in the context of climate change adaptation.

2.2.3 Farmers' Perception on agricultural technologies

A multitude of studies has been undertaken to investigate the determinants affecting the adoption of agricultural technology. Comprehending these variables is crucial for fostering transformational growth within the agricultural sector and enhancing the livelihoods of farm households. The characteristics of emerging technology serve as significant factors in the process of adoption. Moreover, the perceptions held by farmers regarding the technology play a crucial role in shaping their decisions to either embrace or dismiss it.

For example, Khatri et al. (2021) undertook a study in Nepal to evaluate the influence of particular attributes—namely relative advantage, compatibility, complexity, trialability, and observability—on the adoption of Indigenous Technical Knowledge (ITK) practices. The results revealed that farmers regarded ITK methods as significantly compatible, straightforward to test, observable, and comparatively uncomplicated to implement. In a similar vein, Wandji et al. (2012) examined the perspectives of farmers regarding the adoption of aquaculture technology in Cameroon, ultimately concluding that favorable perceptions of fish farming facilitated its uptake. A parallel investigation conducted by Mignouna et al. (2011) in Western Kenya underscored the substantial impact of technology characteristics on the decisions surrounding adoption. Their investigation into Imazapyr-Resistant Maize (IRM) technology revealed that farmers exhibited a greater propensity to embrace it when they regarded it as aligned with their requirements and ecological circumstances, thereby rendering it a judicious investment.

In light of comprehensive investigations, there exists a paucity of studies examining the impact of farmers' attributes on their perceptions regarding the adoption of Indigenous Technical Knowledge, as highlighted by Mwangi & Kariuki (2015). This research, consequently, integrated the perceptions of farmers as a fundamental element, acknowledging that both individual characteristics of farmers and the attributes of technology significantly influence the decision-making process regarding adoption. The research examined factors including affordability, effectiveness, efficiency, availability, acceptability, environmental impact, and the propensity to embrace indigenous technical knowledge in ricebean cultivation.

2.2.4 The Role of Knowledge, Attitudes and Practices (KAP) in the uptake of Agricultural Technologies

Since climate change poses a significant challenge to farmers, adapting sustainable farming practices is essential to mitigate emissions and enhance agricultural sustainability. Sustainable agriculture relies on environmentally friendly practices that minimize greenhouse gas emissions, efficiently utilize local natural resources, and reduce negative effects on both the environment and human health. Since technology adoption is a complex and nonlinear process influenced by multiple factors, focusing solely on external influences may not fully capture the intricacies of farmers' decision-making. A complete framework that considers the integration of intrinsic elements in decision-making is required. This is because such changes to conventional practices rely heavily on farmers' knowledge and attitudes about technology (Nguyen *et al.,* 2019). For instance, Liao *et al.* (2022) used the KAP model to study sustainable agriculture adoption in Thailand, revealing that individual farmers' attitudes and practices contributed to collective sustainable farming behaviors. Similarly, Tarekegne *et al.* (2017) investigated soil conservation practices in Ethiopia using the KAP model and found that, alongside knowledge, attitudes, and behaviors, socioeconomic and cultural factors also played a role. Lower adoption rates of sustainable farming methods have been linked to a lack of information, limited knowledge, inadequate understanding of technology, and uncertainty about its practical benefits (Chuang *et al.,* 2020). However, a study by Nyairo *et al.* (2022) in Kenya indicated that despite farmers having positive attitudes toward agricultural innovations, barriers related to technology access and utilization hindered actual adoption.

In addition to external factors, intrinsic motivations also influence smallholder farmers' adoption of new agricultural practices in Sub-Saharan Africa (Zossou *et al.,* 2020). Farmers learn about new technologies, including their application, expected yields, potential environmental benefits, risks, and costs. The information farmers receive shapes their perceptions and attitudes, which in turn affect their willingness to adopt innovations. Farmers' knowledge and understanding of technology are strongly linked to their perceptions of its usefulness, ultimately influencing their farming practices. Zossou *et al.* (2020) emphasized that the inclusion of intrinsic factors such as perceptions, knowledge, and behaviors is crucial in technology adoption. Attitudes play a fundamental role in shaping farmers' decisions, as they are influenced by personal beliefs and values. Understanding farmers' perspectives on new technology is therefore essential in assessing agricultural innovation uptake.

According to Boufous *et al.* (2020), farmers' awareness and comprehension of sustainable agricultural practices significantly impact their adoption decisions. Farmers who are well-informed about the advantages of sustainable techniques are more inclined to embrace them. Moreover, positive attitudes such as valuing environmental protection and recognizing long-term benefits encourage the use of sustainable methods. Farmers who actively engage in sustainable farming techniques demonstrate a strong commitment to environmental stewardship, leading to improved soil health, reduced chemical use, and greater resilience.

Numerous studies have highlighted the importance of both intrinsic and extrinsic factors in the transition from conventional to sustainable agriculture. While research in developed countries has demonstrated that farmers' knowledge, perceptions, and practices play a significant role in technology adoption, there is limited research on the role of the KAP model in the adoption of indigenous agricultural practices in Kenya. This study aimed to address that gap by exploring the influence of KAP factors on indigenous farming methods.

2.3 Indigenous Technical Knowledge

Indigenous Technical Knowledge (ITK) refers to concepts, beliefs, values, conventions, and traditions that are ingrained in people's minds, local expertise which is specific to a given culture or society (Warren, 1987). Rajasekaran (1993) further defined it as a systematic body of knowledge that local people gain via the accumulation of experiences, informal experimentation, and deep understanding of the environment in a given culture The custodians of Indigenous Technical Knowledge (ITK) systems are local communities, including farmers, artisans, and livestock keepers, who possess deep insights into their environment, resources, and the effectiveness of various practices. They understand how changes impact different components of their systems, allowing them to adapt accordingly.

ITK is dynamic and continuously evolves through innovation, creativity, and interactions with both regional and global knowledge systems (Warren, 1991). These knowledge systems play a crucial role in preserving the livelihoods of local populations. ITK is often complex and highly specialized, adapting to specific environmental, cultural, and ecological conditions, as well as the availability and quality of local resources. Terms such as rural knowledge, indigenous knowledge, and traditional knowledge are frequently used interchangeably to describe these systems.

For generations, Indigenous Technical Knowledge (ITK) has enabled farmers to plan agricultural production and sustainably manage natural resources. For the communities that developed ITK systems, particularly in controlling and adapting to their natural environments, this knowledge was essential for survival. ITK represents decades of accumulated experience, careful observation, and trial-and-error experimentation (Louise, 1998).

This knowledge is preserved in people's memories and daily practices, embedded in stories, songs, folklore, proverbs, dances, myths, community laws, and local languages. It is further reflected in traditional taxonomies, agricultural techniques, tools, materials, plant and animal species, and breeds. Additionally, ITK is transmitted through cultural values, beliefs, rituals, and classification systems, forming a rich and dynamic framework for sustainable resource management.

Indigenous communication techniques are crucial for the transmission and preservation of ITK at the local level (Louise, 1998; Lekshmi 2009; Singh *et al.*, 2018). This body of knowledge has developed over time through the continuous interaction between humans and their environment. Its preservation relies on effective transmission and the ability of future generations to learn and apply it (Atteh, 1980). In traditional African societies, indigenous technological knowledge systems have played a crucial role in protecting natural resources from unsustainable exploitation, thereby preventing potential environmental crises.

Application of ITK in agriculture is illustrated in the use of indigenous agricultural farming practices, such as using indigenous planting and soil preparation materials, indigenous insect and disease management techniques, indigenous weed control techniques, and indigenous harvesting and storing techniques (Awuor, 2013).

2.3.1 Importance of Indigenous Technical Knowledge

In the absence of outside information, traditional cultures mainly rely on their local knowledge, which allows them to be more creative. ITK adds to scientific knowledge and acts as a communication link between researchers and local communities, claim Tanyanyiwa and Chikwanha (2011). Rural poor people's survival rests almost entirely on their ability to employ local skills and knowledge, hence ITK plays a significant role in their daily life. The livelihood of Kenya's small-scale farmers may be improved by mainstreaming and integrating ITK. It can make it easier for technology to be adopted, increasing agricultural output.

Despite the growing influence of technology and economic advancements, several traditional agricultural management and knowledge systems remain dominant. These systems incorporate key sustainability principles, such as preserving natural resources, relying on locally available materials, operating on a small scale, and being decentralized. Additionally, they are well adapted to specific environmental and cultural conditions, ensuring their continued relevance in modern agricultural practices.

According to (Kalita *et al.*, 2010) these indigenous technologies are cost effective, easy to follow, moderate of scientific merit, efficient, affordable, culturally appropriate and environmentally sound. This is also supported by (Singh *et al*., 2018) who pointed out that Indigenous Technical Knowledge may also aid in the design of cost-effective and sustained poverty alleviation techniques that are locally manageable and relevant as it focuses on avoiding risks rather than increasing profits. Critical analysis of such technologies could lead to thorough comprehension of the scientific components behind them which could further be upgraded by merging them with present scientific knowledge.

Indigenous Technical Knowledge (ITK) serves as a valuable source of innovation, particularly at the local level. As noted by Borthakur and Singh (2012), indigenous knowledge is applied across various domains, including natural resource management, agriculture, medicine, and other socioeconomic advancements, thereby fostering innovation. This knowledge has significantly contributed to improvements in rural enterprises. Similarly, Evalindigenous (2021) emphasizes that ITK encourages and safeguards traditional creativity and innovation, ensures proper recognition of Indigenous Knowledge rights, promotes intellectual advancements, and acknowledges the ownership of traditional and local communities over their knowledge.

Despite its numerous advantages, Indigenous Technical Knowledge (ITK) faces several challenges that hinder its continued use. The primary obstacles include a lack of farm records, increasing interest in modern technologies, and inadequate sharing of intellectual property rights, along with limited collaboration among farmers. According to Akullo and Kanzikwera (2007), students are primarily taught modern, structured techniques in classrooms, making traditional knowledge less accessible. Historically, farmers focused on subsistence production, whereas today, agriculture is more commercially driven. While commercialization has led to greater adoption of modern and efficient technologies, factors such as lack of awareness, reduced cooperation, and the monetization of ITK sharing have contributed to its decline.

The application of Indigenous Technical Knowledge (ITK) lacks standardization, which discourages its integration into modern farming practices (Akullo and Kanzikwera, 2007). Additionally, ITK practitioners do not actively seek to develop new tools based on indigenous knowledge. Farmers who earn a stable income from their agricultural activities tend to prefer modern technologies. While off-farm incomes have enabled some farmers to invest in advanced agricultural tools, traditional practices are often undervalued, as they are frequently associated with ignorance, illiteracy, or poverty rather than recognized for their sustainability and effectiveness.

Today's technological know-how is hardly up to the new difficulties related to these new technologies (Akullo and Kanzikwera, 2007). Numerous pests and illnesses have evolved and are impacting animal breeds as well as regional and improved crop varieties. To use and maintain new technologies, though, requires the right training. As a result, many struggling farmers will keep using their traditional methods and knowledge. As of now, development patterns have shown that many impoverished farmers are unable to afford new technologies and instead frequently rely on traditional knowledge and methods. Therefore, it is crucial that research devises methods for locating, gathering, and validating Indigenous Technical Knowledge practices. Such data must be saved in a way that it can be retrieved for use or reference by succeeding generations.

The majority of these might be included into research to improve it and make it more applicable to farmers. Additionally, the majority of farming technology are affordable and simple to acquire. Farmers will have the possibility to increase their revenue because the majority of export markets now favor organic foods produced by this group of farmers. It is important to verify, validate, and, when necessary, improve the potential indigenous farming techniques and knowledge.

2.3.2 Acquisition of Indigenous Technical Knowledge

This is the process of passing on these experiences from one generation to the next, primarily at the community level. Indigenous Technical Knowledge is a repository of agricultural management knowledge, skills, and practices that are passed down via the sharing of cultural and traditional information (Singh, 2007). Its dynamic nature has led to the accumulation of various forms of knowledge over time, making it an essential aspect of cultural evolution. As Wane & Chandler (2002) argue, the process of learning existing knowledge often leads to the discovery of new knowledge, which contributes to the continuous evolution and adaptability of Indigenous Technical Knowledge (ITK).

This ability to evolve ensures that ITK remains relevant and responsive to changing environmental and socio-economic conditions. Singh and Sureja (2008) report that local techniques of managing indigenous agriculture and natural resources are taught to people through a variety of localized sources, including parents, the environment, rural schools and social institutions, family relationships, friends, neighbors, and village wise men. Interaction with senior citizens, parents, grandparents, relatives, and friends are observed to be the main sources of ITK acquisition. Other typical sources of ITK include visits where one observes a technology in use and develops an interest in it. Additional sources of ITK included people migrating from other regions of the country of different ethnicities, radio programs, extension workers, and one's own discoveries through experience. Mishra and Rai (2013) support this view, asserting that traditional or indigenous technologies have developed through a gradual learning process. These technologies emerge from a rich knowledge base built by rural communities through continuous observation, experimentation, and the intergenerational transfer of experiences and wisdom. This accumulated knowledge allows indigenous practices to adapt and evolve over time, ensuring their relevance in changing environmental and socio-economic contexts.

For instance, Kenyans are primarily small-scale farmers who live in rural areas and have thus developed vast ITK on the agricultural production. However, the knowledge of these farmers has typically never been documented, making it difficult for researchers, extension personnel, planners, and development agents to record and disseminate. The greatest impediments to its applicability and accessibility by academics, extension employees, and development practitioners include a lack of documentation of indigenous knowledge, a lack of understanding about its scientific rationality, and insufficient research advances (Devi *et al*., 2014). Due to the lack of formal documentation, a substantial portion of Indigenous Technical Knowledge (ITK) has been lost with the passing of elderly knowledge holders. Furthermore, the increasing adoption of modern scientific methods often perceived as more effective and efficient has led to the complete abandonment of some ITK practices.

However, some are still in use due to the agriculture industry's vitality, and additional discoveries are being discovered through trial and error. In general, Indigenous Technical Knowledge is generally undocumented, elusive, and invisible in Kenya for a variety of reasons (Kiplang'at and Rotich, 2012). This study will therefore contribute to addressing this gap by documenting the acquisition of Indigenous Technical Knowledge in Kenya in the context of Ricebean production.

2.3.3 Use of Indigenous Technical Knowledge in crop farming especially underutilized crops

This paper adopts the South African definition of underutilized indigenous and traditional crops as outlined by Modi and Mabhaudhi (2013). They describe these crops as those that either originated in South Africa or have become "indigenized" through over a century of cultivation, as well as natural and farmer-driven selection within the country. The term ‘indigenous’ is often applied to crops that may have originated elsewhere but have undergone significant domestication locally, resulting in distinct local variations—also referred to as ‘naturalized’ or ‘indigenized’ crops (Mabhaudhi *et al.,* 2017). These indigenized crops are sometimes classified as traditional crops. Underutilized indigenous and traditional crops typically exhibit slower growth relative to their full potential (Mabhaudhi *et al.,* 2019). Consequently, their value chains remain underdeveloped and not well understood, as is the case with Ricebeans in Kenya.

The significance of traditional or underutilized crops has grown in recent years due to increasing global interest in utilizing traditional plants across regions such as Africa, America, and Europe (Duke, 1992; Turner *et al.,* 2011). Knowledge of these crops is an integral part of Indigenous Technical Knowledge, as they are closely associated with traditional farming systems and local farmer expertise, often shaped by a long history of selection and use within communities (Keller *et al.,* 2005). However, the cultivation of these crops largely relies on Indigenous Technical Knowledge. This is reinforced by Vorster *et al.* (2007), who assert that the role of Indigenous Technical Knowledge and traditional crops, including traditional vegetables, in rural livelihood strategies has only recently gained recognition in research.

The significance of Indigenous Technical Knowledge is particularly evident in the value chains of indigenous vegetables, encompassing various aspects such as their production, utilization, processing, and marketing. It also extends to traditional agricultural practices, including the preparation and application of organic fertilizers like compost, which enhance soil fertility and sustainable farming methods. However, there is limited application of this value to other value chains such as grain and legume crop production.

Like other underutilized crops, African Indigenous Vegetables (AIVs) play a vital role in providing nutritious food to both rural and urban populations and have been integral to food systems for centuries (Muhanji *et al.,* 2011; Ngugi *et al.,* 2007). They are widely recognized as essential in bridging the nutrition gap and supporting rural and urban livelihoods (Chweya & Eyzaguirre, 1999). AIVs are particularly significant in ensuring food accessibility for vulnerable populations in both settings (Schippers, 1997). However, despite their potential to address food, nutrition, and economic insecurity, their full utilization in Kenya remains limited (Abukutsa-Onyango, 2007). Furthermore, research and development efforts focusing on farmers' knowledge, attitudes, and perceptions regarding AIVs have been relatively scarce until recent years.

The significance of Indigenous Technical Knowledge (ITK) in African Indigenous Vegetables (AIV) production is highlighted by Ntawuruhunga *et al.* (2020) in their study on farmers' knowledge, attitudes, and practices (KAP) regarding AIV cultivation in Kenya. Their findings indicate that while many farmers incorporate modern inputs into AIV production, they still rely on traditional methods such as organic fertilizers and hand tillage using a hoe. Moreover, a considerable number of AIV farmers refrain from using pesticides, and only a few engage in processing AIVs or employ permanent and casual laborers in farming activities. This suggests that despite ongoing efforts by research organizations to enhance smallholder productivity in AIV farming across Kenya and Sub-Saharan Africa, ITK remains fundamental to the value chain. Modi *et al.* (2006) further support this argument, emphasizing that the resilience of AIV production is deeply rooted in indigenous knowledge, as farmers have preserved thousands of crop species and AIV varieties over generations.

The application of Indigenous Technical Knowledge (ITK) has been observed in various agricultural value chains, leading to positive economic outcomes. For example, farmers in Southern Sudan and Zaire have long recognized that termite mound sites enhance soil fertility, making them ideal for cultivating sorghum and cowpea (Adedipe *et al.,* 2004). This practice is based on the belief that sorghum improves soil aeration and structure, while cowpea contributes to nitrogen fixation, thereby enriching soil fertility. Similarly, in Tanzania, farmers developed a multi-storey farming system incorporating fallowing, intercropping, and selective weeding. Instead of completely removing weeds, they allowed them to cover the soil, preventing excessive moisture loss and promoting beneficial competition that stimulated crop growth. Overgrown weeds were eventually weeded and left as mulch to protect the soil and minimize erosion during heavy rainfall. These traditional soil management practices demonstrate the ingenuity of local farmers in sustainably enhancing agricultural productivity while maintaining ecological balance (Adedipe *et al.,* 2004).

Ugandan farmers employ various Indigenous Technical Knowledge (ITK) practices to manage pests, diseases, and post-harvest losses. For instance, when selecting planting materials for cassava cultivation, they ensure that the cuttings are undamaged and that the nodes face downward to enhance sprouting and root development (Bwambale, 2015). Additionally, burning is used as a pest control method, as the resulting ash is believed to contain essential nutrients while also acting as a deterrent to pests.

Post-harvest management remains a challenge, particularly for root crops, which are highly perishable. To extend cassava's shelf life, farmers bury fresh tubers about one foot deep in moist soil, preserving them for up to seven days. For grain crops like legumes, farmers practice early planting and integrate them into rotation systems, broadcasting seeds before plowing. They also rely on natural pesticides, such as a mixture of ash and dry goat droppings dissolved in water, to combat pests and diseases. Ash plays an additional role in preserving beans, preventing insect infestation.

This aligns with the findings of Reddy (2006), who noted that wood ash, cow dung, soap nut leaves, neem leaves, and pungam leaves are commonly mixed with pulses before storage in bins or bags. These natural substances function as insect repellents, antifeedants, and oviposition deterrents, effectively protecting stored grains from pest infestations. These traditional methods highlight the importance of ITK in sustainable farming and pest management.

However, much research on technical indigenous knowledge or different value chains especially in performance of underutilized crops have been done, Ricebean Indigenous Technical Knowledge has neither been done nor documented. Since it is less popular in Kenya, there is need to ascertain what the farmers know which will form the basis of developing strategies to employ for popularizing the crop. This is because many of the innovations developed by researchers never make it to the point where they can be used in everyday farming by farmers because their inputs were not taken into account during development. Waithaka 2011 stated that Investigations of what local communities know and have in terms of indigenous practices should be conducted before new practices are introduced, and then new practices can be used to improve them. This study therefore seeks to address this knowledge gap.

2.3.4 Indigenous Technical Knowledge as an entry to innovation

In the face of global climate change and its emerging issues and unknown uncertainties, it is essential that decision making for policies and actions be based on the best available knowledge. Reassessment of Indigenous Technical Knowledge is an indispensable part of the introduction of new agricultural technology since the knowledge of farmers must be taken into account before any new technology is developed and disseminated (Singh *et al.*, 2018), because farmers have a wealth of knowledge pertaining to their own environment and have developed specific skills designed to make the best use of it.

In recent years there has been growing wareness that formal scientific knowledge alone is inadequate in addressing the climate crisis (Mafongoya & Ajayi 2017) thus it is inceasingly recognized as an important source of climate knowledge and adaptation strategies for the purpose of increasing agricultural production. Lwoga *et al*., (2010) recognized that sustainable economic development is dependent on local communities' indigenous knowledge, hence bridging the knowledge gap through a knowledge creation model for agricultural development is necessary.

Indigenous people have made significant contributions to knowledge on a global scale. This is due to the ongoing development and adaptation of Indigenous Technical Knowledge to constantly shifting environmental conditions. ITK therefore becomes crucial in the dynamic industry of agriculture. If local people's knowledge has been incorporated into the entire knowledge generation process, as well as their thoughts, experiences, and creativity have been assimilated in the process, local people will generally associate themselves more with new technology. Since scientific and technical information may validate and improve Indigenous Technical Knowledge and drive modernization, there is a growing acceptance of the necessity to include the local population as active partners in all aspects of the research and development process (Awuor 2013). This is supported by Warren and Cashman (1988), who postulated that Indigenous Technical Knowledge can play a key role in the design of sustainable agricultural systems, increasing the likelihood that rural populations will accept, develop, and maintain innovations and interventions.

Results are typically tailored to local conditions, and technologies are low-cost, straightforward, and based on readily accessible materials. Alcorn (1995) acknowledges that resources derived from ethnobotanical knowledge (indigenous knowledge) can help achieve rural development goals, such as improving rural livelihoods, sustainable use of the natural resource base, improved well-being, health, and nutrition, strengthening institutional capacity to meet rural people's needs, and creating surplus capital for financing industrialization. Particularly when developing or carrying out development projects or programs, the development process engages with Indigenous Technical Knowledge (World Bank, 2009).

Moreover, ITK provides for the development of innovations that protect small scale farmers from adverse effects of climate change such as inadequacy and uncertainty of rainfall and its uneven and irregular distribution which is usually compounded by low fertility and high fragility of soils. FAO (2008) reports that Indigenous Technical Knowledge enables its owners to enhance subsistence farming at the time of seasonal and climatic variability. This is achieved through indigenous adaptation mechanisms (Dube and Phiri, 2013 & Rankoana, S.A. 2016), which are described by Reid and Huq (2014) as community-based adaptation that can be defined as 'community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan and cope with the impacts of climate change'.

2.3.5 Integrating Indigenous Technical Knowledge with scientific knowledge for sustainable development.

Indigenous and scientific knowledge systems are synergistic (Kristjanson *et al*., 2009; Pretty, 2003). Local knowledge is crucial for progressing civilization since it helps scholars comprehend farmer science (Castillo, 1998), creates technology (Mundy & Compton, 1991; Briggs, 2005; Nwokeabia, 2006), and generates innovation (Briggs, 2005). (Chakravarty, 2010). Additionally, it is essential for farmers' ability to produce food, preserve the environment, and endure adversity (IIRR, 1996; Ismail & Fakir, 2004). On the other hand, scientific knowledge is crucial for enhancing livelihoods (Pretty &Wesseler, 2004). It is therefore regarded as "common sense" to combine local and scientific knowledge (Saway, 2004).

Farmer field schools (FFS) (Rangi, Day, Asaba, Munyua, & Kimani, 2002) and training programs leverage the blending of farmers' local knowledge and scientific information to improve agricultural productivity and livelihoods (Mchombu, 2003; Nathan, Lund, & Theilade, 2007; Meyer, 2000). The two systems' integration enhances communication, comprehension of community opinions, and local residents' involvement in their own development (Rajasekaran, Martin, & Warren, 1993). In addition to altering social power dynamics, this fusion also shifts the flow of information away from one dominating culture and toward both (IIRR, 1996; Mairura et al., 2008; Meyer, 2003, 2005; Röling & Pretty, 1997).

Additionally, combining information strengthens connections between stakeholders, promotes sustainability (Emery, 2000), raises yields (Adedipe, Okuneye, and Ayinde, 2004), and aids in environmental preservation (Eklund, 2009; Hemp, 2005). Additionally, it aids in risk management (Eklund, 2009), encourages the acceptability and sustainability of both knowledge systems (Breidlid, 2009), makes land management decision-making easier, and lowers production costs (Lewis, 2008). (Mihale et al., 2009).

Discussions about the sustainable use of resources and balanced development often emphasize the importance of Indigenous Technical Knowledge (Brokensha et al., 1980; Compton, 1989; Gupta, 1992; Niamir, 1990; Warren, 1990). The Information Centre for Low External Input and Sustainable Agriculture promotes an agriculture that makes the best use of locally accessible natural and human resources, including labor, local skills, and indigenous knowledge. These resources include climate, landscape, soil, water, vegetation, local crops and animals, and vegetation.

This must meet the four requirements of sustainability, namely being economically viable, ecologically sound, culturally appropriate, and socially just. Although not prohibited, using external inputs is considered as a complement to using local resources (Haverkort, 1995). Traditional agricultural methods, indigenous knowledge, and scientific understanding as evolved in agro-ecology are the key knowledge sources for low external input agriculture.

Asserting that rural people's knowledge and scientific knowledge are complementary in their strengths and shortcomings and that when combined, they may achieve what neither would alone, Chambers (1983) emphasizes the complementary significance of indigenous and scientific knowledge systems. To maintain local ownership and long-term sustainability, Chambers (1983, 1994) emphasizes the necessity of combining indigenous peoples' expertise with contemporary development paradigms.

Due to environmental difficulties, farmers are encouraged to cultivate hybrid crop types, but they should also be encouraged to supplement these with native varieties that have a high nutritional value, a long storage time, and are simple to handle for low-income farmers. For socioeconomic transformation, IK should be discovered, cultivated, harvested and promoted more vigorously (Awuor, 2013).

According to Awuor (2013), Indigenous Technical Knowledgecan be incorporated into development by involving farmers in research planning and execution, using external assessments of local needs as a foundation for research, or actively combining indigenous and scientific knowledge (in addition to working together between the scientist and the farmer) in order to take advantage of their potential complementarity.

Although Kenya's Ministry of Agriculture and Kenya Agricultural and Livestock Research Organization have tried to combine and apply ITK in conjunction with modern technologies to increase yields for food security, very limited documentation has been achieved. The administration and preservation of ITK are also inadequately documented. (Kiplang'at and Rotich, 2012). Therefore, this study addressrd this gap of knowledge.

2.4 Ricebean Overview

This section covers on ricebean morphology, production and its implication in agricultural farming systems.

2.4.1 Ricebean Production

Vigna umbellata also commonly referred to as; red bean, Ricebean, climbing mountain bean, mambi bean or oriental bean, is a tropical to temperate grain legume primarily grown for food. *Vigna umbellata* is a perennial legume however is typically planted as an annual crop by farmers. It has a wide range of habits, including erect, semi-erect, and twining. It grows to a height of 30-100 cm in most cases, but can reach 200 cm in extreme cases (Ecoport, 2014). It has an extensive root system with a taproot that can reach depths of up to 150 cm. The stems are fine hairy and branching. The trifoliate leaves have whole, 6-9 cm long leaflets. The blooms are papilionaceous and bright yellow, and they bloom on 5-10 cm long axillary racemes. The fruits are 7.5-12.5 cm long cylindrical pods with 6-10 oblong, 6-8 mm seeds with a concave hilum. Ricebean seeds come in a wide range of colors, from greenish-yellow to black, yellow, and brown.

Indo-China is thought to be the center of domestication of the crop. It is thought to be derived from its cross-fertile wild variety *V. umbellata* var. gracilis, which is found in southern China, northern Vietnam, Laos, and Thailand, as well as Burma and India (Lawn, 1995; Tomooka *et al*., 1991). With a twining habit, photoperiod sensitivity, and unpredictable growth, wild forms are often fine stemmed, freely branching, and small leaved (Lawn, 1995). Flowering is asynchronous, and seeds are prone to hardening. Many landraces that retain many of these features, particularly with regard to sun sensitivity, growth habit, and hard seeds, still exist in many regions.

Ricebean is a neglected crop grown on small plots by subsistence farmers in Nepal's hilly areas, northern India, and Southeast Asia (Dahipahle *et al*., 2017). It can be cultivated in a variety of environments and is well-known among farmers for its vast adaptability and output, even on marginal soils, sloping places prone to drought, and flat rainfed tars (unirrigated, ancient alluvial river fans). It is mostly grown between 700 and 1300 meters above sea level, while it can be found in residential gardens from 200 to 2000 meters.

Ricebean has nearly little published literature with relevant information on its region and distribution, and the crop's potential is unknown. The majority of the crop farmed in Nepal is for human use, with a lesser percentage being used for fodder and green manuring. Ricebean is typically farmed as a maize intercrop on rice bunds or terrace risers, as a solitary crop on the uplands, or as a mixed crop with maize in khet (bunded pieces of land where transplanted rice is grown) land. Ricebean sowing takes place between the seeding of maize and the first and second earthing up of that crop in mixed cropping, therefore it lasts from April to June (Dahipahle *et al*., 2017).

The crop is cultivated on residual fertility and moisture, as well as in marginal and depleted soils, with essentially no inputs. According to anecdotal evidence, Ricebean production and area are declining as a result of the introduction of high-yielding maize varieties and increased use of chemical fertilizers, while consumption is decreasing as a result of the increased availability of more preferred pulses in local markets. There has been no modern plant breeding, and only landraces with minimal yield potential are grown. These have to compete with other summer legumes such as black gram (*Vigna mungo*), soybean (*Glycine max*), cowpea (*V. unguiculata*), horse gram (*Mactotyloma uniflorum)* and common beans (*Phaseolus vulgaris*).

Small and fragmented land holdings, as well as diminishing productivity, are further production restrictions that limit Ricebean output. There is no institutional support for the development and promotion of this crop, either from research or from extension services. Despite this, as a legume, Ricebean may contribute significantly to mixed subsistence farming systems, is culturally significant, and is regarded to have key nutritional properties that could help improve diets and food security in the areas where it is being produced and elsewhere.

Ricebean is sown in India in February and March for summer harvest and in July and August for December harvest (Khanal *et al*., 2009; Oommen et al., 2002). It can be planted in small fields or along rice terrace bunds. Ricebean thrives when planted between rows of a tall crop like maize or sorghum, which it can climb. Ricebean is a resilient plant that is resistant to a variety of pests and diseases, and it grows without the need for fertilizer or special care.

Farmers cut the plant's tops to encourage pod production. Ricebeans mature approximately 120-150 days after sowing, however higher elevations may require additional time. When 75% of the pods have become brown, the seeds are picked. Harvesting should be done early in the morning or late in the afternoon to avoid heat-induced shattering. The vines and pods are left on the ground for 2-3 days after harvesting before being threshed. Crop wastes can then be utilized as animal feed (Khanal *et al.,* 2009). Ricebean landraces that mature late and are photosensitive are grown as a fodder crop in India. They are planted over lengthy days to prevent the plant from blossoming (Oommen *et al.*, 2002). Cutting may be practiced on dual-purpose varieties the pods are half-grown, however, handling should be limited as much as possible because the leaves drop easily (Göhl, 1982).

The worldwide yield of Ricebean seed is around 225 kg per hectare (Duke, 1981). It can range from 200-300 kg per hectare in West Bengal to 1300- 2750 kg per hectare in Zambia, Brazil, and India, for example (Chandel *et al*., 1988; Chatterjee *et al.,*1977). Fodder yields in Bengal (India) ranged from 5-7 tonnes dry matter per hectare in May and June to 8-9 tonnes dry matter per hectare in November and December, according to reports (Chatterjee *et al*., 1977). Lower levels of 5-6 tonnes dry matter per hectare in Myanmar (Aye, 2001) and 2.9 tonnes dry matter per hectare in Pakistan's sub-humid Pothwar plateau have been reported (Qamar *et al*., 2014). After applying 20 kg nitrogen per hectare to Ricebean planted with Nigeria grass (*Pennisetum pedicellatu*m) in India, yielded 7.6 tonnes dry matter per hectare (Chatterjee *et al*., 1977). Ricebean with sorghum (50:50 mix) yielded up to 12 tonnes dry matter per acre in Pakistan (Ayub *et al*., 2004).

In the context of Kenya, Ricebean along with inorganic fertilizers and organic inputs has been proposed as a solution for reversing the low and declining crop yields in western Kenya. It has been identified as among the most promising grain legumes in Western Kenya to be included in the integrated soil fertility management (ISFM) technologies that could improve crop yields. According to (Esilaba *et al*., 2013), Ricebean can be taken to scale in Western Kenya either in rotation or as intercrops with cereals, especially maize. However, despite its proposed relevance in addressing declining crop yields in western Kenya, there exists no studies on Ricebean in the context of Kenya. Therefore, the production patterns and potential of the crop remains unknown. Thus, this study intends to address this knowledge gap by documenting production aspects and outcomes of Ricebean farming in Kenya.

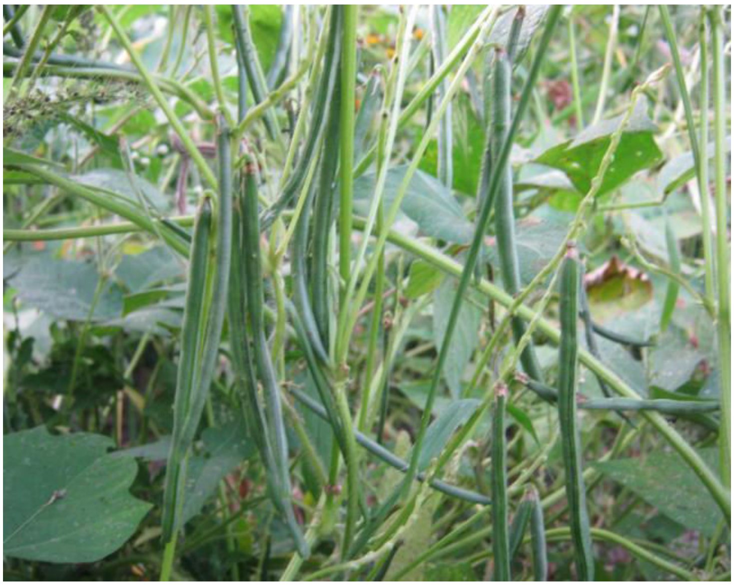


Figure 2. 1:Ricebean plant

Figure 2. 2: Ricebean seed

2.4.2 Implications of Ricebean Production

Ricebean is a multifunctional legume that is employed in traditional and cultural practices all over the world. People are still unaware of the commercial significance and market worth of this pulse; therefore, it is frequently overlooked and underused (Joshi *et al*., 2008).

2.4.2.1 Contribution to Human Nutrition

The legume has enormous nutritional and production potential, but its promise to improve the lives of many small-scale farmers has yet to be completely realized.

Ricebean is a locally important contribution to human nutrition in regions of India and Southeast Asia, however it is less important than cowpea (*Vigna unguiculata*), adzuki bean (*Vigna angularis*), and mung bean (*Vigna radiata*) (Joshi *et al*., 2008; Tomooka *et al*., 2011). All Ricebean plant parts are edible and can be utilized in culinary recipes. The dried seeds can be boiled and eaten with rice, or they can be used in stews and soups instead of rice. They are ground in Madagascar to form a nutritional flour that is used in children's diet. Young pods, leaves, and sprouting seeds are consumed as vegetables after being boiled. Young pods are occasionally consumed raw (Rajerison & Ohashi, 2006).

2.4.2.2 Improves Soil Fertility

Ricebean is a Nitrogen fixing legume that improves the soil's nitrogen status and so provides nitrogen to the next crop. Its taproot improves soil structure and returns organic matter and nitrogen to the soil when ploughed in. It is desirable to plant Ricebeans before or after a rice or maize harvest. It is profitable to seed Ricebean between the rows of maize once the crop has achieved maturity but before harvest in

Thailand, so that the Ricebean covers enough soil during harvest to provide soil cover during the dry season (Echo AIC, 2012).

Ricebean is a valuable green manure in the Thai highlands, outperforming other legumes such as *Canavalia ensiformis, Lablab purpureus*, and *Mimosa diplotricha* in terms of improving rice yields (Chaiwong *et al*., 2012). Ricebean (*Vigna Umbellata*), mung bean (*Vigna radiata*), and cowpea (*Vigna unguiculata*) applied as green manure in tangerine orchards in China produced higher fruit yields than soybean (*Glycine max*), mung bean (*Vigna radiata)*, and cowpea (*Vigna unguiculata*) (Wen *et al*., 2011).

2.4.2.3 Ricebean is a Livestock feed

Ricebean is seen as both a grain and a fodder legume by farmers in Nepal's marginal hills, who seek dual-purpose landraces (Khanal *et al*., 2009). It is an excellent cattle feed. The seeds are fed, while the vegetative parts can be eaten raw or turned into hay. Its straw consists of stems, leafy sections, empty pods, and some seeds left behind from seed harvest (Chaudhuri *et al*., 1981). Before feeding, remove any woody portions of the straw, as well as any unclean or mildewed pieces (Göhl, 1982).

There is a scarcity of information on the composition of Ricebean fodder. Fresh Ricebean forage, like other legume forages, is high in protein, however its content varies greatly (17-23 percent DM). Ricebean hay and straw are slightly less nutritious than Ricebean fodder (16 and 14 percent protein in the DM, respectively). Ricebean forage is extremely high in minerals, particularly calcium (which accounts for 10% of the DM in fresh pasture) (up to 2 percent in the fresh forage). Although it is highly varied, the straw contains a significant amount of mineral matter (greater than 20% of DM). Condensed tannins (0.1-2.8 percent DM) are present in varying levels in Ricebean fodder (Wanapat *et al*., 2012; Chanthakhoun *et al*., 2010).

Ricebean seeds are high in protein (18-26 percent DM), but not as much as pea (*Pisum sativum*) or cowpea (*Pisum aestivum*) (*Vigna unguiculata*). They have a small quantity of fiber and fat (about 4 and 2 percent, respectively). The amino acid composition of this grain legume is similar to that of other grain legumes. It has a lot of lysine (more than 6% of the protein), but it's low in sulphur-containing amino acids. Ricebeans have a high starch content, ranging from 52 to 57 percent of the dry matter (DM) (Kaur *et al*., 1990; Chavan *et al*., 2009). The amylose percentage of starch varies greatly, ranging from 20% to 60%. (Kaur *et al*., 2013).

Ricebean as a fodder crop is a potential resource. It is highly palatable in sheep in the pre-flowering stage (Chandel *et al*., 1988). Farmers in Nepal have highlighted Ricebean fodder's softness and palatability for animals (Joshi *et al*., 2008). Bullocks first resisted eating Ricebean hay in an experiment in India, but after a few days, they became accustomed to it and their dry matter (DM) consumption increased, indicating that the hay was pleasant (Gupta *et al*., 1981).

Cattle have been reported to relish Ricebean straw (Göhl, 1982). In India, 22-month-old calves fed a 54:46 fresh basis mix of fresh Sudan grass (*Sorghum drummondii*) and Ricebean forage for 64 days had a daily DM consumption of 1.90 kg DM/100 kg LW and a daily weight increase of 456 g day-1 (Singh *et al*., 2000). In India, 22-month-old calves fed a 54:46 fresh basis blend of fresh Sudan grass (*Sorghum drummondii*) and Ricebean forage for 64 days had a daily DM consumption of 1.90 kg DM/100 kg LW and a daily weight increase of 456 g/d (Singh *et al*., 2000).

Ricebean hay is commonly utilized as a protein source in ruminant diets to supplement low-quality roughage. The hay supplemented rice straw in swamp buffalo diets at 600 g day-1 enhanced DM consumption, digestible protein, and nitrogen retention. It improved the rumen microbiota, resulting in more VFA production and lower CH4 emissions (Chanthakhoun *et al*., 2011). This hay was found to improve the utilization of high fiber feeds in buffalo diets by increasing cellulolytic rumen bacteria (Chanthakhoun *et al*., 2010).

Ricebean hay had a moderate OM digestibility (50 percent) in an Indian bull experiment, but it had enough nitrogen, calcium, and phosphorus to meet the maintenance needs of mature cattle (Gupta *et al*., 1981). In Vietnam, a 3:1 ratio of cassava hay and Ricebean hay substituted 60% of the concentrate in a forage-based diet (*Pennisetum purpureum* + urea-treated rice straw) fed to developing crossbred heifers, resulting in higher daily weight gain (609 g day-1), improved feed efficiency, and lower feed costs (Thang *et al*., 2008). In India, supplementing grass-fed goats with Ricebean hay (15 percent of diet DM) did not enhance grass consumption, but it did increase total DM consumption and nutrient digestibility. Increases in Ricebean content above 15% had no additional effect on digestibility (Das, 2002).

Ricebean straw had a poor OM digestibility (31-47%) in an Indian study with bullocks, hence it was recommended to augment a rice straw-based diet with energy-rich feed items such cereal grains or bran (Chaudhuri *et al*., 1981).

Ricebean seeds are fed to buffalo calves and lambs in India as a source of energy. These were used to replace half of the cereals and half of the deoiled cake in the buffalo calves' concentrate (Ahuja *et al*., 2001). In sheep, substituting Ricebean seeds for half of the metabolizable energy from oat hay had no negative impact on the N balance, which remained positive (Krishna et al., 1989).

Despite Ricebean's ability to promote environmental sustainability, nurturing community sustainability with its nutritive benefits and fostering economic sustainability due to its low input requirements and wide range of uses, Ricebean has received limited attention from researchers (Andersen, 2012). Most of the existing scientific literature on Ricebean is technical, relating to biological, agronomic or nutritional issues. Many of the authors have written with the aim of evaluating and promoting Ricebean as a crop with significant potential for human consumption with limited attention paid to the production systems of the crop. Due to the limited scientific intervention, Ricebean production in Kenya is presumed to be undertaken using Indigenous Technical Knowledge. Therefore, this work intended to fill the knowledge gap in the current body of literature by documenting technical indigenous knowledge of Ricebean farmers and their application on Ricebean farming in Kenya.

2.5 Indigenous Technical Knowledge in the context of Ricebean production

Ricebean has a long-standing history as a cultivated crop in Nepal, akin to its status in Kenya. It is believed to have been introduced concurrently with maize, though the precise timing of this introduction remains uncertain. In a manner akin to the perspective held by farmers in Kenya, Ricebeans are regarded as a traditional crop. The cultivars of Ricebean in Nepal represent a rich heritage, meticulously transmitted from one village to another and across generations via an informal distribution network, wherein farmers retain full authority over the management and supply of seeds. Therefore, due to these similarities, in order to develop Indigenous Technical Knowledge in the context of Ricebean production, this study draws on research by Khanal et al. (2007) on "Farmers' local knowledge linked with the production, usage, and diversity of Ricebean (Vigna umbellata) in Nepal."

2.5.1 Farmers' Indigenous Technical Knowledge of soil and its implications for Ricebean

The roots can grow deep in rato mato (red soil). These soils yield favorable outcomes for various crops, provided there is adequate irrigation or suitable rainfall. When dry, rato mato is compact. It possesses considerable depth and an extended capacity for water retention. The most productive soil is characterized by its black hue. In such soils, Ricebean yields are low because there is less flowering and fruiting even while vine vegetative growth is greater. In a variety of soil, Ricebean grows well. The optimal soil composition consists of a blend of gravel and red soil (Rato Gagreto mato), facilitating deep root growth even in conditions of limited moisture availability. Ricebean is typically grown on Sano mato (small soil that is typically shallow with more pebbles and stones in it) with little inputs and minimal attention paid to the crop.

2.5.2 Indigenous Technical Knowledge associated with Ricebean-growing lands

Ricebean grows better on medium to less fertile land than on very fertile land. In arid, marginal, and hilly regions, plants exhibit greater yields compared to plains, as fertile soils tend to foster abundant vegetative growth and increased green biomass, often at the expense of floral production. Red soil yields a greater quantity of Ricebeans compared to black soil. Ricebean does not require particularly deep soil. The crop can be grown in marginal or underutilized areas of the land. Farmers in marginal and drought-prone areas grow Ricebeans because they are thought to be drought resistant.

It is posited by farmers that Ricebean enhances soil permeability in these regions, leading to superior crop growth in arid hilly terrains compared to the shaded inclines of the same hills. Ripyan or Tapken are damp, shaded locations where dew or rainwater remnants are not directly exposed to direct sunshine. Due to the rapid vegetative growth and increased production of Pani Kosa (chaffy pods), these locations are not ideal for the production of Ricebean grain. The inner surfaces of these turgid, substantial pods are enveloped in a dense, viscous substance, leading to their designation as "Bose Kosa" (fatty pods).

2.5.3 Indigenous Technical Knowledge basis for naming landraces

Farmers consider the color, maturity, and size of seeds when naming landraces. Names include Thulo (Large), Mailo or madhyam (Medium), and Sano (Small) in terms of seed size. The color of rat (red), seto (white), pahero (yellow), or caro (black) and the maturity of Badaure (early) or Madiyam (middle) and Dila (late).

2.5.4 Indigenous Technical Knowledge classification of landraces on the basis of maturity

Farmers classify Ricebean landraces into three broad categories in terms of maturity period.

2.5.4.1 Early maturity types:

The second or third week of September, is a popular time to harvest early landraces. They are planted alongside maize plants, or they are broadcast just after maize plants have emerged. These landraces have small grains and low biomass. They have smaller vines than other types and do not need strong stakes to support them. They can also be grown as an intercrop with maize, which means they don't need as many stakes. There is less variation among these items. The Ricebean is less productive than the two other types of Ricebean. Farmers generally do not like these crops, preferring other types. Their colors vary, with early black varieties being found mainly in lower-altitude regions (Bensi areas), while yellowish white and brown types are more common at higher altitudes (1000-1400 meters).

2.5.4.2 Medium maturity types:

These are usually planted during the second planting period of maize, between the last week of May and mid-June, but the timing depends on soil moisture and rainfall. Harvest times vary slightly with altitude, but are generally from the third week of October to the first week of November. Colors range from yellow, red, purple, brown or cream to mottled gray. Farmers report greater diversity in this category and generally prefer early harvest types to ensure subsequent successful planting of Tori or Canola (Brassica spp.).

2.5.4.3 Late maturity types:

Late maturing types are planted at the same time as the mid maturing types, but their longer duration means harvest lasts into the first week of December. They have larger grains and longer pods, and farmers prefer them for home consumption as a food crop, although they also have a luxuriant growth habit and higher forage yields. These species require strong stakes for support but will produce more than others, especially when planted in sunnier and more fertile soil. The seed color of these species is yellow, mottled grey, white, black and light green. Although they have a good yield and quality, fewer farmers grow them due to their late maturity.

2.5.5 Indigenous Technical Knowledge associated with landraces

Rainfall during flowering has no effect on early landraces since they are immune to chaffy pods. They are least farmed by farmers, have a poorer taste, and have little grains. Low-altitude, river basin regions are where small, white to yellowish-yellow seeded types are cultivated. Small grains, non-twining vines, and an early maturity are their main characteristics. They yield best when grown as a single crop, and are ideally suited for growing atop rice bunds. Indeterminate vines with luxuriant growth habits and late maturity can be seen in big grey mottled seeded kinds. They produce best when intercropped with maize at higher elevations (1000–1800 m). In extremely dry and marginal areas, small seeded and early- to late-maturing landraces yield better than the big seeded late maturing landraces.

Large-seeded, late-maturing landraces and those with luxuriant growth habits produce more in more fertile soil. Because of this, some farmers also plant small-seeded early- to mid-maturing landraces in the field's margins and corners where the soil is shallow and fertile, whereas large-seeded varieties are given preference for the more productive land. According to farmers, combining Ricebeans with varied colors and seed sizes has long been a customary practice. They contend that blending seeds from the same maturity group reduces risks because there isn't a significant loss in production and at least one type should perform well under challenging circumstances.

2.5.6 Indigenous cropping patterns adapted for Ricebean in different parts of Nepal

2.5.6.1 Mixed or intercropping with maize in bari lands (upland)

In Nepal as a whole and in the research locations, this is the Ricebean cropping pattern that is most prevalent. Indeterminate varieties of Ricebean seeds are typically planted between rows of maize plants or disseminated with the maize seeds. The Ricebean vine uses the maize stalk in both instances as a stake. The height and type of landraces affect the Ricebean growing season differently. Some farmers change the planting date to prevent the twining habit from reducing the crop's potential output. Mid- and late-maturity landraces are typically planted after the first or second earthing up of maize, while early-maturity landraces are planted simultaneously with maize. Farmers favor medium maturing landraces with optimal vine development for intercropping with maize. In other places, farmers plant Ricebeans around the edges of their primary bari lands. This is more prevalent where finger millet is grown alongside maize as a relay crop.

2.4.6.2 On rice bunds and margins of the bari lands

In Nepal's mid and far western regions, rice bunds are also used to grow Ricebean. On rice bunds, farmers cultivate determinate Ricebeans, for which no stakes are needed. When the indeterminate types reach a particular vegetative growth, they are steered along the slopes of the bari fields.

2.5.6.3 Sole cropping in home gardens or uplands

Some farmers cultivate Ricebeans exclusively for family consumption in their backyard gardens and on tiny plots of land nearby. In this instance, stakes are given to the crop. Green immature seeds are used by farmers as a fresh vegetable. Typically, for this purpose, landraces with tall pods and bold grains are grown.

2.5.7 Cultivation practices of Ricebean based on Indigenous Technical Knowledge

2.5.7.1 Planting Time and Method

Dibbling or disseminating are the two planting techniques most frequently used by farmers. The high seed rate needed for broadcasting results in a larger initial plant population, which is then thinned down to the ideal population. In terms of giving livestock more fodder, this provides benefits. The state of the soil's wetness affects the planting technique as well. Where there is sufficient soil moisture and friable soil, broadcast sowing is common. After plowing or digging up the maize, seed is disseminated dispersed; in dry conditions, two or three seeds are dibbled per hill. The seed rate varies depending on the farming system, practices, and planting method.

2.5.7.2 Intercultural Operations

Ricebean requires little maintenance. Weeding is done once or twice, usually during the vegetative growth stage. For indeterminate varieties, staking is required. Landraces that mature later have lush growth that requires sturdy stakes. When Ricebean plants are interplanted with maize, the maize plant serves as a stake, however for solitary cropping and in backyard gardens, farmers provide the Ricebean plants stakes. In order to use the remaining stalk as a support for the Ricebean, the dried maize plant's tip is chopped off right above the mature maize cob. To make the maize stalk long and sturdy enough to sustain the Ricebean plant, some farmers even cut off the Ricebean vine's head.

Early landraces reach maturity alongside maize and are harvested at the same time. Late kinds continue to grow until mid-November, whereas mid-maturing landraces typically mature from the last week of October to the first week of November. When the Ricebean reaches maturity, the vine dries out and the green pods turn brown. Because there is no coordination between the upper and bottom pods' maturation in indeterminate types, the maturing pods are picked over, requiring two or three more harvests. Although most farmers only harvest the entire vine when more than 60% of the pods are ready, this approach is also used with late-maturing landraces.

2.5.7.3 Post-harvest Operations

Following harvest, the vines and their pods are dried in the sun for two to three days before being beaten with sticks to remove the seeds. Since not all of the grains are entirely removed during the initial threshing, farmers typically thresh Ricebeans twice. The leftover is used as animal feed after all the grains have been taken from the vines. Farmers dry the Ricebean grains in the sun for at least two to three days following harvest. Grain that has been thoroughly dried is subsequently kept in wooden boxes, mud pots, or sacks. Farmers claim that properly dried Ricebean seeds are less prone to post-harvest pests. Common seed selection methods are rare. Farmers typically prefer to save seed from the initial threshing, especially from strong grains seen by eye. It's also unusual to grade Ricebean seeds according to their size or color. Farmers do, however, divide the seeds of early, mid, and late maturing landraces.

2.5.8 Farmers' Local Knowledge Associated with Cultivation Practices

The crop is only grown in the summer since Ricebeans require warm temperatures and enough sunlight for flowering and pod production. Continuous rain (often in September) during the flowering phase causes chaffy pods to develop, which significantly reduces yield (Pani Kosa). Avoid shaking the Ricebean vines in the morning or while it is raining because doing so could cause the nodes to bulge and break. Ricebean intercropping has little impact on maize production. The maize stems are kept standing after the harvest to serve as a stake for indeterminate vines. Without staking, indeterminate landraces may decay after coming into touch with the soil. Additionally, saprophytic fungi or rodent attacks are a possibility in this situation. Therefore, compared to solitary planting without staking, indeterminate Ricebean landraces yield more when they are intercropped with maize.

When Ricebean vines are severed at the peak of maize maturity, lateral branches are produced, increasing yield. The ideal time to plant Ricebeans is during the first week of Jestha, or the third week of May. If Ricebean is planted after that in an intercropping system, the maize canopy may shade it and slow its growth. Plants are trained to spread along rice bunds in semi-determinate types and for landraces grown there, such as Sano Seto and Pahenli Masyang. If not, the yield will be decreased. This should be done when the plant has reached its maximum vegetative development. Typically, Ricebeans are not treated with manures or fertilizers. Vegetative growth is lush when planted in fertile soil, but seed set and pod development are weak. In extremely fertile soil, chaffy pods (pani kosa) are a bigger issue.

2.5.8.1 Knowledge Associated with Chaffy Pods (pani kosa):

Chaffy pods (pani kosa), a situation in which a creamy white thick moist layer develops on the inner surface of the pods, resulting in the creation of fatty pods, are referred to as pods that do not develop seeds (bose kosa). Because south and east facing slopes are bright and dry, the problem with chaffy pods is less on north-facing aspects and more prevalent there. Chaffy pods are more of an issue for landraces grown at higher elevations (more than 1000m asl), such as Ghorle Masyang, than they are for plants grown at lower elevations.

2.5.8.2 Knowledge associated with Shattering

Semi-determinate types like Sano Seto have the lowest shattering loss. To reduce loss from breaking, harvesting is done in the morning.

2.5.9 Indigenous Technical Knowledge associated with Seed and Seed Management

The majority of farmers make an educated guess as to how much seed they will require for the following season, and they typically store Ricebeans for seed separately as soon as they are harvested and dried. Some farmers store the seeds in wooden crates, while others place them in sacks and pots made of dirt. Ricebean grains from vines grown on slopes with a northerly exposure are not suitable for seed. They frequently wrinkle when drying and are more likely to be attacked by pests when they are stored. The best grains for seed use come from the initial threshing.

Before being stored, Ricebean grains must be sun dried for at least 3 to 4 days. Drying seeds properly reduces insect and pest infestation. Ricebean seeds are less susceptible to insect pest assault during storage than other legumes including cowpea, chickpea, and common pea. Pest infestation is reduced when seeds are treated with timur (Sichuan pepper) - Xanthoxylum spp., titepati (Artemesia spp.), or neem (Azadirachta indica). Due to its resistance to air and moisture, seed stored in earthen pods is less likely to be attacked by pests. For use as seed, Ricebeans can be kept for up to a year, but longer storage results in lower germination rates.

2.5.9.1 Knowledge associated with Hard Seed coat/ Hard seeds

Some legume seeds, including Ricebean seeds, do not properly absorb water and do not soften when cooked or soaked. Locally, these seeds are known as daino seeds (hard seeds). Ricebean has a lower daino problem than common pea, cowpea, and Gahate simi. The issue of hard seededness gets worse as the seed ages. Between landraces, the quantity of daino seed is the same. Before soaking or cooking, the issue cannot be determined. Rainfall during harvest, according to some farmers, increases the likelihood that hard seed coats will form.

2.6 Theoretical Framework

The principle theory upon which the present study is constructed is the Cognitive social theory (Bandura 1977; Smith 1999; Miwa 2005). This theory wa used to guide the study as well as adequately explain the study variables.

2.6.1 Social Cognitive Theory / Social Learning Theory

Bandura (1977) developed the Social Learning Theory, which stressed involvement and emphasized learning as social participation. Bandura’s social learning theory was later renamed social cognitive theory to emphasize the origins and actions of human behavior, which are primarily social (Miwa 2005) and to capture the meaning of his theory, which extended beyond how it was initially described - social learning to include motivation and behavior, which was misleading because it was connected to other similar theories (Bandura 2007).

By emphasizing the importance of individual elements, the key components of the social cognitive theory include observational learning, reciprocal determination, self-efficacy and outcome expectations, thus focuses on ordinary human behavior such as information seeking (Munyua and Stilwell, 2013). People learn about new behavior through observation, which they then code, and this coded information ultimately dictates the course of action. From the study, during observational leaning (modeling), **f**armers learn and adopt Indigenous Technical Knowledge by observing and imitating the practices of other farmers within their community. This is crucial in understanding how ITK is transmitted and sustained within farming communities.

The principal of reciprocal determinism states that behavior, personal factors, and environmental influences interact with each other. According to the social cognitive theory, people's behavior is continuously influenced by interactions between environmental factors and individual traits including knowledge, expectations, and attitudes (Bandura 1977). Consequently, environmental, behavioral, and psychological factors all have an impact on how people behave and function (Mayer 2005). In this study, the adoption of ITK in ricebean production can be influenced by personal beliefs (efficacy beliefs), socio-economic factors (such as education and income), and environmental factors (such as access to resources and support from agricultural extension officers).

Wenger (1998) claims that the social cognitive theory is related to the social theory of learning and draws inspiration from theories of practice, social structure, identity, situated experience and self-efficacy. From this theory, Knowledge is a matter of competence and that humans are social beings. Bandura's (2007) thesis emphasized the importance of self-efficacy, or the belief in one's ability to succeed in specific situations. He studied significance of symbols like how people viewed their surroundings, what drove them to act, how they resolved issues, and how they learned new information. The knowledge gained as a result could build one's confidence to succeed at whatever the situations. Smallholder farmers' confidence in their ability to successfully apply ITK can significantly impact their willingness to adopt and integrate these practices with scientific knowledge.

Social Cognitive Theory enables individuals to build upon the outcomes of others' behavior of come up with their suited workable solutions (Smith 1999). The ability to pay attention to other people's models, the capacity to keep or recall the behavior being observed, the ability to recreate the model of the seen behavior, and the drive to exhibit the new behavior are all requirements for effectively modeling other people's behavior (Bandura 1977). Very importantly, farmers' expectations of the outcomes of using ITK (such as increased productivity, sustainability, and resilience) can influence their decision to adopt these practices.

2.6.2 Application of Social Cognitive Theory to Adoption of ITK

The Social Cognitive Theory was regarded as being crucial to comprehending Indigenous Technical Knowledge seeking behavior and the application of this information in the current study. The reasons behind which are discussed below;

Albert Bandura's Social Cognitive Theory (SCT) offers a valuable framework for examining the socio-economic analysis of Indigenous Technical Knowledge (ITK) use in ricebean production among smallholder farmers in the Nyanza region, Kenya. SCT's emphasises on the interaction between individual, behavioral, and environmental factors is particularly relevant to understanding how ITK is adopted, sustained, and integrated with scientific knowledge to enhance ricebean production. This application aligns with the study's dependent variable, which is ITK adoption in rircebean production, and the independent variables, which include, socio-economic factors, farmers' perceptions, and comparative utilization in different counties.

Observational learning is the first component of SCT, where individuals learn by observing the behavour of others. In the context of this study, smallholder farmers acquire ITK through observing and imitating the farming practices of other experienced farmers in their community. For example, a farmer in Migori County may observe a neighbor using specific seed selection techniques, natural pest management strategies, or organic soil fertility practices, and then adopt these methods. This process of modeling is crucial for the transmission and maintenance of ITK, as farmers witness the success and benefits of these practices first-hand, which in turn influences their own adoption behavior.

Bandura's concept of reciprocal determinism highlights the dynamic interaction between behavior, personal factors, and environmental influences. In this study, the adoption of ITK in ricebean production is influenced by a complex interplay of these factors. For instance, a farmer's decision to use ITK may be shaped by their educational background (social factor), the availability of production resources (economic factors), and the observed success of ITK practices in neighboring farms (behavior). A farmer in Siaya County with higher education may be more likely to integrate ITK with scientific innovations if they have access to extension services and credit facilities. This reciprocal relationship ensures that the behavior (adoption of ITK) is continuously influenced by and influences personal and environmental factors.

Self-efficacy, or the belief in one's capability to execute behaviors necessary to produce specific performance attainments, is a critical element of SCT. In this study, farmers' confidence in their ability to effectively utilize ITK significantly impacts their adoption of these practices. For example, a farmer in Kisii County who believes in their ability to manage pests using traditional knowledge (such as the use of natural pesticides) is more likely to adopt and persist with these methods. Enhancing farmers' self-efficacy through training programs and successful demonstration plots can therefore play a pivotal role in promoting the widespread adoption of ITK in ricebean production.

SCT also focuses on outcome expectations, which refer to the anticipated consequences of adopting certain behaviors. In this study, smallholder farmers' expectations regarding the benefits of ITK adoption such as increased ricebean yield per hectare, improved quality of produce, and higher economic returns are crucial determinants of their behavior. For instance, if farmers in Siaya County expect that integrating ITK with scientific practices will lead to better yields and market prices, they are more likely to adopt these practices. Conversely, if they perceive the benefits as negligible or uncertain, they may be less inclined to change their current farming methods.

The study's objective to compare the utilization of ITK in Siaya, Migori, and Kisii Counties underscores the importance of environmental influences in SCT. Different counties present unique environmental and socio-economic contexts that affect the adoption and effectiveness of ITK. For example, farmers in Siaya County might face different environmental challenges, such as soil types and climate conditions, compared to those in Kisii County. Additionally, local policies, support systems, and access to markets can vary significantly between counties, influencing how ITK is utilized. By examining these comparative elements, the study aims to identify specific environmental factors that facilitate or hinder ITK adoption and integration, thereby providing insights into how similar strategies can be adapted and applied in different contexts.

Bandura's Social Cognitive Theory provides a robust theoretical framework for understanding the complex interactions between individual beliefs, social influences, and environmental factors in the adoption of Indigenous Technical Knowledge for ricebean production. By applying SCT to this study, we gain deeper insights into the mechanisms that drive knowledge transmission, adoption, and integration, ultimately leading to more effective and sustainable agricultural practices among smallholder farmers in the Nyanza region. This comprehensive understanding can help in formulating strategies to enhance ricebean production, improve food security, and promote sustainable agricultural practices in Kenya.

2.7 Conceptual Framework

The independent variables in the study were the social-economic characteristics of Ricebean farmers (gender, age, education level, marital status, household size, occupation, annual income, income source, land tenure, access to production support services, farming experience, Source of rice bean information, source of planting materials and Group membership), Indigenous Technical Knowledge (traditional farming practices, pest &disease management, soil fertility management, harvesting & post harvesting practices, utilization) and comparative utilization of ITK (Prevalence of ITK use, Regional difference in application of ITK, environmental factors and socioeconomic factors specific to a region and Local policies & Support systems).

These variables form the extrinsic factors for adoption. The dependent variables in the study was the uptake of Indigenous Technical Knowledge in Ricebean farming among communities in Kenya.

Given that technology adoption is a complicated nonlinear process driven by a variety of factors, extrinsic factors alone may not provide a whole picture to analyze decision-making process. A complete framework that considers the integration of intrinsic elements (farmers' attitudes and perception) in decision-making is required. Therefore, framework that highlights these interactions of both extrinsic and intrinsic factors to technology uptake and decision-making is important. During decision making process, the information or knowledge a person has about a new technology serves as the foundation for the perceptions and attitudes he or she develops toward it. Farmers' perceptions then strongly correlate with their knowledge of it. Farmers' attitudes are then determined by their knowledge and perceptions of technology. These then inform the decision to adopt or not (Ajzen 1991). Other than extrinsic factors, knowledge attitudes and perceptions can also be influenced by external factors called intervening variables which include technology characteristics and government policies.

Figure 3 therefore shows the linkages and interrelationships between extrinsic, intrinsic, and the influence of the intervening variable in the decision-making process of adoption of agricultural technologies.

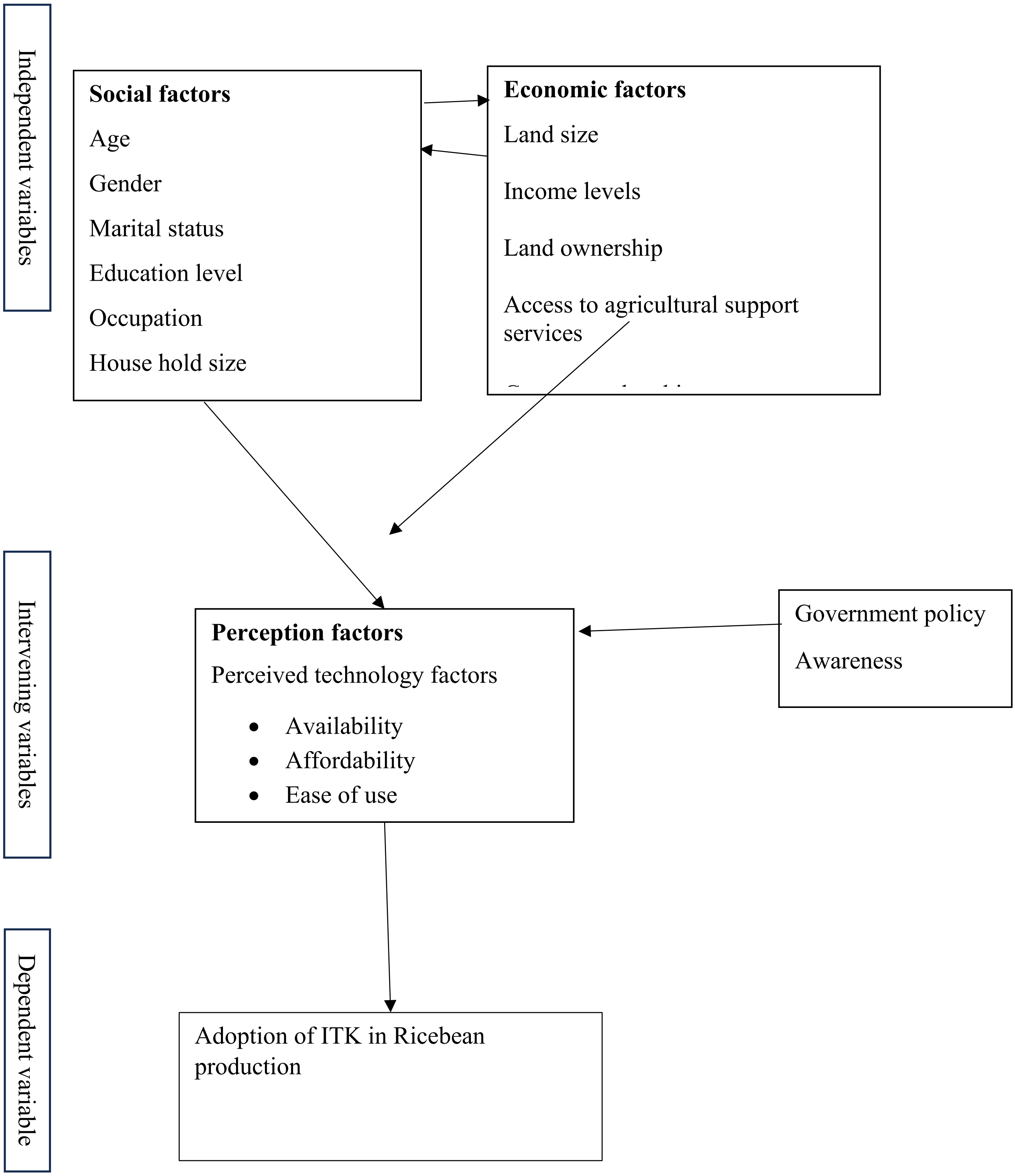


Figure 2. 3: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology used in carrying out the study. It details various processes that were carried out in the entire research period. It covers the research design, the study area, target population, sampling procedures and sample size, the data collection instruments, data collection procedures and data analysis process.

3.2 Research Design

The study was based on cross-sectional survey design. This research design is applicable where data is collected at one point in time and the researcher examines the study variables without influencing them (Thomas, 2023). Cross-section survey design was useful for the study because the information was obtained in a short period of time and captured data at a specific point, that provided an up-to-date view of a population's characteristics or opinions, which could be useful for decision-making or policy development (Sedgwick, 2015). The data was obtained from different group of respondents with recall period of up to twelve months.

3.3 Study Area

The study was done in Nyanza regions of Kenya; carried out in three selected counties; namely Migori and Siaya and Kisii Counties Fig. 4. These areas were selected because they are the most Ricebean growing regions in Kenya.

3.4 Description of the Study Area

3.4.1. Migori County

Migori County is located in Southwestern Kenya sitting at Longitude of 34°28'14.2"E and Latitude of 1°4'7.98"S. It borders Homa Bay County to the North, Kisii County to the North East, Narok County to the South East, Tanzania to the West and South and Lake Victoria to the West. The county also borders Uganda via Migingo Island in Lake Victoria. It covers an area of *2,586 sq.km.* The county's is headquarters is Migori town and has a population of 1,116,436 (The Kenya National Census of 2019).

Migori County is located in the sugar belt wetlands of Western Kenya and serves as in important link between Kenya and Tanzania. The county's water bodies include the Kuja, Migori rivers, and Lake Victoria. In addition, the county enjoys a pleasant climate because of high altitude which modifies the climate alongside the cool breeze from Lake Victoria. Migori county has two main rainy seasons; long rainy seasons starts in March and ends in May and short rainy season that starts in September and ends in November. The driest months are between December and February and June and September with an average temperature of 24 degrees Celsius. The main economic activities include agriculture, fishing, manufacturing and mining. Crops grown in the area include cassava, rice, sweet potato and maize and Nyota beans and livestock include fish, bee keeping and few dairy and beef farming.

The county has eight constituencies namely; Awendo, Kuria East, Kuria West, Nyatike, , Rongo, Suna East, Suna West and Uriri Constituencies.

3.4.2 Siaya County

Siaya County is one of the counties in the Nyanza region that lies between latitude 0° 26' to 0° 18' north and longitude 33° 58' east and 34° 33' west. It is bordered by Busia

County to the north, Kakamega and Vihiga Counties to the northeast and Kisumu County to the southeast. It shares a water border with Homa Bay County which is located south of Siaya County. The total area of the county is approximately 2,496.1 km^2 with population of 993,183 people (The Kenya National Census of 2019). The county experiences a tropical climate with Rainy Season Occurring between March and May, with moderate to heavy rainfall and dry Season takes place from June to October, characterized by sunny and warm weather. Additionally, Siaya County has an annual rainfall of approximately 2155 mm, and the mean temperature hovers around 21.4°C (70.6°F) . The soils range from moderate to low fertility. The socioeconomic activities include: subsistence farming of crops such as maize, millet, sorghum, beans, vegetables, and fruits rice Farming is another important activity in the County. Fishing is also done due to its proximity to Lake Victoria, it plays a significant role in the local economy . The county has six constituencies namely; Alego-Usonga, Bondo, Gem, Rarieda, Ugenya, and Ugunja**.**

3.4.3 Kisii County

Kisii County is situated in the southwestern part of Kenya with a Longitude of 34° 46' 37.4196" E and Latitude of 0° 40' 49.7352" S. It shares borders with Kisumu to the north, Homa Bay to the north west, Narok County to the south, Bomet County to the south east, Nyamira County to the east and Migori County to the west. The county covers an area of approximately 1,318 square kilometers and has a population of 1.267 million people (The Kenya National Census of 2019). The county experiences a highland equatorial climate with abundant rainfall throughout the year. It receives an averages annual rainfall of 1500 millimeters with long rains occurring between March and June, while the short rains fall from September to November. The maximum temperature experienced ranges from 21°C to 30°C, while the minimum temperatures range between 15°C and 20°C. The region is known for its fertile soils and terraced hillsides. Agriculture plays a central role, with small-scale farming of crops like bananas, maize, tea, and coffee being common and livestock include dairy, sheep, goats, poultry and pig rearing. Additionally, handcrafts such as soapstone carvings, woven baskets, and pottery contribute to the local economy.

The county has nine constituencies namely; Bobasi, south Mugirango, Nyaribari chache,Nyaribari masaba, Kitutu chache South, Bonchari, Bomachoge, Kitutu Chache North and Bomachoge Chache.

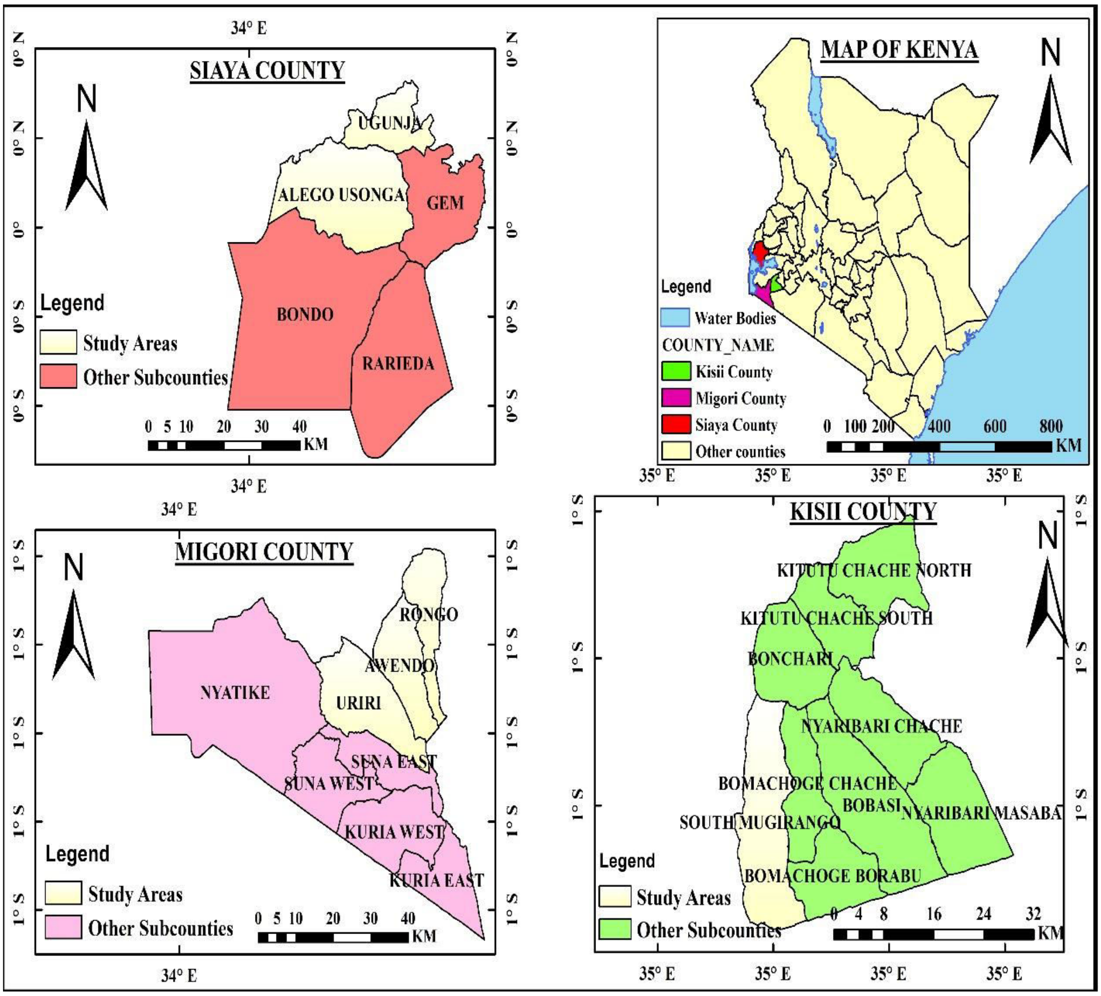


Figure 3. 1: The Maps of the study Regions

3.6 Target Population

The target population describe a group of individuals having desired attributes that the researcher can draw conclusions from. In this study the target population were all small holder farmers involved in ricebean production in the selected regions. These are farmers who typically own and farm small plots of land, usually less than two hectares, and rely primarily on family labor. They are a crucial demographic in agricultural studies, especially when focusing on traditional or indigenous farming practices. The target population specifically included those farmers who were engaged in the cultivation of ricebean. This focus ensured that the study gathered relevant data on the Indigenous Technical Knowledge related to this particular crop. The study geographically focused on the Nyanza region of Kenya, which included counties such as Siaya, Migori, and Kisii. The farmers in these areas were the primary subjects of the research, reflecting the region's cultural and environmental context that may influence the use of ITK. The number of smallholders ricebean farmers was obtained from the sampling frame from the Ministry of Agriculture in the selected counties.

3.7 Sampling Design and Sampling Procedure

Multistage sampling procedure was employed in the study. This is because the population under study is geographically dispersed, scarce and deals with a unique commodity which is less popular in a population (Bhandari 2023). Thus, this technique was appropriate in Ricebean research which is a less popular crop. First, Migori, Siaya and Kisii counties were purposely selected to represent the entire Nyanza region. These were the counties where Ricebean farming is mostly practiced in the regions thus would give appropriate information on Ricebean farming. Secondly, the sub-counties growing Ricebean in each of the counties were purposely selected basing on the information from the Ministry of Agriculture in these counties. Thirdly, proportionate sampling was used to get the number of respondents to study per sub-county. Lastly snow ball sampling procedure was adopted to get the required sample for the study in each county. Snowball sampling is a non-probability sampling method where new units are recruited by other units to form part of the sample. This technique is particularly useful when studying hard-to-reach or rare populations where the process begins with one or more initial study participants, and then continues based on referrals from those participants (Nikolopoulou, 2023). In this study ricebean farmers were very scarce and could not easily be identified, thus snowball sampling was appropriate.

The multistage sampling procedure is illustrated in Figure 3.2 below;

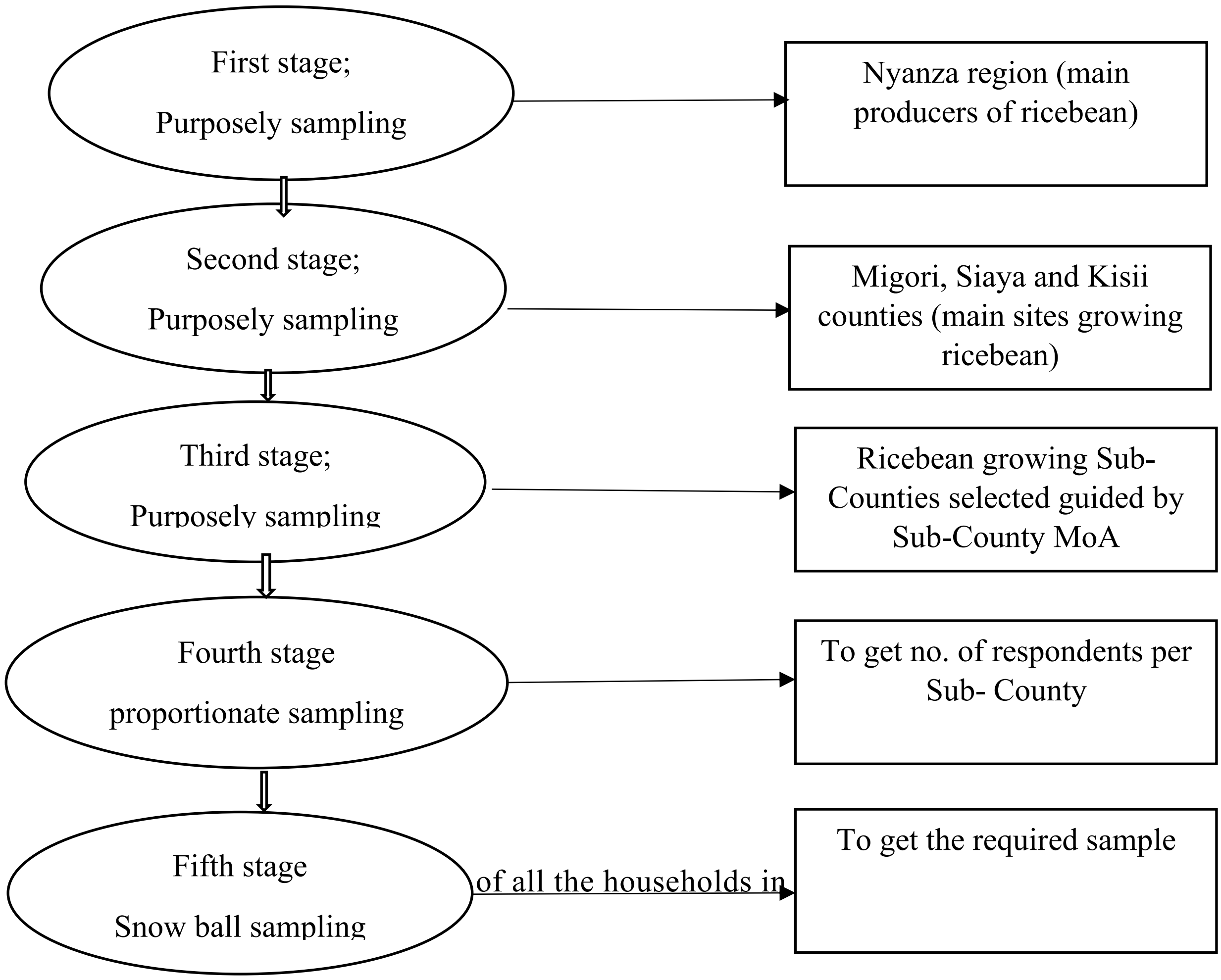


Figure 3. 2: Multistage Sampling Procedure

Ricebean farming in the study area. The sample size was determined by the number of identified households with the help of agricultural extension officers from the selected counties.

Cochran (1953) suggests that when the population size for the study area is not known, the following formula is appropriate in determining the sample size.

$$n = \frac{P(1-P)z^2}{d^2}$$

Where; n = Sample size

p= Estimated proportion of population which has the attribute in question; representing 50% (0.5)

z = The standard error (1.96)

d^2= Level of precision which is margin of error (0.05). This gave a sample size of 385 respondents.

Thereafter, 5% of the sample size was added to take care of any missing data. This gave additional of 20 respondents.

Therefore, a random sample of 405 households in the target population was used.

3.8 Sample Size Distribution

The study sample size was distributed to the three counties as follows;

Table 3. 1: Sample Size

County	Subcounty	Sample size	Total
Migori	Awendo	63	195
	Rongo	71	
	Uriri	61	
Siaya	Alego Usonga	73	135
	Ugunja	62	
Kisii	South Mugirango	67	67
Total			**397**

3.9 Data Collection Tools and Procedures

This section describes the tools and procedure of data collection that were used in the study.

3.9.1 Research Instruments

These are tools used by researcher to collect data relevant to the study.

3.9.1.1 Questionnaires

These are structured or semi structured sets of questions that participants answer. The participants provided information about themselves, their feelings, attitudes, or behaviors about the subject matter. Questionnaires are used by the researcher to collect large amount of data and allows participants to express their own experiences and opinions in their own words, which can provide richer insight into complex issues (Ponto, 2015). The questionnaires were administered to the farmers to capture their information on household socio-economics, ITK of ricebean farming and farmers' perceptions on ITK.

3.9.1.2 Observations and Photographs

Researchers observe ongoing behavior and record specific actions or events using observational checklist. Observational instruments capture real-world behavior without relying on self-reports. They are valuable for studying non-verbal cues and social dynamics (Angrosino, 2007). The checklist captured specific ITK practices in ricebean production, seed variety and climatic conditions of the study regions including soil type and terrain of the study area. The researcher also took photos of the observable practices in ricebean production. The photos captured visual evidence of experiments, equipment, and fieldwork. They serve as a record for future reference and validation.

3.9.1.3 Focus Group Discussions Guide

Focus Group Discussions (FGDs) are a qualitative research tool that involves guided group discussions with a small number of participants, typically facilitated by a researcher who follows a structured guide. This guide includes predetermined topics or questions aimed at generating dialogue and eliciting a range of perspectives on the subject being studied. FGDs are particularly valuable for exploring attitudes, opinions, and group dynamics, as they encourage participants to engage in conversation, often revealing insights that may not emerge through individual interviews (Krueger & Casey, 2015).

3.9.1.4 Interview Schedule

Interviews involve verbal interactions between an interviewer and key informants in the study area. Interviews provide in-depth insights, allow clarification, and build rapport. They are useful when exploring complex topics or understanding context. Kallio et al. (2016) highlight that interviews allow researchers to delve deeply into participants' thoughts, thus enriches the quality of data collected. The interview schedule captured issues pertaining ricebean production including level of awareness, production trends (ITK use, yield perception), government support, challenges and future plans for ricebean farming.

3.9.2 Type of Data

The study used both primary and secondary data. Primary data was obtained from the respondents while secondary data was obtained from the literature sources.

3.9.3 Piloting of Data Collection Tools

Piloting is the process of pretesting the quality of data collection tools. This plays a vital role in identifying errors that may interfere with the outcomes in research (Caspar et al., 2016). A pretest of 10 percent of the sample size was used to provide sufficient information about the quality of the research instruments in the study (Connelly, 2008). From these, 40 common beans farmers from Busia County were interviewed during the pretesting. The information of the pretest provided the basis for correction of errors in the data collection tools in terms of the challenges observed in filling the tools; including time required, difficulty in answering some of the questions and the resources required for the study.

3.10 Validity and Reliability

Validity and reliability are two important aspects of ensuring the quality and credibility of research instruments, such as surveys, questionnaires, tests, or observational checklists.

3.10.1 Validity

Validity is the ability of a method to accurately measure what is intended to measure in research (Middleton, 2022). This study tested both content and construct validity. The research tools were evaluated by checking whether they address the purpose of the study and whether all the variables under study were well covered. This was done in consultation with the supervisors.

3.10.2 Reliability

Reliability measures the extent to which results are consistent. According to (Middleton, 2022), If the same result could be obtained consistently using the same methods under the same circumstances, then the test is said to be reliable. In this study it measured the consistency of responses by different people across each item in the tool. If some consistency is achieved the tool would meet the reliability test. In this case, the reliability of the tools were tested using Cronbach Alpha coefficient α. The threshold of 0.7 set by Fraenkel and Wallen, (2000) to determine the reliability of a research tool as observed. This is the most appropriate measure of reliability in this study especially when likered scale questions are used. From the piloting, the Cronbach Alpha coefficient was 0.68, meaning the tool was reliable.

3.11 Ethical Considerations of the Research

This study was carried out with strict adherence to research ethics. First, an authorization permit was obtained from Masinde Muliro University of science and technology which was used to get permit from the National Commission of Science, Technology and Innovation (NACOSTI). The same information was communicated to the counties' Ministry of Agriculture before the research was conducted. Secondly, Voluntary participation by the respondents was embraced, that is the respondent were free to participate or to withdraw from the study. Thirdly, the respondents were also assured confidentiality of the information obtained and that it would only be used for the purpose of the research. Lastly, respect for respondents' culture and decisions was observed.

3.12. Data Collection Procedure

This is an important aspect of the research process that describes how the researcher collect data to answer research questions or test hypotheses. A well-structured procedure guarantees that data is collected systematically, consistently, and ethically.

3.12.1 Administration of Structured Questionnaire

During the collection of data, enumerators were sourced from the local villages, identified by the local leaders. This would ensure that farmers were comfortable to co-operate during the study. The enumerators were then trained by the researcher on how to translate the questions to vernacular languages especially to the respondents who could not understand English. The respondents were asked the questions captured in the questionnaire which were then translated and noted by the enumerator. The researcher used Kobo collect tool to collect the data since this assured high response rate, saved time and also took care of semi- illiterate respondents.

3.12.2 Focus Group Discussions

Data was also sourced through interactive focus group discussions (FGD). In each county, two FGD were used. Each focus group comprised of between 8 and 10 participants. The groups differed according the age. This would ensure group members were free to express their opinions. The first group comprised of youth between 18 and 35 years; and the other groups were individuals of 36 years and above. During discussions, information relating to ITK on ricebean farming and its perception toward use in ricebean farming was sought. Structured guidelines were used during the discussions; however, participants were not strictly limited to the guide. Field notes were taken during the discussion.

3.12.3 Interview schedule with Key informants

The researcher booked an interview schedule with the ministry of Agriculture officials in Migori, Siaya and Kisii Counties. Issues pertaining use of ITK by ricebean farmers were discussed. The researcher noted down each of the emerging issues.

3.13 Analytical Framework

Objective one: To identify and document the technical indigenous knowledge of Ricebean farming among small older farmers in Nyanza region, Kenya

Deductive and Inductive thematic analysis was used to identify and document the technical indigenous knowledge of Ricebean farming communities in Kenya. Researchers can systematically organize and analyze large, complicated data sets using the qualitative research method known as thematic analysis. Finding themes that can include the narratives present in the account of data sets is the goal. It entails the meticulous reading and rereading of the recorded material to identify themes (King, 2004; Rice & Ezzy, 1999). The results of a thorough thematic analysis technique can be enlightening and reliable (Nowell, Norris, White, & Moules, 2017).

Both deductive (top-down) and inductive (bottom-up) methods of thematic analysis are possible (Braun & Clarke, 2006). Without attempting to fit the themes into an already-existing coding frame or the researcher's beliefs about the research, the data is coded in an inductive manner (Brown & Clark, 2006). As a result, themes develop independently of those found in previous studies by looking at the data itself. Instead of the researcher's theoretical interest in the subject, themes are closely related to the data. The deductive approach, on the other hand, is clearly researcher-driven and enables the researchers to analyze the data in light of their theoretical interest in the problems under investigation (Braun & Clarke, 2006). When employing this method, the researcher usually starts the analysis with the themes they have found in the literature.

The themes that will be used in the thematic analysis are; ITK in planting timing, ITK in land preparation, ITK in sowing, ITK in weed control, ITK in pest control, ITK in plant nutrition management, ITK in harvesting timing, ITK in harvesting method, ITK in post-harvest processing, ITK in sorting and grading, ITK in storage, ITK in processing, ITK in nutrition benefits of rice bean, ITK in agroecological value of ricebean.

Both deductive and inductive methods is applied to increase the analysis's overall depths. As a starting point, a deductive approach was utilized to analyze data in respect to the themes that have arisen from the literature review conducted for the study or the research questions created for the study. Themes that emerge from the data that are intriguing or pertinent can also be taken into account. For a deeper understanding of the phenomenon under study, even the unexpected themes might be taken into account. As a result, when analyzing data, many inductive codes may be generated.

Objective two: To evaluate the socioeconomic factors affecting adoption of technical indigenous knowledge in Ricebean farming among small older farmers in Nyanza region, Kenya

In relation to this objective, the technical indigenous knowledge practices that were considered are: ITK in planting timing, ITK in land preparation, ITK in sowing, ITK in weed control, ITK in pest control, ITK in plant nutrition management, ITK in harvesting timing, ITK in harvesting method, ITK in post-harvest processing, ITK in sorting and grading, ITK in storage. The practices were used as the dependent variables and they were measured using Likert scale of three outcomes (0=not used, 1=used partially, 2=used entirely). Multiple linear regression analysis was used to estimate the factors that influence adoption of ITK practices.

The general equation of the model is expressed as follow:

$$yi=\beta 0+\beta 1xi1+\beta 2xi2+\ldots+\beta pxip+\epsilon$$

where,

i=n observations

yi=dependent variable

xi=explanatory variables

β0=y-intercept (constant term)

βp=slope coefficients for each explanatory variable ϵ=the model's error term (also known as the residuals)

The explanatory variables that will be used in the study were selected from previous (Hosseini and Zand, 2011; Getyengana et al., 2023), and they include: Age, Gender, household size, Occupation, annual income, land tenure, farming experience in years, Frequency of access to production support services, Source of rice bean information, source of planting materials and Group membership.

Table 3. 2: Description of variables to be used in ordered probit analysis

Variable	Variable Description	Hypothesized sign
Independent variables		
Social economic characteristics	Age	+
	Gender Dummy=1 if farmer is male and 0 if female	+/-
	education level 1=no education, 2=primary education, 3=secondary education, 4=higher education	+
	household size	+
	Occupation Dummy=1 if farmer is employed and 0 if unemployed	+/-
	annual income	+

	land tenure 1=leased, 2=own land, 3=both own and lease	
	farming experience in years	+
	Frequency of access to production support services	+
	Source of rice bean information	+
	source of planting materials	+
	Group membership Dummy=1 if farmer belongs to farmer group and 0 if not a member	+/-
Dependent variables		
Adoption of ITK in ricebean farming	Using ITK in planting timing 0=not used, 1=used partially, 2=used entirely	+
	Using ITK in land preparation 0=not used, 1=used partially, 2=used entirely	+
	Using ITK in sowing 0=not used, 1=used partially, 2=used entirely	+
	Using ITK in weed control 0=not used, 1=used partially, 2=used entirely	+
	Using ITK in pest control	+

	0=not used, 1=used partially, 2=used entirely	
	Using ITK in plant nutrition management	+
	0=not used, 1=used partially, 2=used entirely	
	Using ITK in harvesting timing	+
	0=not used, 1=used partially, 2=used entirely	
	Using ITK in harvesting method	+
	0=not used, 1=used partially, 2=used entirely	
	Using ITK in post-harvest processing	+
	0=not used, 1=used partially, 2=used entirely	
	Using ITK in sorting and grading	+
	0=not used, 1=used partially, 2=used entirely	
	Using ITK in storage	+
	0=not used, 1=used partially, 2=used entirely	

Objective three: To assess and analyze smallholder farmers' perception on the integration of Indigenous Technical Knowledge in ricebean production in Nyanza region, Kenya.

In this objective, farmers ranked the reasons for using ITK on a 5-point likert scale with 1 being strongly disagree and 5 being strongly agree. The reasons for using ITK were ranked based on; Effectiveness, Availability, Affordability, efficiency, cultural acceptability, Human safety, environmentally friendly and similarity with conventional knowledge. This objective was analyzed using descriptive statistics. The descriptive statistics used included means, frequencies, and percentages using multi response analysis and cross tabulations. Multivariate regression analysis was also used to determine the socioeconomic factors affecting farmers' perception on ITK in ricebean farming.

Objective four: To compare the utilization of Indigenous Technical Knowledge in ricebean production among smallholder farmers in Siaya, Migori, and Kisii Counties in the Nyanza region, Kenya.

The comparison of ITK usage across Siaya, Migori, and Kisii counties employed Pearson Chi-square tests and cross-tabulation. These methods determine whether there are significant regional differences in ITK practices, accounting for environmental and socioeconomic variables. Descriptive statistics are useful here for illustrating the prevalence of ITK and comparing regional practices systematically. The Chi-square test further establishes whether these differences are statistically significant.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents results and discussions of the study. It encompasses both descriptive and inferential statistics. Data was collected at the household level using kobo collect tool and complimented by focus group discussions and key informant interviews with the Sub-County agriculture officers and ward administrators.

4.2 Response Rate

A total of 405 questionnaires were distributed for the research, with 397 responses successfully obtained. The remaining questionnaires were not completed due to some respondents being unavailable or unwilling to participate. This resulted in a response rate of 98.02%, indicating a strong participation level.

4.3 Demographic and Farming Characteristics of Ricebean Farmers in Nyanza Region

4.3.1 Demographic Characteristics of Ricebean Farmers

This included characteristics such as gender, age, education level, marital status, household size, annual income and occupation of the respondents. The aim was to understand the demographics of the sample and determine how these features influence ricebean production and Indigenous Technical Knowledge use by the farmers. Descriptive analysis was used to characterize and summarize the data.

Figure 4.1 revealed that males made up 29.7% and females made up 70.3% of the 397 study participants. This suggests that a greater number of women are involved in the ricebean farming.

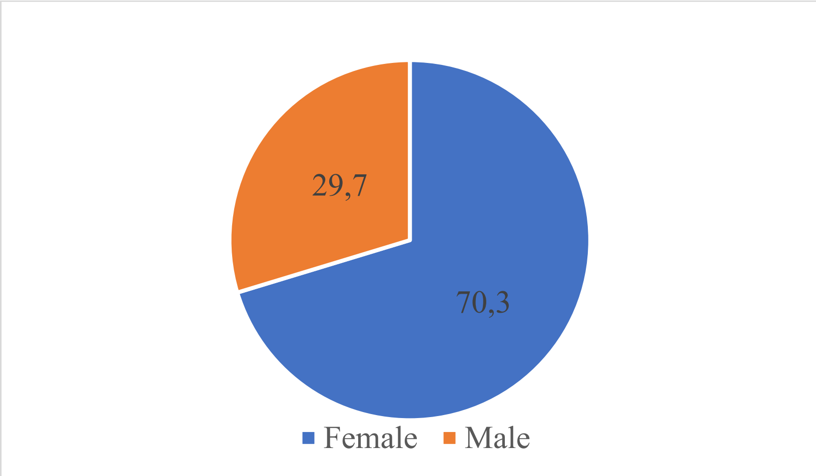


Figure 4. 1: Gender of the Farmers

These findings are in line with those of Finid *et al*., (2022) who reported a variance in gender participation in ricebean cultivation, with women being more involved than males. This is consistent with research by Adebayo *et al*. (2009), which found that women were more likely to cultivate crops thought to increase food security for individual households. This could perhaps be the cause of the dominance of women in ricebean farming. Similarly, research by Milicent (2014) found out that female farmers were more likely to produce bambara, a crop that is orphaned (neglected) yet contributes to household food security. Consequently, given that males were typically linked with cash crops, which are focused on generating income, suggests that women were more active in the development of crops that directly contribute to household food security.

In Table 4.1 the minimum, maximum, mean and standard deviation statistics results of the listed dependent variables are reported. The average age of the respondents was 44 years.

Table 4. 1: Age of the Farmers

	Minimum	Maximum	Mean	Std. D
Age (in years)	20.00	90.00	44.2141	14.47837

This finding indicates that the average ricebean farmer is of middle aged which is by far the most productive age group in the human growth and development cycle. The middle age class, which typically spans 35 to 50 years of age is important to Sub-Saharan Africa's small-scale agricultural productivity (Babangida, 2016). The desire to maintain their family's food security and the experience they have gained from ricebean cultivation have led to their involvement.

The farmers were also asked to indicate their demographic characteristics and the results are presented as shown in Table 4. The findings indicated that the majority of the farmers had primary education (57.2%) followed by secondary (27.2%), ones with completely no formal education (10.1%), middle college (4.8%), and undergraduate (0.8%). This indicates that ricebean farming is dominated by people with low education level thus predominantly relied on their own experience and knowledge as the majority lacked advanced formal education.

The results further indicated that majority of the farmers were married (80.1%). Marriage remains the predominant marital status in many societies, reflecting cultural and social norms that still place significant value on the family. Majority of the households had less than 5 household members (51.9%). This implies that ricebean is cultivated by smaller sized rural households.

Table 4. 2: Demographic Characteristics of Ricebean Farmers

Characteristisc	Frequency	Percent
Education Level		
No Formal Education	40	10.1
Primary	227	57.2
Secondary	108	27.2
Middle College	19	4.8
Undergraduate	3	.8
Total	**397**	**100**
Marital status		
Divorced	1	.3
Married	318	80.1
Single	19	4.8
Widow/Widower	59	14.9
Total	**397**	**100**
Household size		
Between 11-15	3	.8
Between 5-10	187	47.1
Less than 5	206	51.9
More than 15	1	.3
Total	**397**	**100**
Occupation		
Both employed and Farmer	5	1.3
Employed/ Salaried	3	.8
Full time farmer	350	88.2
Part time farmer	39	9.9
Total	**397**	**100**
Income (Ksh)		
Below 35000	220	55.4
36000-45000	72	18.1
46000-55000	60	15.1
56000- 65000	26	6.5
Above 65000	19	4.8
Total	**397**	**100**
Main Income source		
Casual Work	9	2.3
Crop Farming	347	87.4
Employment/salary	8	2.1
Livestock Farming	33	8.2
Total	**397**	**100**

This is due to the fact that underutilized crops with lower yield per unit area, like ricebean, have been shown to be crucial in maintaining food and nutrition security for households and communities by offering nutritious substitutes in the event that the primary crop fails or in the interim between harvests (Mabhaudhi *et al.,* 2011).

The results further shows that majority of the farmers (88.2%) were full time farmers. Similarly, majority (87.4%) of the farmers' main livelihood source was crop farming. This is attributed to most of the farmers lacking advanced formal education which is required for entry to formal employment. Anang & Yeboah (2019) found that a farmers' participation in off-farm labor is influenced by their years of education. The findings of this study are also consistent with those of Babatunde & Qaim (2010), who discovered that households with lower levels of education had fewer opportunities to participate in more profitable off-farm labor activities.

Education increases human capital capacity which increases likelihood of entry and successful participation in off-farm activities. The results also indicated that most of the farmers (55.4%) earned less than KES 35000 annually. This is in agreement with Kenya National Bureau of Statistics 2023 who reported the monthly average wage earnings in the private Agricultural sector to be KES 33231.40.

4.3.2 Farming Characteristics of Ricebean Farmers

The farming characreristics of the farmers as indicated in Table 4.3 shows that majority (50.99%) of the ricebean farmers were found to cultivate on community owned land. This finding explains the choice of growing ricebean among the farmers. This is because farmers tend to grow food crops and undervalued crops such as ricebean on community and family-owned land with preference of commercial high value crops being reserved for rented or individually owned land.

Table 4. 3: Farming Characteristics of Ricebean Farmers

Farming characteristics	Frequency	Percent
Land ownership		
Community Land	202	50.9
Individual Ownership	182	45.8
Rented	13	3.3
Total	**397**	**100.0**
Land size (Acres)		
Below 2.5	321	80.9
2.5-5	75	18.9
Above 10	1	.3
Total	**397**	**100.0**
Land size under Ricebean		
Below 2.5	385	97.0
2.5-5	12	3.0
Total	**397**	**100.0**
Group membership		
No	298	75.1
Yes	99	24.9
Total	**397**	**100.0**
Distance to market		
Less than 30 min	106	26.7
30-60 min	231	58.2
60-90 min	44	11.1
90-120 min	11	2.8
More than 120 min	5	1.3
Total	**397**	**100.0**
Farming experience		
Less than 1year	119	30.0
1-5 years	236	59.4
6-10 years	24	6.0
More than 10 years	18	4.5
Total	**397**	**100.0**

According to Mdoda & Gidi (2023), since land is the primary and critical component of agricultural production, having secure access to and ownership of land is essential to enhanced productivity and output across the board in agricultural production.

The results further illustrated that majority of the farmers (80.9%) had less than 2.5 acres of land. Correspondingly, most of the farmers (97.0%) cultivated ricebean on less than 2.5 acres of land. This indicates that ricebean is predominantly cultivated in small land holding. Because of the introduction of high-yielding crops like maize, the areas under rice-bean cultivation have been gradually diminishing despite the crop's nutritional benefits. Small and fragmented land holdings have also contributed to the decline in the crop's acreage (Acharya, 2008). The results further showed that 75.1% of ricebean farmers did not belong to any farmer groups. This shows there is limited institutionalized collaboration among ricebean farmers. Farmers have been found to create and join farmer groups to alleviate capital, production and marketing challenges in order to boost profitability. Thus, the limited subscription to farmer groups stands to allude that ricebean production is predominantly subsistence. The results also showed that most ricebean farms (58.2%) are located 30-60 minutes from output market. The relatively short time to market indicates that if value chain development of rice bean is conducted, the farmers are strategically placed to transition to production for market. With regards to farming experience, the largest proportion of the farmers (89.4%) have been cultivating ricebean for less than 5 years. This result stands to show an upsurge in ricebean cultivation which is classified as a neglected crop.

4.3.3 Access to Agricultural Support Services by Ricebean Farmers

Farmers' response on the availability of government support services in ricebean farming is indicated in Table 6. From the results, most of the ricebean farmers (77.6%) have difficulty in accessing extension services. This indicates that rice bean farmers find it difficult to access government support that could facilitate the improvement and commercialization of ricebean farming. Limited access to extension services is synonymous to all agricultural value chains. Nkurumwa *et al.,* (2023) reports that insufficient funding for public extension services and a growing disparity between the number of extension employees and farmers have hindered the provision of extension services.

Table 4. 4: Access to Agricultural Support Services by Ricebean Farmers

	Not easy		Easy		Very easy	
Support Services	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Extension services	308	77.6	46	11.6	43	10.8
Farm inputs	303	76.3	62	15.6	32	8.1
Marketing services	311	78.3	47	11.8	39	9.8
Agricultural credit	328	82.6	39	9.8	30	7.6

Furthermore, most of ricebean farmers (76.3%) reported not finding it easy to access farm inputs. By not easily accessing farm inputs such as planting seeds, the rice bean farmers are impeded from intensifying their ricebean production. This is in agreement with Gichangi *et al.,* (2019) who stated that utilizing of inputs that increase productivity is still a significant obstacle for smallholder farmers in Kenya. With regards to access to marketing services, majority of ricebean farmers (78.3%) find it difficult to access marketing services. The implication of this limitation is that ricebean farmers are constrained from meaningfully participate and gain from the ricebean value chain. According to Birch (2018), institutional marketing barriers and transaction costs associated with market knowledge and marketing procedures limit farmers' output in marketplaces. Similarly, most of the farmers (82.6%) did not have access to agricultural credit. Limited access to credit constraints farmers from procuring farm inputs required to increase and intensify their ricebean production. To a large extent, it is believed that credit constraints are the cause of smallholder farmers' low productivity (Assouto & Houngbeme, 2023).

4.3.4 Ricebean Production Trends

Ricebean production produced by the farmers annually is illustrated in Figure 4.2. The results indicate that majority of the ricebean farmers (75%) produced less than one bag of ricebean.

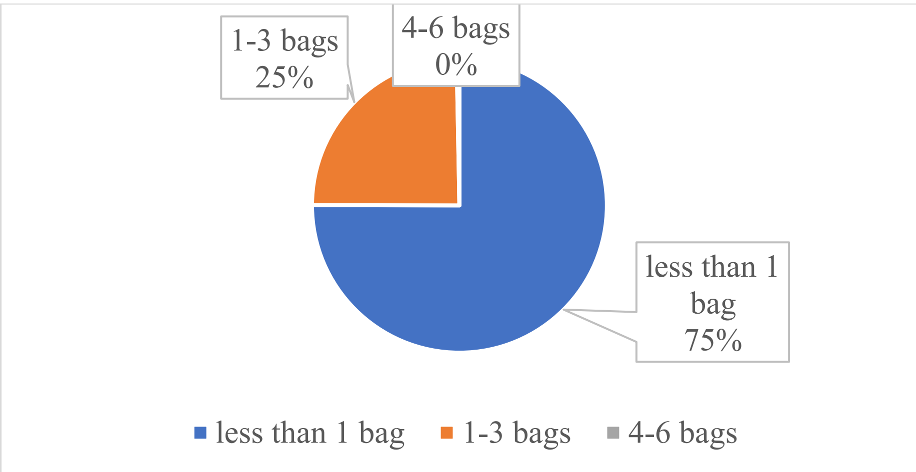


Figure 4. 2: Ricebean Production trends

This indicates that ricebean production has not been commercialized and is to a large extent just subsistent and characterized by low productivity. This concur with Finid *et al.,* (2022) who reported that the productivity of ricebeans in Kenya has decreased, relegating farming to a small number of farmers and even confined to tiny areas of land where they are grown as intercrops.

4.3.5 Cross Tabulations of Socioeconomic Characteristics and Ricebean Production

Cross tabulations were done to determine how the socioeconomic factors such as gender, age, education level, marital status, household size, annual income, occupation, land ownership, land size, market access, group membership, and farming experience of the respondents influence ricebean production among the small holder farmers in Nyanza region. The significant factors were discussed below.

4.3.5.1 Farming Method used and Ricebean Production

As shown in Table 4.5, most (0.4%) and (28.7%) of the highest producing ricebean farmers (4-6bags and 1-3 bags respectively) used both Indigenous Technical Knowledge (ITK) and conventional knowledge (CK).

Table 4. 5: Cross Tabulation of Farming Method used and Ricebean Production per acre (50kg bag)

Farming method	1-3 bags	4-6 bags	less than 1 bag	df	Pearson Chi-Square
Both ITK and CK	28.7%	0.4%	70.9%	2	6.518 (P=0.038)
ITK	18.0%	0.0%	82.0%		

Contrarywise, more (82.0%) of the lowest producing farmers (less than 1 bag), only used ITK. The association between farming method and yield was significant at a 5% significance level. This implies that those farmers who supplemented their ITK with CK achieved more yield. Increasing smallholder farmers' productivity in agriculture requires using blended innovations and technology (Habtewold & Heshmati, 2023).

4.3.5.2 Gender and Ricebean Production

Gender and production relationship is depicted in Table 4.6 From the result, female ricebean farmers constituted a larger proportion (0.8%) of the high producing farmers (4-6 bags). On the other hand, male ricebean farmers constituted the larger proportion (77.8%) of lower ricebean producers (less than 1 bag).

Table 4. 6: Cross tabulation of Gender and Ricebean Production per acre (50kg Bag)

Gender	1-3 bags	4-6 bags	less than 1 bag	df	Pearson Chi-Square
Male	22.2%	0.0%	77.8%	2	5.5938 (P=0.061)
Female	30.5%	0.8%	68.6%		
Total	24.7%	0.3%	75.0%		

The association between gender and production was significant at a 10% significance level. This implies that female farmers are more likely to produce more in ricebean farming. Given that men are usually associated with cash crops, which are primarily grown for financial gain, it is possible that women are more actively involved in the production of crops that directly improve the food security of households such as ricebeans.

4.3.5.2 Farming Experience and Ricebean Production

According to the results in Table 4.7, more (5.56%) of the high producing farmers (4-6 bags) had the most years of experience. Inversely, more (92.5%) of the least performing farmers (less than 1 bag) had the least years of experience.

Table 4. 7: Cross tabulation of Farming Experience and Ricebean production per acre (50kg bag)

Farming Experience	1-3 bags	4-6 bags	less than 1 bag	df	Pearson Chi-Square
Less than 1 year	7.50%	0.00%	92.50%	6	58.156 (P=0.000)
1-5	30.21%	0.00%	69.79%		
6-10	29.17%	0.00%	70.83%		
More than 10 years	61.11%	5.56%	33.33%		
Total	**24.68%**	**0.25%**	**75.07%**		

The association between farming experience and yield was statistically significant at 1% significance level. This implies that the more years a farmer practices ricebean farming the more yield they produce. Older farmers' expertise results in more effective input combinations, increasing the effectiveness of a unit of work (Guo *et al.,* 2015).

4.3.5.3 Market access and Ricebean Production

Results as shown in Table 4.8 shows the relationship between market access and production. The results depict that more (0.94%) of the highest producing farmers (4-6 bags) took less than 30 minutes to get to market. The association between production and time to market was significant at a 10% significance level.

Table 4. 8: Cross tabulation of Market access and Ricebean Production per acre in 50kg bag

Market access	**1-3 bags**	**4-6 bags**	**less than 1 bag**	**df**	**Pearson Chi-Square**
30-60 min	29.48%	0.00%	70.52%	8	14.489 (P=0.070)
60-90 min	13.64%	0.00%	86.36%		
90-120 min	18.18%	0.00%	81.82%		
Less than 30 min	17.92%	0.94%	81.13%		
More than 120 min	60.00%	0.00%	40.00%		
Total	**24.68%**	**0.25%**	**75.07%**		

This implies that the closer a farmer lived to a market the more likely they are to produce more. This is because easy access to market incentivizes increased production due to increased likelihood of sale of produce. Ndegwa *et al.,* (2016) alluded that distance to market is negatively related to marketed quantities for most agricultural commodities due to the transaction costs involved.

4.3.5.4 Land size and Ricebean Production

As shown in Table 4.9 more (100%) of the highest producing farmers (4-6 bags) have a lager land size of more than 10 acres. In contrary, more (77.3%) of the least performing farmers (less than 1 bag) had land size below 2.5 acres. The association between yield and land size was significant at a 10% significance level. This implies that the more the land size a farmer has the more likely they are to produce more.

Table 4. 9: Cross tabulation of Land size and Ricebean Production per acre in 50kg bag

Land Size	1-3 bags	4-6 bags	less than 1 bag	df	Pearson Chi-Square
2.5-5	33.33%	1.33%	65.33%	4	8.539 (P=0.074)
Above 10	0.00%	100.00%	0.00%		
Below 2.5	22.74%	0.00%	77.26%		
Total	**24.68%**	**0.25%**	**75.07%**		

This is because more land encourages the farmer to practice new technologies thus increased production. Consistently, Langat *et al.,* (2024) found out that farmers who own large tracks of land will allocate more land for legume production and participate more in the commercialization of the product.

4.4 Indigenous Technical Knowledge of Ricebean Farmers in Nyanza Region

The first objective of this study was designed to explore the Indigenous Technical Knowledge that assist ricebean farmers in the region of study. It encompassed all activities along the value chain of ricebean which include and not limited to land preparation, agronomic practices, harvesting, processing, marketing and utilization. The study aimed to understand the indigenous technical aspects of small holder ricebean farmers. Thematic analysis was used to analysze this objective.

4.4.1 Awareness of ITK by Ricebean Farmers

The respondents were asked if they were aware of any ITK in ricebean farming. Table 4.10 shows that all the respondents were aware of ITK of ricebean farming. As stated by Naharki & Jaisi (2020), ITK is sporadically distributed throughout communities, and there are numerous hidden sources of ITK in our societies.

Table 4. 10: Awareness of ITK by Ricebean Farmers

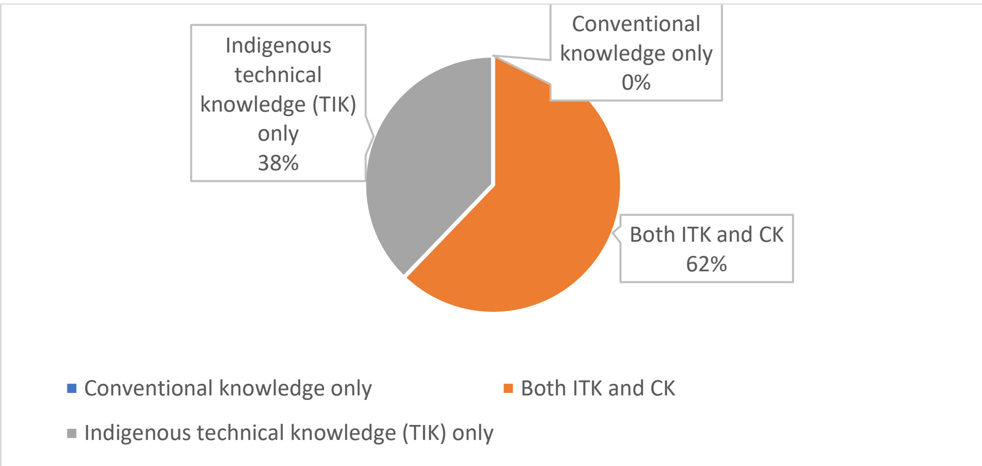
	Frequency	Percent
No	0	0
Yes	397	100.0

It is therefore quite likely that members of the community are aware of ITK's use in the production of local crops. This form of agricultural knowledge need to be tapped, documented and upgraded to adapt the climate change effects.

4.4.2 Adoption of ITK in Ricebean Farming

The results in Figure 4.3 indicate that all ricebean farmers utilized ITK in ricebean production. The ITK was either used entirely (38%) or combined with conventional knowledge (62%).

Figure 4. 3: ITK Adoption in Ricebean Farming



These results are consistent with those of Cheplogoi *et al.,* (2021) that households relied on blending both indigenous and modern knowledge systems with the hope to reap the benefits associated with both with regard to technologies and innovations. Similarly, most farming communities use ITK extensively in order to increase productivity (Melash *et al.,* 2023). This is due to the fact that ITK is seen as a crucial component of the communities' human capital for boosting sustainable agricultural development and increasing crop performance.

4.4.3 Local Names of Ricebean

In every part of the world, plants are referred to by their local names. The nomenclature of useful plants is an ancient and fundamental human urge. Names of plants or animals are useful in reducing the need for descriptive phrases to refer to objects, making communication easier. These names are often accurate and aid in the deduction of certain details related to the characters (Singh, 2008). Similarly in the context of ricebean, the crop was found to have localized names in the different study areas as shown in Table 4.12. The predominant local name in study areas in Luo regions was Leso riadore (64%). Riadore is a Luo word referring to a shattering effect. Thus, ricebean is named riadore because of how its pods shatter when dry. The predominant local name for ricebean in Kisii regions was Etengu (17%). According to the respondents, it is plausible that ricebean was intentionally named Etengu to differentiate it from a similar legume, green grams, which are referred to as Edengu.

Table 4. 12: Local Names of Ricebean

	Frequency	**Percent**
Etengu (Kisii)	66	16.6
Leso barore (Luo)	65	16.4
Leso riadore (Luo)	254	64.0
Mmbochi (Kisii)	8	2.0
Not known	1	0.3
Olayo (Luhya)	3	0.8
Total	397	100.0

Reliable crop variety identification is essential to optimal evaluation of expected production results (Kosmowski *et al.,* 2019). Fruits, grains, flowers, and many other agricultural and horticultural products have long been recognized by humans based on their size, shape, color, and patterns (Patil *et al.,* 2011). Similar to this, ricebean varietal identification is determined by seed color as shown in Table 4.13. The predominant (30%) ricebean variety in Alego Usonga subcounty was red/green in colour. The most common (41%) variety in Awendo subcounty was brown in color. The most common (34%) ricebean variety cultivated in Nyamarambe subcounty was yellow/brown in colour. In Rongo subcounty, the predominant (21%) ricebean variety was brown in colour. In Ugunja, the most common (26%) ricebean variety was red/green in colour. The most common (31%) ricebean variety in Uriri subcounty was brown in colour.

Overall, brown ricebean was the most common (19%) cultivated variety as shown in Figure 4.4.

Figure 4. 4: Ricebean Varieties

Table 4. 13:Identification of Local Varieties of Ricebean by Color

	Alego Usonga	Awendo	Nyamarambe	Rongo	Ugunja	Uriri	Total
Black	1.40%	1.60%	1.50%	0.00%	0.00%	13.10%	2.80%
Black/white	0.00%	0.00%	0.00%	1.40%	0.00%	0.00%	0.30%
Brown	1.40%	**41.30%**	16.40%	**21.10%**	3.20%	**31.10%**	**18.60%**
Brown/black	2.70%	7.90%	0.00%	1.40%	4.80%	3.30%	3.30%
Green	0.00%	1.60%	0.00%	0.00%	1.60%	0.00%	0.50%
Green/black	0.00%	0.00%	0.00%	0.00%	3.20%	1.60%	0.80%
Green/black/ white	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.30%
green /brown	4.10%	7.90%	3.00%	8.50%	11.30%	4.90%	6.50%
Green/brown/ black	1.40%	0.00%	0.00%	0.00%	6.50%	0.00%	1.30%
Green/brown/ white	1.40%	0.00%	0.00%	0.00%	1.60%	0.00%	0.50%
Green/yellow	9.60%	1.60%	3.00%	14.10%	6.50%	3.30%	6.50%
Green/yellow/brown	8.20%	0.00%	1.50%	2.80%	0.00%	0.00%	2.30%
Red	0.00%	0.00%	0.00%	8.50%	1.60%	0.00%	1.80%
Red/black	0.00%	1.60%	0.00%	0.00%	3.20%	0.00%	0.80%
Red/black/ white	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.30%
Red/brown	2.70%	7.90%	1.50%	16.90%	1.60%	6.60%	6.30%
Red/brown/black	0.00%	0.00%	0.00%	1.40%	0.00%	0.00%	0.30%
Red/brown/ black/white	1.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%
Red/green	**30.10%**	1.60%	4.50%	1.40%	**25.80%**	0.00%	10.80%
Red/green/ black	0.00%	0.00%	0.00%	1.40%	0.00%	0.00%	0.30%
Red/green/ brown	5.50%	0.00%	0.00%	0.00%	6.50%	0.00%	2.00%
Red/green/ white	1.40%	0.00%	0.00%	0.00%	1.60%	0.00%	0.50%
Red/green/ yellow	6.80%	0.00%	0.00%	1.40%	3.20%	1.60%	2.30%
Red/green/ yellow/brown	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.30%
Red/white	4.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%
Red/yellow	5.50%	7.90%	3.00%	2.80%	6.50%	8.20%	5.50%
Red/yellow/ black	1.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%
Red/yellow/ black/white	1.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%

Red/yellow/ brown	0.00%	1.60%	0.00%	0.00%	1.60%	1.60%	0.80%
Red/yellow/ brown/black	1.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%
Red/yellow /white	0.00%	0.00%	0.00%	0.00%	1.60%	0.00%	0.30%
Yellow	2.70%	4.80%	31.30%	12.70%	0.00%	3.30%	9.30%
Yellow/ brown	5.50%	12.70%	**34.30%**	4.20%	3.20%	21.30%	13.40%

4.4.4 Planting Conditions for Ricebean

The appropriate planting time for ricebean as prescribed by ITK is shown in Table 4.14.

Table 4. 14: Appropriate Planting Conditions for Ricebean

Planting conditions	Frequency	Percent
Planting time		
During long rains	113	28.8
During short rains	284	71.5
Total	**397**	**100.0**
Preferred soil type		
Clay soil	32	8.1
Loam soil	304	76.6
Sandy soil	61	15.4
Total	**397**	**100**
Planting sites		
Disused land	22	5.5
Fallow land	2	0.5
Fertile land	271	68.3
Flat land	95	23.9
Rocky land	4	1
Sloppy land	3	0.8
Total	**397**	**100**

The farmers further explained that trailing ricebean types are mostly planted on disused soils because of their coiling effects on main crops whereas the erect types are planted as an intercrop in the fertile soils because they have no effect on the main crop. Scientific research and farmers' experiences recommend fertile loam soils for ricebean cultivation (HDRA, 2002).

4.4.5 Planting Procedures for Ricebean

The results in Table 4.15 indicates the planting procedures for ricebean as recommended by ITK. The planting procedure adopted by most farmers (58%), was land clearing followed by ploughing, harrowing and then planting.

Table 4. 15: Planting Procedures for Ricebean

	Frequency	Percent
Land preparation		
Land clearing and planting	0	0
Land clearing, ploughing and planting	167	42.1
Land clearing, ploughing, harrowing and planting	230	57.9
Total	**397**	**100**
Planting method		
Broadcasting	72	18.1
Dibbling	12	3
Row planting	313	78.8
Total	**397**	**100**
Seeding rate		
1	6	1.5
2	148	37.3
3	146	36.3
4-5	48	12.1
Broadcasted randomly	49	12.3
Total	**397**	**100**
Cropping pattern		
Intercropped	305	76.8
Sole crop	92	23.2
Total	**397**	**100**

According to the respondents, the land is ploughed during dry season to give time for the weeds to decompose well thus improve the soil fertility. Before planting, harrowing is done to minimize soil disturbance. ITK prescribes harrowing for soil and water conservation (Verma *et al.,* 2016). Because ricebean is predominantly planted during short rains, farmers harrow land during land preparation to enhance soil and water conservation. Majority of ricebean farmers (79%) use row planting with most (37%) of them adopting a seeding rate of 2 seeds per planting hole. Row planting is preferred over broadcasting for water conservation since planting of ricebean is mainly done in short rains. This is in coherence with Khadka & Khanal (2013) who reported that during dry conditions, sowing of ricebean is conducted by dibbling two or three seeds per hill.

To further reduce chances of pest attack, the seeds are sometimes dusted with wood ash. Intercropping is the most common (77%) cropping pattern followed by ricebean farmers.

4.4.6 Suitable Crops for Intercropping with Ricebean

As shown in Table 4.16, maize is ranked the highest (59.2% with mean= 4.6) in terms of suitable crop to intercrop with ricebean. The respondents explained that ricebean, especially the erect type, is planted mainly as an intercrop mostly in maize farms and sometimes with sorghum. The ricebean in intercropped systems is sowed after planting the maize but pruning is later done in the maize to reduce shading. During harvesting of maize, only cobs are harvested leaving the stalks to support the ricebean.

Table 4. 16: Suitability of Crops for Intercropping with Ricebean

	Mean	S.D	very poor	poor	Moderate	good	very good
			%	%	%	%	%
Maize	4.59	0.96	3.5	1.3	1	11.8	59.2
Millet	1.54	0.846	49.6	15.4	9.6	1.8	0.5
Sorghum	3.54	1.355	10.6	8.6	7.1	30.2	20.4
Cash crops	2.32	1.321	30	13.1	18.6	7.6	6.8

Trailing types are mostly grown as sole crop and supported by sticks. The cropping systems are shown in Figure 4.5. This result is consistent with Khadka & Acharya (2009) who reported that most ricebean farmers implement mixed cropping systems in which farmers dibble ricebean seeds in between maize plants. Intercropping cereals and legumes has long been practiced by smallholder farmers in Africa as a paradigm for resource-constrained farmers seeking to sustain output and food security (Semahegn, 2022).

Intercropping is highly beneficial to the farmers as it ensures maximum utilization of the land and that legumes improve the soil fertility as it encourages nitrogen fixation in the soil.

a) Ricebean Sole crop *b) Ricebean/Maize intercrop*

Figure 4. 5: Ricebean Cropping Systems

4.4.7 Agronomic Practices in Ricebean

Results in Table 4.17 shows utilization of ITK agronomic practices in ricebean cultivation. The most used (94%) weed control practice was uprooting. According to Wale & Patil (2020) hand weeding is considered an effective method for managing weeds in ITK. Mulching and cover cropping are rarely used because the crop itself serves as a mulch and a cover crop. With regards to pest and disease control, the most prevalent methods used were home remedies (52%), intercropping (51%) and crop rotation (43%). According to the respondents, due its predominant cultivation in intercropped patters, the crop is rarely attacked by pests and diseases. However, some measures used in prevention and controlling infestation and infection include application of water mixed with wood ash, cow dung or tithonia extracts to the crop. ITKs is utilized in weed and insect-pest management because of its significant effect in reducing the cost of cultivation and minimizing environmental pollution (Wale & Patil, 2020).

Table 4. 17: Agronomic Practices in Ricebean

	No		Yes	
Weed control	**Frequency**	**Percent**	**Frequency**	**Percent**
Cover cropping	357	89.9	40	10.1
Mulching	364	91.7	33	8.3
Uprooting	23	5.8	374	94.2
Pest& disease control				
Home remedies	192	48.4	205	51.6
Handpicking	246	62	151	38
planting resistant varieties	358	90.2	39	9.8
Crop rotation	225	56.7	172	43.3
Trap crop	374	94.2	23	5.8
Intercropping	195	49.1	202	50.9

The respondents further indicated that in terms of crop management, no manure is applied to the crop as it encourages excessive vegetative growth which in turn leads to low pod formation or increased number of chaffy pods.

4.4.8 Maturity Period for Ricebean

The results in Table 4.18 showed that the average maturity period of ricebean cultivated by farmers was 3 months. According to Khadka & Acharya (2009) ricebean is usually ready to harvest at 120-150 days of growing with longer crop durations associated with higher altitudes and late maturing varieties.

Table 4. 18: Maturity Period for Ricebean in Months

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	
						Statistic	Std. Error
Maturity period	397	2.0	4.0	3.174	.5228	.400	.123

The farmers planted the short varieties to facilitate harvesting along with maize since late varieties usually require an additional 3-4 weeks after harvesting of maize to be ready for harvest.

With regards to using pod color an indicator of maturity, most of the farmers perceived black pods (58%) and brown pods (38%) as an indication of maturity of the crop as indicated in Table 4.19.

Table 4. 19: Pod Color Maturity Indicator for Ricebean Harvesting

	Frequency	**Percent (%)**
Black	230	57.9
Brown	149	37.5
Yellow	18	4.5
Total	**397**	**100.0**

According to the farmers, harvesting is done when pods turn black for the green-yellow variety and brown for the red-brown variety.

Figure 4.6 Shows the different pod colors that determine maturity of ricebean. According to the respondents, harvesting is normally done in the morning before intense sunlight to reduce shattering of the pods. Harvesting is conducted by either by plucking dry pods or uprooting the whole crop. Uprooting is used since it minimizes shattering and the residues after post-harvest processing can be fed to livestock instead of being left to decompose in the farm.

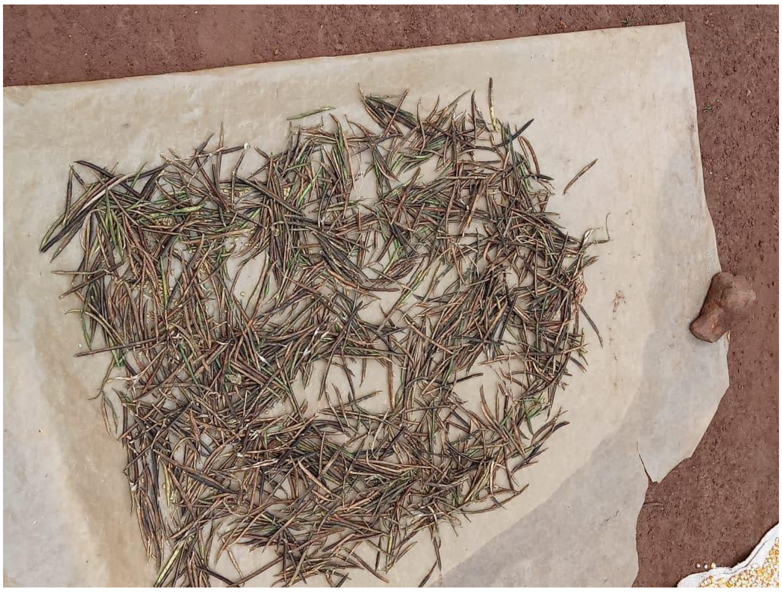


Figure 4. 6: Mature Pod Colors

4.4.9 Post-harvest Practices carried out on Ricebean

The results in Table 4.20 presents the post-harvest practices carried out on ricebean after harvesting.

Table 4. 20: Post-harvest Practices carried out on Ricebean

	No		Yes	
	Frequency	**Percent**	**Frequency**	**Percent**
Drying	1	0.3	396	99.7
Threshing	4	1	393	99
Winnowing	8	2	389	98
Treatment	217	54.7	180	45.3

The predominant practices conducted included drying, threshing and winnowing. The farmers reported that after harvesting, the produce is dried in the sun using a mat (*Par-Luo; richambe- Kisii*) before threshing is done. Threshing is done by beating with a stick either on a mat or inside a sack to minimize loss by shattering. Threshing can be done twice in the case of seeds that stick to the pods. After threshing, winnowing is done mostly during windy period to separate the seeds from the chaffs.

The produce is then dried for three to four days to reduce moisture content before storage in sacks or tins as illustrated in figure 4.7

a) Drying

b) Threshing

c) sorting and packaging

d)Storage

Figure 4. 7: Post-harvest Practices for Ricebean

According to the respondents, ricebean is not commonly treated as the crop is rarely attacked by pests. However, dusting of the seeds with wood ash is the most common practice to control any pest and disease infestation.

4.4.10 Storage of Ricebean

As shown in Table 4.21, majority of ricebean farmers (97%) store ricebean in sacks (*Ogunde-Luo, Eguni- Kisii*). With regards to storage period, most of the farmers (54%) stored their produce for 1 – 3 years. The respondents explained that after drying, seeds are stored in sacks or tins. The most preferred duration for storage is one year, or up to three years. A long storage period of more than three years is avoided because it is associated with hardening of seeds which make them difficult to cook. The produce is sold in different quantities; for instance, one cup at ksh 50, half kg, one kg and in tins (*Gorogoro. Chigorogoro*) at ksh 250. This means that ricebean attracks high prices than other similar legumes thus need to be promoted.

Table 4. 21: Storage of Ricebean

Storage	Frequency	Percent
Storage method		
Pots	4	1.0
Sacks	384	96.7
Both Sacks and Pots	9	2.3
Total	**397**	**100.0**
Less than 1 year	133	33.5
1-3 years	214	53.9
4-6 years	4	1.0
No storage limit	46	11.6
Total	**397**	**100.0**

4.4.11 Hard Seeds in Ricebean

According to the results in Table 4.22, majority (71%) attribute hard seeds to harvesting immature seeds. Ricebean has been established to have a problem of hard-seededness which constrains germination and difficulty during cooking (Khadka & Acharya, 2009). However, this trait does not appear to be consistent among all varieties. This was corroborated by the farmers who reported that hard seeds in the local ricebean varieties are rare compared to other cereals like cowpeas and green grams.

Table 4. 22: Cause of Hard Seeds in Ricebean

	Frequency	Percent
Harvesting immature seeds	281	70.8
Harvesting during rainy seasons	9	2.3
Lack of enough rainfall	21	5.3
Not sure	78	19.6
Storage for long time	8	2.0
Total	**397**	**100.0**

According to the farmers, hard-seededness may mainly be caused by harvesting immature pods or as a result of harvesting during rainy season and long storage time.

4.4.12 Utilization of Ricebean

Table 4.23 illustrates the results of farmers' ranking on their perception on ricebean uses.

Table 4. 23: Farmer's Perception on the Utilization of Ricebean

	Mean	S.D	very poor	poor	moderate	good	very good
			Percent	Percent	Percent	Percent	Percent
Food provision	4.54	1.074	6.8	0.8	2	12.3	78.1
Source of income	3.96	1.11	8.8	2	4.3	53.7	31.2
Livestock feed	3.77	1.29	8.1	9.3	20.9	21.2	40.6
Provision of fuel	3.33	1.327	16.9	9.6	14.1	42.8	16.6
Cultural values	3.6	1.271	10.3	5	31.7	20.4	32.5
Soil fertility	4.07	1.228	9.8	2.5	5.3	35.3	47.1

Utilization of ricebean ranked in order from most revered use to least important use is as follows; food provision, soil fertility, source of income, livestock feed, cultural values and provision of fuel.

According to the account of the respondents, ricebean is mainly utilized as food (78.1% , mean =4.54) and is a preferred legume because it is relatively less acidic compared to other legumes thus suitable for children, old people and people with ulcers. The respondents explained that ricebean improves soil fertility and health (47.1%, mean= 4.07) because its thick rooting system increases soil aeration and its leaves drop to the ground or whole crop residue can be ploughed to the soil. Ricebean as source of income is ranked thirs by the respondent (mean=96). The farmers reported that ricebean is a good livestock fodder as it can be fed green or dried to livestock. However, green ricebean plant material has been found to cause bloating in livestock thus, it is common practice to dry first before feeding the livestock. The respondent also indicated that ricebean is acceptable culturally since it is cooked during community functions and severed with rice or ugali which are staple cereals. This implies that ricebean serves as a vital crop for mitigating food insecurity, as evidenced by its widespread cultivation among farmers who rely on it for sustenance. Additionally, the crop's multipurpose nature is highlighted by the fact that many respondents identified various uses for it. Haug & Schilling (2020) noted that ricebean is an underutilized crop found to have diverse uses.

4.4.13 Cooking of Ricebean

Table 4.24 shows the indigenous method of preparing ricebean is by boiling. Majority, 77% of the respondents explained that ricebean seeds are soaked with water overnight to enhance a shorter boiling time.

Table 4. 24: Cooking of Ricebean

Cooking method	Frequency	Percent
Boiling	307	77.3
Flour	69	17.3
Vegetable leaves	21	5.2
Total	397	100

The seeds are also boiled directly if not so hard and prepared into stew or soup and taken with either rice, chapati, ugali or potatoes. A small number of the respondents (17.3%) alluded that they grind the ricebean to make flour which is used to make porridge for children while few (5%) cook the rice bean leaves to make vegetables for taking with ugali.

4.4.14 Level of ITK Adoption in Ricebean Farming

Table 4.25 shows the level of ITK adoption for the different processes of ricebean production and processing. Mean of 2.5 or higher translates to entirely using ITK in conducting the processes. The processes that were entirely conducted with ITK include plant timing, land preparation, agroecological practices, harvesting and post harvesting. ITK on timing of planting time was cultivation at the onset of short rains to avoid excess moisture which causes excessive vegetativeness and chaffy pods. Planting time was also done according to reports given by traditional weather men who describe when rains will start and its trend in the entire season. ITK on land preparation was ploughing the land during dry season; this encourages proper decomposition of weeds before planting the crop. Harrowing of land is then done just before planting for soil water conservation. ITK on agroecological practices was using plant residue as animal feed, ploughing-in soil crop residue for soil fertility, intercropping and uprooting for weed control and use of home remedies for pest control.

Table 4. 25: Level of ITK Adoption in Ricebean Farming

ITK use	Mean	S.D	not used	partially used	used entirely
			%	%	%
ITK in planting timing	**2.63**	0.555	3.8	29	67.2
ITK seed selection	2.21	0.583	8.6	61.5	30
ITK in land preparation	**2.61**	0.561	3.8	31.7	64.5
ITK in sowing	2.17	0.647	13.9	55.4	30.7
ITK in weed control	2.34	0.657	10.3	45.3	44.3
ITK in pest control	2.23	0.624	10.6	55.9	33.5
ITK in plant nutrition management	2.39	0.648	9.1	42.8	48.1
ITK in harvesting timing	2.42	0.57	4	49.9	46.1
ITK in harvesting method	**2.45**	0.574	4	46.9	48.9
ITK in post-harvest processing	**2.45**	0.569	3.8	47.4	48.9
ITK in sorting and grading	2.27	0.667	12.3	48.4	39.3
ITK in storage	2.41	0.555	3.3	52.4	44.3
ITK in food uses of ricebean	2.42	0.628	7.6	43.3	49.1
ITK in agroecological uses of ricebean	**2.5**	0.562	3.3	43.1	53.7

Average mean = 2.39

ITK on harvesting was using pod colour as maturity indicator. ITK on post harvesting was drying, threshing, winnowing, sun drying of seeds and mixing of ash with seeds during storage to avoid pest attacks. According to the respondents, since ricebean production is not supported by the government, ITK adoption is the optimal alternative to ensure performance of the crop. Moreover, the respondents adopted ITK because it is cheap, not complicated and does not destroy the environment. Also, food from ITK does not have chemicals thus safe for human consumption and it is associated with minimizing exposure to lifestyle diseases. According to Hambati, (2021); Melash et al., (2023), ITK is a valuable resource that can be used to develop sustainable agricultural practices that are adapted to local conditions which can help farmers to increase crop yields, reduce soil erosion, improve soil fertility and ensure environmental health. This implies that this valuable knowledge needs to be promoted by improving it to make it more productive and sustainable.

4.4.15 Summary of the Key Informants, Focus Group Discussions and Participant Observations

The key informants, Focus Group Discussions (FGDs) and participant observations on Indigenous Traditional Knowledge (ITK) in ricebean farming reveals the deep-rooted connection between agricultural practices and cultural traditions.

Origin, Local name and Cultural Significance

The farmers indicated that ricebean, though its origin is uncertain, it is believed to be from Uganda brought by researchers, though its popularity is still low. Participants shared that ricebean is known by different local names, such as "Etengu" (Kisii) and "Leso barore/riadore " (Luo) meaning of its shattering behavior. It symbolizes resilience due to its ability to thrive in poor soils, minimal rainfall and resistance to pests and diseases making it crucial for food security during dry seasons. The crop is often part of post-harvest festivals and religious ceremonies, underscoring its cultural importance. This aligns with studies by Mbow et al., (2019) indicating that traditional crops play an essential role in community resilience and cultural identity in agrarian societies.

Land Preparation

Traditional tools, such as wooden plows drawn by oxen and manual hoes, remain common, especially on sloped terrains. Farmers favor sandy-loamy soils and ensure good drainage to prevent waterlogging. Land preparation often involves rituals, such as offerings to nature spirits, reflecting the spiritual dimension of farming. Rituals in traditional agriculture are well-documented as a means to maintain harmony with nature (Pretty et al., 2020).

Seed Selection and Storage

Farmers grow different ricebean varieties such as brown/yellow, green/yellow and red. Seeds for the next season are selected based on size and maturity from healthy plants. Traditional storage methods, including sisal containers, tins or earthen pots mixed with ash were mostly used as the effective method in keeping seeds viable.

FGD 2: *"when the seeds are coated with wood ash, it makes it bitter for pests when they come in contact with the seeds making them to run away"*

"Seeds preserved for next planting season is also mixed with ash and sand to discourage family members from cooking them for food"

Seed sharing, especially during festivals, promotes genetic diversity and community social wellbeing. This practice of local seed systems supports agrobiodiversity and crop resilience (Jarvis et al., 2016).

Sowing Practices and Cultural Markers

Line sowing, using sticks or hoes, is the preferred method among the farmers for better crop management. Sowing is timed with climatic conditions like the arrival of short rains or cultural festivals marking the planting season. Farmers noted that ricebean a drought resistant crop requires minimal rainfall thus planting during short rains (from September- December) is ideal. These practices demonstrate the integration of environmental observation with ITK. Similarly, a study by Altieri, (2018) related traditional farming's reliance on seasonal indicators.

Crop Management and Soil Conservation

Farmers used manual weeding and intercropping ricebean with maize or sorghum to help maintain soil fertility. Ricebean is also important crop for its role as a cover crop that conserves soil moisture and prevent soil erosion.

FGD 1*: "Because the land size is small, we plant ricebean in maize farms where maize will also help support ricebean above the ground making it bear a lot of seeds. This also helps us get extra income"*

Similarly, in hilly areas contour farming is practiced to prevent erosion. These sustainable practices align with the concept of agroecology, which emphasizes the role of traditional systems in ecological sustainability (Wezel et al., 2020).

Pest and Disease Management

Pests and diseases are not significant issues in ricebean farming because they are rarely attacked. Sometimes farmers use tithonia extracts and ash as natural repellents to cushion the crop against any pest and disease attack. Such organic approaches reduce dependency on chemical pesticides, which is consistent with sustainable farming practices that minimize environmental harm (Altieri, 2018).

Harvesting and Labor Sharing

Harvesting is determined by pod maturity, with the pods turning brown or black indicating mature pods. Labor-sharing practices witnessed during the harvest season reduces harvesting challenges and promotes community cohesion. Thompson et al., (2019) noted on the importance of cooperative labor in traditional agriculture.

Post-Harvest Processing and Utilization

Ricebeans are sun-dried and stored in traditional containers such mats or flat floor surfaces before threshing. Threshing is done manually by beating with stick inside a bag to minimize shattering f beans. Winnowing is then done to separate the beans from the chaff. Clean ricebean seeds are then sun dried properly before storage to minimize pest infestation. Ricebean plant residues are then used as livestock feed or left in the farm to decompose to boost soil fertility.

FGD 4: *"In our area we prefer uprooting the entire crop because it will reduce shattering, less labourous and after threshing we can feed the resisdues to our cows because the cows love it very much. Lactating cows will produce a lot of milk when they feed on these residues."*

Ricebean's versatility in human diets and its use in fodder exemplify its multifunctionality in subsistence farming, which is crucial for food security (FAO, 2017).

Knowledge Transfer

The farmers indicated that traditional knowledge is passed down through oral transmission, demonstrations and apprenticeships, with elders playing a central role. However, younger generations are increasingly adopting modern techniques, leading to a blending of ITK with contemporary agricultural methods. This hybridization of knowledge is seen as both a challenge and an opportunity for the future of ITK (Nyantakyi-Frimpong et al., 2020).

Challenges and Adaptation

Ricbean farmers noted a number of challenges facing them including climate change, erratic rainfall and limited access to quality seesd posing challenges to traditional ricebean farming. However, the farmers are adapting by adjusting planting schedules and adopting agroforestry techniques.

FGD 5: *"This crop is very good especially in our area where we have limited rainfall because the crop is very resistant. The main challenge we have is lack of seeds, especially the ones that does not climb other crops because the climbing ones (mostly available) suffocate the maize reducing their production. We therefore request the government to give us seeds"*

Also lack of government support has been limiting factor, though some institutions have provided training in sustainable ricebean production. Mbow et al., (2019) noted that the ongoing pressure of modern agriculture underscores the need for more targeted support to preserve ITK.

Economic and Social Impact

Ricebean farming is vital for household food security but contributes minimally to income due to limited production. Women were involved in most stages of ricebean farming, from sowing to harvesting, men typically handled land preparation, while labor for post-harvest processing was shared. Farmers also cited lack of ricebean agricultural support services by the government, farmer groups and cooperatives which could boost their production.

FGD 4: *"We have no ricebean farmer groups unlike other crops like maize which help farmers get seeds and fertilizers. Ricebean farmers are left to struggle on their own making it more challenging to farm the crop. If the government could assist us form farmer groups so that we also have leaders who will fight for us."*

According to Pretty et al., (2020), farmer groups could improve bargaing power, market access and economic outcomes for the farmers.

Environmental Sustainability

Farmers supported traditional ricebean farming as it contributes to environmental sustainability through organic methods use and minimal use of chemicals.

FGD 3: *"This crop is very resistant; we don't like using chemicals which has caused diseases like cancer. Since the crop also has no acids when consumed, applying chemicals is destroying the value of the crop since these chemicals will accumulate in the the seeds making it more acidic when consumed."*

Practices like intercropping and crop rotation preserve biodiversity and soil health. This is consistent to study by Altieri, (2018) who alluded the role of ITK in sustainable agriculture.

4.5 Socio-economic Factors Affecting Adoption of Indigenous Technical Knowledge in Ricebean Production

Multiple linear regression analysis was use to determine the socioeconomic factors that affect the adoption of Indigenous Technical Knowledge by ricebean farmers. The independent variables of study were Age, Gender, Education level, Household size, Annual income, Landsize, Land size under ricebean, Group membership, Distance to market, Access to Extension services, Access to agricultural credit facilities, Access to

Farm inputs, Access to Marketing services and Rice bean farming experience. The dependent variable was adoption of ITK in ricebean faming.

Results in Table 4.26 depicts the model fitting. From the results, the adjusted R is 0.659.

Table 4. 26: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.802	.764	.659	.542

Predictors: (Constant), Farming experience, Occupation, Land ownership, Marital Status, Market access, Education level, Gender, H /Hold size, Group membership, Land size, annual Income, Age

This indicates that 65.9% of the variance in the dependent variable is explained by the independent variables under study. Also, the model has a strong ability to explain the factors influencing the adoption of ITK because of the lower standard error of 0542. This aligns with prior studies on the adoption of agricultural innovations, where socioeconomic factors like farming experience, education level, and market access are shown to be key drivers of adoption behavior (Mwangi & Kariuki, 2015).

The ANOVA Table 4.27 shows a significant p-value (.000).

Table 4. 27: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	33.536	13	2.580	2.908	.000
	Residual	339.764	383	.887		
	Total	373.300	396			

Dependent Variable: Adoption of ITK in ricebean production

Predictors: (Constant), Farming experience, Occupation, Land ownership, Marital Status, Market access, Education level, Gender, H /Hold size, Group membership, Land size, annual Income, Age

This implies that these socioeconomic factors have significant contribution to the adoption of ITK by ricebean farmers. Similar findings have been observed in agricultural adoption studies that underscore the importance of a wide range of factors such as personal, economic and institutional in influencing farmer decisions to adopt agricultural technologies (Rogers, 2003).

According to the results as shown in Table 29., age was found to negatively influence adoption of ITK at a 10% significance level (p-value=0.065 β=-0.011995). This implies that younger farmers are more likely to adopt ITK in ricebean farming compared to older farmers. This finding is contrary to many studies which find that ITK is mostly practiced by older farmers. In fact, the association between farmers' age and adoption of innovations has been the subject of conflicting research (Rizzo *et al.,* 2024). He further stressed the importance of younger farmers in driving agricultural innovation, despite some studies suggesting that older farmers are more likely to accept innovation. Similarly, Barnes *et al.,* (2019) discovered that younger farmers have a higher ability for adaptation, which makes them more inclined to adopt innovations.

The results also indicated that gender significantly influenced adoption of ITK at a 10% significance level with male farmers more likely to adopt ITK in ricebean farming (p-value=0.053 β=-0.391751). According to Ndlela *et al.,* (2021) males are more likely use ITK than their female counterparts because they normally make production decisions and they attend more agricultural meetings, which then increases their knowledge of ITK.

Land size was also found to positively and significantly influenced adoption of ITK at a 10% significance level farming (p-value=0.095 β=-0.3935456). This means that the farmers with larger sizes of land were more likely to adopt ITK in ricebean farming. Ricebean farming is predominantly practiced in mixed cropped systems with use of

ITK. Thus, ricebean ITK farming is more likely to be conducted by farmers with larger land sizes as wealthier households are better positioned to deal with any risks that come with the adoption of various agricultural technologies such as mixed cropping (Teklewold et al., 2013).

Distance to market was found to negatively and significantly influence adoption of ITK at 1% significance level (p-value=0.001 β=-0.329509). This implies that the closer the produce market was to a farmer the more likely they were to utilize ITK in ricebean farming.

Table 4. 28: Multiple Linear Regression of Socio-economic Factors Influencing Adoption of ITK in Ricebean Farming

	Coef.	Std. Err.	t	P>t	[95% Conf.Interval]	
Age	-0.011995	0.0065	-1.85	0.065*	-0.024722	0.0007319
Gender	0.391751	0.2016	1.94	0.053*	-0.0047294	0.7882314
Education level	-0.0375173	0.0993	-0.38	0.706	-0.2328277	0.1577932
Household size	-0.2595634	0.1765	-1.47	0.142	-0.60659	0.0874631
Annual income	-0.0452351	0.0563	-0.8	0.422	-0.1559397	0.0654695
Landsize	0.3935456	0.2354	1.67	0.095*	-0.0692521	0.8563432
Land size under ricebean	0.3912271	0.5293	0.74	0.460	-0.6495754	1.43203
Group membership	0.0273055	0.2204	0.12	0.901	-0.4059651	0.4605762
Distance to market	-0.329509	0.0663	-4.97	0.001***	-0.459771	-0.199247
Access to Extension services	-0.7860988	0.2249	-3.49	0.001***	-1.228397	-.3438006
Access to credit facilities	-0.4058007	0.2412	-1.68	0.093*	-0.879978	0.0683765
Access to Farm inputs	0.1074148	0.2199	0.49	0.625	-0.3249477	0.5397774
Access to Marketing services	1.24569	0.2858	4.36	0.001***	0.6837959	1.807585
Rice bean farming experience	0.0342553	0.1335	0.26	0.798	-0.2282548	0.2967654
_cons	14.76251	0.8504	17.36	0.000	13.0904	16.43463

*, **, *** significance at 10%, 5%, 1% respectively

Current market demand trends are shifting towards agricultural produce grown with minimal agrichemicals. Thus, proximity to market incentivizes ricebean farmers to utilize ITK in ricebean production because of the opportunity of fulfilling the market need of endogenous and healthy crops. Similarly, access to government marketing services positively and significantly influenced adoption of ITK at a 1% significance level (p-value=0.0001 β=1.24569). Access to marketing services guarantees farmers of market reliability thus encourages farmers participation in produce markets. Because of the ease of market participation, farmers are more incentivized to participate in the ricebean market which is known for having demand for healthy produce which is produced with minimal agrichemicals. These findings agree with those of Astorga (2024) who alluded that there is favorable correlation between improved market access through infrastructure and government support and the adoption of new agricultural technologies.

The results further showed that access to extension services negatively and significantly influenced adoption of ITK at 1% significance level (p-value=0.001 β=-0.7860988). This means that farmers who accessed extension services more frequently and easily were less likely to adopt ITK in ricebean farming. This is due to the fact that small-scale farmers' access to and availability of extension services has a bigger impact on how quickly farmers adopt new, modern farming technologies (Ngongo, 2016). This is also consistent with the findings of Ntshangase *et al.,* (2018), who found that extension service played a role in encouraging farmers to undertake no-till conservation.

Access to agricultural credit was also found to be an important factor that negatively and significantly influenced adoption of ITK at 10% significance level (p-value=0.093 β=-0.4058007). This means that farmers with access to credit were less likely to adopt ITK in ricebean farming. Credit enables farmers to procure modern agricultural technologies such as fertilizer and pesticides. These farmers with access to agricultural credit are very likely to utilize the credit in transforming their production systems to modern systems. This conquered with Marshall and Miguel (2014) who found that low adoption rates of agricultural technologies is linked to poor access of credit and loan facilities by farmers. This also accords with the study by Masca *et al.,* (2022) which found that access to credit had a positive significant influence on the adoption of good agricultural practices among smallholder potato farmers in Kenya.

The results therefore indicate that the successful adoption of sustainable agricultural practices requires strong government support in addressing farmers' socioeconomic factors, including extension services, market access, and social challenges affecting the farmers.

Hypothesis Testing

The study hypothesis tested the influence of socioeconomic factors on adoption of ITK in ricebean production.

The multiple regression analysis revealed a significant relationship between socioeconomic factors and the use of Indigenous Technical Knowledge (ITK) in ricebean production among smallholder farmers in the Nyanza region, as evidenced by a p-value of 0.000, which is less than the significance level of 0.05. As a result, the null hypothesis, which states that socioeconomic factors have no significant influence on the use of ITK in ricebean production, is rejected. In contrast, the alternative hypothesis is accepted, demonstrating that socioeconomic considerations do have a significant impact on ITK uptake.

This finding indicates that socioeconomic factors such as age, gender, education level, household size, annual income, land size, the portion of land allocated to ricebean, group membership, proximity to markets, access to extension services, agricultural credit facilities, farm inputs, marketing services, and ricebean farming experience all have a significant impact on ITK uptake in ricebean farming. As a result, in order to effectively promote and implement sustainable farming methods, these socioeconomic variables must be considered and addressed.

4.6 Farmers Perception on ITK Integration in Ricebean Farming

The study sought to find out farmers' perception on ITK integration in ricebean farming.

4.6.1 Farmers' Perception on ITK

Rating of the perception factors was done using likerd scale on their influence on adoption of ITK. A scale of 1-5 was used in rating the perception factors. The scores strongly disagree and disagree represented very low rating represented by mean score of 1-2.5 in the continuous likerd scale (1<disagree<2.5). The scores of Neutral represented indecision equivalent to 3 on the scale (2.6<neutral<3.5). the scores agree and strongly agree represented very high rate of agreements with the perception factor equivalent to 3.6-5.0 on the scale (3.6<agree<5.0). the mean was also used to rank the factors from the highly perceived factor to the lowest perceived factor. The results are presented in Table 30.

In terms of effectiveness, the findings shows that 45.8% of respondents "strongly agree" that ITK is effective, whereas 32.5% "disagree" with this assessment. This implies a divided opinion, but with a strong preference for recognizing ITK's usefulness, which is consistent with research that highlight the importance of ITK in improving agricultural resilience in conventional farming systems. According to Jha *et al*. (2020), the effectiveness of ITK is generally attributed to its adaption to local conditions, making it a feasible alternative for smallholder farmers. However, the large difference may indicate issues about scalability and competitiveness with modern approaches (Bora *et al.,* 2021). Effectiveness is ranked among the lowest in terms of mean (3.63). This suggests that ITK effectiveness is not as good as modern practices. While effectiveness is viewed positively, it is the area with the most room for improvement compared to others.

Table 4. 29: Farmers' Perception on ITK In Ricebean Farming

Description	**Mean**	**S.D**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
			%	%	%	%	%
Effectiveness	3.63	1.451	5	32.5	2.5	14.1	45.8
Availability	**4.18**	0.926	3.5	2.8	5.8	47.6	40.3
Affordability	**4.33**	0.896	2	3.5	6.3	35.5	52.6
Easier to use	3.96	1.153	6.8	7.1	6.5	42.8	36.8
ITK same as CK	3.08	1.563	25.7	14.4	12.8	20.4	26.7
Human safety	**4.16**	0.868	2.8	1.8	9.1	49.9	36.5
Culturally acceptable	**4.17**	0.895	3	1.3	10.8	45.1	39.8
Environmentally friendly	**4.49**	0.747	0.5	2.3	5.5	31.5	60.2

Availability is another important perception factor in ITK adoption. The vast majority of farmers (47.6%) or strongly agree (40.3%) that ITK is available. The significant favorable view of availability may be due to the fact that ITK methods have been passed down through generations and are widely available in farming communities. According to Sarkar and Mishra (2021), ITK is still embedded in many rural communities, making it a broadly accessible source of agricultural knowledge. Availability is ranked third perception factor with a mean of 4.18. This score shows that availability is generally well-regarded and the respondents feel that ITK is readily accessible within the community.

Another perception factor in the study is affordability. A large number of the respondents 52.6% "strongly agree" and 35.5% "agree" that ITK is relatively cheap, supporting its cost effectiveness. This may be due to the low input requirements of traditional farming systems, which are usually resource-efficient and rely on locally available materials (Singh *et al.,* 2019). ITK is frequently linked with lower external expenses, which makes it advantageous for smallholder farmers with limited financial resources. The mean for affordability is 4.33. This is also ranked high, indicating that respondents believe ITK is reasonably cheap, thus this high mean signals a positive reception among the farmers.

The respondents' ease of use of ITK indicates that 42.8% agree and 36.8% strongly agree that ITK is simple to use. ITK's simplicity and familiarity make it easy to use. According to Sharma and Reddy (2021), ITK is typically user-friendly since it aligns with traditional knowledge systems passed down through generations, making it easy for farmers who are experienced with such techniques. However, the 6.8% who strongly disapprove may represent farmers who experience difficulties in implementing ITK on larger or more modernized farms. The low mean of 3.96 shows that this perception factor is less strongly endorsed compared to the other factors.

A mixed respond is reported about ITK's closeness to conventional knowledge (CK), with 25.7% strongly rejecting that ITK is the same as CK and 26.7% strongly agreeing. This demonstrates variation in perceptions, with some farmers distinguishing ITK from CK by including local knowledge, biodiversity, and sustainability principles (Patnaik *et al.,* 2022). Others may see ITK as compatible or similar to CK, maybe due to the growing trend of combining traditional ways with conventional agricultural operations. This factor is ranked the lowest with mean of 3.08, indicating mixed feelings about whether ITK is the same as CK.

Human safety factor elicited high positive response with half of respondents (49.9%) agree, and 36.5% strongly agreeing, that ITK supports human safety, which could be attributed to its emphasis on organic practices that avoid synthetic substances while promoting health and wellness. This is consistent with the findings of Mertz *et al.* (2019), who stated that ITK, with its organic foundation, tends to encourage safer farming practices. With mean of 4.16 reflects a strong perception of ITK safety for human use.

Furthermore, the cultural acceptance of ITK is exceedingly positive, with 45.1% agreeing and 39.8% strongly agreeing. ITK has an unbreakable connection to cultural norms and heritage, making it naturally acceptable to many farmers. A study by Thapa *et al.* (2020) discovered that ITK frequently aligns significantly with local cultural norms, facilitating widespread adoption. This cultural attachment ensures that ITK is relevant and acceptable throughout generations. This is also rated positively with a mean of 4.17 suggesting that ITK is perceived as culturally appropriate and acceptable among the farming communities.

Lastly, ITK is seen as exceptionally environmentally friendly, with 60.2% strongly agreeing and 31.5% agreeing. Traditional practices have a tendency to function in harmony with the environment, preserving biodiversity and encouraging sustainability. This is consistent to a study by Chhetri *et al.* (2021) that ITK's low reliance on artificial inputs and emphasis on natural processes make it a significant instrument for promoting ecologically friendly agriculture. This variable has the highest mean score of 4.49, indicating that respondents generally view ITK as very environmentally friendly. This suggests strong approval in terms of its positive environmental impact.

4.6.2 Factors Influencing farmers' Perception on ITK in Ricebean Farming

Farmers; decision to adopt or reject a technology is dependent on their perception on that particular technology. Similarly, how farmers perceive a technology is also dependent on factors surrounding them. This study therefore sought to find out the socioeconomic factors affecting farmers' perception on a technology. These factors included age, gender, education level, income level, marital status, land size, market access and group membership. Multivariate regression was used to determine the factors affection famers' perception on ITK use in ricebean farming. The results are presented in Table 31.

Different variables were found to influence various perceptions of ITK as discussed below. For the ITK, which is the same as CK, age was found to be negatively and significantly associated with the perception that ITK is the same as Conventional Knowledge (CK), with a coefficient of -0.01467. This implies that older farmers are more likely to recognize the differences between ITK and modern agricultural techniques. As individuals age, they accumulate more experience and knowledge, which may make them more aware of the nuances and distinctions between traditional and conventional practices. This agrees with a study of Vietnamese indigenous farmers adapting to climate change, where age was a crucial factor in decision-making regarding the use of traditional and modern practices (Smyl & Cooke, 2019).

Table 4. 30: Multivariate Regression Analysis of Factors Influencing Famers's Perception on ITK in Ricebean Farming

		Age	Gender	Education years	Marital status	Hholdsize	Income level	Land size	Group membership	Market time	_cons
Effectiveness	Coef.	-0.00098	0.040493	0.252243	0.077325	0.4189734	-0.19912	-0.1715	0.437455	-0.03568	2.068038
	P>t	0.848	0.799	0.001***	0.443	0.002***	0.001***	0.058*	0.007***	0.494	0.003
Availability	Coef.	-0.00328	-0.05205	0.128089	0.116882	-0.1324414	-0.00824	-0.14388	-0.01237	-0.08782	4.537563
	P>t	0.331	0.619	0.013**	0.078*	0.141	0.777	0.016**	0.908	0.011**	0
Affordability	Coef.	0.001749	-0.10337	0.11651	0.056974	-0.1002644	-0.05807	-0.11481	-0.05257	-0.03359	4.682803
	P>t	0.595	0.312	0.02**	0.379	0.253	0.041**	0.048**	0.615	0.316	0
Easier to use	Coef.	0.001669	0.087781	0.047036	0.163749	-0.0996686	-0.00585	-0.14495	0.16709	-0.1693	3.980376
	P>t	0.69	0.5	0.459	0.047**	0.372	0.871	0.05**	0.209	0***	0
ITK sameas CK	Coef.	-0.01467	0.315259	-0.04122	0.130538	0.0851954	-0.14205	-0.17975	0.137929	-0.20975	4.205699
	P>t	0.009***	0.07*	0.627	0.236	0.568	0.003***	0.069*	0.438	0***	0
Humansafety	Coef.	-0.00258	0.212265	0.01453	0.073958	-0.215805	0.003148	-0.05484	-0.00358	-0.05808	4.559631
	P>t	0.42	0.033**	0.764	0.24	0.012**	0.909	0.33	0.972	0.075*	0
Culturally acceptable	Coef.	0.004683	-0.14166	0.004902	-0.02097	-0.0069224	-0.0029	0.077269	0.142908	0.024517	3.777386
	P>t	0.16	0.171	0.923	0.749	0.938	0.919	0.188	0.177	0.47	0
Environmentally friendly	Coef.	0.003506	-0.18179	0.053085	-0.07025	-0.2053246	-0.0213	-0.02822	-0.05315	-0.00347	5.258502
	P>t	0.201	0.033**	0.202	0.193	0.005***	0.367	0.559	0.542	0.901	0

Note: *, **, ***=significant at 10%,5% and 1% significance level respectively

Gender was found to have a marginally significant positive effect on the perception that ITK is equivalent to CK and human safety. This indicates that men might be more inclined to view ITK as similar to conventional knowledge while at the same time perceiving ITK as safer compared to women. This perception could be influenced by cultural or social factors where men, who often dominate decision-making in many ricebean farming communities, may prioritize practical outcomes over the distinctiveness of traditional practices and have more experience with methods passed down through generations. In contrast however, gender was found to have a significant negative effect on the perception of ITK being environmentally friendly. This possibly implies that men might be more skeptical about the environmental benefits of ITK compared to women. This skepticism could stem from differing priorities or experiences in agricultural practices, where men might prioritize productivity or efficiency over environmental considerations. These findings conquer with those of Karimi *et al.,* (2020) who documented on gender differences in environmental priorities, suggesting that men might prioritize productivity over sustainability, while women often emphasize ecological benefits.

Results from the findings further indicate that education plays a crucial role in shaping farmers' perceptions of ITK effectiveness, availability and affordability. The results indicate that ricebean farmers with more years of formal education are more likely to perceive ITK as effective, available and affordable. Notably, educated farmers are more disposed to different scientific principles behind ITK, are more open to integrating traditional agricultural farming techniques with modern practices and view it as a cost-effective option. Notably, education further equips farmers with skills that are key in evaluating the various outcomes of the ITK, hence their uptakes. Essentially, educated individuals have better access to information and resources that allow them to implement ITK more efficiently, thereby reducing costs. Additionally, education enhances a farmer's ability to evaluate and appreciate the long-term benefits of ITK, such as sustainability and reduced dependence on external inputs, which positively contributes to their perception of affordability. Study by Syahruna, (2022) in Indonesian rice farmers who integrated both indigenous and scientific methods highlights that educated farmers are more open to blending traditional and modern knowledge systems, improving ITK's adoption through better resource evaluation, as noted

Marital status was also found to have a positive influence on the perception of ITK availability and the fact that it is easier to use. The findings possibly indicate that farmers who are married are likely to perceive ITK as more available and are user-friendly compared to their unmarried counterparts. This could be due to the collaborative nature of married households, where farming practices such as labor and knowledge, including ITK, are often shared and discussed between partners. Married individuals might also have better support systems, making it easier to access and implement ITK. In such households, the division of tasks and responsibilities might make the application of ITK more efficient and less burdensome, thus enhancing its perceived ease of use in rice-bean farming activities. The shared experience and support within a married household could reduce the individual workload and increase the overall effectiveness of traditional practices, making them appear more manageable. Married farmers often benefit from improved communication and collaboration in farming decisions, which contributes to a more positive outlook on the practicality and availability of ITK practices (Syahruna, 2022).

Results also indicated that household size had a significant influence on the perception of ITK's effectiveness, with a positive coefficient. This means that larger families are more likely to rely on traditional farming methods like ITK due to the collective decision-making process and shared labor within the household. The practices, which are more likely to be passed down through generations, hence more deeply embedded in larger families, which eventually leads to a stronger belief in their effectiveness. This aligns with findings that emphasize the role of family dynamics in sustaining traditional agricultural knowledge, for example, Ullah *et al.* (2018) found that in larger households, ITK is often passed down through generations, reinforcing its perceived effectiveness due to shared experiences and labor contributions. In contrast, household size was found to have a negative association with the perception of ITK's human safety and environmental friendliness. Larger families often have concerns about the applicability or risks of ITK in their specific context and are likely to view ITK as unsafe, less sustainable or environmentally beneficial. The need to ensure the safety and resource demands such as food, water and energy, for a larger number of people are likely to make traditional practices seem less reliable, less effective in meeting their needs sustainably and to a larger extent more hazardous.

Income level has a negative association with the perception of ITK’s effectiveness, affordability and that ITK is the same as CK. This suggests that wealthier farmers, who may have greater access to modern farming techniques and resources, are less likely to view ITK as effective. Higher-income farmers might prefer modern agricultural practices that promise higher yields, quicker results, or better scalability, reducing their reliance on or belief in traditional methods. This further indicates the fact that for every increase in the farmers’ income level, there is a shift in preferences whereby, they may perceive modern technologies as more aligned with their goals and capabilities. Additionally, high income farmers are more inclined to view modern agricultural practices as more affordable or preferable, despite potentially higher costs. These farmers might have the financial resources to invest in modern inputs, technologies, or services that offer immediate or more predictable returns, leading them to perceive ITK as less cost-effective in comparison. Also, wealthier farmers may have greater access to advanced agricultural technologies and practices, which could highlight the differences between traditional and conventional approaches. The financial resources available to wealthier farmers might also lead them to favor modern techniques, further distinguishing ITK from CK in their perception. Similar trend is also observed in studies analyzing the economic priorities of higher-income farming households who tend to focus more in high income activities (Ullah *et al.,* 2018).

The findings from the multivariate regression analysis further indicate that, land sizes are negatively associated with the perception on ITKs' effectiveness, availability, affordability, easier to use, and that ITK is the same as CK. Farmers with larger land sizes may find ITK less effective due to the challenges in labour demands. According to Kansiime *et al.* (2019), the scaling of traditional practices such as ITK often becomes impractical due to labor demands and reduced efficiency in managing large, diverse plots of land. Furthermore, the complexity and diversity of managing larger land sizes often dilutes the applicability of ITK, leading to a perception of reduced availability. Also, farmers managing larger farms may find ITK less affordable. The increased costs associated with implementing ITK on a larger scale, such as labor, time, or specific inputs required for traditional practices, could make ITK seem less economical for these farmers. The complexities of managing more significant amounts of land could require more resources, labor, and time, making ITK seem less practical and more difficult to implement. Lastly, farmers with more extensive landholdings are more likely to see a distinction between traditional and conventional knowledge. The challenges of applying ITK on a larger scale, such as labor intensity and inefficiency in covering vast areas, may highlight the differences between ITK and more scalable modern practices. Traditional knowledge systems, tailored to smaller plots, may not be as effective on a larger scale, leading farmers to favor modern approaches. This is in line with findings from Ali *et al.* (2020), who noted that as farm sizes increase, there is a higher reliance on modern agricultural practices to maximize output, rendering ITK less favorable.

Group membership significantly enhances the perception of ITK's effectiveness. Being part of a group likely facilitates the exchange of knowledge and experiences related to ITK, reinforcing its perceived effectiveness. These groups often provide a platform for collective problem-solving and sharing of best practices, which can enhance the success of ITK applications indicating the social networks and community engagement in sustaining and promoting traditional agricultural knowledge among farmers. A similar study by Mutunga *et al.,* (2019) showed that farmers involved in social networks and cooperatives were more likely to adopt and promote sustainable farming practices due perception created through the support and shared knowledge within the group.

The findings also indicate that market times have a negative yet significant association with the perception on ITK's availability and environmental friendliness. This relationship is possibly due to the opportunity costs or time constraints faced by farmers who spend more time in the market. The time spent in market activities could reduce the time available for learning, sharing, or implementing ITK on their farms. Additionally, the demands of market-oriented production might shift focus away from traditional practices toward more commercially driven techniques, further reducing the perceived availability of ITK. In addition, longer market times, which could likely imply more extended exposure to market environments, may introduce farmers to modern or commercially driven agricultural practices, which can lead to skepticism about ITK's environmental benefits decreases the perceived environmental safety of

ITK. This is supported by Kansiime *et al.,* (2019) study that longer market times exposes farmersto synthetic fertilizers, pesticides, or other market-driven agricultural inputs might create doubts about the environmental safety of ITK, which is often perceived as less aligned with market-oriented agricultural demands

4.7 Comparison of Regional Utilization of Indigenous Technical Knowledge in Ricebean Production

The regional prevalence rate of ITK utilization, difference in ITK application and socioeconomic factors specific to each of the three counties of study were compared and the results presented in Table 28 and 29.

4.7.1 Prevalence of ITK practices and Regional Differences in its use in each county

The prevelance of ITK practices in each county was determined by the percentage of farmers using ITK whereas the regional differences in its application was determined using chi-square analysis. The results were presented in Table 28.

4.7.1.1 Planting Time and Method

From the result in Table 28, there are notable differences in planting practices across Kisii, Migori, and Siaya counties. In Kisii, 59.7% of farmers prefer planting during the long rains, while in Migori, 81.5% opt for short rains. This preference in Migori aligns with climatic variability, as noted by Gachene et al. (2022). Siaya shows similar trends to Migori, with short rains being preferred. However, the p-value for planting time is 0.373, indicating no statistically significant difference between the counties, suggesting that the observed differences might be due to chance or shared factors.

In contrast, the method of planting shows a statistically significant association across the counties (p-value = 0.000). Kisii (80.6%) and Siaya (90.4%) predominantly use row planting, whereas Migori has a notable proportion using broadcasting. This difference highlights county-specific factors, such as extension services or traditional practices, that influence planting methods (Muthoni et al., 2021).

4.7.1.2 Land Preparation and Seed Source

Land preparation methods across the counties involve both clearing and ploughing, particularly in Migori (63.6%). However, the p-value of 0.081 indicates no significant association between counties and land preparation methods. This uniformity suggests that the counties face similar agricultural challenges or have similar traditional practices.

Table 4. 31: Prevalence of ITK practices in each county

Parameter	County	Categories	Frequencies (%)	Chi-square (p-value)
Planting Time	Kisii	Long Rains	59.7%	
		Short Rains	40.3%	
	Migori	Long Rains	18.5%	0.373
		Short Rains	81.5%	
	Siaya	Long Rains		
		Both Rains	27.4%	
		Short Rains	2.9%	
			69.6%	
Planting Method	Kisii	Broadcasting	11.9%	
		Dibbling	7.5%	
		Row Planting	80.6%	
	Migori			0.000
		Broadcasting	26.7%	
		Dibbling	3.1%	
		Row Planting	70.3%	
		Broadcasting	8.9%	
	Siaya			
		Dibbling	0.7%	
		Row Planting	90.4%	
Land Preparation	Kisii		47.8%	
		Clearing, Ploughing	52.2%	
		Clearing, Ploughing & Harrowing		
	Migori		36.4%	0.081
		Clearing, Ploughing	63.6%	
		Clearing, Ploughing & Harrowing		
	Siaya		47.4%	
		Clearing, Ploughing	52.6%	
		Clearing, Ploughing & Harrowing		
Seed Source	Kisii	Own Preserved	100%	

	Migori	Own Preserved	100%	0.378
	Siaya			
		Gov't Subsidy	0.7%	
		Own Preserved	99.3%	
Seeding Rate	Kisii	2	44.8%	
		3	37.3%	0.000
		4	11.9%	
		Broadcast	6.0%	
	Migori			
		1	3.1%	
		2	45.1%	
		3	27.2%	
		4	6.7%	
		5	0.5%	
		Broadcast	17.4%	
	Siaya	2	22.2%	
		3	50.4%	
		4	17.0%	
		5	2.2%	
		Broadcast	8.1%	
Weed control				
	Kisii			
Cover Cropping		Yes	6.0%	0.000
		No	94.0%	
	Migori	Yes	2.6%	
		No	97.4%	
	Siaya	Yes	23.0%	
		No	77.0%	
Mulching	Kisii	Yes	7.5%	
		No	92.5%	0.000
	Migori	Yes	2.1%	
		No	97.9%	
	Siaya	Yes	17.8%	
		No	78.5%	
		Unknown	3.7%	
Uprooting	Kisii	Yes	98.5%	
		No	1.5%	0.000
	Migori			
		Yes	97.9%	
		No	2.1%	
	Siaya			
		Yes	86.7%	
		No	12.6%	
		Unknown	0.7%	
Pests and disease control				
Home Remedies	Kisii			
		Yes	80.6%	0.000
		No	19.4%	
	Migori			
		Yes	39.0%	
		No	61.0%	
	Siaya			

		Yes	55.6%	
		No	44.4%	
Crop Rotation	Kisii			
		Yes	50.7%	0.002
		No	49.3%	
	Migori		39.5%	
		Yes	60.5%	
		No		
	Siaya			
		Yes	29.6%	
		No	66.7%	
		Unknown	3.7%	
Planting Resistant	Kisii			
Varieties		Yes	7.5%	0.012
		No	91.0%	
	Migori			
		Yes	6.2%	
		No	93.8%	
	Siaya			
		Yes	16.3%	
		No	82.2%	
		Unknown	1.5%	
Hand Picking	Kisii	Yes	68.7%	
		No	29.9%	0.000
		Unknown	1.5%	
	Migori			
		Yes	50.8%	
		No	49.2%	
	Siaya			
		Yes	20.0%	
		No	76.3%	
		Unknown	3.7%	
Trap Crop	Kisii			
		Yes	3.0%	0.008
		No	95.5%	
		Unknown	1.5%	
	Migori			
		Yes	3.6%	
		No	96.4%	
	Siaya			
		Yes	10.4%	
		No	86.7%	
		Unknown	3.0%	
Intercropping	Kisii			
		Yes	71.6%	0.001
		No	28.4%	
	Migori			
		Yes	47.7%	
		No	52.3%	
	Siaya			
		Yes	45.2%	
		No	52.6%	
		Unknown	2.2%	
Harvesting method	Kisii	Plucking dry pods		
		Plucking Greenpods	100%	0.273
		Uprooting the plant	0.00%	
			0.00%	
	Migori	Plucking dry pods		
		Plucking Greenpods	94.9	
		Uprooting the plant	0.5	

			4.6	
		Plucking dry pods		
	Siaya	Plucking Greenpods	97.8%	
		Uprooting the plant	0.00%	
			2.29%	
Drying	Kisii	Yes	100%	
				0.378
	Migori	Yes	100%	
	Siaya			
		Yes	99.3%	
		No	0.7%	
Threshing	Kisii	Yes	100%	
	Migori	Yes	100%	0.020
	Siaya	Yes	97.0%	
		No	3.0%	
Winnowing	Kisii	Yes	97.0%	
		No	3.0%	0.015
	Migori	Yes	100%	
	Siaya			
		Yes	95.6%	
		No	4.4%	
Treatment	Kisii	Yes	67.2%	
		No	32.8%	0.000
	Migori	Yes	47.2%	
		No	52.8%	
	Siaya	Yes	31.9%	
		No	68.1%	
Storage Method	Kisii	Sacks	100%	
				0.000
	Migori	Sacks	100%	
	Siaya	Pots	3.0%	
		Sacks	90.4%	
		Tins	6.6%	
Storage Period	Kisii	<1 year	4.5%	
		1-3 years	88.1%	0.000
		4-6 years	1.5%	
		No Limit	6.0%	
	Migori	<1 year	19.0%	
		1-3 years	67.7%	
		4-6 years	1.0%	
		No Limit	12.3%	
	Siaya	<1 year	68.9%	
		1-3 years	24.4%	
		4-6 years	1.5%	
		No Limit	5.2%	
Ricebean Utilization				
Food Provision	Kisii	Very High	82.1%	
		High	16.4%	0.000
		Moderate	1.5%	
	Migori	Very High	76.4%	
		High	23.6%	
	Siaya	Very High	78.5%	
		High	19.3%	
		Moderate	2.2%	

Income Generation	Kisii	Very High	22.4%	
		High	77.6%	0.000
	Migori			
		Very High	23.1%	
		High	56.9%	
		Moderate	20.0%	
	Siaya	Moderate	19.3%	
		High	37.0%	
		Very High	37.0%	
Livestock Feed	Kisii	Moderate	17.9%	
		High	13.4%	0.000
		Very High	68.7%	
	Migori	Moderate	35.9%	
		High	45.6%	
		Very High	18.5%	
	Siaya	Moderate	25.9%	
		High	36.3%	
		Very High	37.0%	
Cultural value	Kisii	Moderate	4.5%	
		Very high	68.7%	0.000
		High	26.9%	
	Migori			
		Moderate	7.7%	
		Very high	53.8%	
	Siaya	High	38.5%	
		Moderate	43.7%	
		Very high	31.9%	
		High	24.4%	

The reliance on own-preserved seeds is unanimous in Kisii and Migori (100%), emphasizing seed sovereignty. The p-value of 0.378 indicates no significant association between counties and seed sources, reflecting the economic realities of smallholder farming where farmers primarily depend on locally preserved seeds, as highlighted by Karanja et al. (2021).

4.7.1.3 Seeding Rate

The seeding rates vary significantly across the counties (p-value = 0.000). Kisii prefers 2-3 seeds per hole (44.8%), while Siaya demonstrates more variation, including broadcasting. These differences suggest regional factors like soil fertility, rainfall, and traditional knowledge influence seeding practices, as supported by Nyangena and Karanja (2022).

4.7.1.4 Weed Management

The use of cover crops is minimal across all counties, especially in Kisii (6.0%), despite their known benefits for soil health (Njoroge et al., 2023). This is also due to the fact that ricebean itself is a cover crop. In contrast, uprooting practices are widely used in Kisii (98.5%) and Migori (97.9%), highlighting a reliance on manual labor for weed control. Mulching is also minimally practiced, especially in Migori (2.6%). The low use of mulching suggests a gap in agroecological adoption, potentially due to limited resources or knowledge. Uprooting remains consistent with traditional legume harvesting methods in East Africa (Alemu et al., 2020).

The p-values for weed control practices such as cover cropping, mulching, and uprooting are all highly significant (p-value = 0.000), indicating strong associations between counties and these methods. Kisii employs traditional methods like cover cropping and mulching more than Migori and Siaya, reflecting localized traditions and environmental conditions.

4.7.1.5 Pest and Disease Control

Crop rotation is practiced by most (50.7%) of farmers in Kisii, which is consistent with findings by Puskur et al. (2022) that emphasize its role in maintaining soil health. However, the use of resistant varieties is lower (7.5%), suggesting an area for improvement, as integrating resistant crops could help mitigate pest and disease losses (Dixon et al., 2021).

Pest and disease control methods also show significant differences across counties, with all p-values below 0.05. Home remedies are widely used for pest control in Kisii

(80.6%) compared to Migori (39%) and Siaya (55.6%), indicating a reliance on Indigenous Traditional Knowledge (ITK) for managing soil fertility and pest control (Munyua & Lwasa, 2020; Njeru et al., 2022). The significant variation in practices like handpicking and trap crops suggests that localized pest pressures, access to knowledge, and available inputs strongly influence these methods.

4.7.1.6 Intercropping

Intercropping practices show a significant association with the counties (p-value = 0.001). Kisii has the highest proportion of farmers practicing intercropping (71.6%) compared to Migori and Siaya (47.6% and 45.2&) respectively. This may be driven by land use practices, cultural preferences, or ecological conditions, making intercropping more favorable in Kisii.

4.7.1.7 Harvesting Method

Harvesting methods, such as plucking dry pods, green pods, and uprooting, show no significant association across counties (p-value = 0.273). This suggests that traditional harvesting practices for crops like ricebean are consistent across Kisii, Migori, and Siaya.

4.7.1.8 post-harvest practices

While drying practices do not differ significantly across the counties (p-value = 0.378), threshing (p-value = 0.020) and winnowing (p-value = 0.015) methods do. These differences may be due to varying local infrastructure, labor availability, or cultural preferences.

4.7.1. 9 Storage Method

Sacks are the most common storage method across Kisii and Migori (100%). In Siaya, some farmers also use pots (3%) and tins (6.6%), likely reflecting cultural heritage and the need for better pest protection (Laker et al., 2023). Storage methods show a significant association across counties (p-value = 0.000). Siaya uses a wider range of storage options, such as pots and tins, alongside sacks, whereas Kisii and Migori primarily rely on sacks. This variation may be attributed to cultural practices and local resource availability.

4.7.1.10 Ricebean Utilization

Ricebean is primarily used for food provision, with the majority of farmers across all counties rating this usage as "Very High" (Kisii 82.1%, Migori 76.4%, Siaya 78.5%). Kisii also has a high reliance on ricebean for income generation (77.6%), reflecting its growing importance as a cash crop (Mutuma et al., 2020). Ricebean utilization for food provision, income generation, livestock feed, and cultural value shows significant differences between counties (all p-values = 0.000). Ricebean holds significant cultural value in Kisii (68.7%), followed by Migori (53.8%) and Siaya (31.9%). This cultural significance is tied to its role in traditional ceremonies and diets, influencing its continued cultivation despite modern agricultural trends (Van Etten et al., 2021).

Kisii farmers heavily rely on ricebean for income generation (77.6%), reflecting the need for diversified income streams, as noted by Mwanga et al. (2023). Kisii also shows the highest rating for ricebean as livestock feed (68.7%), underscoring its role in improving livestock productivity (Kimani et al., 2022).

4.7.2 Socioeconomic Differences in each County

The results of the socioeconomic analysis across the counties of Kisii, Migori, and Siaya reveal significant disparities in various socioeconomic factors such as gender, income, land size, group membership, market time, access to extension services, farm inputs, and credit facilities as show in Table 29. These disparities, supported by highly significant p-values ($p < 0.001$ for most parameters), suggest meaningful differences across the counties, likely influenced by historical, geographical, and infrastructural factors.

4.7.2.1 Gender

The gender distribution across counties shows significant differences ($p = 0.001$). Siaya has the highest proportion of females (82.2%), while Kisii and Migori have more balanced gender distributions. These gender disparities could reflect regional differences in migration patterns or labor participation rates, particularly in agricultural sectors, where men might dominate larger farms or specific labor-intensive activities, with women forcusing on food security crops as noted in similar research on rural farming populations (Odera et al., 2021).

Table 4. 32: Socioeconomic Differences among the Counties

Parameter	County	Category	Frequency (%)	Chi-Square (p-value)
Gender	Kisii	Female	67.2	0.001
		Male	32.8	
	Migori	Female	63.1	
		Male	36.9	
	Siaya	Female	82.2	
		Male	17.8	
Income	Kisii	36000-45000	20.9	0.000
		46000-55000	32.8	
		56000-65000	10.4	
		Above 65000	9.0	
		Below 35000	26.9	
	Migori	36000-45000	16.9	
		46000-55000	18.5	
		56000-65000	9.2	
		Above 65000	5.1	
		Below 35000	50.3	
	Siaya	36000-45000	18.5	
		46000-55000	1.5	
		56000-65000	0.7	
		Above 65000	2.2	
		Below 35000	77.0	
Land Size	Kisii	2.5-12.5	4.5	0.000
		22.6-32.5	0.0	
		Below 2-5	95.5	
	Migori	2.5-12.5	26.7	
		22.6-32.5	0.0	
		Below 2-5	73.3	
	Siaya	2.5-12.5	14.8	
		22.6-32.5	0.7	
		Below 2-5	84.4	
Group Membership	Kisii	No	80.6	0.000
		Yes	19.4	
	Migori	No	83.6	
		Yes	16.4	
	Siaya	No	60.0	
		Yes	40.0	
Market Time	Kisii	30-60 min	67.2	0.000
		60-90 min	9.0	
		Less than 30 min	23.8	

Parameter	County	Category	Frequency (%)	Chi-Square (p-value)
	Migori	30-60 min	65.6	
		60-90 min	9.7	
		90-120 min	3.1	
		Less than 30 min	19.0	
		More than 120 min	2.6	
	Siaya	30-60 min	43.0	
		60-90 min	14.1	
		Less than 30 min	39.3	
Extension Services	Kisii	Not easy	80.6	0.000
		Easy	7.5	
		Very easy	11.9	
	Migori	Not easy	87.7	
		Easy	7.7	
		Very easy	4.6	
	Siaya	Not easy	61.5	
		Easy	19.3	
		Very easy	19.3	
Farm Inputs	Kisii	Not easy	82.1	0.001
		Easy	14.9	
		Very easy	3.0	
	Migori	Not easy	80.0	
		Easy	15.9	
		Very easy	4.1	
	Siaya	Not easy	68.1	
		Easy	15.6	
		Very easy	16.3	
Credit Facilities	Kisii	Not easy	79.1	0.000
		Easy	17.9	
		Very easy	3.0	
	Migori	Not easy	87.2	
		Easy	9.2	
		Very easy	3.6	
	Siaya	Not easy	77.8	
		Easy	6.7	
		Very easy	15.6	

4.7.2.2 Annual Income

Income levels across the counties are significantly different (p = 0.000). Siaya has the highest percentage of households earning below 35,000 (77.0%), while Migori has a more distributed income spectrum. Kisii, with a notable proportion earning between 46,000-55,000 (32.8%), reflects a higher middle-income bracket in contrast to Siaya. The income disparities may be tied to access to markets, education, and urbanization trends, with studies indicating that proximity to urban areas enhances household income potential (Muchira, 2022).

4.7.2.3 Land Size

Landholding sizes also show substantial differences (p = 0.000). Kisii overwhelmingly has small landholdings (95.5% under 2-5 acres), while Migori and Siaya have larger landholdings of 2.5-12.5 acres in 26.7% and 14.8% of cases, respectively. These differences are crucial as they impact agricultural productivity and mechanization potential, with smaller landholdings often associated with subsistence farming and lower productivity (Mwangi et al., 2020). The results reflect the historical land fragmentation in Kisii, where high population density has led to continuous subdivision of agricultural land.

4.7.2.4 Group Membership

Group membership is significantly different across counties (p = 0.000), with Siaya having the highest proportion of people involved in groups (40.0%). Kisii and Migori show lower engagement in social or farming groups. Group membership is vital for collective bargaining, accessing credit, and training, which significantly affects productivity and resilience in agricultural economics (Muriuki & Njiru, 2023).

4.7.2.5 Market Access (Market Time)

Access to markets, measured by travel time, significantly differs between the counties (p = 0.000). Kisii (67.2%) and Migori (65.6%) have the majority of their populations within 30-60 minutes of a market, whereas Siaya shows more diversity in market access time, with 39.3% being less than 30 minutes away and 43.0% being 30-60 minutes away. Market access is critical for farmers to sell their produce and access inputs, influencing agricultural efficiency and income (Wainaina et al., 2020).

4.7.2.6 Extension Services

Access to extension services, which provide crucial agricultural knowledge and innovations, is significantly varied ($p = 0.000$). Migori reports the lowest ease of access, with 87.7% finding it not easy. In contrast, Siaya shows a higher ease of access, with 19.3% finding it "very easy." This disparity affects the ability to adopt sustainable agricultural practices, which are key to improving productivity and sustainability, as indicated by Gido et al. (2018). Poor access in Migori could be due to geographic isolation or underinvestment in extension networks.

4.7.2.7 Farm Inputs

There is also a significant difference in the ease of accessing farm inputs ($p = 0.001$). Kisii and Migori both report high percentages (82.1% and 80.0%, respectively) of people finding it difficult to access inputs, such as seeds. Siaya shows better access, with 16.3% of respondents reporting ease of access. Easy access to inputs is essential for improving yields and agricultural sustainability, particularly in small-scale farming systems (Maina & Kibor, 2023).

4.7.2.8 Credit Facilities

Credit facilities are critical for enabling farmers to invest in better inputs and technologies. Kisii and Migori show the highest difficulty in accessing credit (79.1% and 87.2%, respectively), while Siaya fares slightly better with a lower percentage (77.8%) reporting difficulty and a higher proportion (15.6%) finding it easy to access credit ($p = 0.000$). Access to credit is known to be a major constraint in rural agricultural systems, and disparities in credit access are often tied to factors like land tenure, financial literacy, and the presence of microfinance institutions (Kamau et al., 2021).

Hypothesis Testing

The study hypothesis tested the influence of socioeconomic factors on adoption of ITK in ricebean production.

The chi-square analysis revealed a significant difference in the regional utilization of Indigenous Technical Knowledge in ricebean production and socioeconomic differences among smallholder farmers in Siaya, Migori, and Kisii Counties, as evidenced by a (p-values <0.005). As a result, the null hypothesis, which states that there are no statistical significant differences in the regional utilization of Indigenous Technical Knowledge in ricebean production and socioeconomic differences among smallholder farmers in Siaya, Migori, and Kisii Countiesis rejected. In contrast, the alternative hypothesis is accepted, demonstrating asocioeconomic variations and utilization of ITK across the three counties.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study was conducted in Migori, Siaya, and Kisii counties in the Nyanza region of Kenya, focusing on smallholder ricebean farmers. The findings highlight key socioeconomic, demographic, and farming-related factors influencing the adoption of Indigenous Technical Knowledge (ITK) in ricebean farming. Using a cross-sectional survey design and data from 397 respondents, the study sheds light on how ITK is integrated into various aspects of ricebean farming, including planting, pest and weed control, and storage, with varying levels of adoption.

5.2 Demographic and Farming Characteristics of Ricebean Farmers

The demographic profile revealed that ricebean farming in the region is dominated by female farmers (70.3%), with an average age of 44 years. Most participants had primary education (57.2%), while only a small fraction had an undergraduate degree (0.8%). The majority were married (80.1%), with household sizes predominantly less than five members (51.9%). The primary occupation was farming, with 88.2% being full-time farmers. A significant portion of the participants earned below Ksh 35,000 annually (55.4%), with crop farming as their main income source (87.4%).

Regarding farming characteristics, most farmers owned community land (50.9%), with small land sizes under 2.5 acres (80.9%) and ricebean farming done on even smaller plots, below 2.5 acres (97.0%). Most respondents were not part of any farming group (75.1%) and typically traveled between 30 and 60 minutes to reach the market (58.2%). Farming experience varied, with 59.4% having between 1 to 5 years of experience, and the majority produced less than 1 bag of ricebean (75%). The Pearson Chi-square analysis indicated significant relationships between ricebean yields and factors such as gender, farming methods, experience, market access, and land size.

5.3 ITK Adoption in Ricebean Farming

The majority of respondents planted during short rains (71.5%), preferring loam soil (76.6%) and fertile land (68.3%) as planting sites. Most farmers prepared the land by clearing, ploughing, harrowing, and planting (57.9%). Row planting was the dominant method (78.8%), with 2-3 seeds per hole being the most common seeding rate (73.6%). Intercropping was practiced by 76.8% of farmers. Weed control strategies included uprooting (94.2%) and mulching (91.7%), while pest control was primarily done through home remedies (51.6%) and handpicking (62%). Farmers preferred brown ricebeans (57.9%) and used sacks for storage (96.7%), storing ricebeans for up to 1-3 years (53.9%). Harvesting occurred mainly when the seeds were immature (70.8%) with pods turning black or brown. The ricebean crop was valued for food provision (78.1% rating it highly), income generation, livestock feed, and enhancing soil fertility (47.1%). Additionally, cultural significance and fuel provision were moderately appreciated aspects of ricebean cultivation.

The data reveals that all respondents utilized Indigenous Technical Knowledge (ITK) in some form, with 62% combining it with Conventional Knowledge (CK) and 38% relying solely on ITK. ITK practices were more widely embraced in areas such as planting timing, land preparation, crop management and post-harvest processing, with over 60% of farmers fully adopting these methods. ITK in seed selection and sowing showed lower full adoption rates, with most farmers partially using these techniques. Weed and pest control through ITK were somewhat adopted, with 44.3% and 33.5% fully adopting these practices, respectively. Other areas like plant nutrition management, harvesting, and storage saw moderate full adoption rates, while food uses and agroecological applications of ricebean had relatively higher uptake. Overall, ITK played a significant role in ricebean farming, though the level of adoption varied across different farming practices. Similar findings were reported by Adhiambo et al. (2023), who noted that while ITK is integral to traditional farming systems, its adoption can vary across different farming practices, particularly in weed and pest management.

5.4 Factors Influencing ITK Adoption by Ricebean Farmers

Key factors influencing ITK adoption included gender, access to extension services, market proximity, and access to marketing services. The regression analysis demonstrated that male farmers were more likely to adopt ITK compared to female farmers (p=0.053), which is consistent with studies suggesting that men often have more access to agricultural resources and information, enabling higher adoption rates. On the other hand, access to extension services and proximity to markets had significant negative effects on ITK adoption (p=0.001). Farmers located farther from markets and those with limited access to extension services were less likely to adopt ITK, supporting previous research showing that extension services and market access are critical drivers of sustainable farming practices.

Interestingly, access to marketing services positively influenced ITK adoption (p=0.001), emphasizing the importance of market-oriented support systems in promoting traditional and sustainable farming methods. This finding is corroborated by Barungi et al. (2020), who found that market access directly influences farmers' decisions to adopt both conventional and indigenous farming technologies.

5.5 Farmers' Perceptions on ITK

Farmers' perceptions of ITK revealed mixed views across various factors. While most respondents agreed on the affordability (mean score 4.33) and environmental friendliness (mean score 4.49) of ITK, there were concerns regarding its effectiveness, with a mean score of 3.63, and comparability to conventional knowledge (CK) (mean score 3.08). These results reflect findings from Mukiri et al. (2022), who reported that while ITK is appreciated for being low-cost and eco-friendly, its perceived effectiveness can vary depending on the farming context.

The regression analysis showed that higher education levels were positively associated with perceptions of ITK's effectiveness (p=0.001) and affordability (p=0.02). Similarly, group membership played a role in shaping perceptions of ITK's availability (p=0.016) and affordability (p=0.048). These findings are consistent with the work of Muchiri et al. (2021), who found that farmers with higher education and those involved in social networks were more likely to view ITK favorably. Additionally, larger household sizes were negatively associated with perceptions of ITK's effectiveness (p=0.012), potentially reflecting resource constraints within larger households, which may limit the ability to implement ITK fully.

5.6 Regional Comparative Application of ITK and Socioeconomic Differences

The analysis reveals significant differences across Kisii, Migori, and Siaya counties in various socioeconomic and agricultural parameters. Gender distribution shows Siaya having the highest percentage of female farmers (82.2%) compared to Kisii (67.2%) and Migori (63.1%), reflecting regional labor dynamics. Income levels vary significantly, with 77% of Siaya households earning below 35,000, compared to 50.3% in Migori and 26.9% in Kisii, where more farmers fall into higher income brackets. Landholding size is much smaller in Kisii, with 95.5% owning less than 2-5 acres, while Migori and Siaya have more farmers with larger land sizes. Group membership is highest in Siaya (40%) and lower in Kisii (19.4%) and Migori (16.4%). Access to markets is also more favorable in Kisii and Migori, where over 65% of farmers are within 30-60 minutes of a market, compared to Siaya's more varied access times.

Agricultural practices further emphasize these disparities. Siaya has better access to extension services (19.3% "very easy"), farm inputs (16.3% "very easy"), and credit facilities (15.6% "very easy") compared to Migori and Kisii, where the majority report challenges in accessing these services. Kisii leads in traditional practices like intercropping (71.6%), and 80.6% rely on home remedies for pest control, compared to 39% in Migori. Planting methods differ, with Kisii (80.6%) and Siaya (90.4%) predominantly using row planting, while Migori leans towards broadcasting. Finally, ricebean is crucial across all counties, with over 76% of farmers in Kisii, Migori, and Siaya rating its use for food provision as "very high," and Kisii leads in utilizing ricebean for income generation (77.6%).

5.7 Conclusion

The demographic profile and farming features of the region's ricebean farmers provide important insights into ricebean production dynamics and the adoption of Indigenous Technical Knowledge (ITK). Female farmers dominate the sector, with relatively small land holdings and inadequate formal education. Despite these problems, ricebean farming remains the predominant occupation, though most farmers earn relatively low annual incomes. The small-scale structure of farming, with communal land ownership and lack of farming groups, emphasizes the traditional and subsistence orientation of ricebean production.

Regarding ITK adoption, it is clear that ricebean farmers rely substantially on ITK techniques, particularly for planting timing, land preparation, crop management, and post-harvest handling. However, the use of ITK is not consistent across all farming activities. Weed and pest control have lower adoption rates, since many farmers mix ITK with Conventional Knowledge (CK), potentially due to perceived limitations in ITK's efficacy. Gender, education, access to extension services, and market proximity all have significant influence on ITK adoption. Male farmers, those with greater education, and those who have access to marketing services are more likely to use ITK. Meanwhile, limited access to extension services and distant markets reduce ITK uptake, thus emphasizing the need for improved agricultural support systems.

Farmers' perception of ITK further highlight its benefits and shortcomings. While ITK is regarded for affordability and environmental benefits, doubts regarding its efficacy remain a concern. Higher education and social networks, such as involvement in farming groups, have a beneficial impact on favorable attitudes of ITK, however larger household sizes may make it more difficult to implement these practices due to budget restrictions.

There is also significant socioeconomic disparities across Kisii, Migori, and Siaya counties, particularly in areas such as income, land size, market access, extension services, and access to farm inputs and credit facilities. These factors are interlinked and impact agricultural productivity and rural livelihoods. Policymakers and development practitioners should focus on improving access to credit, extension services, and markets, particularly in Migori and Kisii, where constraints are more severe. Addressing these disparities is crucial for enhancing agricultural productivity, reducing poverty, and improving food security in these regions.

5.8 Recommendations

Integration of ITK and Modern Farming Practices: Given the complementary use of ITK and CK by many farmers, research and development should focus on creating integrated systems that blend traditional practices with modern farming technologies. This can enhance productivity while preserving environmentally friendly and cost-effective farming practices.

Strengthening Agricultural support Services: Given that limited access to extension services negatively impacts ITK adoption, efforts should be made to improve outreach programs. Tailored training sessions and workshops that emphasize ITK's benefits, particularly in areas like pest and weed management, should be prioritized. Similarly, promotion of ricebean as an important crop for diversification especially in drought prone areas need to be enhanced. Also, Since proximity to markets and marketing services play a crucial role in ITK adoption, improving infrastructure and access to markets is vital. This could involve the government setting up local collection points, improving transport infrastructure, or providing incentives for farmers to access larger, more profitable markets.

Enhance Educational and Training Programs: Since female farmers dominate the sector but are less likely to adopt ITK than male farmers, specific programs aimed at empowering women with resources and knowledge are needed. Also, with most of the farmers are of primary level of education, access to agricultural inputs, training, and market linkages should be enhanced and be made more equitable.

Focus on Regional Equity: Since disparities are witnessed in the different counties of study in terms of utilization of a ITK and socioeconomic characterristics, there is need for the government to focus in the limitations experienced by the farmers in each county and encourage more interaction the among farmers.

5.9 Recommendations for Further Research

Sustainability and Impacts of integrating ITK and modern farming: Research should focus on the long-term sustainability of integrating ITK with modern agricultural practices in ricebean farming, particularly in terms of productivity, environmental impact, and food security. Studies that track the environmental benefits of integration over time can provide a stronger case for its widespread adoption.

Effectiveness of ITK in Specific Farming Practices: Future research should explore the effectiveness of ITK across different farming contexts and practices, particularly in areas like pest and weed management, where adoption rates are lower. Comparative studies between ITK and CK can provide deeper insights into how these methods complement each other and where improvements can be made.

Impact of Education, Gender and Social Networks on ITK Adoption: Further studies should investigate how education, gender and social networks influence ITK adoption across diverse demographics and regions. Research into the role of informal education, gender and farmer-to-farmer knowledge transfer could offer new approaches to scaling ITK adoption.

REFERENCES

Abtew, A., Niassy, S., Affognon, H., Subramanian, S., Kreiter, S., Garzia, G. T., & Martin, T. (2016). Farmers' knowledge and perception of grain legume pests and their management in the Eastern province of Kenya. *Crop Protection*, *87*, 90-97.

Abubakar, B.Z., D.H. Yakubu, F.J. Yelwa & S.A. Abubakar (2009). The role of Cooperative Society in Community Development: A Case Study of Agae Local Government Area, Niger State. Proceedings of the 23rd Annual Conference of the Farm Management Association of Nigeria, Sokoto. Pp211-215.

Abukutsa-Onyango MO (2012) Good agricultural practices for underutilized vegetables in sub-Saharan Africa: current status anwamed future perspectives. In: Scripta Horticulturae number 15, International Society for Horticultural Science (ISHS), Leuven 1, Belgium

Acharya BK. (2008) Cultivation and use of ricebean. A case study of Dang District, Nepal (Master's thesis, The University of Bergen).

Addaney, M., Sarpong, G. E., & Akudugu, J. A. (2021). Climate change adaptation in Akropong, Ghana: experiences of female smallholder farmers. Journal of Land and Rural Studies, 9(2), 344-367.

Adebayo K, Lamboll R, Westby A. (2009) Social Implications of the Development of Cassava Postharvest Systems in Africa.Expert Consultation at the NaturalResource Institute;.Available:http://www.nri.org/projects/GCPMD/files/2 Adebayo paper.pdf). Universityof Greenwich, United Kingdom.

Adedipe, N. O., Okuneye, P. A., & Ayinde, I. A. (2004). The relevance of local and Indigenous Technical Knowledgefor Nigerian agriculture. Paper presented at the International Conference on Bridging Scales and Epistemologies: Linking Local Knowledge with Global Science in Multi-scale Assessments, Alexandria, Egypt.

Adhiambo, M., Onyango, C., & Ouma, J. (2023). Adoption of Indigenous Technical Knowledge in Pest and Weed Management among Smallholder Farmers in Kenya. *Journal of Sustainable Agriculture*, 15(3), 45-58.

Ahuja, A. K. ; Kakkar, V. K. ; Gupta, B. K.Nutritional evaluation of Ricebean in buffalo calves. Indian J. Anim. Nutr., 2001;18(2): 172- 175

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211.

Alcorn, Janis B. (1995) 'Ethnobotanical Knowledge Systems – A Resource for Meeting Rural Development Goals.' In Warren, D. Michael, L. Jan Slikkerveer, and David Brokensha, eds. 1995. The Cultural Dimension of Development: Indigenous Technical KnowledgeSystems. London: Intermediate Technology. 1 – 12.

Alemu, T., Birru, A., & Assefa, T. (2020). Traditional harvesting methods and post-harvest losses of legumes in East Africa. *African Journal of Agricultural Research*, 15(3), 123-135.

Ali, S., Liu, Y., & Ishaq, M. (2020). Adoption of modern agricultural technologies in the presence of traditional systems: Evidence from Pakistan. *Sustainability*, 12(5), 1942. https://doi.org/10.3390/su12051942

Anang, B. T., & Yeboah, R. W. (2019). Determinants of off-farm income among smallholder rice farmers in Northern Ghana: Application of a double-hurdle model. Advances in Agriculture, Article ID 7246176, 7 pages, 2019. https://doi.org/10.1155/2019/7246176.

Andati, P., Majiwa, E., Ngigi, M., Mbeche, R., & Ateka, J. (2022). Determinants of adoption of climate smart agricultural technologies among potato farmers in Kenya: Does entrepreneurial orientation play a role?. *Sustainable Technology and Entrepreneurship*, *1*(2), 100017.

Andersen, P. (2012). Challenges for under-utilized crops illustrated by ricebean (Vigna umbellata) in India and Nepal. *International journal of agricultural sustainability*, *10*(2), 164-174.

Angrosino, M. (2007). *Doing ethnographic and observational research*. Sage.

Anino, C., Onyango, A. N., Imathiu, S., Maina, J., and Onyangore, F. (2019). Chemical composition of the seed and 'milk' of three common bean (Phaseolus vulgaris L) varieties. J Food Meas Charact. 13, 1242–1249. doi: 10.1007/s11694-019-00039-1

Annan, B. O. (2018). Farming technology adoption by smallholder farmers in Ghana. Review of Agriculture and Applied Economics, 2. 41-47

Anthony O.Esilaba, Cyrus Githunguri, Stephen Kimani, Peterson Njeru, John Lekasi, Fredah Maina, Maina Muniafu, Joseph Miriti, Charles Gachene, Mary Baaru, Anne Muriuki, Sospeter Nyamwaro, Catherine Kibunja, Nesbert Mangale (2013) "Transforming rural livelihoods in Africa: How can land and water management contribute to enhanced food security and address climate change adaptation and mitigation?" Proceedings of the 27th Soil Science Society of East Africa and the 6th African Soil Science Society Conference 20 – 25 October 2013 Nakuru, Kenya

application in pest management in the western mid-hill of Nepal. *SAARC Journal of*

Assouto, A. B., & Houngbeme, D. J. L. (2023). Access to credit and agricultural productivity: Evidence from maize producers in Benin. Cogent Economics & Finance, 11(1). https://doi.org/10.1080/23322039.2023.2196856

Astorga-Rojas, D. (2024). Access to Markets and Technology Adoption in the Agricultural Sector: Evidence from Brazil.

Atsriku, G. E. (2020). The adoption of agriculture technology in small-scale farming in the Adumasa community in Ghana. *Agricultural, Food and Environmental Studies. The Hague, The Netherlands*.

Atteh, O.D. (1980). Resources and decisions. Peasant Farmer Agriculture Management and its relevance for Rural Development Planning, in Kwata, state, Nigeria. PHD Thesis University of London.

Awuor Ponge (2013) Integrating Indigenous Technical Knowledgefor Food Security: Perspectives from the Millennium Village Project at Bar-Sauri in Nyanza Province in Kenya. A Paper presented to the African Research and Resource Forum (ARRF) and the Economic Policy Research Centre (EPRC) for the International Conference on Enhancing Food Security in the Eastern and Horn of Africa regions. A Conference held at the Imperial Royale Hotel in Kampala, Uganda on 16 – 17 November 2011.

Ayub, M.; Tanveer, A. ; Nadeem, M. A. ; Shah, S. M. A. Studies on the fodder yield and quality of sorghum grown alone and in mixture with Ricebean., 2004;Pak. J. Life Soc. Sci., 2(1): 46- 48

Babatunde, R. O., & Qaim, M. (2010, May). Off-farm labor market participation in rural nigeria: driving forces and household access. In *Contributed paper for the 5th IZA/World Bank Conference: Employment and Development, May 03–May 04, 2010, Cape Town, South Africa*.

Bandura A. 2007. Albert Bandura: biographical sketch. <http://www.des.emory.edu/mfp/bandurabio.html> 17 May 2010.

Bandura, A. (1977). Social learning theory. Englewood Cliffs: Prentice Hall.

Barnes AP, Soto I, Eory V, Beck B, Balafoutis A, Sánchez B, Vangeyte S, van der Fountas T, Wal, and Gómez-Barbero M, (2019) Exploring the adoption of precisionagricultural technologies: a cross regional study of EU farmers. Land use policy 80:163–174

Barungi, M., Kaizzi, K., & Ogwal, P. (2020). Market Access and Its Influence on Adoption of Sustainable Agricultural Practices Among Smallholder Farmers in Uganda. *African Journal of Agricultural Economics*, 8(1), 12-26.

Agriculture, 18(1), 251-261. https://doi.org/10.3329/sja.v18i1.48397

Begho, T., Glenk, K., Anik, A. R., & Eory, V. (2022). A systematic review of factors that influence farmers' adoption of sustainable crop farming practices: Lessons for sustainable nitrogen management in South Asia. *Journal of Sustainable Agriculture and Environment*, *1*(2), 149-160.

Below, T. B., Schmid, J. C., & Sieber, S. (2015). Farmers' knowledge and perception of climatic risks and options for climate change adaptation: a case study from two Tanzanian villages. *Regional environmental change*, *15*, 1169-1180.

Bhandari, P. (2023, June 22). *Multistage Sampling | Introductory Guide & Examples.* Scribbr. Retrieved July 30, 2024, from https://www.scribbr.com/methodology/multistage-sampling/

Birch, I. (2018). Agricultural productivity in Kenya: barriers and opportunities. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies. https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://assets.publishing.service.gov.uk/media/5c70028ee5274a0ecbe9a1c2/483_Agricultural_Productivity_in_Kenya_Barriers_and_Opportunities.pdf&ved=2ahUKEwjT5NSV29yFAxWryAIHHWTMASoQFnoECEYQAQ&usg=AOvVaw2WxKqTimVm6UGRQC8XkNnu

Bora, A., Chhetri, S., & Tamang, S. (2021). Indigenous knowledge and its role in sustainable agriculture. *Journal of Environmental Management*, 287, 112267. https://doi.org/10.1016/j.jenvman.2021.112267

Borthakur, A., & Singh, P. (2012, November). Indigenous Technical Knowledge (ITK) and their role in sustainable grassroots innovations: An illustration in Indian context. In *Proceedings of International Conference on Innovation & Research in Technology for Sustainable Development (ICIRT 2012)* (Vol. 38).

Breidlid, A. (2009). Culture, Indigenous Technical Knowledgesystems and sustainable development: A critical view of education in an African context. International Journal of Educational Development, 29, 140–148.

Briggs, J. (2005). The use of Indigenous Technical Knowledgein development: Problems and challenges. Progress in Development Studies, 5(2), 99–114.

Brokensha, D., Warren, D. & Werner, O. (eds.) (1980) Indigenous Technical KnowledgeSystems and Development. Lanham, MD: University Press of America.

Bwambale, N. (2015). *Farmers ' Knowledge , Perceptions , and Socioeconomic Factors Influencing Decision Making For Integrated Soil Fertility Management Practices in Masaka and Rakai Districts , Central Uganda*.

Caspar, R., Peytcheva, E., Yan, T., Lee, S., Liu, M., & Hu, M. (2016). Pretesting. CrossCultural Survey Guidelines. August

Castillo, G. T. (1998). A social harvest reaped from a promise of springtime: Userresponsive, participatory agricultural research in Asia. In N. G. Röling, & M.A. E. Wagemakers (Eds.), Facilitating sustainable agriculture: Participatory learning and adaptive management in times of environmental uncertainty (pp. 191–213). Cambridge, UK: Cambridge University Press.

Central Kenya regions (Doctoral dissertation, MS thesis].[Nairobi (Kenya)]: Kenyatta

Chaiwong, U. ; Yimyam, N. ; Rerkasem, K. ; Rerkasem, B. Green manures for highland paddy in a mountainous area. J. Nat. Sci., 2012;11(1): 103-168

Chakravarty, R. (2010). Preserving traditional knowledge: Initiatives in India. IFLA Journal, 36(4), 294–299.

Chambers, R. (1983) Rural Development: Putting the Last First. London: Longman.

Chambers, R. (1994) “Participatory Rural Appraisal (PRA): Challenges, Potentials and Paradigm.” World Development. 22 (10).

Chandel, K. P. S. ; Arora, R. K; Pant, K. C. (1988) Ricebean: A potential grain legume. NBPGR Sci. Monograph No.12,; National Bureau Of Plant Genetic Resources , New Delhi

Chanthakhoun, V. ; Wanapat, M. (2010) Effect of legume (Phaseolus calcaratus) hay supplementation on rumen cellulolytic bacterial populations in swamp buffaloes investigated by the real-time PCR technique. J. Anim. Vet. Adv.,;9(11): 1654-1659

Chanthakhoun, V. ; Wanapat, M. ; Wachirapakorn, C. ; Wanapat, S.,. (2011) Effect of legume (Phaseolus calcaratus) hay supplementation on rumen microorganisms, fermentation and nutrient digestibility in swamp buffalo. Livest. Sci.,;140(1/3): 17-23

Chanza, C., Tchuwa, F., Anugwa, I. Q., Liverpool-Tasie, S., Ukamaka, D. M., Agwu, A. E., ... & Sasidhar, P. V. K. (2023). Strengthening Agricultural Extension Training.

Chatterjee, B. N. ; Dana, S. Ricebean (Vigna umbellata (Thumb.) Owhl and Ohashi. Trop. Gr. Leg. Bull. N°10, 1977;Int. Grain Leg. Info Center

Chaudhuri, A. B. ; Singh, R. P. ; Gupta, B. N. (1981) Chemical composition and nutritive value of Ricebean straw. Indian J. Dairy Sci.,; 33(4): 438-442

Chawe, K., Venkataramana, P., & Ndakidemi, P. (2019). Assessment of Farmers' Indigenous Technical Knowledgeand Preferences: A Tool for Sustainable Lablab Bean (Lablab purpureus. L. Sweet) Improvement and Utilization in Northern Tanzania.

Cheplogoi, S. K., Ombati, J. M., Udoto, M. O., & Njoro, K. (2021). Diversification of indigenous agricultural practices and implications on household food security: Practices and lessons from local communities of Baringo County, Kenya. *International Journal of Advanced Research*, 9(10), 1232-1240. RUFORUM Repository

Chhetri, N., Pandey, R., & Shrestha, S. (2021). Indigenous knowledge and climate change adaptation in the Himalayas. *Climate and Development*, 13(3), 255-267. https://doi.org/10.1080/17565529.2021.1918054

Chianu, J. N., Tsujii, H., & Nkonya, E. (2021). Ricebean: A nutritious legume for food security in smallholder farming systems. *Food and Nutrition Bulletin*, 42(1), 54-63.

Chisango, F., Muchai, D., & Maponya, P. (2021). Land Size and the Adoption of Sustainable Farming Technologies in Sub-Saharan Africa. *Journal of Agricultural Science and Technology*, 23(2), 103-120.

Chweya JA, Eyzaguirre PB (1999) The biodiversity of traditional leafy vegetables. International Plant Genetic Resources Institute, Rome

Compton, J. (1989) 'The Integration of Research and Extension'. In J.L. Compton. (Ed.) The Transformation of International Agricultural Research and Development. Boulder: Lynne Rienner. pp. 113-136.

Connelly, L. M. (2008). **Pilot studies.** *MedSurg Nursing, 17*(6), 411-412.

D. Michael Warren and Kristin Cashman (1988) Indigenous Technical Knowledgefor Sustainable Agriculture and Rural Development. International Institute for Environment and Development Gatekeeper Series No. 10

Dahipahle, AV & Kumar, Sandeep & Sharma, Neha & Singh, Hari & Kashyap, Sanjeev & Meena, Hemraj. (2017). Ricebean - A Multipurpose, Underutilized, Potential Nutritive Fodder Legume - A Review. Journal of Pure and Applied Microbiology. 11. 433-439. 10.22207/JPAM.11.1.57.

Das, P. K., Bhavani, R. V., & Swaminathan, M. S. (2014). A farming system model to leverage agriculture for nutritional outcomes. *Agricultural Research*, *3*(3), 193-203.

Devi, R., Pandit, A. and Kashyap, D. (2014). Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam. Indian Journal of fisheries, 61(3):104-110

Diana Akullo and Rogers Kanzikwera (2007) Indigenous Technical Knowledgein Agriculture: A case study of the challenges in sharing knowledge of past generations in a globalized context in Uganda. World Library and Information Congress: 73rd IFLA General Conference and Council 19-23 August 2007, Durban, South Africa http://www.ifla.org/iv/ifla73/index.html

Dissanayake, C. A. K., Jayathilake, W., Wickramasuriya, H. V. A., Dissanayake, U., & Wasala, W. M. C. B. (2022). A Review on Factors Affecting Technology Adoption in Agricultural Sector. *Journal of Agricultural Sciences (Sri Lanka)*, *17*(2).

Dixon, J., Nalley, L., Kosina, P., & La Rovere, R. (2021). The role of resistant varieties in reducing crop losses due to pests and diseases. *Plant Protection Quarterly*, 26(2), 97-105.

Dixon, J., Taniguchi, K., & O'Brien, P. (2021). Enhancing the resilience of smallholder farmers: The role of resistant varieties. *Agricultural Systems, 188,* 102915. https://doi.org/10.1016/j.agsy.2021.102915

Dube, T.; Phiri, K. (2013) Rural livelihoods under stress: The impact of climate change on livelihoods in South Western Zimbabwe. Am. J. Contemp. Res., 3, 11–25.

Duke, J. A., (1981) Handbook of legumes of world economic importance.,;Plenum Press, New York, USA, 345 p.

Duke, J.A. (1992), Handbook of Edible Weeds, CRC Press, Boca Raton.

Echo Asia Impact Center. (2012) The use of various green manure/cover crops.;ECHO Asia Impact Center, Chiang Mai, Thailand

Ecoport, (2014). Ecoport database. 2014;Ecoport

Eklund, J. (2009). Agroforestry as a tool toward sustainable development in Babati district (Unpublished bachelor's thesis). Södertörn University College, Stockholm, Sweden. Retrieved from http://sh.diva-portal.org/smash/get/diva2:272572/FULLTEXT01.pdf

Emery, A.R. (2000). Guidelines: Integrating Indigenous Technical Knowledgein project planning and implementation. Nepean, Canada: KIVU Nature. Retrieved from http://www.cbnrm. net/pdf/emery_ar_001_ik.pdf

Enujiugha, V. N., Oluwole, T. F., Talabi, J. Y., & Okunlola, A. I. (2014). Selected bioactive components in fluted pumpkin (Telfairia occidentalis) and amaranth (Amaranthus caudatus) leaves. *American Journal of Experimental Agriculture*, *4*(9), 966-1004.

Evalindigenous (2021). *The EvalIndigenous Network for Evaluation FINAL Protocol – Indigenous African Ethical Protocol for Evaluations*. *January*.

Finid, O. G., Kariaga, M. G., Palapla, V., & Nandi, O. M. J. (2022). A Gender Analysis on the Involvement of Farmers in Rice-bean (Vigna umbellata) Production Activities in the Selected Regions of Nyanza, Kenya. Asian Journal of Agricultural Extension, Economics & Sociology, 40(9), 340–351. https://doi.org/10.9734/ajaees/2022/v40i931012

Food and Agricultural Organization (FAO) (2008). Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required. In Proceedings of the High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, Rome, Italy.

Gachene, C. K., Karuku, G. N., & Wambua, S. (2022). Climatic variability and its influence on local farming practices: A case study from Western Kenya. *Journal of Climate and Agriculture*, 15(4), 78-90.

Gachene, C., Muthoni, F., & Njeru, J. (2022). Climate variability and its impact on agriculture in East Africa: Lessons from Kenya. *Climate and Development, 14*(2), 108-115. https://doi.org/10.1080/17565529.2021.1885432

Gbegeh, B. D., & Akubuilo, C. J. C. (2013). Socioeconomic determinants of adoption of yam minisett by farmers in Rivers state, Nigeria. *Wudpecker Journal of Agricultural Research*, *2*(1), 033-038.

Getyengana, K., Kamba, E. T., Mkwanazi, M. V., Ndlela, S. Z., Mwale, M., & Chimonyo, M. (2023).Factors influencing the integration of indigenous and conventional knowledge of water security for livestock. Tropical animal health and production, 55(2), 136. https://doi.org/10.1007/s11250-023-03529-z

Gichangi, A.; Birachi, E.; Wambua, S.; Kavoi, J.; Karanja, D.; Muriithi, F.; Mutua, M. (2019) factors influencing smallholder farmers' inputs use in major bean production corridors in kenya. Journal of Agriculture & Food Science, 2019, Vol 17, Issue 1, p136. DOI: 10.4314/jafs.v17i1.11

Gichuki, C. N., Han, J., & Njagi, T. (2020). The impact of household wealth on adoption and compliance to GLOBAL GAP production standards: Evidence from smallholder farmers in Kenya. *Agriculture*, *10*(2), 50.

Gido, E. O., Ayuya, O. I., Owuor, G., & Bokelmann, W. (2018). Role of access to extension services on agricultural productivity among smallholder farmers in Kenya. *Journal of Rural Studies*, 64, 76-83.

Göhl, B., (1982) Les aliments du bétail sous les tropiques. FAO, Division de Production et Santé Animale,;Roma, Italy

Grenier, Louise. (1998) Working with Indigenous Knowledge: A Guide for Researchers

Guo, Guancheng & Wen, Qiyu & Zhu, Jingjuan. (2015). The Impact of Aging Agricultural Labor Population on Farmland Output: From the Perspective of Farmer Preferences. Mathematical Problems in Engineering. 2015. 1-7. 10.1155/2015/730618.

Gupta, A. (1992) Building upon people's ecological knowledge: Framework for studying culturally embedded CPR institutions. Ahmedabad: Indian Institute of Management, Center for Management in Agriculture.

Habtewold, T. M., & Heshmati, A. (2023). Impacts of improved agricultural technology adoption on welfare in Africa: A meta-analysis, Heliyon,Volume 9, Issue 7, e17463, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2023.e17463.

Hambati, H. (2021). The role of indigenous knowledge systems (IKS) in improving farm productivity in Kainam Village, Mbulu District–Tanzania. *University of Dar es Salaam Library Journal*, 16(2), 34-52. AJOL.

Haug, W., & Schilling, E. (2020). "Diverse Uses of Ricebean: A Review." *Agricultural Research Reviews*.

HDRA - the organic organization. (2002). Green manures/cover crops. *Tropical Advisory Service*.https://sriwestafrica.files.wordpress.com/2014/05/green-manures-cover-crops_hdra1.pdf

Hemp, C. (2005). The Chagga home gardens: Relict areas for endemic Saltatoria species (Insecta: Orthoptera) on Mount Kilimanjaro. Biological Conservation, 125, 203–209.

Hindu. Sci. Tech.,; Online ed. India's Nat. Newspaper https://www.google.com/url?89978449

Hu, Y., Li, B., Zhang, Z., & Wang, J. (2022). Farm size and agricultural technology progress: Evidence from China. *Journal of Rural Studies*, *93*, 417-429. influencing smallholder pumpkin production, consumption and marketing in Eastern and integrated seed sector development approach. Journal of Sustainable Development: 161 Vol. 8, No. 2; 2015. doi:10.5539/jsd. v8n2p161

International Institute of Rural Reconstruction (1996). Recording and using indigenous knowledge: A manual. Silang, Philippines: IIRR.

Ismail, Z., & Fakir, T. (2004). Trademarks or trade barriers? Indigenous Technical Knowledgeand the flaws in the global IPR system. International Journal of Social Economics, 31(1/2), 173–194.

Jamal, Seyed & Hosseini, Jamal & Zand, Azita & Arfaee, Masoumeh. (2011). Determining factors influencing the adoption of indigenous knowledge in agriculture water management in dry areas of Iran. African Journal of Agricultural Research. 10.13140/2.1.4941.8885.

Jarvis, D. I., Brown, A. H., Cuong, P. H., Collado-Panduro, L., Latournerie-Moreno, L., Gyawali, S., Tanto, T., Sawadogo, M., Mar, I., Sadiki, M., Thi, H. T. X., Rijal, D., Bajracharya, J., Castillo, F., Rios Labrada, H., Schoen, D., Sthapit, B., De Santis, P., & Fadda, C. (2016). *Crop genetic diversity in the field and on the farm: Principles and applications in research practices*. Yale University Press.

Jha, R., Mishra, S., & Giri, B. (2020). Indigenous Technical Knowledge for sustainable agriculture in India. *Sustainable Agriculture Reviews*, 41, 57-72. https://doi.org/10.1007/978-3-030-39175-1_3

Joshi, K. D. ; Bhanduri, B. ; Gautam, R. ; Bajracharya, J. ; Hollington, P. B. (2008) Ricebean: a multi-purpose underutilized legume. In: Smartt, J. Haq, N. New crops and uses: their role in a rapidly changing world. CUC,;UK pp: 234-248

Kafle, B. (2010). Determinants of adoption of improved maize varieties in developing countries: A review. *International Research Journal of Applied and Basic Sciences*, *1*(1), 1-7.

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing*, *72*(12), 2954-2965.

Kalita, B., Dutta, A., Bhagabati, S. K., & Sharma, A. (2010). *Indigenous Technical Knowledge for fish harvesting in Karbi-Anglong district of Assam*. *9*(April), 252–255.

Kamau, C. M., Mwangi, S., & Ndungu, G. K. (2021). Determinants of credit access among smallholder farmers in Kenya: A case study of Nakuru County. *African Journal of*

Agricultural and Resource Economics, 16(1), 85-102.

Kansiime, M. K., Wambugu, S. K., & Owuor, G. (2019). Agricultural knowledge systems and adaptation to climate change in smallholder farming systems in East Africa. *Land Use Policy*, 88, 104130. https://doi.org/10.1016/j.landusepol.2019.104130

Karanja, D. M., Njeru, E. M., & Macharia, J. M. (2021). Enhancing resilience to climatic changes through locally adapted seeds in Kenya. *Journal of Agricultural Science and Technology*, 13(5), 203-215.

Karanja, N., Njoroge, J., & Mwanga, D. (2021). Seed sovereignty: Implications for food security in rural Kenya. *Journal of Rural Studies, 88,* 245-252. https://doi.org/10.1016/j.jrurstud.2021.03.014

Karimi, V., Karami, E., & Keshavarz, M. (2020). Climate change adaptation strategies in livestock systems: A systematic review. *Sustainability*, 12(4), 1517. https://doi.org/10.3390/su12041517

Katoch, R. (2020). Nutraceutical Potential of Ricebean. In *Ricebean* (pp. 293-314). Springer, Singapore.

Kaur, A. ; Kaur, P. ; Singh, N. ; Singh Virdib, A. ; Singh, P. ; Chand Ranac, J. (2013) Grains, starch and protein characteristics of Ricebean (Vigna umbellata) grown in Indian Himalaya regions.;Food Res. Int., 54(1): 102–110

Keller, G.B., Mndiga, H. and Maass, B.L. (2005), “Diversity and genetic erosion of vegetables in Tanzania from the farmer’s point of view”, Plant Genetic Resources, Vol. 3 No. 3, pp. 400-413.

Khadka, K., & Acharya, B. D. (2009). Cultivation practices of ricebean. Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal. http://www.ricebean.org/deliverables/LI-BIRD%20ricebean%20cultivation.pdf.

Khadka, K., & Khanal, A. R. (2013). Ricebean in home gardens of the Chitwan Valley. *Journal of Agriculture and Environment*, 14, 141-148. NepJOL

Khanal, A. R. ; Khadka, K. ; Poudel, I. ; Joshi, K. D. ; Hollington, P.,. (2009) Report on farmers' local knowledge associated with the production, utilization and diversity of Ricebean (Vigna umbellata) in Nepal.;In: The Ricebean Network: Farmers Indigenous Technical Knowledgeof Ricebean in Nepal (report N°4), EC. 6th FP, Project no. 032055, FOSRIN (Food Security through Ricebean Research in India and Nepal)

Khanal, A. R., Khadka, K., Poudel, I., Joshi, K. D., & Hollington, P. A. (2007). Food security through ricebean research in India and Nepal (FOSRIN): Report 3. Farmers' local knowledge associated with the production, utilization, and diversity of ricebean (Vigna umbellata) in Nepal. Local Initiatives for Biodiversity, Research and Development, Rampur, Chitwan, Nepal: Institute of Agriculture and Animal Sciences, and Bangor, Wales, UK: CAZS Natural Resources, College of Natural Sciences, Bangor University.

Khatri, S., Khanal, S., & Kafle, S. (2021). Perceived attributes and adoption of Indigenous Technological Knowledge on agriculture-a case study from Bhirkot municipality of Syangja District, Nepal. *Cogent Food & Agriculture*, *7*(1), 1914384.

Kimani, J., Njuki, J., & Karanja, N. (2022). Enhancing livestock productivity through improved feeding strategies. *Tropical Animal Health and Production, 54*(3), 102-113. https://doi.org/10.1007/s11250-021-02856-y

Kimani, P. M., Mwangi, J. K., & Wachira, A. M. (2022). Improving livestock productivity through enhanced feed quality in smallholder systems. *East African Journal of Animal Science*, 25(2), 110-125.

Kiplang'at, Joseph & Rotich, Daniel. (2012). Mapping and auditing agricultural Indigenous Technical Knowledgein Kenya: a case study of the Uasin Gishu and Keiyo districts. Innovation. 44. 81 - 100.

Kosmowski, F., Aragaw, A., Kilian, A., Ambel, A., Ilukor, J., Yigezu, B., & Stevenson, J. (2019). Varietal identification in household surveys: Results from three household-based methods against the benchmark of DNA fingerprinting in Southern Ethiopia. *Experimental Agriculture*, 55(3), 371–385. https://doi.org/10.1017/S0014479718000030

Krishna, G. ; Mandal, A. B. ; Paliwal, V. K. ; Yadav, K. R.,. (1989) Ricebean (Vigna umbellata) as feed for adult sheep.;Indian J. Anim. Nutr., 6 (4): 365-368

Kristjanson, P., Reid, R. S., Dickson, N., Clark, W. C., Romney, D., Puskur, R., et al. (2009). Linking international agricultural research knowledge with action for sustainable development. Proceedings of the National Academy of Sciences (PNAS), 106(13), 5047–5052. Retrieved from http://www.pnas.org/content/106/13/5047.full

Krueger, R. A., & Casey, M. A. (2015). *Focus Groups: A Practical Guide for Applied Research* (5th ed.). Sage Publications

Laker, S., Muthamia, K. M., & Ndegwa, J. (2023). Traditional storage methods and their impact on grain preservation in Kenya. *Journal of Rural Development and Innovation*, 16(2), 45-58.

Langat, S. C., Njogu, M. K., & Gathungu, G. K. (2024). Effect of socio-economic and institutional factors on common bean commercialization among smallholder farmers in Chepalungu sub-county, Bomet County, Kenya.

Lansing, MI: Alliance for African Partnership, Michigan State University.

Lawn, R J (1995)The Asiatic Vigna species. In: Smartt, J. and Simmonds, N.W. (eds) Evolution of Crop Plants.,; Longman Scientific and Technical, Harlow, UK. ISBN 0-582-08643-4, pp. 321- 326.

Leerzem, S. V. (2015). *Market Access and the Adoption of Integrated Soil Fertility Management in Mbeya Region, Tanzania* (Doctoral dissertation, Sl: sn).

Lekshmi, P. S. (2009). Indigenous Technical Knowledge and ancient proverbs of the coastal fisher folk of Kerala and their implications.

Lewis, J. A. (2008). The power of knowledge: Information transfer and açaí intensification in the peri-urban interface of Belém, Brazil. Agroforestry Systems, 74, 293–302.

Lwoga, E. T., Ngulube, P., & Stilwell, C. (2010, January). The Management of Indigenous Technical Knowledgewith Other Knowledge Systems for Agricultural Development: Challenges and Opportunities for Developing Countries. Scientific and Technical Information and Rural Development-IAALD XIIIth World Congress, Montpellier..

Mabhaudhi T., Modi A.T., Beletse Y.G. ISHS (2011) Acta Horticulturae 979: II International Symposium on Underutilized Plant. Species: Crops for the Future-Beyond Food Security. ISHS (International Society for Horticultural Science); Leuven, Belgium: Growth response of selected taro [Colocasia esculenta (L.) schott] landraces to water stress.

Mabhaudhi, T. & Chibarabada, Tendai Polite & Chimonyo, Vimbayi & Murugani, Vongai & Pereira, Laura & Sobratee, Nafiisa & Govender, Laurencia & Slotow, Rob & Modi, Albert. (2019). Mainstreaming Underutilized Indigenous and Traditional Crops into Food Systems: A South African Perspective. Sustainability. 11, 72. 1-22. 10.3390/su11010172.

Mabhaudhi, T.; Chimonyo, V.G.P and Modi, A.T. (2017) Status of Underutilised Crops in South Africa: Opportunities for Developing Research Capacity. Sustainability, 9, 1569.

Mafongoya, P. L., & Ajayi, O. C. (2017). Indigenous Technical Knowledgeand climate change: Overview and basic propositions. *Indigenous Technical Knowledgesystems and climate change management in Africa*, *17*, 17-28.

Maina, J. W., & Kibor, S. J. (2023). Farm input access and its impact on agricultural productivity in rural Kenya. *Journal of Agricultural Economics and Development*, 8(2), 145-158.

Mairura, F. S., Mugendi, D. N., Mwanje, J. I., Ramisch, J. J., Mbugua, P. K., & Chianu, J. N. (2008). Scientific evaluation of smallholder land use knowledge in Central Kenya. Land Degradation and Development, 19, 77–90.

management & host resistance against root rot and wilt disease in Rice bean (Vigna

Masca, U., Mirriam, K. N., & Bor, E. K. (2022). Does access to credit influence the adoption of good agricultural practices? The case of smallholder potato farmers in Molo Sub-County, Kenya. *Journal of Agricultural Extension and Rural Development*, *14*(1), 24-32.

Mashall, B. & Miguel, E. (2014*). Innovative Finance for technology adoption in Western Kenya.* Innovation for poverty publication from; www.povertyactionlab.org

Massresha, S. E., Lema, T. Z., Neway, M. M., & Degu, W. A. (2021). Perception and determinants of agricultural technology adoption in north shoa zone, Amhara regional state, Ethiopia. *Cogent Economics & Finance*, *9*(1), 1956774.

Mayer, R. E. (2005). The Cambridge handbook of multimedia learning. Cambridge: Cambridge University Press.

Mbow, C., Reisinger, A., Canadell, J., & O'Brien, P. (2019). *The role of indigenous knowledge in sustainable development*. Springer.

Mchombu, K. J. (2003). Information dissemination for development: An impact study. Information Development, 19(2), 111–125.

Mdoda, L., & Gidi, L. (2023). Impact of Land Ownership in Enhancing Agricultural Productivity in Rural Areas of Eastern Cape Province. South African Journal of

Agricultural Extension (SAJAE), 51(2), 1–23. https://doi.org/10.17159/2413-3221/2023/v51n2a11553

Melash, A. A., Bogale, A. A., Migbaru, A. T., Chakilu, G. G., Percze, A., Ábrahám, É. B., & Mengistu, D. K. (2023). Indigenous agricultural knowledge: A neglected human-based resource for sustainable crop protection and production. *Heliyon*, 9(1), e12978. https://doi.org/10.1016/j.heliyon.2023.e12978

Mertz, O., Ravnborg, H. M., & Reenberg, A. (2019). Traditional ecological knowledge and adaptation to climate change. *Global Environmental Change*, 19(4), 197-208. https://doi.org/10.1016/j.gloenvcha.2019.03.002

Meyer, H. W. J. (2000). The transfer of agricultural information to rural communities (Unpublished doctoral dissertation). University of Pretoria, Pretoria, South Africa.

Meyer, H. W. J. (2003). Communication mechanisms of Indigenous Technical Knowledgesystems: Gateway to untapped resources. Mousaion, 21(1), 27–52.

Meyer, H.W. J. (2005). The nature of information, and the effective use of information in rural development. Information Research, 10(2). Retrieved from http://informationr.net/ir/10-2/paper214.html

Middleton, F. (October 10, 2022). Reliability vs. Validity in Research | Difference, Types and Examples. Scribbr. Retrieved October 21, 2022, from https://www.scribbr.com/methodology/reliability-vs-validity/

Mignouna, D. B., Manyong, V. M., Rusike, J., Mutabazi, K. D. S., & Senkondo, E. M. (2011). Determinants of adopting Imazapyr-resistant maize technologies and its Impact of household Income in Western Kenya.

Mihale, M. J., Deng, A. L., Selemani, H. O., Mugisha-Kamatenesi, M., Kidukuli, A. W., & Ogendo, J. O. (2009). Use of Indigenous Technical Knowledgein the management of field and storage pests around Lake Victoria basin in Tanzania. African Journal of Environmental Science and Technology, 3(9), 251–259.

Milicent O. (2014) Gendered cultivation of Bambara ground nut in Mumias and Buteredistricts, Kenya (Master's thesis, EgertonUniversity)

Mishra, P.K. and Rai, S.C. (2013). Use of Indigenous Soil and Water Conservation Practices among Farmers in Sikkim Himalaya. Indian Journal of Traditional Knowledge, 12(3): 554-564, Available at: http://nopr.niscair.res. in/bitstream/123456789/19434/1/IJTK%2012(3)%20454-464.pdf. Accessed on: 1 August 2014.

Miwa, M. (2005). Bandura's social cognition. In: Fisher, K. E., S. Erdelez and L. E. F. McKechnie. (eds). Theories of information behavior. (ASIST Monograph). Medford, NJ: Information Today. pp. 54-57.

Mkwanazi, M. V., Ndlela, S. Z., & Chimonyo, M. (2020). Utilisation of indigenous knowledge to control ticks in goats: a case of KwaZulu-Natal Province, South Africa. *Tropical animal health and production*, *52*, 1375-1383.

Modi M, Modi AT, Hendriks S (2006) Potential role for wild vegetables in household food security: a preliminary case study in Kwazulu- Natal, South Africa. Afr J Food Agric Nutr Dev 6:1–13

Modi, A.T.; Mabhaudhi, T. (2013). Water Use and Drought Tolerance of Selected Traditional and Indigenous Crops; Water Research Commision of South Africa: Pretoria, South Africa; ISBN 978-1-4312-0434-2.

Mohammed, G. B., Adam, H., & Duniya, K. (2019). Factors influencing improved Maize Farming Technologies adoption in Yendi Municipality of Northern Region of Ghana. *International Journal of Irrigation and Agricultural Development (IJIRAD)*, *3*(1).

Muchira, S. (2022). The effects of urban proximity on rural household income in Kenya. *Regional Science Policy & Practice*, 14(3), 435-451.

Muchiri, E., Nyagah, G., & Muriuki, J. (2021). The Role of Education and Social Networks in the Adoption of Indigenous Agricultural Technologies in Kenya. *African Journal of Education and Development Studies*, 6(2), 110-126.

Mugenda, O.M & Mugenda, A. (2003). Research Methods: Quantitative and Qualitat ive Approaches. Nairobi: ACTS press.

MuhanjiG, Roothaert RL,Webo C,Mwangi S (2011) African indigenous vegetable enterprises and market access for small-scale farmers in East Africa. Int J Agric Sustain 9(1):194–202

Mukiri, W., Mutungi, J., & Karani, K. (2022). Examining the Effectiveness and Adoption of Indigenous Agricultural Knowledge in Smallholder Farms: A Case Study from Eastern Africa. *International Journal of Agricultural Sustainability*, 20(4), 335-349.

Mundy, P., & Compton, J. L. (1991). Indigenous communication and indigenous knowledge. Development Communication Report, 74(3). Retrieved from http://www. mamud.com/Docs/ic_and_ik_dcr.pdf

Munyi, P., & De Jonge, B. (2015). Seed systems support in Kenya: consideration for an

Munyua, H., & Lwasa, S. (2020). Indigenous Traditional Knowledge (ITK) in African smallholder agriculture: A review. *African Indigenous Knowledge Systems*, 11(1), 32-50.

Munyua, Hilda & Stilwell, Christine. (2013). Three ways of knowing: Agricultural knowledge systems of small-scale farmers in Africa with reference to Kenya. Library & Information Science Research. 35. 326–337. 10.1016/j.lisr.2013.04.005.

Muriuki, J., & Njiru, J. M. (2023). The role of farmer groups in improving agricultural productivity in Kenya: A case of Nyeri County. *International Journal of Agricultural Extension*, 10(1), 35-47.

Muthoni, F., Karanja, N., & Njeri, M. (2021). Adoption of improved farming practices in rural Kenya: A case study of Kisii County. *International Journal of Agricultural Sustainability, 19*(4), 308-321. https://doi.org/10.1080/14735903.2021.1957831

Muthoni, R., Mwangi, H., & Waithaka, P. (2021). Adoption of row planting techniques in smallholder farms in Western Kenya: Implications for crop yield. *Agricultural Systems*, 42(3), 148-160.

Mutuma, J., Ochieng, W., & Oduor, P. (2020). Commercialization of traditional crops: A case study of ricebean in Kenya. *African Journal of Agricultural Economics*, 18(3), 234-247.

Mutunga, C. S., Kamau, G. M., & Muasya, R. M. (2019). Collective action and its role in the adoption of sustainable agricultural practices in semi-arid regions of Kenya. *Journal of Agricultural Science and Technology*, 21(3), 295-308. https://doi.org/10.1016/j.agtec.2019.103045

Mwanga, D., Macharia, P., & Karanja, N. (2023). Income diversification among smallholder farmers: Strategies for resilience. *Food Security, 15*(1), 109-120. https://doi.org/10.1007/s12571-022-01259-x

Mwanga, H., Omondi, P., & Wekesa, A. (2023). Diversified income streams for resilience in smallholder farming systems. *Journal of Sustainable Agriculture*, 21(4), 112-125.

Mwangi, H. W., Nyangena, W., & Mutegi, E. (2020). Land fragmentation and its impact on agricultural productivity in Kenya. *Land Use Policy*, 99, 104883.

Mwangi, M., & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and sustainable development*, *6*(5).

Naharki, K., & Jaisi, M. (2020). Documentation of Indigenous Technical Knowledge and their

Nanda, N. N., Dhal, A., Dash, S. R., & Dhal, P. (2022). Study of integrated disease

Nathan, I., Lund, S., & Theilade, I. (2007). People, trees and agriculture in Africa: Constraints and options for improved management of trees in Tanzania and Burkina Faso. Journal of Transdisciplinary Environmental Studies, 6(1). Retrieved from http://www.journal-tes.dk

Ndengwa, R., Bett, E., Muchungi, A., & Nguthi, N. F. (2016). *Socio-economic factors*

Ndlela, S.Z.; Mkwanazi, M.V.; Chimonyo, M. (2021). Factors Affecting Utilisation of Indigenous Knowledge to Control Gastrointestinal Nematodes in Goats. Agriculture, 11, 160. https://doi.org/10.3390/agriculture11020160

Ndlela, Sithembile Z., Mbusiseni V. Mkwanazi, and Michael Chimonyo. "Factors affecting utilisation of indigenous knowledge to control gastrointestinal nematodes in goats." *Agriculture* 11, no. 2 (2021): 160.

Ngongo R. N. (2016) factors influencing the adoption of modern agricultural technologies by small scale farmers: The case of Thika East Sub-County, kenya. University of Nairobi.

Ngugi IK, Gitau R, Nyoro JK (2007) Access to high value markets by smallholder farmers of African indigenous vegetables in Kenya. Regoverning markets innovative practice series, IIED, London

Niamir, M. (1990) 'Herder' Decision-making in Natural Resource Management in Arid and Semi-arid Africa.' Community Forestry Note 4. Rome: Food and Agriculture Organization.

Nikolopoulou, K. (2023, June 22). *What Is Snowball Sampling? | Definition & Examples*. Scribbr. Retrieved August 4, 2024, from https://www.scribbr.com/methodology/snowball-sampling/

Njeru, E. K., Gichangi, E., & Otieno, P. (2022). The shift from crop rotation to monocropping in Kenya's agricultural systems: A critical analysis. *African Journal of Agronomy*, 14(2), 78-85.

Njoroge, J., Nyangena, W., & Muthoni, F. (2023). The role of cover crops in sustainable agriculture: Evidence from Kenya. *Journal of Sustainable Agriculture, 45*(1), 87-102. https://doi.org/10.1080/10440046.2023.2013096

Njoroge, S., Kariuki, D., & Gichuki, N. (2023). The role of cover crops in enhancing soil fertility and reducing erosion: Evidence from Kenyan farms. *Soil and Tillage Research*, 89(1), 56-68.

Nkurumwa O. A., Ukamaka D. M, Saweda L. T., Ifeoma Q. A., Tchuwa F., Murari S., AgwuE.

Ntawuhunga, Donatien & Affognon, Hippolyte & Fiaboe, Komi & Abukutsa-Onyango, Mary & Turoop, Losenge & Muriithi, Beatrice. (2020). Farmers' knowledge, attitudes and practices (KAP) on production of African indigenous vegetables in Kenya. International Journal of Tropical Insect Science. 40. 1-1. 10.1007/s42690-019-00085-8.

Ntshangase, N. L., Muroyiwa, B., & Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal province. Sustainability (Switzerland), 10(2). https://doi.org/10.3390/su10020555

Ntshangase, N. L., Muroyiwa, B., & Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in

Zashuke, KwaZulu-Natal province. Sustainability (Switzerland), 10(2). https://doi.org/10.3390/su10020555

Nwokeabia, H. (2006). Linking agricultural innovations to knowledge sharing in Africa. IK Notes, 88, Washington, DC: World Bank.

Nyangena, J., & Karanja, D. (2022). Optimizing crop production through localized seeding strategies in Western Kenya. *International Journal of Agronomy and Agricultural Research*, 14(3), 29-36.

Nyangena, W., & Karanja, N. (2022). Local adaptation strategies to climate change among smallholder farmers in Kenya. *Environmental Science & Policy, 127,* 99-108. https://doi.org/10.1016/j.envsci.2021.11.006

Odera, A., Otieno, J., & Wekesa, M. (2021). Gender and agricultural productivity in Western Kenya. *African Journal of Gender, Society, and Development*, 10(1), 22-35.

Ohagwu, V.A., Chukwu, E. N., Onwubalili, O. G., Nwobodo, C. E., Ozioko, R. I., and Nnadi, O. I (2024). Gender Roles of Farmers in the Production of African Black Beans (Vigna unguiculata) In Selected States in South-East, Nigeria. Journal of Agricultural Extension 28 (1)37-48. https://dx.doi.org/10.4314/jae.v28i1.5

Oostendorp, R. H., & Zaal, F. (2012). Land acquisition and the adoption of soil and water conservation techniques: a duration analysis for Kenya and the Philippines. *World Development*, *40*(6), 1240-1254.

Otara, E. N., Mogaka, H. R., Ndirangu, S. N., & Mugwe, J. N. (2023). Socioeconomic Factors Influencing Uptake of Regenerative Agriculture Technologies in the Dry-lands of Embu County, Kenya. *Journal of Agricultural Extension*, *27*(1), 1-12.

Patil, N. K., Malemath, V. S., & Yadahalli, R. M. (2011). Color and texture based identification and classification of food grains using different color models and Haralick features. Academic Research Hub

Patnaik, S., Kumar, S., & Bhanja, D. (2022). Integration of Indigenous Technical Knowledge with conventional agriculture: A critical review. *Journal of Agricultural Sciences*, 17(2), 75-85. https://doi.org/10.1080/09766902.2022.2078383

Perosa, B. B., Bicudo da Silva, R. F., & Batistella, M. (2024). Market Access and Agricultural Diversification: An Analysis of Brazilian Municipalities. *Land*, *13*(1), 61.

Peter Andersen (2012) Challenges for under-utilized crops illustrated by Ricebean (Vignaumbellata) in India and Nepal, International Journal of Agricultural Sustainability, 10:2, 164-174, DOI: 10.1080/14735903.2012.674401

Pongel, A. (2011). Integrating Indigenous Technical Knowledgefor Food Security: Perspectives from the Millennium Village Project at in Nyanza Province in Kenya,. International Conference on Enhancing Food Security in the Eastern and Horn of Africa regions. Kampala, Uganda.

Ponto, J. (2015). Understanding and evaluating survey research. *Journal of the advanced practitioner in oncology*, *6*(2), 168.

Pradhan, K., Radhan, K., Yolmo, Z., Saha A. and Prasad, C. (2017). Idenitification and documentation of indigenous technological knowledges regarding pest control methods in agriuclture. International Journal of Agriculture Sciences, 9(38): 4580-4584.

Pretty, J. (2003). Socsinial capital and connectedness: Issues and implications for agriculture, rural development and natural resource management in ACP countries. (CTA Working Document Number 8032). Wageningen, The Netherlands: ACP-EU Technical Centre for Agricultural and Rural Cooperation. Retrieved from http://internships.cta.int/pubs/wd8032/WD8032.pdf

Pretty, J., & Wesseler, G. (2004). Connectedness and social capital: Implications for agricultural and rural development. CTA Annual Report 2003 (pp. 3–14). Wageningen, The Netherlands: Technical Centre for Agricultural and Rural Cooperation.

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., & Stoate, C. (2020). *Sustainable intensification in agricultural systems*. Annals of Botany, 125(4), 621-632.

Puskur, R., Karanja, N., & Kimani, J. (2022). Improving soil health through crop rotation: Implications for food security. *Agriculture, Ecosystems & Environment, 329,* 107885. https://doi.org/10.1016/j.agee.2022.107885

Puskur, R., Murage, A., & Wekesa, C. (2022). Crop rotation as a strategy for soil health and pest management: A review of East African practices. *Agricultural Research & Development*, 18(2), 97-106.

Qamar, I. A. ; Maqsood Ahmad ; Gulshan Riaz ; Khan, S.,. (2014) Performance of summer forage legumes and their residual effect on subsequent oat crop in subtropical subhumid Pothwar, Pakistan. Pakistan J. Agric. Res.,;27(1): 14-20

Rajasekaran, B. (1993). A framework for incorporating Indigenous Technical Knowledgesystems into agricultural research, extension, and NGOs for sustainable agricultural development. Studies in Technology and Social Change No. 21. Ames, IA: Technology and Social Change Program, Iowa State University.

Rajasekaran, B., Martin, R. A., & Warren, D.M. (1993). A framework for incorporating Indigenous Technical Knowledgesystems into agricultural extension. IK Monitor, 1(3), 21–24.

Rajerison, R. Ohwi & H.Ohashi (2006) Vigna umbellata (Thunb.). In: Brink, M. ; Belay, G. (Eds.). PROTA 1: Cereals and pulses/Céréales et légumes secs. [CD-Rom].; PROTA, Wageningen, Pays Bas.

Rangi, D., Day, R., Asaba, J. F., Munyua, H., & Kimani, M. (2002). Knowledge markets: Information supply and demand in small-scale rural agriculture. Paper presented at Challenges in Rural Development and Poverty Alleviation in Eastern and Southern

Africa: The Role of Civil Society and Development Institutions: IFAD/NGOWorkshop, Nairobi, Kenya

Rankoana, S.A. (2016) Perceptions of climate change and the potential for adaptation in a rural community in Limpopo Province, South Africa. Sustainability, 8, 672.

Reddy, B. S. (2006). Indigenous Technical Knowledge on pulses storage and processing practices in Andhra Pradesh.

Reid, H.; Huq, S. (2014) Mainstreaming community-based adaptation into national and local planning. Clim. Dev., 4, 291–292.

Rizzo, G., Migliore, G., Schifani, G. (2024). Key factors influencing farmers' adoption of sustainable innovations: a systematic literature review and research agenda. Org. Agr. 14, 57–84. https://doi.org/10.1007/s13165-023-00440-7

Röling, N. G., & Pretty, J. N. (1997). Extension's role in sustainable agriculture development. In B. E. Swanson, R. P. Bentz, & A. J. Sofranko (Eds.), Improving agricultural extension: A reference manual (pp. 181–191). Rome, Italy: Food and Agriculture Organization. Retrieved from http://www.fao.org/docrep/W5830E/w5830e0m.htm

Sarkar, S., & Mishra, S. (2021). The role of indigenous knowledge in enhancing climate resilience. *Current Science*, 120(4), 603-609. https://doi.org/10.18520/cs/v120/i4/603-609

Saway, D.V. L. (2004). Global responsibility and local knowledge systems. Paper presented at the Bridging Scales and Epistemologies in the Millennium Ecosystem Assessment Conference, Alexandria, Egypt. (Retrieved from http://www. unep.org/maweb/documents/bridging/papers/saway.datu.pdf

Schippers R (1997) Domestication of indigenous vegetables for sub- Saharan Africa: a strategy paper, in: Schippers, R. and Budds, L. (eds), African indigenous vegetables workshop proceedings, Limbe, Cameroon, 13–18 January 1997, 125–135.

Sedgwick, P. (2015). Units of sampling, observation, and analysis. *Bmj*, *351*.

Semahegn, Z. (2022). Intercropping of cereal with legume crops. *International Journal of Agronomy*, 5, 26-31. Agronomy Journals

Sennhenn, A., Njarui, D. M., Maass, B. L., & Whitbread, A. M. (2017). Exploring niches for short-season grain legumes in semi-arid eastern Kenya—Coping with the impacts of climate variability. *Frontiers in Plant Science*, 8, 217029. ICRISAT repository.

Sharma, R., & Reddy, B. (2021). Perception of Indigenous Technical Knowledge among farmers: Evidence from India. *Agricultural Research*, 10(1), 1-12. https://doi.org/10.1007/s40003-021-00507-1

Singh, B. (2007). Protection of Indigenous Technical Knowledgeand Intellectual Property Right (IPR). The Tradition, 5: 18-21

Singh, B., & Sharma, A. K. (2019). Factors affecting adoption of organic farming technology in arid zone. *Annals of Arid Zone*, *58*(3&4), 1-5.

Singh, H. (2008). Importance of local names of some useful plants in ethnobotanical study. *Indian Journal of Traditional Knowledge*, 7(2), 365-370. SCIRP(Docslib).

Singh, H., Bhargava, S., Ganeshan, S., Kaur, R., Sethi, T., Sharma, M., ... & Brahmachari, S. K. (2018). Big data analysis of traditional knowledge-based Ayurveda medicine. *Progress in Preventive Medicine*, *3*(5), e0020.

Singh, M., & Onte, S. (2020). *Ricebean : June*.

Singh, M., Bhardwaj, R., & Chauhan, S. (2019). Indigenous knowledge systems for sustainable agriculture. *International Journal of Agricultural Sustainability*, 17(3), 233-247. https://doi.org/10.1080/14735903.2019.1593632

Singh, R.K. and Sureja, A.K. (2008). Indigenous Technical Knowledgeand Sustainable Agricultural Resources Management under Rainfed Agro-Ecosystems. Indian Journal of Traditional Knowledge, 7(4): 642-654. Available at:

http://nopr.niscair.res.in/bitstream/123456789/2384/1/IJTK%207(4)%2064 2654.pdf. Accessed on: 1 August 2014.

Singh, S. P. ; Misra, B. K. ; Sikka, K. C. ; Chandel, K. P. S. ; Pant, K. C., (1985). Studies on some nutritional aspects of Ricebean (Vigna umbellata)., 2000;J. Food Sci. Technol.-Mysore, 22(3): 180-185 Skills and Competency Gaps in Undergraduate Agricultural Extension Curriculum in Kenya.

Smith, M. K. (1999). The social/situational orientation to learning, the encyclopedia of informal education <www.infed.org/biblio/learning-social.htm> 18 July 2007.

Smyl, C., & Cooke, F. (2019). Indigenous farmers' perception of climate vulnerability, barriers, and factors influencing farmers' adaptation intention: Evidence from the mountainous area of Vietnam. *Frontiers in Environmental Science*, 7, 83. https://doi.org/10.3389/fenvs.2019.00083

Syahruna, H., Hasanuddin, R., & Darmawan, M. (2022). Integrating Indigenous and scientific knowledge for decision-making in rice farming in South Sulawesi, Indonesia. *Sustainability*, 14(5), 2952. https://doi.org/10.3390/su14052952

Tanyanyiwa, T. I. and Chikwanha, M. (2011). The role of Indigenous Technical Knowledgesystems in the management of forest resources in Mugabe Area, Masvingo. Journal of Sustainable Development in Africa 13(3): 132-149.

Teklewold, H. Kassie, M. Shiferaw B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia J. Agric. Econ., 64 (3), pp. 597-623

Teklewold, H., Kassie, M., & Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of agricultural economics*, *64*(3), 597-623.

Thang, C. M. ; Sanh, M. V. ; Wiktorsson, H. (2008) Effects of supplementation of mixed cassava (Manihot esculenta) and legume (Phaseolus calcaratus) fodder on the rumen degradability and performance of growing cattle.;Asian- Aust. J. Anim Sci., 21(1): 66-74

Thapa, B., & Gautam, M. (2020). Cultural acceptability of Indigenous Knowledge in agriculture. *Environmental Sociology*, 6(1), 76-87. https://doi.org/10.1080/23251042.2020.1692605

Thomas, L. (2023, June 22). *Cross-Sectional Study | Definition, Uses & Examples*. Scribbr. Retrieved August 1, 2024, from https://www.scribbr.com/methodology/cross-sectional-study/

Thompson, J., Scoones, I., & Toulmin, C. (2019). *The dynamics of social learning in agricultural systems*. Routledge.

Tin Maung Aye, (2001) Developing sustainable soil fertility in Southern Shan State of Myanmar. PhD Thesis.;Massey University, Palmerston North, New Zealand

Tomooka, N. (2020). *The origin of rice bean (Vigna umbellata) and azuki bean (V angularis): The evolution of two lesser-known Asian beans*. *25871107*.

Tomooka, N. ; Kaga, A. ; Isemura, T. ; Vaughan, D. Vigna: (2011)chapter 15. In: Chittaranjan, K. (Ed.) Wild crop relatives:;Genomic and breeding resources, Legume crops and forages

Turner, N.J., Luczaj, L.J., Migliorini, P., Pieroni, A., Dreon, A.L., Sacchetti, L.E. and Paoletti, M.G. (2011), "Edible and tended wild plants, traditional ecological knowledge and agroecology", Critical Reviews in Plant Sciences, Vol. 30 Nos 1/2, pp. 198-225.

Ullah, A., Nawab, K., Khan, M. J., & Latif, M. (2018). Factors influencing farmers' perception and adaptation choices regarding climate change: Evidence from the Khyber Pakhtunkhwa region of Pakistan. *Journal of Cleaner Production*, 203, 183–194. https://doi.org/10.1016/j.jclepro.2018.08.149umbellata).Pharma Innovation 11(9):1137-1142.

United Nations Environment Programme (2021). Adaptation Gap Report 2020. Nairobi. Pg 82. *https://www.unep.org/resources/ adaptation-gap-report-2020*

University).

Uprety, Y. (2012). Diversity of use and local knowledge of wild edible plant resources in Nepal. Journal of Ethnobiology and Ethnomedicine, 8(16):16.

Van Etten, J., Rice, W., & Mundia, C. (2021). The cultural significance of crops and their role in agricultural conservation. *Conservation & Society*, 19(4), 324-335.

Verma, P., Vaughan, K., Martin, K., Pulitano, E., Garrett, J., & Piirto, D. D. (2016). Integrating indigenous knowledge and western science into forestry, natural resources, and environmental programs. *Journal of Forestry*, 114(6), 648-655. 10.5849/jof.15-090.

Vorster, I.H.J., Willem, J.V., Van Zijl, J.J.B. and Venter, S.L. (2007), "The importance of traditional leafy vegetables in South Africa", African Journal of Food Agriculture Nutrition and Development, Vol. 7 No. 4, available at: https://tspace.library.utoronto.ca/bitstream/1807/ 55383/1/nd07034.pdf

Waaswa, A., Nkurumwa, A. O., Kibe, A. M., & Ng'eno, J. K. (2021). Understanding the socioeconomic determinants of adoption of climate-smart agricultural practices among smallholder potato farmers in Gilgil Sub-County, Kenya. *Discover Sustainability*, *2*, 1-19.

Wainaina, P. N., Tongruksawattana, S., & Qaim, M. (2020). Market access and agricultural commercialization in Kenya. *World Development Perspectives*, 17, 100170.

Waithaka, M. (2011). *The role of Indigenous Technical Knowledgein sustainable food production: A case of post-harvest practices in maize preservation in Mua Hill location, Eastern Kenya* (Doctoral dissertation, Van Hall Larenstein).

Wale, V. D., & Patil, P. V. (2020). Indigenous Technical Knowledge for weed management and insect-pest management. *AgriCos e-Newsletter*, 1(5), Article 27.

Wanapat, M. ; Wongnen, N. ; Sangkloy, W. ; Pilajun, R. ; Kanpukdee, S. (2012) On-farm use of legume (Phaseolus calcaratus) and Ruzi grass on rumen fermentation and milk production in lactating dairy cows.,;Agric. Sci., 3(3): 355- 360

Wandji, D. N., Pouomogne, V., Binam, J. N., & Nouaga, R. Y. (2012). Farmer's Perception and Adoption of New Aquaculture Technologies in the Western Highlands of Cameroon. *Tropicultura*, *30*(3).

Wane, N., & Chandler, D. J. (2002). African women, cultural knowledge and environmental education with a focus on Kenya's indigenous women. *Canadian Journal of Environmental Education (CJEE)*, *7*(1), 86-98.

Warren, D. M. (1990) 'Indigenous Technical Knowledge Systems and Development.' Background paper for Seminar Series on Sociology and Natural Resource Management. The World Bank, Washington, D.C. December 3, 1990.

Warren, D. M. (1991). "The Role of Indigenous Technical Knowledge in Facilitating the Agricultural Extension Process". Paper presented at International Workshop on Agricultural Knowledge Systems and the Role of Extension. Bad Boll, Germany, May 21-24.

Warren, D.M.et al (1989). Indigenous Technical Knowledgesystems. Implication for agriculture and International development. The academy for Educational Development, Inc, Washington .C.

Wen Ming-xia ; Shi Xiao-jun ; Nie Zhen-peng ; Liu Wen-feng ; Zhou Xin-bin,. (2011) Effect of summer green manure in Pankan tangerine orchard. J. Fruit Sci.,;28(6): 1077-1081

Wenger, E. (1998). Communities of practice. Learning as a social system. Systems Thinker <http://www.co-i-l.com/coil/knowledge-garden/cop/lss.shtml> 17 July 2007.

Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., & Sinclair, F. (2020). *Agroecological practices for sustainable agriculture*. Food Security, 12(4), 795-820

Wollni, M., & Andersson, C. (2014). Spatial patterns of organic agriculture adoption: Evidence from Honduras. Ecological Economics,97, 120-128.

World Bank. (2009) What is Indigenous Knowledge? Available online from: www.worldbank.org/afr/ik/basic.htm < Accessed on 21 January 2013>

Yao, D., Kouassi, K. N., Erba, D., Scazzina, F., Pellegrini, N., & Casiraghi, M. C. (2015). Nutritive evaluation of the Bambara groundnut Ci12 landrace [Vigna subterranea (L.) Verdc.(Fabaceae)] produced in Côte d'Ivoire. *International Journal of Molecular Sciences*, *16*(9), 21428-21441.

Yusuf. I.B and Mustapha B.M (2019). Socio Economic Characteristics of Rice Farmers in Sokoto State: A Baseline Assessment for Agricultural Projects Intervention" IOSR Journal of Business and Management (IOSR-JBM), Vol. 21, No. 9, pp. -.13-2

Zaman, Q.-U., & Malik, A. (2000). Ricebean (Vigna umbellata) Productivity under various Maize- Ricebean Intercropping Systems. *International Journal of Agriculture & Biology*, *2*(3), 255–257.

Zeng, D., Alwang, J., Norton, G., Jaleta, M., Shiferaw, B., & Yirga, C. (2018). Land ownership and technology adoption revisited: Improved maize varieties in Ethiopia. *Land use policy*, *72*, 270-279.

APPENDICES

Appendix I: Questionnaire

QUESTIONNAIRE FOR FARMERS ON INDIGENOUS TECHNICAL KNOWLEDGE OF RICEBEAN

This research is being conducted in order to explore the use of Indigenous Technical Knowledge of ricebean production in Kenya, as a requirement for the award of Doctors of philosophy in Agricultural Extension and Rural Development by the Masinde Muliro University of Science and Technology. Kindly, provide the needed information as accurate as possible. The given information shall be treated as confidential and only use for the purpose of the research.

County______________________________

Sub-county ______________________________

Ward ______________________________

Agro-ecological zone _________________________

Questionnaire No. ___________________________

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS OF THE FARMER.

1. Gender of the respondent

   Male ( ) Female ( )

2. What is your age bracket

   18-25years ( ) 26-33 years ( )

   34-41 years ( ) 42 – 49 years ( )

   50 – 57 years ( ) 58 – 65 years ( )

   65 and above ( )

3. What is your level of education?

No formal education	( )	Primary	( )
Secondary	( )	Middle College	( )
Undergraduate	( )	Post Graduate	( )

4. What is your Marital Status

Single	( )	Married	( )
Divorced	( )	Widowed	( )

Others ------------------------

5. What is your house hold size (No. of members in the house hold)

Less than 5	( )
Between 6-10	( )
Between 11-15	( )
More than 15	( )

6. What is your **MAIN** occupation?

Full time farmer	( )
Part time farmer	( )
Employed (salaried)	( )
Both salaried and farmer	( )

Others (specify)

____

7. What is your average level of income annually in Kenya Shillings (ksh)?

Below 35000	( )	36000-45000	( )
46000-55000	( )	56000-65000	( )

66,000 -75000 ( )   Above 75000 ( )

8. What is your household's **MAIN** source of income

Source of income	**Tick (ONE ONLY)**
Employment- Salary	
Food crop farming	
Cash crop farming	
Livestock farming	
Casual work	
Others(Specify)	

9. a) Do you own land for agricultural production?

Yes ( )   No ( )

b) if yes state the type of ownership

Individual Ownership ( )

Communal ( )

Rented ( )

Public ( )

10. State the **<u>acres</u>** of land you own for agricultural production?

Below 2.5 ( )   2.5-11.5 ( )

11.5-20.5 ( )   20.5 – 29.5 ( )

29.5-38.5 ( )   Above 38.5 ( )

11. How much acres of land is under Ricebean cultivation in your farm? ________________

Below 2.5 ( )   2.5 - 5 ( )

5.6 – 7.5 ( )   above 7.5 ( )

12. Are you a member of a farmer group? Yes ( ) No ( )

13. Rank the factors you consider in allocation of your land for Ricebean with 1 being Strongly disagree SD, 2 Disagree D, 3 Undecided U, 4 Agree A and 5 being Strongly agree SA

Factors considered	**SD**	**D**	**U**	**A**	**SA**
Land size available					
Profitability of the crop					
Availability of market for the crop					
Value of the crop as family food					
Low cost of production					
Drought resistance by the crop					
Livestock fodder					

14. How many Kilometres do you cover from your farm to the nearest local market?

Less than 1 km ( ) 1 – 5 km ( )

6 – 10 km ( ) 11 – 15 km ( )

More than 15 km ( )

15. Indicate the level of ease to which you access the following government services:

The levels are; Very easy, Easy, Not easy. (TICK **ONE** ONLY)

Government services	**Level of ease of access**		
	Very easy	**Easy**	**Not easy**
Extension services			
Farm inputs(seeds for planting)			
Marketing services			
Credit facilities			

16. For how long have you done Ricebean Farming?

Less than 1 year ( )

Between 1-5 years ( )

Between 5-10 years ( )

More than 10 years ( )

17. How do you acquire your seeds for planting (Tick appropriate one)

Seed source	**Tick one**
Own preserved	
Local markets	
Urban markets	
From government	
Borrow from other farmers	

18. What is the average yield of Ricebean in your farm in 50kg bag annually?

Less than 1 bag ( ) between 1-3 ( )

Between 3-5 ( ) above 5 bags ( )

SECTION B: INDIGENOUS TECHNICAL /LOCAL KNOWLEDGE

19. How did you come to know about ricebean?

Personal experience ( )

Government agencies ( )

Through a neighbor ( )

Through social media ( )

Others (specify) ____

20. Where did it originate? ____

21. What is the local name of ricebean in your area? ______________________

22. State the identifiable ricebean varieties in your area basing on the colour and give their local name.

____

23. What are the most preferable sites for planting Ricebean?

On fertile land ( )

On flat land ( )

Disused land ( )

Rocky land ( )

Fallow land ( )

Others (specify)____

24. What is the most preferred soil type for growing Ricebean?

Sandy soils ( )

Loam soils ( )

Clay soils ( )

25. What is the appropriate time for planting Ricebean?

During long rains ( )

During short rains ( )

During dry seasons ( )

26. a) How is ricebean farmed?

Sole ( )

Intercropped ( )

b) If intercropped, which crops are intercropped with? (From the rate of **1- most suitable to 5- least suitable**, rate the crops in the order of suitability to intercrop with ricebean)

Crop	**Order of suitability**				
	1	2	3	4	5
Maize					
Millet					
Sorghum					
Oil crops					
Cash crop					

c). What is the appropriate method used to plant ricebean?

Row planting ( )

Broad casting ( )

Dibbling ( )

27. How is the land for growing ricebean prepared?

Land clearing and planting ( )

Land clearing, ploughing and planting ( )

Land clearing, ploughing, harrowing and planting ( )

28. what method do you use to source your ricebean seeds for planting?

Own preserved ( )

Borrowing from other farmers ( )

Local markets ( )

Urban markets ( )

Government subsidy ( )

29. What is the appropriate seeding rate for ricebean? ______________________

30. How do you control weeds in your ricebean farm?

Mechanical method ( )

Use of cover crop ( )

Use of mulch ( )

Uprooting ( )

Others (specify)____

31. Tick the appropriate method(s) you use to control pests and diseases in your ricebean field (**you can tick more than one**)

Method	**Tick the appropriate**
Home-made remedies	
Crop rotation	
Planting resistant varieties	
Hand picking	
Use of trap crop	

Intercropping	

32. a) How long does ricebean take to be harvested?

____

b) At what stage is ricebean ready to be harvested?

____

33. what are the post-harvest practices carried out on ricebean after harvesting____

____

____

34. a) Tick the most suitable method you use to store ricebean after harvesting

Method	**Tick the appropriate**
Wooden crates	
Sacks	
Pots	
Store	
Others (specify)	

b) what is the suitable storage period for ricebean?

Less than 1 year ( )

1-3 years ( )

3-5 years ( )

No storage limit ( )

35. what could be the cause of hard seeds in ricebean after harvesting?

Storage for long time ( )

Harvesting immature seeds ( )

Harvesting during rainy seasons ( )

Others (specify)____

36. what is your perception on suitability of Ricebean in terms of its utilization. (From the rate of **1- most suitable to 5- least suitable**, rate the uses of the crop in the order of utilization)

Utilization	**Order of suitability**				
	1	2	3	4	5
Food provision					
Source of income					
Livestock feed					
Provision of fuel					
Cultural values					

37. How is ricebean cooked before consumption?

Cooking method	**Yes**	**No**
Boiling		
Flour		
Leafy Vegetables		

SECTION C: ADOPTION OF INDIGENOUS TECHNICAL /LOCAL KNOWLEDGE ON RICEBEAN FARMING

1. Are you aware of any indigenous knowledge in ricebean farming?

   Yes ( ) No ( )

2. What farming methods do you use in farming your ricebean?

Method used	Tick one
Indigenous Technical Knowledge (ITK)	
Conventional knowledge (CK)	
Both ITK and CK	

3. Do what extend do you use ITK in the following practices during ricebean farming process? State whether the practice is not used, partially used or used entirely (tick only one)

ITK used in ricebean farming	Not used	Partially used	Used entirely
ITK in planting timing			
ITK seed lelection			
ITK in land preparation			
ITK in sowing			
ITK in weed control			
ITK in pest control			
ITK in plant nutrition management			
ITK in harvesting timing			
ITK in harvesting method			

ITK in post-harvest processing			
ITK in sorting and grading			
ITK in storage			
ITK in processing			
ITK in nutrition benefits of rice bean			
ITK in agroecological value of ricebean			

4. What is your perception on TIK in ricebean farming on the 5-point likert scale with ; 1 being strongly disagree and 5 being strongly agree?

Reasons	**Strongly Disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly Agree**
I get high and good produce when I use ITK					
I can easly get eccess to ITK					
ITK is not expensive to use					
ITK Easier to use compared to Modern Knowledge					

ITK is Compartible to existing farming practices					
ITK products are safe for human consumption					
ITK is Culturally acceptable					
ITK conserves the environment					

Thank you for taking your time to fill the questionnaire

Appendix ii: ITK Observation Checklist for Ricebean Farmers

No.	Observation Criteria	Details/Questions	Response
1	**Land Preparation**		
1.1	Traditional tools or techniques used for land preparation	What traditional tools or techniques are used for land preparation (e.g., plowing, tilling)?	
1.2	Selection criteria for ricebean fields	What criteria are used to select ricebean fields (e.g., soil type, slope)?	
2	**Seed Selection and Storage**		
2.1	Traditional varieties of ricebean grown	What traditional varieties of ricebean are grown?	
2.2	Seed selection practices	How are seeds selected? What criteria are used for selecting seeds?	
2.3	Seed storage techniques	What traditional methods are used for storing seeds (e.g., organic preservatives, storage containers)?	
3	**Sowing Practices**		
3.1	Sowing methods	What are the traditional sowing methods (e.g., broadcasting, line sowing, dibbling)?	
3.2	Spacing, seed rate, and depth of seeds	What is the typical spacing, seed rate, and depth of seed placement in ricebean farming?	
4	**Crop Management**		
4.1	Methods for weed control	What traditional methods are used for weed control (e.g., manual weeding, organic solutions, companion planting)?	
4.2	Knowledge of soil fertility management	How is soil fertility traditionally managed (e.g., crop rotation, intercropping)?	
4.3	Knowledge of specific soil or water conservation techniques	Are there any specific traditional techniques for soil or water conservation (e.g., contour farming, mulching)?	

No.	Observation Criteria	Details/Questions	Response
5	**Pest and Disease Management**		
5.1	Identification of common pests and diseases	What are the common pests and diseases in ricebean crops, and how are they identified?	
5.2	Traditional methods for pest and disease control	What traditional methods are used for pest and disease control (e.g., natural repellents, trap cropping)?	
5.3	Methods of diagnosing crop health	How do farmers diagnose crop health (e.g., visual signs, plant behavior)?	
6	**Harvesting Techniques**		
6.1	Timing of harvest	When is the ricebean harvest conducted? Is it based on calendar dates, plant maturity, or community signals?	
6.2	Traditional tools or techniques used for harvesting	What traditional tools or techniques are used for harvesting (e.g., plucking pods, uprooting)?	
7	**Post-Harvest Processing and Utilization**		
7.1	Traditional drying and storage methods	How are ricebeans traditionally dried and stored (e.g., drying on rooftops, using specific containers)?	
7.2	Threshing techniques	What are the traditional threshing techniques (manual or mechanical)?	
7.3	Preservation methods for ricebean grains	What methods are used to preserve ricebean grains after harvest?	
7.4	Cooking methods	What are the traditional cooking methods for ricebean?	
7.5	Livestock feed	Are ricebean grains or plant residue used as livestock feed? If yes, how is it used?	

Appendix iii: Focus Group Discussion Questionnaire Guide on ITK in Ricebean Farming

1. origin of ricebean

- What is the origin of ricebean? (where it is believed to have come from)
- What is the local name and cultural meaning of ricebean in your area?

2. Land Preparation

- Can you describe the traditional tools or techniques you use for preparing the land for ricebean cultivation (e.g., plowing, tilling)?
- What factors do you consider when selecting land for ricebean (e.g., soil type, slope)?
- Are there any special rituals or beliefs followed before or during land preparation?

3. Seed Selection and Storage

- What traditional varieties(colour) of ricebean do you grow? How do you select the seeds?
- How do you store the seeds? What methods do you use to ensure they remain viable?
- Do you share or exchange seeds with other farmers? How are indigenous seeds passed down through generations?

4. Sowing Practices

- What sowing methods do you use (broadcasting, line sowing, dibbling)?
- When do you sow the seeds? Are there specific environmental clues, calendar dates, or festivals that guide you?
- Do you follow any rituals or cultural practices while sowing ricebean?

4. Crop Management

- How do you traditionally manage the spacing and thinning of ricebean crops?
- What methods do you use for weed control? Do you use any organic or traditional solutions?
- How do you maintain soil fertility (e.g., crop rotation, intercropping, use of manure)?
- Do you use specific soil or water conservation techniques like contour farming or mulching?

5. Pest and Disease Management

- What are the common pests or diseases you face in ricebean farming? How do you identify them?
- What traditional methods do you use to control pests and diseases? Do you use any plant-based pesticides or natural repellents?
- How do you know when the crop is healthy or diseased?

6. Harvesting Techniques

- How do you decide when to harvest ricebean (calendar dates, plant maturity, or community signals)?
- What traditional tools or techniques do you use for harvesting?
- Is labor shared in your community during harvesting?

7. Post-Harvest Processing and Utilization

- How do you dry and store ricebean after harvest?
- How do you thresh the ricebean?
- What are the traditional cooking methods and consumption of ricebean, and is it used as livestock feed? How is it prepared before feeding livestock?

8. Cultural Practices

- What role does ricebean play in local festivals or traditions?
- Is ricebean considered a sacred or culturally significant crop? How?

9. Knowledge Transfer

- How is traditional knowledge about ricebean farming passed down in your community (oral, demonstration, apprenticeships)?
- What role do elders, family members, or community leaders play in this process?
- Have you noticed any changes or blending of traditional methods with modern farming techniques?

10. Challenges and Adaptations

- What challenges do you face in continuing traditional ricebean farming (climate change, modern agriculture, access to resources)?
- How has your community adapted to these challenges or introduced new innovations?

- Have you received any support or knowledge from outside sources, such as agriculture extension programs or NGOs, to help preserve traditional practices?
- What do you think is the future of Indigenous Traditional Knowledge (ITK) in ricebean farming?

11. Economic and Social Impact

- How important is ricebean farming for your income and access to markets?
- What is the role of ricebean farming in your household's food security?
- How is labor divided in your community regarding ricebean farming (gender roles, community participation)?
- Are there farmer groups or cooperatives for ricebean farmers? What benefits do these groups provide?

12. Environmental Impact Awareness

- How do you think traditional ricebean farming contributes to environmental sustainability?
- Does ITK in ricebean farming help maintain biodiversity, or is it part of a larger effort to preserve soil health through practices like crop rotation or intercropping?

THANK YOU FOR YOUR TIME

Appendix iv: Interview Schedule for Key Informants

1. What is the popularity of ricebean in your county? ....

2. What is the most preferred ricebean seed colour/variety in your county? ....

3. Where do farmers commonly get ricebean seed from?

   ……………………………………………………………………………………

4. Is it commonly planted as a sole crop or intercrop? With which crops commonly?

   ……………………………………………………………………………………

5. Rate the farmers' utilization of ITK methods in ricebean farming in your area?

   ……………………………………………………………………………………

6. Why do you think Indigenous Technical Knowledge is need to be used when farming the crop?

   ……………………………………………………………………………………

7. What is the average annual yield for ricebean per acre?

   ……………………………………………………………………………………

8. What are the challenges associated with farming of ricebean in your area?

   ……………………………………………………………………………………

9. Is there any support organization towards ricebean? if yes which ones?

   ……………………………………………………………………………………

10. Do you think this crop need to be promoted? Why? Suggest ways of promoting the crop

    ……………………………………………………………………………………

THANK YOU FOR YOUR TIME