Sokoine University of Agriculture

MA Dissertation

Impact of Farmers Research Network Project on Diversified Legumes among Smallholder Farmers in Singida Region, Tanzania

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April 2024

THE IMPACT OF FARMERS RESEARCH NETWORK PROJECT ON DIVERSIFIED LEGUMES AMONG SMALLHOLDER FARMERS IN SINGIDA REGION, TANZANIA

Dissertation Submitted in partial fulfillment of the requirements for the degree of Masters of Arts in Project Management and Evaluations of the Sokoine University of Agriculture. Morogoro, Tanzania.

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EXTENDED ABSTRACT

Legume production in Singida Region has been conducted for years but with low yield production. The study aimed at assessing the impact of Farmers Research Network on diversified legumes among smallholder farmers in Singida Region. The study employed cross-section research design with 204 respondents using questionnaire survey and key informant interviews. A two-stage Heckman selection model was used to determine factors influencing the adoption of diversified legume production and farmers perception was assessed using Likert scale and the analysis was then subjected to principal component analysis for factor analysis. Descriptive and content analysis were conducted for quantitative and qualitative data respectively employing Microsoft excel for results presentation. The results on the factors influencing adoption showed that age, education, farm size, major occupation, experience, land size, access to credit, and motivation were significantly associated with adoption of diversified legume production. The adoption of varied legume production in the research area was found to be statistically significantly influenced by the farmers' age, education level, farm size, main occupation, experience, land size, availability to credit, and motivation. Factors such as ease of cultivation, fair distribution of seeds, food availability, increase in income level, high legume harvest, and higher profitability of legumes ($p < 0.05$) significantly influenced smallholder farmers' awareness and perception of diversified legumes. Therefore, Farmers Research Network project has positively impacted diversified legumes on smallholders farmers in Singida Region. There is a need to increase training sessions to create awareness on diversified legumes.

Key words: Diversified legumes, Smallholder farmers, Two Stage Heckman Selection Model, Principal Component Analysis

IKISIRI KUU

Uzalishaji wa mikunde Mkoani Singida umekuwa ukifanyika kwa miaka mingi lakini kwa uzalishaji wa mazao umekua kidogo. Utafiti huu ulilenga kutathmini athari za Mradi wa Utafiti wa Wakulima FRN kwenye mazao ya aina mbalimbali ya mikunde miongoni mwa wakulima wadogo wa Mkoa wa Singida. Utafiti huu uliajiri muundo wa utafiti wa sehemu mbalimbali na wahojiwa wakulima wadogo wadogo 204 kwa kutumia dodoso na usaili muhimu wa watoa taarifa. Muundo wa hatua mbili wa uteuzi wa Heckman ulitumiwa kubainisha mambo yaliyoathiri kupitishwa kwa uzalishaji wa aina mbalimbali za mikunde na mtazamo wa wakulima ulitathminiwa kwa kutumia kipimo cha Likert na kisha uchanganuzi ukafanyiwa uchanganuzi wa vipengele kuu kwa uchanganuzi wa sababu uchambuzi wa maelezo na maudhui ulifanywa kwa data ya kiasi na ubora mtawalia inayotumia Microsoft excel kwa uwasilishaji wa matokeo. Matokeo ya mambo yanayoathiri kuasili yalionyesha kuwa umri, elimu, ukubwa wa shamba, kazi kubwa, uzoefu, ukubwa wa ardhi, upatikanaji wa mikopo, na motisha zilihusishwa kwa kiasi kikubwa na upitishwaji wa uzalishaji wa aina mbalimbali za mikunde. Kupitishwa kwa uzalishaji wa aina mbalimbali za mikunde katika eneo la utafiti kulionekana kuathiriwa sana kitakwimu na umri wa wakulima, kiwango cha elimu, ukubwa wa shamba, kazi kuu, uzoefu, ukubwa wa ardhi, upatikanaji wa mikopo, na motisha. Mambo kama vile urahisi wa kulima, usambazaji sawa wa mbegu, upatikanaji wa chakula, ongezeko la kiwango cha mapato, mavuno mengi ya mikunde, na faida kubwa ya mazao ya jamii ya kunde ($p < 0.05$) yaliathiri kwa kiasi kikubwa uelewa wa wakulima wadogo na mtazamo wa aina mbalimbali za kunde. Kwa hiyo, mradi wa Mtandao wa Utafiti wa Wakulima umeathiri vyema aina mbalimbali za mikunde kwa wakulima wadogo wa Mkoa wa Singida. Kuna haja ya kuongeza vipindi vya mafunzo ili kujenga uelewa juu ya aina mbalimbali za mikunde Uzalishaji wa mikunde Mkoani Singida umekuwa ukifanyika kwa miaka mingi lakini kwa uzalishaji wa mazao umekua kidogo. Utafiti huu ulilenga kutathmini athari za Mradi wa Utafiti wa Wakulima FRN kwenye mazao ya aina mbalimbali ya mikunde miongoni mwa wakulima wadogo wa

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Maneno muhimu: Uzalishaji wa mikunde, wakulima wadogo wa Mkoa wa Singida, Muundo wa hatua mbili wa uteuzi wa Heckman

DECLARATION

I, Caroline Fredy Lema, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted for a higher degree in any other institution.

_____ _____

Caroline Fredy Lema Date

(MA. Candidate)

The above declaration is confirmed by;

_____ _____

Prof. Kim Abel Kayunze Date

(Supervisor)

_____ _____

Dr. Michael Kadigi Date

(Supervisor)

LIST OF PAPER PUBLISHED AND MANUSCRIPT

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DEDICATION

The accomplishment of this research is dedicated to my parents (Fredrick Lema and Beatrice Lema) together with my husband and son (Eng. Ansgar Kabutelana and Diego). They have all been in touch with me at priceless cost and time throughout my study period

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LIST OF ABBREVIATION

BNF	Biological Nitrogen Fixation
FAO	Food and Agriculture Organization
FRN	Farmers Research Network
FYDP II	Five Years Development Plan II
GDP	Gross Domestic Product
KG/HA	Killogram Per Hector
KIIs	Key Informant Interview
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
MT	Metric Tones
RECODA	Research Community and Organization Development Associates
SDGs	Sustainable Development Goals
STATA	Statistics and Data
TDU	Tanzania Development Vision
URT	United Republic of Tanzania
WFP	World Food Programme

CHAPTER ONE

1.0 General Introduction

1.1 Background Information

Grain legumes are important agricultural crops contributing to small and big-holder production, income generation and nutrition across the world (Erana, 2020). Legumes' importance is further depicted in the role they play that includes; provision of food security, generation of income, and maintenance of environment through soil improvement in most smallholder farming systems in sub-Saharan Africa (Odendo *et al.,* 2016). Falling in the Leguminosae family, one among the largest flowering family, legumes crop includes; nuts (Bambara, Ground) peas (Chicken, Cow) and beans (Common, Soy) (Ahmed and Hassan, 2014). All these are particularly important for human food but also used animal feed, as they are rich in protein. According to FAO (2018), most legumes are consumed alongside staple foods such as maize, millet, sorghum, rice, cassava, Irish and sweet potatoes etc.

Global production of legumes has lacked consistency despite the importance the crops pose compared to other crops such as cereals. According to the Food and Agriculture Organization (FAO), global production of legumes by 2014 was only 77 million tonnes, which is 2.8% decline trend when compared using the global legumes production to cereal production ratio (FAO, 2019). The global production of legumes traced from 1970 was characterized by a one third-yield harvest per hector when comparing yield harvests between legumes and cereals. The current trends show the gap has widening but also showing a sharp increase in some legumes that are peas and dry beans (FAO, 2019). Generally, most of the legumes crops highly produced, that include dry beans and chicken pea, soybeans, groundnuts and pigeon pea have been recorded to be produced highly in the Sub-Saharan Africa (Nedumanaran *et al.,* 2015).

In Africa, studies have identified low legume yield gaps and low productivity to less than 1 ton per hectare despite the crops' importance. This has been due to poor soil fertility, pests, and diseases and other climatic factors (Mercy, 2017). According to FAO (2016), cultivation of some legumes in the Sub-Saharan Africa averages 1.7 MT per ha (groundnuts = 2 MT and pigeon peas = 1.4 MT). The Eastern Africa region has an average productivity of 1.00 MT per ha (groundnuts = 1.15 MT and pigeon pea = 0.78 MT). This is about 28.6% of Sub-Saharan Africa production. Bambara groundnut production in Africa is reported to be approximately 0.3 million tons annually with an average of 0.85 t/ha, although the yield potential is reported to be over 3 t/ha (Lin Tan, 2020). This has also been the case for Tanzania. According to the Ministry of Agriculture, Food Security and Cooperatives (MAFSC) in Tanzania, groundnuts occupy 25% of the total area planted to grain legumes, followed by pigeon peas, cowpeas, chickpeas and soybean.

According to Tsedeke (2020), estimates indicate that pigeon peas acreage grew from about 64 000 ha in 2003 to 170 000 ha in 2010 and it is reported to be the highest yielding legume in Tanzania. Household surveys in Tanzania generally show high rates of household dependence on legumes, as they are cheaper sources of dietary protein, contributing to 16.9% protein and 7.3% calories (N2Africa, 2019). Total harvest of the major grain legumes are estimated to be more than 1.5 million ha and 1 million metric tons (MT), groundnut 694 Kg/Ha and pigeon pea 1 012 Kg/Ha (Tsedeke, 2020) and the harvest have been both confined to consumption and income generation purposes. Currently, legumes consumption in Tanzania currently sits about 20 kg per person per year despite the fact that that smallholder farmers are more interested in making food available and getting income (Akibode and Maredia, 2011; Tarirai *et al.,* 2019), where Bambara nuts production in most areas produced have been used for the latter compared to groundnut (Boulay, 2017).

Efforts to improve legume productivity in Tanzania have been eminent in most regions of the country. Among efforts, the Farmers Research Network (FRN) project has been under implementation in Singida since 2016 with the aims to improve productivity by emphasizing inter-cropping cereals that have been predominantly produced with legumes. This has been due to the fact soil fertility has been among the core reason hindering crops production causing food insecurity and thus malnutrition. The project is a collaborative research program funded by Mc Foundation that integrates the participation of farmers in the research process, collaborative learning and knowledge sharing and developing solution in a participatory means (Richardson *et al.,* 2021).

1.2 Overall Problem Statement

Legume productivity in Tanzania especially chicken peas, Bambara nuts and groundnuts just like most Sub-Saharan countries is recorded to be low. Produced during short and long rainy seasons, legumes produced in Tanzania have been under low quantities especially for Singida region hence affecting the food security and nutrition status of the region. According to the crop and livestock survey, Singida ranked among the least regions in Tanzania producing Bambara nuts and Pigeon peas while fairy doing well on groundnuts production (URT, 2018). Soil fertility ranks high among factors affecting legumes production in Singida region. According to the National Bureau of Statistics Singida ranks among ten regions with a large land in farm with an area above 1 000 000 hectares (URT, 2018). However, the productivity especially with legumes have not been convincing as opposed to other regions.

Efforts to improve crop production have been scaled from the national level to regional level from both governmental and non-governmental ends. Governmental efforts include policy and strategies development that include the introduction of the Agricultural Sector Development Programme phase II which priorities improvement of the Agricultural sector along with improving crop production. In Singida region the introduction of the FNR project aimed to improve productivity by emphasizing inter-cropping cereals that have been predominantly produced with legumes.

However, adoption and integrating legumes in the crop system among smallholder farmers is still a challenge, hence affecting the productivity (Erana, 2020). Less is known on the adoption of diversified legumes (pigeon peas, Bambara nuts and groundnuts) in Singida region. Available studies have been confined on the production of other legume crops such as dry beans chicken peas and cow peas (Tsekede, 2012; Shiferaw *et al.,* 2017; FAO, 2018; Mercy, 2020). This study therefore assessed the impact of FRN project on diversified legumes (pigeon peas, groundnuts and Bambara nuts) among smallholder farmers in Singida region.

1.3 Justification of the Study

Different efforts have regularly been made in the attempt to improve productivity of legume as a means to improve the nutritional income statuses of smallholder farmers. This in-turn helps in combating food insecurity and poverty. The study is important because the findings of the study will contribute to the government's efforts in improving livelihoods of the people, as far as legume productivity improvement is concerned. The study will also generate more information, useful to development planners, policy makers and practitioners in relevant ministries and other bodies concerned in improving people's nutrition through diversified legumes.

Moreover, the study is in line with the Tanzania Development Vision (TDV) 2025, which intends to achieve high quality livelihood for the people through food self-sufficiency and food security. At the global perspective, the study is also in line with the Sustainable Development Goals (SDGs), specifically goal number one and two that targets poverty eradication in all forms, attaining food security, and promoting sustainable agriculture that indeed eradicate hunger respectively. Also according to ASDP II, legumes are among the priority commodities in national food security, food import bill, poverty reduction and economic growth.

1.4 Objective of the Study

1.4.1 General objective

The overall objective of this study was to examine the impact of FRN project on diversified legumes (pigeon peas, groundnuts and Bambara-nuts) among smallholder farmers in Singida Region.

1.4.2 Specific objectives

The specific objectives of the study were to:

i. To determine the extent and factors of adoption of diversified legumes among smallholder farmers in the study area.
ii. To assess the profits coming along with the adoption of diversified legumes among smallholder farmers on the study area.
iii. To determine the contribution of diversified legumes on the households' nutritional improvement.
iv. To assess smallholder farmers awareness and attitude towards diversified legumes.

1.5 Research Questions

The study intended to address the following research questions:

i. To what extent have the smallholder farmers adopted the use of diversified legumes in their farming systems?
ii. What are the factors affecting adoption of introduced legume varieties?
iii. What are the nutritional and economic benefits coming along with the adoption of selected legumes?
iv. What are the farmers' knowledge and perceptions on diversified legumes?

1.6 Conceptual Framework

A conceptual framework elaborates a research problem and summarizes the variables and their indicators in relation to the study objectives and reviewed literature. A conceptual framework gives details of variables that are to be examined and expected in relation to the study. The framework shows the relationship between the dependent and independent variables (Adom *et al*., 2018).

The dependent variable for this study is extent of adoption of legumes production among farmers engaged in the FRN project while the independent variable is the productivity, nutritional and income benefits of the legume crop supported by background variables that are hypothesized to affect productivity such as household size of the household, sex, education and occupation of household head. According to Figure 1.1, households involved in the FRN project are most likely to be with improved socio-economic factors due to being exposed to enhancement factors that lead to improved legumes productivity. In a similar way, socioeconomic characteristics such as age, sex, education level and occupation will affect household involvement in the legumes productivity supported by the involvement of the project that targets improvement of the legume productivity hence improve the socio-economic factors of the smallholder farmers involved in legumes production as illustrated below.

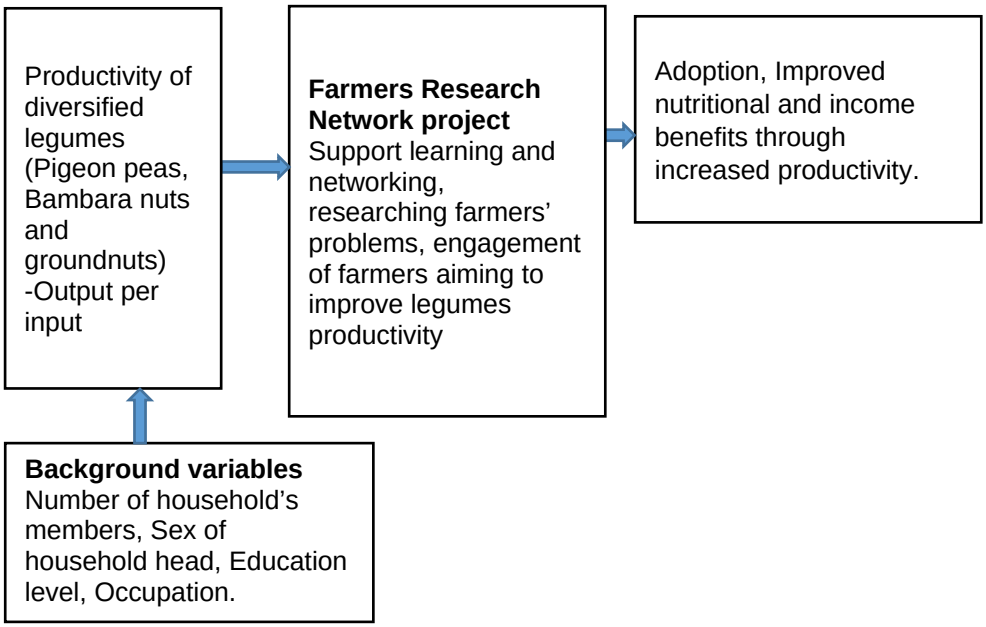

Figure 1.1: Conceptual framework (Author, 2023)

1.7 Study Limitations

The study was limited by unwillingness of some respondents to provide reliable information when requested, language barrier as others used native language only. These were overcome by doing participant observation and residing within their premises in order to understand the meaning behind their languages.

CHAPTER TWO
MANUSCRIPT I

2.0 FACTORS INFLUENCING ADOPTION OF DIVERSIFIED LEGUMES AMONG SMALLHOLDER FARMERS IN SINGIDA REGION, TANZANIA

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Abstract
Smallholder farming structures in Tanzania are mostly characterized by persistently high food insecurity levels. In the largest part of the country, efforts have been made to increase the yield of the legume crop in Tanzania, but there is still low adoption of crop diversification for most of smallholder farmers, particularly in Singida Region with scarcity of studies that have analysed why there have been the situation. This paper investigates factors influencing smallholder farmers' adoption to diversified legume production in Singida Region, Tanzania. The paper is based on a cross-sectional research whereby primary data were collected at once from 204 smallholder legume farmers using a structured questionnaire. Descriptive statistical analysis was used to analyse the data, which included socio-economic characteristics. A two-stage Heckman selection model was used to check the extent and the influence of relevant factors on adoption of diversified legumes. The results on the factors influencing adoption showed that age, education, farm size, major occupation, experience, land size, access to credit, and motivation were significantly associated with adoption of diversified

legume production. The adoption of varied legume production in the research area was found to be statistically significantly influenced by the farmers' age, education level, farm size, main occupation, experience, land size, availability to credit, and motivation. It is further stated that non-adopters of diverse legumes encounter a number of difficulties, such as missing RECODA FRN project training and education sessions and not being aware of the advantages of diversifying their crops. Therefore, this study recommends that Government and other stakeholders such as RECODA FRN project should formulate and implement strategies to increase educational training and extension services to smallholder farmers on Diversified Legume Production.

Key words: Diversified legumes, Smallholder farmers, Two Stage Heckman Selection Model.

2.1 Introduction

Agricultural sector plays a crucial role to human wellbeing. The sector provides food for people, money for farmers, raw materials for businesses, feeds for livestock, and jobs that generate foreign exchange for countries anywhere around the globe. In Tanzania, the agricultural sector accounts for an average of 27.7% to the GDP, 24.1% to export earnings and 65.0% of total employment (URT, 2021).

According to Alexandratos & Bruinsma (2012), the increase in crop yield per unit area in sub-Saharan Africa was predicted to fall from 3.3% per year (1987–2007) to 2.4% and to 1.9% per year from 2007–2030 and 2030–2050, in contrast, to an anticipated 335% increase in cereal demand between 2010 and 2050 (van Ittersum *et al.,* 2016). Similar to this, demand for legumes is anticipated to rise as consumer income rises and their preferences for nutrient-dense foods over cereal grains are predicted to change (Syngenta, 2017). The combined impacts of using low-yielding cultivars, insufficient and inconsistent rainfall, weed infestations, the presence of pests and diseases, and the sparing use of the nation's irrigation potential are blamed for the subsistence legume growers' low yields (Fischler, 2020). The government of Tanzania intends to boost legume productivity and production given the vast amounts of appropriate, unfarmed, fertile land, a high percentage of self-sufficiency, and existing low productivity.

In the largest part of Tanzania, efforts have been made to increase the yields of legume crops. One of organisations making such efforts is the Farmers Research Network (FRN) project, which has been running in Singida since 2016. Its goal is to increase productivity by focusing on intercropping cereals that are mostly grown with legumes. This is because one of the main factors impeding crop output and thus leading to food insecurity and subsequent malnutrition has been low soil fertility. The project is a cooperative research programme supported by the Mc Foundation that incorporates farmers' involvement in the research process, cooperative learning and knowledge sharing, and developing solutions in a participatory manner (Richardson *et al.,* 2021). In order to

increase legume production, diversification of crops is necessary, but still there is low adoption of crop diversification for most of smallholder farmers.

Similar studies argue in favour of the notion that farmers' adoption of legume varieties depends on various legumes' attributes including yield, taste, adaptability and capacity for soil fertility improvement (Tarari, 2019). According to Simone (2019), barriers to adoption of legume varieties include farm size, risk preferences, human capital, labour availability, and credit constraints. A study done by Kamaga *et al.* (2019) postulated that legume production intensification faces barriers such as seed access, appropriate genotypes and labour requirements. However, this research did not establish to what extent and factors which influence the adoption of diversified legume production among smallholder farmers. This paper looks into key factors which influence adoption of diversified legumes in Singida Region, Tanzania.

The results of this study will help fight food insecurity and poverty because they will help identify various factors that greatly influence the adoption of a variety of legumes. The study is significant because its results will help the government in its attempts to enhance the livelihoods of the populace by increasing the productivity of legumes. The paper will also produce additional data that will be beneficial to development planners, decision-makers, and practitioners in pertinent ministries and other entities interested in boosting the adoption of legume varieties. Additionally, the paper is consistent with the Tanzania Development Vision (TDV) 2025, which aims to provide people with high quality livelihoods through food security and self-sufficiency. The paper also complies with the Sustainable Development Goals (SDGs), particularly goals number one and two, which are focused on eradicating all forms of poverty and achieving food security and sustainable agriculture, respectively.

2.2 Methodology

2.2.1 Description of the study area

The study was conducted in Singida Region in the central corridor of Tanzania in Mtinko and Ilongero Divisions in 9 villages. Singida District Council (SDC) is one of the four councils within Singida Region. It is located between 3^0 and 7^0 latitudes south of the Equator and between 34^0 and 35^0 longitudes east of the Greenwich. Singida District has semi-arid climatic conditions. There are two seasons: the dry season that is the longest (April to November) and the rainy season that is December to March. The average rainfall is between 600 and 700mm per annum while the average minimum temperature is 15^0C to 30°C. It is one of the poorest regions in Tanzania (Lekule, 2014). Singida is itself a region, a district, and a town. From Arusha, Singida is accessible through Babati and Katesh, while from Dar Es Salaam it is accessible through Morogoro and Dodoma, and from Mbeya it is accessible through Morogoro and Dodoma. From Shinyanga and Mwanza, Singida is accessible through Nzega in Tabora Region. Singida Region is deemed neither small nor big. It is the 13^{th} in size and occupies about 5.6% of Mainland Tanzania's total area of 881 289 km^2. The motives behind choosing the region for the research on which this paper is based was that the FRN project was being implemented in the region providing the smallholder farmers with legume varieties.

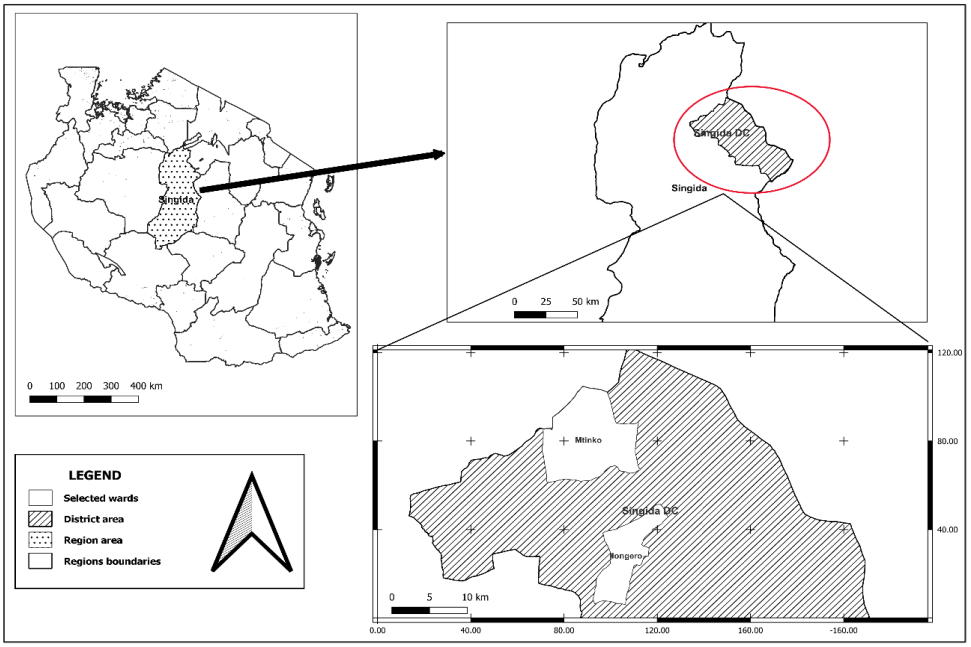

Figure 2.1: A Study Map Area
Source: Field Survey (2022)

2.2.2 Research design, sample size and sampling procedure

This study applied a cross-sectional research design as primary information was collected direct from farmers at one point in time. The study further adopted both purposive and simple random sampling techniques. The Singida region was selected purposively since the FRN project was being implemented in the region. Moreover, since the exact population for this study was not known, the formula suggested by Kothari (2004) was used to determine sample size. The formula did not require study population in sample size calculation, instead it just required margin error/ precision level= e (0.06858), proportion estimated for the population =p (0.5), and the confidence level of 95% which is standard with value of 1.96 = z. The formula is extensively expressed hereunder.

$$n = \frac{z^2 pq}{e^2}$$

$$n = \frac{1.96^2 0.5(0.5)}{0.03^2}$$

$$n = 204.2$$

Therefore, 204 farmers were randomly drawn as representatives from study area. Several studies targeting beneficiaries of FRN project in Singida region like of Kanjanja *et al*. (2022) and Chilewa *et al*. (2023) also used same formula to determine sample size of 176 and 212 respectively for data collection of their studies related to adoption of practices emphasized by FRN project.

2.2.3 Data collection

Using a structured questionnaire with both open-ended and closed-ended questions, primary data were gathered from respondents. The primary goal of the questions was to gather information on the variables affecting the adoption of production of diversified legumes. Data from Key Informant Interviews (KIIs) were also gathered. Four KIIs were performed in all, with participants including FRN project leaders and village executive officials. To confirm the data gathered through the questionnaire, extensive qualitative data were obtained using the KIIs checklist. The data collecting instruments were pre-tested in the study area before real data collection was done to ensure familiarity and clarity, which helped to assure the validity and reliability of the data gathered. The study's final analysis excluded the collected data from pre-testing. In addition, secondary data were also collected through SUA institutional Repository (SUAIRE) as well as reputable journals to make discussion of the primary data even more integrated.

2.2.4 Data analysis

Quantitative data collected through the questionnaire were analysed using the STATA software, whereby both descriptive statistical analyses and inferential statistical analyses were done.

In this research, data analysis involved the utilization of descriptive statistics such as mean, standard deviation, percentages, frequency, t-test, Chi-square, and graphical representations. The study considered smallholder farmers engaged in teff cultivation, acknowledging the possibility of them either cultivating or not cultivating diversified legumes. Consequently, the dependent variable in this model is discrete, presenting two possible outcomes: adoption or no adoption. The ordinary Least Square (OLS) technique is deemed unsuitable for such variables, as it introduces inference challenges when investigating dichotomous or limited dependent variables. In such scenarios, maximum likelihood estimation procedures like logit or probit models are generally considered more efficient, as suggested by Gujarati (1995).

Numerous researchers have employed different models to analyze the factors influencing technology adoption at the farm level. Some adoption studies have opted for the Tobit model to estimate relationships with limited dependent variables, while others have employed the double-hurdle model. However, in cases where selection bias is anticipated in the sample, Heckman's (1979) two-step procedure is a conceivable approach. The expectation of selection bias arises in this study, as not all households among the representative sample are assumed to engage in diversified legume adoption due to individual issues. The Heckman two-step selection model allows for the separation of the initial decision to adopt technology (Y>0 versus Y≤0) and the subsequent determination of the level of its application.

Therefore, a two-stage Heckman selection model was used to determine factors influencing the adoption of diversified legume production. The model had two stages where the first stage involved the estimation of a Probit model to determine the influence of adopting the diversified legume production, and the second stage involved estimating the outcome of the factors influencing the adoption of diversified legume production. Differences or associations between variables were considered statistically significant if the p-value was (<0.05, 0.01, and 0.1) respectively.

The first stage of Heckman two step or the probit model analyzes the factors determining the probability of diversified legume adoption. The decision to adopt technology is associated with an assessment by the farmers of the costs and benefits associated with it with the decision specified as:

$$Y_i^{¿} = \beta X_i + \varepsilon_i ; \varepsilon_i \approx N(0, \delta^2) \quad (1)$$

Where Y is a latent variable reflecting the net benefits (not observable) from the technology and it is a dummy dependent variable (1 = adoption, 0 = non-adoption). These are influenced by the explanatory variables represented by the column vector X, β_i is a vector of the estimated parameters and ε_i is a vector of the error term. What is observed in practice is a smallholder farmer either adopted the technology (Yi=1) or did not adopt the technology (Yi=0). The relationship between the index model and the observed decision is presented in equation (2).

$$Y_i = \begin{pmatrix} 1\, if & Y_i^{¿} > 0 \\ 0\, if & Y_i^{¿} \leq 0 \end{pmatrix} \quad (2)$$

The conditional probability that smallholder farmer I adopt the technology is given in equation (3)

$$P(Y_i = 1 | X_i) = P(Y_i^{¿} > 0 | X_i) = P(\beta X_i + \varepsilon_i > 0 \vee X_i)$$

$$P(Y_i = 1 | X_i) = P(\varepsilon_i > -\beta X_i | X_i) = P(\varepsilon_i \leq \beta X_i \vee X_i)$$

$$P(Y_i = 1 | X_i) = \int_{-\infty}^{\beta X_i} \varnothing(\beta X_i) \partial X_i$$

$$P(Y_i = 1 | X_i) = \Phi(\beta X_i) \quad (3)$$

Under the assumption of standard normal distribution of the error term equation (3) represents the Probit model whose parameters were estimated by the maximum likelihood (ML) method.

In the second stage parameters can consistently be estimated by an ordinary least square regression (OLS) by incorporating an estimate of the inverse Mills ratios denoted as λi from probit regression model as additional explanatory variable as specified bellow:

Involves the estimation of an ordinary least square regression (OLS) of a sub sample of the farmers that actually use the improved maize varieties such as:

$$L_i = \beta_i X_i + \beta_\lambda \lambda_i + \mu_i if\ Y_i^{\iota} > 0 \quad (4)$$

Where:

L_i- Land (acreage) allocated for diversified legumes

X_i- Vector of the explanatory variables (These are the same with the selection equation)

β_i- Vector of the estimated coefficients

λ - Inverse Mills Ratio computed from first stage estimation,

β_λ- Coefficient of Inverse Mills Ratio

μ_i- Error term

Based on Heckman (1979), the Inverse Mills Ratio (IMR), denoted as (λ_i), serves as a variable to manage bias arising from sample selection. This term is formulated through the probit regression model in the initial stage and subsequently integrated into the second stage model (OLS) as an independent variable. Its derivation is feasible;

$$\lambda_i = \frac{\varnothing\left(\beta_0 + \beta_{1i} X_{1i}\right)}{\phi\left(\beta_0 + \beta_{1i} X_{1i}\right)} \quad (5)$$

Where; $\varnothing$(.) represents the probability density function of the standard normal distribution, and ϕ(.) represents the cumulative distribution function for a standard normal random variable. However, since the value

of λ_i is unknown, the parameters β_0 and β_{1i} can be determined through a probit model, utilizing the observed binary outcome. Subsequently, the calculated IMR is based on these estimated parameters as;

$$\hat{\lambda}_i = \frac{\varnothing\left(\widehat{\beta_0} + \widehat{\beta_{1i}} X_{1i}\right)}{\phi\left(\widehat{\beta_0} + \widehat{\beta_{1i}} X_{1i}\right)} \quad (6)$$

The independent variables and their definitions

A multitude of factors is found in the literature that affect the decision of farmers to adopt new agricultural technology and the level of adoption of these technologies. The set of explaining variables are household characteristics, physical, socio-institutional, and plot-level characteristics included in the empirical models are selected following a review of many literatures on farm-level investment theory (Gebremedhin and Swinton, 2003; Tafesse and Sodo, 2016; Tsehay, 2016). These are explained in Table 2.1 below.

Table 2.1: Summary of definitions, measurements, and expected signs of variables

Variable	Nature of variable	Variable definition and measurement	Expected Sign
Age	Continuous	Number of years since birthdate	+/-
Gender	Dummy	Gender of respondent (1=Male 0=Female)	+/-
Marital status	Dummy	Current marital status (1=Married, 0=otherwise)	
Education status	Dummy	Educational status of the household head (1 literate, 0, otherwise)	+
Farm size legumes	Continuous	Farmland size allocated for legumes in hectares	+
Occupational status	Dummy	Nature of occupation (1=Formally Employed,0=Otherwise)	+
Farm land Ownership	Dummy	Ownership of farm plot(1=Fully owned, 0=Rented)	+
Farm experience	Continuous	Farming experience	+
Distance to output market	Continuous	Distance from selected farm household to the nearby marketplace in Km	-
Land size	Continuous	Total farmland owned by the household in acres	+
Access to credit	Dummy	Access to credit from financial institutions (1=Yes 0=No)	+
Motivation from FRN project	Dummy	Motivation from the project campaigns(1=Motivated, 0=Not motivated)	+
Access to ext. services	Dummy	Access to extension agent support (if have access Yes=1, 0 Otherwise)	+
Membership to cooperative	Dummy	Household's membership to cooperative (if member Yes=1,0 Otherwise)	+

2.3 Results and Discussion

2.3.1 Socio-economic characteristics of respondents (Farmers)

Different characteristics of respondents were used in this study. The respondents' characteristics included sex, age, marital status, education level, major occupation, land size, access to credit, and income. The findings in Table 2.2 show that, among non-adopters, 57.7% were male while 42.3% were female. Among adopters, 59.2% were males and 40.8% were females. The results show that more than a half of the respondents among both adopters and non-adopters were males. This implies that most of the legume farming activities are done by males in the study area. This is highly influenced by the fact that in most of the area men are the ones responsible for doing most of the economic activities so as to feed the families while women are taking care of children and doing house chores (Mdoe and Macha, 2002).

The results in Table 2.2 also show that, among the non-adopters, 59.9% were married and 48.1% were not married. Also, among the adopters, 38.2% were married and 61.8% were not married. The influence of marital status on the adoption of diversified legume production can vary widely depending on cultural, social, and economic factors, and may not hold true for all farmers in all regions (William *et al.,* 2016). Marital status can play a role in the adoption of diversified legume production, by affecting household decision-making, division on labour, access to resources, and social networks. However, this can vary greatly depending on a variety of cultural, social, and economic factors (Mutenje *et al.,* 2016).

Further, the results in Table 2.2 show that, among non-adopters, 25.0% had informal education; 59.6% had primary education; and 15.4% had secondary education, while among adopters of diversified legume production 30.3% had informal education; 58.6% had primary education; and 11.6% had secondary education. This shows that more than a half of the respondents (59.6% and 58.6%) of the respondents had primary education. This suggests that higher levels of education can equip farmers with the knowledge, skills, and resources needed to understand

the importance of diversified legume, access information and resources, and experiment with new practices that can improve their farming practices. Moreover, attitude has widely been expressed, with the idea that in farming communities that are literate, the task of convincing or educating them about the adoption of diverse legumes has been greatly simplified (Tegegne, 2017).

As summarized in Table 2.2, among non-adopters, 25.0% were employed; 61.5% were unemployed; and 13.5% were self-employed. Among adopters, 9.9% were employed; 66. 5% were unemployed; and 23.68% were self-employed. More than a half of the smallholder farmers who had adopted the diversified legumes production were unemployed. This implies that most of the smallholder farmers who had adopted the diversified legume production were able to adopt the diversified legume production since it was the only farming activity which they were doing; so it was easy for them to attend several training sessions which were conducted by the FRN project.

In Table 2.2, the findings show that, among non-adopters, 67.3% owned land, and 32.7% rented land, while among adopters 64.5% owned land, and 35.5% rented land. The results imply that both adopters and non-adopters owned farms. In the case of access to credit, among non-adopters 42.3% had access to credit and 46.2% had no access to credit. Furthermore, among the adopters, 50.7% had access to credit and 49.3% had no access to credit. The results show that more than a half of the respondents who adopted diversified legume farming had access to credit. This implies that access to credit increases the chances of the farmers to adopt the diversified legume farming practices. Access to credit can be a key factor in the adoption of diversified legume production by smallholder farmers by providing them with necessary funds, reducing their risks, increasing their bargaining power, and improving their livelihoods (Nyasimi *et al.,* 2017).

The respondents who were adopters and non-adopters had average ages of 35.94 and 34.46 years, respectively. This shows that the majority of legume farmers in the study area were of a productive age (31 to 45 years). This finding is in line with Punch's (2001) findings that farmers in their middle years appear to be more productive than those in their early years and those in their later years due to their heavier workloads in the family and community. Taking care of kids and elderly household members, paying for the children's education, covering household health expenses, and contributing to social welfare initiatives in the community are a few examples of chores performed by the productive aged people.

As seen in Table 2.2, adopters had an average land size of 3.93 ha, compared to non-adopters who had an average land size of 2.49 ha. The results demonstrate that adopters owned greater land plots than non-adopters. Large-scale farmers may have more financial resources and economies of scale to devote to varied legume production. Although this can limit their ability to fully profit from diversity, farmers with huge land holdings may also have less time and effort to spend to the care and maintenance of their crops (Anang *et al.,* 2016).

Lastly, in Table 2.2, the average incomes of the legume farmers among non-adopters and adopters of diversified legume production were TZS 221 923.08 and TZS 472 171.05 respectively. The findings reveal that adopters had more income compared to non-adopters. This shows that the income of a farmer can be a significant factor in the adoption of diversified legume production in Tanzania, as it can provide necessary resources, increase market opportunities, increase access to information and technology, increase risk resilience, and improve livelihoods (Makate *et al.*, 2019).

Table 2.2: Cross tabulation of demographic characteristics based among Adopters and Non-adopters of legumes (n = 204)

Socio-economic Variables	Not adopted		Adopted		Chi-square test (P-value)
	Frequency	%	Frequency	%	
Categorical variables: Gender					
Male	30	57.7	90	59.2	0.848
Female	22	42.3	62	40.8	
Marital status					
Married	27	51.9	58	38.2	0.082
Not married	25	48.1	94	61.8	
Educational level					
Informal education	13	25.0	46	30.3	
Primary education	31	59.6	89	58.6	0.626
Secondary education	8	15.4	17	11.2	
Occupation					
Employed	13	25.04	15	9.9	
Unemployed	32	61.5	101	66.5	0.014***
Self employed	7	13.5	36	23.7	
Land ownership					
Own land	35	67.3	98	64.5	0.711
Rent land	17	32.7	54	35.57	
Access to credit					
Yes	28	42.3	77	50.7	0.691
No	24	46.2	75	49.3	
Continuous variables					
Age	35.94	(13.44)	34.46	(12.27)	0.582
Land size	2.49	(1.28)	3.93	(1.64)	0.000***
Income	221,923.08	(90,164.09)	472171.05	(160755.33)	0.000***

2.3.2 Factors influencing adoption of diversified legume production among smallholder farmers

A generalized two stage Heckman selection model was used to determine the extent of and factors influencing smallholder legume farmers to adopt the production of diversified legumes. Explanatory variables included age of the household head, sex of the household head, marital status, education level, farm size, major occupation, ownership, experience, distance, land size, access to credit, and motivation. The results are presented in Table 2.3 and show that mean dependence variance was 0 relationship between mean and variance.

Table 2.3: Generalized two stage Heckman selection model result of adoption of legumes

	Second stage Augmented regression estimates		**First stage Probit model estimates**	
	Level of adoption		**Influence for adoption**	
Model variables	**Coefficients**	**Standard Error**	**Coefficients**	**Standard Error**
Age	-0.007***	0.003	-0.011	0.009
Gender	0.017	0.069	-0.164	0.238
Marital	-0.046	0.068	0.165	0.229
Education	0.154**	0.063	-2.460***	0.372
Farm size legumes	0.203***	0.050	1.545***	0.261
Occupation	0.388***	0.057	0.876***	0.199
Ownership	0.045	0.066	0.305	0.256
Experience	0.186**	0.073	-0.860**	0.346
Distance	-0.001	0.001	0.001	0.003
Land size	0.092***	0.019	0.252***	0.074
Access to credit	0.150**	0.062	0.275	0.223
Motivation	0.095**	0.047	1.124***	0.244
Constant	-0.607**	0.236	-1.548**	0.759
Athrho			1.877***	0.280
Lnsigma			-0.931***	0.062
Mean dependent var	0.745		SD dependent var	0.437
Number of Observation	204		Chi-square	258.060
Prob > chi2	0.000		Akaike crit. (AIC)	296.332

**** p<.01, ** p<.05, * p<.1*

Also, Table 2.3 shows that the number of observations was 204. The probability Chi-squared was 0.000, which implies that the data set had adequate goodness of model. Furthermore, the Akaike information criterion measure from Table 2.3 was found to be 296.332; this implies that the model best fitted the data..745 indicating that the statistical model was appropriate, hence more stable.

The results presented in Table 2.3 show that the respondents' age was not statistically significant to influence of adoption ($p>0.01$, but it was statistically significant for the level of adoption of the diversified legume production ($p<0.01$). For the case of influence and level of adoption of diversified legumes, the result show that as a person's age increased, their level of adopting the diversified legume production decreased by 0.7% and 1.1% respectively. The findings show that the age of the farmer did not influence adoption of diversified legume but significantly influenced the level of adoption of diversified legumes. This could be explained by the fact that as the farmers' age increase they become less risk tolerant and their health deteriorates; as farmers age, they may become risk-averse and not willing to take on new challenges. This can decrease their willingness to adopt new crops and farming practices (Teklewold *et al.,* 2013).

Moreover, sex of the respondent had significant influence on the adoption of diversified legume production among smallholder farmers. This is highly influenced by low agricultural knowledge and skills; the knowledge and skills of farmers, such as their understanding of legume production and how to manage the crops can play a significant role in the adoption decision (Abebe *et al.,* 2013). Additionally, the result in Table 2.3 on marital status show that there was no statistical significance for both the influence of adoption and the level of adoption of diversified legume; the beta coefficients were positive, (0.165) and negative (-0.046) for influence on adoption and level of adoption respectively. This could be explained by poor access to resources such as land, finances, and information about diversified legume production; they could be equal for both married and single individuals, thereby reducing the influence of

marital status on adoption (Assan *et al.,* 2018). However, in some other contexts, individuals may be part of similar social networks regardless of their marital status, and these networks can provide access to information, resources and support for diversified legume production, thereby reducing the influence of marital status (Leavy and Hossain, 2014).

From the Table 2.3, education level of the respondents had statistically significant influence on adoption and the level of adoption of diversified legume production. It is observed that the increase in education level of the respondents increased the adoption level of diversified legumes by 0.154 times. A higher level of education can provide farmers with the information, skills, and resources they need to successfully implement varied legume production and assist them in making well-informed decisions about doing so (Mango *et al.,* 2018).

Farm size had high and statistically significant ($p<0.01$) influence on adoption of diversified legumes. This implies that as the farm size increased there was increase by 1.545 times of adoption of diversified legumes and 0.203 times in the level of adoption of diversified legume production. This is explained by resource constraints whereby farmers with small farm sizes for production of legumes may have limited resources such as land, finances, and labour, which can make it challenging for them to adopt diversified legume production. On the other hand, larger farmers may have more resources and be better equipped to implement diversified legume production (Mizik, 2021).

The findings in Table 2.3 also show that the major occupation of the farmers has significant influence on the adoption and level of adoption of diversified legumes ($p<0.01$). Also, the influence on adoption and the level of adoption have positive beta coefficients which are 0.876 and 0.388 respectively. This implies that occupation increases the adoption of diversified legumes 0.876 times and level of adoption by 0.388 times. Improved access to information and resources has a significant impact on this because it may be easier for farmers with jobs outside of

agriculture to access resources like market information, training programs, and extension services, which can support their adoption of diversified legume production (Kassie *et al.,* 2015). However, the adoption of diverse legume production might also be negatively impacted by occupation. For instance, farmers may not have the time or energy to devote to their farming activities if they work time-consuming occupations, which could limit their ability to use varied legume production (Makate *et al.,* 2016).

The results in Table 2.3 show that ownership of land show had no statistically significant influence adoption and level of adoption of diversified legume production. This implies that ownership of land does not influence the adoption of diversified legume production in the study area. This could be explained by lack of awareness as many small-scale farmers were not aware of the benefits of growing a variety of legume crops, such as improved soil fertility, higher yields, and higher food security. This can limit their motivation to adopt diversified legume production practices (Mapiye *et al.,* 2006). This argument was supported by a key informant from the RECODA FRN project in Singida District:

> "*Among the things we consider is increasing awareness of the importance of the production of diversified legumes production in the area. Lack of awareness among the farmers highly decreases the adoption of the diversified legume farming. Therefore, some of the smallholder farmers who do not adopt this farming practice are not aware of the importance of the practice".* (Key Informant, RECODA FRN Project)

The results in Table 2.3 also show that legume farming experience had statistically significant influence on adoption of diversified legumes and the level of adoption of diversified legume production respectively ($p<0.05$). That is to say, the legume farmers who were more experienced in legume production had a better understanding of the legume production; the adoption of diversified legume production would increase their level of production thus increasing food security in their area. According to Sekaran *et al.* (2021), farming experience can play a critical

role in the adoption of diversified legume production by affecting knowledge, risk assessment, resource utilization, technology adoption, and networking. However, these results are different from results of a study by Omache (2016) who found that there was no correlation between experience of farming and increase in production of agricultural crops.

Furthermore, as seen in Table 2.3, distance to the farm had no statistically significance influence ($p>0.05$) on adoption of diversified legume production. Institutional support may have a significant impact on this since the adoption of diverse legume production practices can depend on support of regional institutions and organizations, such as extension services. The distance from the farm to these groups may not be a significant factor in deciding the adoption of diverse legume production practices if these organizations are absent or if the capacity to support farmers is lacking (Oyetunde-Usman *et al.,* 2021).

For the case of land, the findings show that land size had statistically significant influence on adoption of diversified legumes ($p<0.01$). The beta coefficients were also positive for the land size on its influence and the level of adoption of diversified legumes (0.252 and 0.092) respectively. Access to land as a resource, according to Ashfaq *et al.* (2008), is a key factor that impacts the quantity of crops that can be grown, given a set of resources. This finding indicates that farmers are more likely to diversify than their competitors if they have relatively larger parcels of land.

The findings in Table 2.3 also show that access to credit had significant positive influence on adoption and the level of adoption of diversified legume production ($p<0.05$). This shows that a unit increase in access to credit increased the level of adoption of diversified legume by 0.15 times. This is due to the fact that the production of legumes can be capital-intensive since it necessitates acquisition of equipment, fertilizers, and seeds. Farmers may find it difficult to afford these inputs without access to loans and may not be able to make investments in diversified production (Tambo & Abdoulaye, 2012). Additionally, having access to

credit can aid farmers in expanding their operations and boosting their income. With more money, farmers could buy more land, hire more workers, and make other expenditures that would boost their total productivity and marketability. The results are in line with findings of a study by Ololade & Olagunju (2013) who reported that access to credit is a crucial factor in provision of income to the smallholder farmers in their farming activities.

Lastly, as indicated in Table 2.3, motivation to the farmers had statistically significant impact on adoption of diversified legume production and level of adoption of diversified legume production ($p<0.01$ and $p<0.05$ respectively). Positive beta coefficients were observed in both cases (1.124 and 0.095 respectively). The results imply that motivating farmers through various campaigns has significant influence on adoption of diversified legume production. This could be facilitated by several reasons such as provision of information and education to smallholder farmers by the RECODA FRN project in Singida District, as famers need first to understand the benefits of diversifying their production, including higher yields, improved soil health, and reduced pest and disease pressures. By providing educational materials and training programmes, farmers can learn about the benefits and best practices of diversified legume production. Also, by showcasing successful case studies and farmers who have successfully adopted diversified legume production, others can see the potential benefits and be motivated to try it themselves. Moreover, offering of financial incentives to smallholder farmers such as subsidies, tax credits, or low-interest loans can help make it more attractive for farmers to adopt diversified legume production. The argument was made by one key informant in Ilongero ward:

> *“We conduct several education training programmes to smallholder farmers in order to motivate them to diversify their production activities so as to raise their production, thus reducing the issue of food insecurity, facilitated mainly by climate change effects in our area. Also, the RECODA FRN project assists the famers with different incentives such as fertilizers and lowering*

interest for the loans so that they can adopt diversified legume production; as you know, Singida is among areas in Tanzania with little food production." (Key Informant, RECODA FRN Project).

2.4 Conclusions and Recommendations

Findings of this study proved that age of the farmers, education level of the farmers, farm size, major occupation of the farmer, experience of the farmer, land size, access to credit, and motivation had statistically significant influence on adoption of diversified legume production in the study area. It was further concluded that non-adopters of diversified legumes face several challenges such as not attending training and education training sessions conducted by RECODA FRN project, thus being not aware of the benefits of diversifying their crops. The study recommends that central government should increase investment in the agricultural sector through providing incentives and subsidies to smallholder legume farmers and other stakeholders and RECODA FRN project should increase educational training sessions and extension services to smallholder farmers in order to motivate them to adopt diversified legume production to increase food security.

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CHAPTER THREE

PAPER II

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Farmers' Awareness of and Attitude towards Diversified Legumes Production in Singida Region, Tanzania

Caroline Fredy Lema, Michael Kadigi, and Kim Abel Kayunze

ABSTRACT

For an extended period, legumes have served as nutritional sources in the diets of both humans and animals. Efforts have been made to increase the yield of the legume crops in Tanzania, but there is still low awareness of and unfavourable attitudes towards legume crop diversification among farmers. The study, on which this paper is based, aimed at investigating farmers' awareness of and attitude towards diversified legumes, specifically to analyze socio-demographic characteristics of the respondents, assess awareness of and attitude towards diversified legumes production, and determine effects of awareness of and attitude towards diversified legumes production on management practices of diversified legumes production. A cross-sectional survey was employed whereby primary data were collected from 204 legume farmers using a semi-structured questionnaire. Content analysis was conducted using Nvivo software to analyze qualitative data. For quantitative data, Likert scale analysis was employed as a method for descriptive statistics, and Principal Component Analysis was used as a method for inferential analysis. These analyses were performed using Smart PLS software. The findings of the study revealed that several factors significantly influenced smallholder farmers' awareness and perception of diversified legumes. These factors included ease of cultivation, fair distribution of seeds, food availability, increase in income level, high legume harvest, and higher profitability of legumes ($p < 0.05$). Furthermore, the statement "enough of information" did not show statistical significance ($p > 0.05$). However, it exhibited a positive association. Conclusively, criteria like "easy cultivation" and "fair seed distribution" had a big impact on how smallholder farmers perceived and knew about diverse legumes. However, "enough information" did not appear to have a major significance. In addition, it was found that major influences on farmers' attitudes and understanding of diversified legumes included the availability of food, rising income levels, high yields of legumes, and perceived profitability. The paper recommends for the improvement of farmers' awareness and perception of diversified legumes, fair seed distribution methods must be established that provide equal access to high-quality seeds with the help of government organizations, non-profit organizations, and seed businesses.

Keywords: Analysis of smallholder farmers, diversified legumes, principal component.

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I. Introduction

Food and nutrition insecurity and poverty are major challenges in developing countries, particularly in sub-Saharan Africa which require much more agricultural production and productivity to feed its expanding population [1]. Legume grains have long been key sources of nutrition for both human and animal diets. In many developing countries, where small-scale farming predominates, farmers' knowledge and perceptions of diversified legumes are often characterised by traditional practices and a lack of exposure to innovative farming techniques [2]. Farmers' knowledge and perceptions regarding diversified legumes play a very crucial role in shaping agricultural practices, sustainable farming systems, and food security at large. In developing countries, understanding farmers' perspectives on legume diversity, agronomic practices, access to improved varieties, and the socio-economic factors influencing their decisions is very essential for developing targeted interventions and more likely in promoting effective agricultural development strategies [3].

During their growth or after harvest, the majority of legumes produce multiple products or perform a variety of activities and are frequently referred to as being multifunctional. These purposes include producing money, supplying food, fuel, and livestock feeds, enhancing soil fertility through biological nitrogen fixation (BNF), preventing soil erosion, and a host of additional advantages [4]. In many developing countries, where small-scale farming predominates, farmers' knowledge and perceptions of diversified legumes are often limited by traditional practices and a lack of exposure to innovative farming techniques [2]. Kenya is the largest producer of a variety of legumes in East African nations, followed by Uganda and Tanzania in terms of area [5].

Singida Region, located in central Tanzania, is a region of

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significant agricultural importance. It is characterized by small-scale farming systems, with agriculture serving as a primary source of livelihood for the majority of the population. Legumes are an integral part of the agricultural landscape in Singida, contributing to food security, soil fertility improvement, and income generation for farmers [6]. Obtaining comprehensive global statistics on farmers' knowledge and attitude towards diversified legumes is challenging due to variations in agricultural practices, cultural contexts, and available data. However, farmers' knowledge of and attitude towards diversified legumes have been subjects of several studies. However, some studies and reports provide insights into the overall trends. A study conducted by Haug *et al.* [7] assessed farmers' knowledge and perceptions on diversified legumes in Tanzania which revealed that farmers possessed varying levels of knowledge regarding different legume species, their benefits, and management practices. While some farmers had good knowledge of legumes like beans and cowpeas, they showed limited awareness of other legume species, their nutritional value, and their role in soil fertility improvement.

In a study conducted by FAO [8], it was found that farmers' knowledge and perceptions of diversified legumes are influenced by various factors, including cultural practices, availability of information, access to markets, and socio-economic conditions. The study emphasized the need for targeted capacity-building programmes and knowledge transfer initiatives to enhance farmers' understanding of the benefits and management practices associated with diversified legume production. Furthermore, studies by Udoh and Nwosu [9], Awiti *et al.* [2], and Muoni *et al.* [4] showed that farmers' knowledge and perceptions of diversified legumes were influenced by traditional farming practices, market demand, availability of support services, influenced by agro-ecological conditions, access to improved varieties, and market opportunities. The research undertakings stressed on the importance of farmer education and extension services in improving knowledge and promoting the adoption of diversified legume cropping systems.

However, the previous studies did not clearly establish the extent of knowledge of and attitude towards diversified legumes among smallholder farmers. This paper looks into key aspects which illustrate knowledge of and attitude towards diversified legumes in the Singida Region, Tanzania. This study's findings will contribute to the fight against food insecurity and poverty by identifying key factors that significantly impact the acceptance and utilization of various legumes. The study holds significance as its results will aid the government in raising awareness about diverse legume options. The research generated additional data valuable to development planners, decision-makers, and practitioners in relevant ministries and organizations seeking to enhance the adoption of legume varieties. Furthermore, this paper aligns with the Tanzania Development Vision (TDV) 2025, which aims to ensure high-quality livelihoods for individuals through food security and self-sufficiency. Additionally, the paper adheres to the Sustainable Development Goals (SDGs), specifically goals one and two, which concentrate on eliminating all forms of poverty and achieving food security and sustainable agriculture, respectively.

II. Theories Related To The Study

A. Social Learning Theory

This theory highlights the role of social interactions and learning processes in shaping individuals' knowledge and perceptions. This theory suggests that learning is not solely reliant on direct personal experiences but can also be facilitated through the observation of others' actions and the consequences that follow. By observing and imitating the behaviours, attitudes, and skills demonstrated by role models or peers, individuals can acquire new knowledge, develop new skills, and shape their own behaviour [10]. According to this theory, people learn through observing and imitating others, as well as through the consequences of their own actions [11].

The Social Learning Theory highlights the influence of social norms, role models, and social reinforcement on behaviour adoption. When farmers observe their peers adopting new agricultural practices or technologies, it can positively influence their own decision-making on the same practices. By witnessing the success and benefits experienced by others, farmers are more likely to adopt and integrate innovative techniques or technologies into their own farming systems [11]. Farmers often engage in knowledge-sharing networks and participate in farmer field schools or community-based organizations. Through these interactions, farmers exchange information and experiences related to diversified legumes, which can influence their knowledge, perceptions, and practices.

B. Social Construction of Technology

This theory suggests that technology is not just a neutral tool but is socially shaped and influenced by the values, knowledge, and perceptions of individuals and communities [12]. Farmers' knowledge, needs, and perceptions influence the development, modification, and implementation of technologies within their farming practices. Farmers' input, feedback, and interactions with technology developers and suppliers can shape the design and functionality of agricultural technologies, including those related to diversified legumes. In the context of diversified legumes, farmers' knowledge and perceptions can influence the development and adoption of appropriate technologies, such as improved seed varieties, agro-ecological practices, or post-harvest processing methods that are suitable for local conditions and meet farmers' needs with regard to the promotion and preservation of diverse legume varieties.

C. Conceptual Framework

The conceptual framework (Fig. 1) for farmers' knowledge and perceptions on diversified legumes provides a structure for understanding various factors which influence farmers' decision-making processes, attitudes, and practices related to diversified legumes. Here's a brief explanation of each component: The socio-cultural factors on the left-hand side explain cultural beliefs and traditions, social networks, and farmer communities together with gender roles and dynamics. The knowledge and information in the middle, with an arrow pointing to the FRN project, comprises existing knowledge of legume crops and cultivation practices, access to agricultural extension services, training programmes, indigenous knowledge systems and local ecological knowledge that farmers experience.

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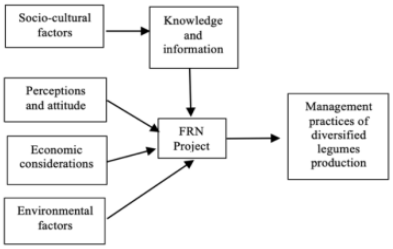

Fig. 1. Conceptual framework on farmers' knowledge and attitudes towards diversified legumes.

The other aspects on the left-hand side, perception and attitude, economic considerations, and environmental factors, point to the FRN projects, which are responsible for aligning farmers' adoption and management practices on diversified legumes.

III. Materials and Methods

A. Description of the Study Area

The research was carried out in the Singida Region, situated in the central corridor of Tanzania, specifically in the Mtinko and Ilongero Divisions across nine villages. Singida District Council (SDC) is one of the four councils within Singida Region. Geographically, it is located between latitudes 30° and 70° south of the Equator and longitudes 340° and 350° East of Greenwich. Singida District experiences semi-arid climatic conditions, which are characterized by two distinct seasons: a lengthy dry season from April to November and a rainy season from December to March. The annual rainfall ranges between 600 mm and 700 mm, while the average minimum temperature ranges from 15°C to 30 °C. Singida is considered one of the most impoverished regions in Tanzania [13]. The headquarters of the region are in Singida town and can be reached from Arusha via Babati and Katesh. From Dar es Salaam, it can be via Morogoro and Dodoma, and from Mbeya, it can be reached via Morogoro and Dodoma. Additionally, Singida can be accessed from Shinyanga and Mwanza through Nzega in the Tabora Region. Singida Region is of moderate size, ranking 13th in terms of area and covering approximately 5.6% of Mainland Tanzania's total area of 881,289 km^2. The choice of Singida Region for this research was motivated by the implementation of the FRN project in the region, which aimed to provide legume varieties to smallholder farmers.

B. Data Collection

Using a structured questionnaire with both open-ended and closed-ended questions, primary data were gathered from the respondents. The primary goal of the questions was to gather information on the variables affecting the adoption of the production of diversified legumes. Data from Key Informant Interviews (KIIs) were also gathered. Four KIIs were held, with participants including FRN project leaders and village executive officials. To confirm the data gathered through the questionnaire, extensive qualitative data were obtained using the KIIs checklist.

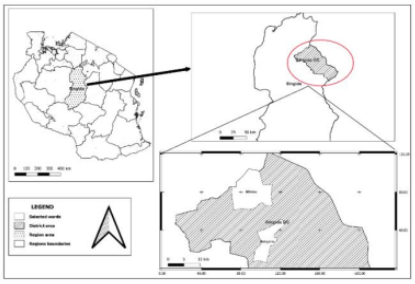

Fig. 2. A study map area.

The data collecting instruments were pre-tested in the study area before real data collection was done to ensure familiarity and clarity, which helped to assure the validity and reliability of the data gathered. The study's final analysis excluded the collected data from pre-testing.

C. Data Analysis

Quantitative data collected through the questionnaire were analysed using the STATA software, whereby both descriptive statistical analyses and inferential statistical analyses were done. Qualitative data were analysed using content analysis.

Smallholder farmers' perception was assessed using a Likert scale with 5 levels, which were categorized as 1= Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly agree. Means for the Likert scale categories were calculated, and they were then grouped into three groups, which are High Awareness, Moderate Awareness, and Low Awareness. Values greater than 3 were considered high awareness, statements with a mean of 3 were considered moderate awareness level, and statement values that had mean values less than 3 were considered low awareness. The analysis was then subjected to principal component analysis for factor analysis. This analysis involved clustering together related attitudinal statements regarding the diversified legumes. The clustered perception statements gave a summary of the individual statements. Using the principal component analysis was due to its ability to yield robust results [14]. Principal component is mathematically represented as follows:

$$PC_n = f(a_{ni}x_i \dots\dots\dots\dots a_{1j}x_j) \quad (1)$$

where:
PC – Principal component,
N – Number greater than one,
a_{1j} – Regression coefficient for the jth variable and is known as the eigenvector of the covariance matrix between variables,
x_j – is the value of the jth variable.

Explicitly, the equation can be written as:

$$PC_1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1j}x_j \quad (2)$$

where PC_1 is the first principal component, X_1 and X_2 are the first and second independent variables of PC_1 in the linear additive model needed to derive the principal component, and

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the a_{11} and a_{12} are coefficients (component loadings) associated with the X_1 and X_2 variables.

IV. Results and Discussion

A. Socio-economic Characteristics of Respondents (Farmers)

Different characteristics of the respondents were analysed in this study. The respondents' characteristics included sex, age, marital status, education level, major occupation, land size, access to credit, and income. The findings in Table I show that, among non-adopters of diversified legumes, 57.7% were male, while 42.3% were female. Among adopters, 59.2% were males and 40.8% were females. The results show that more than half of the respondents among both adopters and non-adopters were males. This implies that most of the legume farming activities were mainly done by male farmers in the study area. This was highly influenced by the fact that in most areas, men were the ones responsible for doing most of the economic activities so as to feed their families, while women were more responsible for taking care of children and doing house chores [15].

The results in Table I also show that, among the non-adopters, 59.9% were married, and 48.1% were not married. Also, among the adopters, 38.2% were married, and 61.8% were not married. The influence of marital status on the adoption of diversified legume production can vary widely depending on cultural, social, and economic factors and may not hold true for all farmers in all regions [16]. Marital status can play a role in the adoption of diversified legume production by affecting household decision-making, division of labour, access to resources, and social networks. However, this can vary greatly depending on a variety of cultural, social, and economic factors [17].

Further, the results in Table I show that, among non-adopters, 25.0% had informal education, 59.6% had primary education, and 15.4% had secondary education, while among adopters of improved practices for diversified legume production, 30.3% had informal education; 58.6% had primary education; and 11.6% had secondary education. This shows that more than half of the respondents (59.6% and 58.6%) had primary education. This suggests that higher levels of education can equip farmers with the knowledge, skills, and resources needed to understand the importance of diversified legumes, access to information and resources, and experimenting with new practices that can improve their farming practices. Moreover, the attitude has widely been expressed, with the idea that in farming communities that are literate, the task of convincing or educating them about the adoption of diverse legumes has been greatly simplified [18].

As summarized in Table I, among non-adopters, 25.0% were employed, 61.5% were unemployed, and 13.5% were self-employed. Among adopters, 9.9% were employed; 66.5% were unemployed, and 23.68% were self-employed. More than half of the smallholder farmers who had adopted the diversified legume production were unemployed. This implies that most of the smallholder farmers who had adopted the diversified legume production were able to adopt the diversified legume production since it was the only farming activity that they were doing; so, it was easy for them to attend several training sessions that were conducted by the FRN project.

In Table I, the findings show that, among non-adopters, 67.3% owned land and 32.7% rented land, while among adopters, 64.5% owned land and 35.5% rented land. The results imply that both adopters and non-adopters of diversified legume production owned farms. In the case of access to credit, among non-adopters, 42.3% had access to credit, and 46.2% had no access to credit. Furthermore, among the adopters, 50.7% had access to credit, and 49.3% had no access to credit. The results show that more than half of the respondents who adopted diversified legume farming had access to credit. This implies that access to credit increases the chances of the farmers to adopt diversified legume farming practices. Access to credit can be a key factor in the adoption of diversified legume production by smallholder farmers by providing them with necessary funds, reducing their risks, increasing their bargaining power, and improving their livelihoods [19].

TABLE I: Cross-Tabulation of Demographic Characteristics and Adopters of Diversified Legumes Production (N = 204)

Socio-economic	Not adopted diversified legumes production		Adopted diversified legumes production		Chi-square test
Variables	Frequency	%	Frequency	%	(P-value)
Categorical variables:					
Gender					
Male	30	57.7	90	59.2	0.848
Female	22	42.3	62	40.8	
Marital status					
Married	27	51.9	58	38.2	0.082
Not married	25	48.1	94	61.8	
Educational level					
Informal education	13	25.0	46	30.3	
Primary education	31	59.6	89	58.6	0.626
Secondary education	8	15.4	17	11.2	
Occupation					
Employed	13	25.04	15	9.9	
Unemployed	32	61.5	101	66.5	0.014***
Self employed	7	13.5	36	23.7	
Land ownership					
Own land	35	67.3	98	64.5	0.711
Rent land	17	32.7	54	35.57	
Access to credit					
Yes	28	42.3	77	50.7	0.691
No	24	46.2	75	49.3	
Continuous variables					
Age	35.94	(13.44)	34.46	(12.27)	0.582
Land size	2.49	(1.28)	3.93	(1.64)	0.000***
Income	221,923.08	(90,164.09)	472171.05	(160755.33)	0.000***

*** p<0.001.

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The respondents who were adopters and non-adopters had average ages of 35.94 and 34.46 years, respectively. This shows that the majority of legume farmers in the study area were of the productive age range, which is 15 to 64 years. This finding is in line with Lugamara's [20] findings that farmers in their middle years appear to be more productive than those in their early years and those in their later years due to their heavier workloads in the family and community. Taking care of kids and elderly household members, paying for the children's education, covering household health expenses, and contributing to social welfare initiatives in the community are a few examples of chores performed by productive aged people.

As seen in Table I, adopters had an average land size of 3.93 ha, compared to non-adopters, who had an average land size of 2.49 ha. The results demonstrate that adopters owned greater land plots than non-adopters. Large-scale farmers may have more financial resources and economies of scale to devote to varied legume production. Although this can limit their ability to fully profit from diversity, farmers with huge land holdings may also have less time and effort to spend on the care and maintenance of their crops [21].

Lastly, in Table I, the average incomes of the legume farmers among non-adopters and adopters of diversified legume production were TZS 221 923.08 and TZS 472 171.05, respectively. The findings reveal that adopters had more income compared to non-adopters. This shows that the income of a farmer can be a significant factor in the adoption of diversified legume production in Tanzania, as it can provide necessary resources, increase market opportunities, increase access to information and technology, increase risk resilience, and improve livelihoods [22].

B. Smallholder Farmers' Perception and Awareness on Diversified Legumes

The analysis on perceptions was conducted using a 5-point Likert scale. This analysis aimed to group together attitudinal statements related to diversified legumes. According to the results in (Table II) below, the majority (86.8%) of the respondents strongly agreed with the statement "the distribution of seeds was fair", (12.7%) agreed, and (0.5%) strongly disagreed. On the statement "cultivation of legumes is more profitable than other crops", nearly one-third (33.8%) of the respondents strongly agreed, (4.9%) agreed, (2.9%) were neutral, (11.8%) disagreed, and (46.6%) strongly agreed. On the statement "cultivation of legumes is easier than other crops", more than four-fifths (81.4%) of the respondents strongly agreed, (4.9%) agreed, (4.4%) were neutral and (9.3%) disagreed. On the statement "enough information is given before legumes before cultivation", more than seven-eighth (78.9%) of the respondents strongly agreed, (17.2%) agreed, and (3.9%) strongly disagreed.

Statement on "legumes varieties have increased the income level" more than four-fifths (82.4%) of the respondents strongly agreed, (9.8%) agreed, (2.5%) were neutral and (5.4%) strongly disagreed. Statement on "legume varieties have increased food availability to the household" (90%) agreed, (4.9%) agreed, (2.0%) disagreed, and (2.5%) strongly agreed. Statement on "legume harvest is higher than other crops", nearly a quarter (24.5%) strongly agreed, (2%) agreed, (4.9%) were neutral, (14.2%) disagreed, and (54.4%) strongly disagreed.

Moreover (Table III) presents a general overall result on the perception and awareness of diversified legumes, with the grand mean of 4.07 showing there is high awareness.

C. Effects of Awareness of and Attitude towards Diversified Legumes Production on Management Practices of Diversified Legumes Production

Further, analysis on perceptions was conducted using principal component analysis or factor analysis. This analysis aimed to group together attitudinal statements related to diversified legumes.

According to the results in Table IV below, the statement easy to cultivate was statistically significant (p = 0.000) in influencing the awareness and perceptions of smallholder farmers in adopting the diversified legume production.

TABLE II: LIKERT SCALE SHOWING PERCEPTION AND AWARENESS ON DIVERSIFIED LEGUMES

	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
The distribution of seeds was fair	1	0.5%	0	0.0%	0	0.0%	26	12.7%	177	86.8%
Cultivation of legumes is more profitable than other crops	95	46.6%	24	11.8%	6	2.9%	10	4.9%	69	33.8%
Cultivation of legumes is easier than other crops	0	0.0%	19	9.3%	9	4.4%	10	4.9%	166	81.4%
Enough information is given about legumes before cultivation	8	3.9%	0	0.0%	0	0.0%	35	17.2%	161	78.9%
Legume varieties have increased the income level	11	5.4%	0	0.0%	5	2.5%	20	9.8%	168	82.4%
Legume varieties have increased food availability to the household	5	2.5%	4	2.0%	0	0.0%	10	4.9%	185	90.7%
Legume harvest is higher than other crops	111	54.4%	29	14.2%	10	4.9%	4	2.0%	50	24.5%

TABLE III: OVERALL PERCEPTION AND AWARENESS ON DIVERSIFIED LEGUMES

	N	Mean	Std. Deviation	Remark
The distribution of seeds was fair	204	4.85	0.430	HA
Cultivation of legumes is more profitable than other crops	204	2.68	1.815	LA
Cultivation of legumes is easier than other crops	204	4.58	0.946	HA
Enough information is given about legumes before cultivation	204	4.67	0.833	HA
Legume varieties have increased the income level	204	4.64	0.965	HA
Legume varieties have increased food availability to the household	204	4.79	0.760	HA
Legume harvest is higher than other crops	204	2.28	1.677	LA
Grand Mean		4.07		HA

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TABLE IV: FACTOR ANALYSIS

Statements	X	SD	P-Values
Easy to cultivate -> Awareness score	0.230	0.045	0.000
Enough information -> Awareness score	-0.040	0.108	0.923
Fair distribution of Seed -> Awareness score	0.169	0.087	0.031
Food availability -> Awareness score	0.223	0.077	0.001
Increase income level -> Awareness score	0.562	0.127	0.000
Legume harvest is higher -> Awareness score	0.718	0.059	0.000
Legume is more profitable -> Awareness score	0.277	0.046	0.000

Furthermore, easy to cultivate statement was positive influencing with a mean score of 0.230. This implies that the positive influencing mean score of 0.230 suggests that smallholder farmers perceive diversified legume production as relatively easy to cultivate. This indicates that the farmers consider the cultivation of diversified legumes to be a manageable and feasible practice.

These findings suggest that the perception of ease in cultivating diversified legumes plays a significant role in shaping smallholder farmers' awareness and willingness to adopt such agricultural practices. It implies that promoting the notion of easy cultivation techniques and highlighting the benefits of diversified legume production may enhance awareness and encourage more smallholder farmers to engage in this form of farming. The results are in line with the study by Ojiewo *et al.* [23] and Mhango *et al.* [24] who reported that perception of ease in cultivating diversified legumes plays a significant role in shaping smallholder farmers' awareness and willingness to adopt such agricultural practices, so promoting the notion of easy cultivation techniques and highlighting the benefits of diversified legume production may enhance awareness and encourage more smallholder farmers to engage in this form of farming. The results were further mentioned in one of the key informant interviews, who said that:

"At first we needed to promote the notion that diversified legumes are easy to cultivate, since in these areas there's a notion that, cultivating a lot of crops become expensive and results into low yields" (Key Informant RECODA FRN PROJECT, 2022)

Furthermore, enough of information statement was also assessed to see the perception and awareness of the stallholder farmers on diversified legumes. The results in Table 4 show that, enough information is not significantly influencing smallholder farmer's perception and awareness on the diversified legumes ($p>0.05$). It also shows that the negative men score towards awareness of diversified legumes (-0.040). Negative mean score of -0.040 indicates that, on average, smallholder farmers have a slightly negative perception or awareness of diversified legumes in relation to "enough information." This means that, overall, farmers feel that they do not have sufficient information regarding diversified legumes, which may impact their perception and awareness of diversified legumes. Based on these findings, it can be inferred that there may be a lack of information dissemination or communication channels to effectively provide enough information about diversified legumes to smallholder farmers. Similar argument was raised by one of the respondents who has not yet adopted diversified legumes:

"FRN project is somehow seen as a bias project since most of us smallholder farmers do not have access to most of the information about this new technology to us, such as how we can diversify legumes, how to start planting, which legumes are easy to grow together, and many other. I suggest that FRN people should improve their educational trainings so that the education and information on the diversified legumes can be well understood by most of the farmers, thus easy adoption" (A 53YEAR-old man, Mughanga Village).

Results in Table IV further looked on the fair distribution of seed statement. The result show that, fair distribution shows statistical significance towards awareness and perception of diversified legumes among small holder farmers ($p<0.05$), also there was a positive mean score shown by the fair distribution of seed (0.169). The positive mean score of 0.169 indicates that the fair distribution of seeds has a beneficial effect. This suggests that when smallholder farmers receive seeds through a fair distribution system, they have a more positive perception and awareness of diversified legumes compared to other distribution methods. Therefore, smallholder farmers have a more positive perception and awareness of diversified legumes when they receive seeds through a fair distribution system, compared to other distribution methods, as suggested by one study in Malawi [24]. Furthermore, the potential of legume crops to diversify farming systems, increase sustainability, provide multiple benefits, and enhance food security [25]-[27].

On food availability statement, the results in Table IV shows significance influence on the smallholder farmer's perceptions and awareness of diversified legumes ($p<0.05$) and also shows positive mean factor score of 0.223. The positive mean factor scores of 0.223 suggests that the factor food availability have a beneficial effect on the perceptions and awareness of diversified legumes among smallholder farmers. This means that the food availability contributes positively to the smallholder farmers' understanding and awareness of diversified legumes. According to a number of studies, food accessibility helps smallholder farmers learn about and become aware of a variety of legumes. In terms of ensuring food and nutrition security as well as generating money, legumes are crucial in sub-Saharan African smallholder farming systems [28]. Smallholder farmers in Ethiopia are aware of the variety of legume crops that are grown in their local areas; yet, to increase the variety of legumes that individual household's plant, community-level conservation is required [27]-[29]. Another study done in Ghana and Kenya discovered that increasing smallholder farmers' production of grain legumes is a practical way to enhance rural communities' nutrition.

For the case of increase income level, the findings show that increase in income level had statistically significant influence on awareness and perceptions on diversified legumes ($p<0.05$). The factor mean score for the increase income level had a factor mean score of 0.562. The results imply that an increase in income level has a statistically significant influence on the awareness and perceptions of diversified legumes. The very low p-value of less than 0.05 ($p<0.000$) suggests that the relationship between income level and awareness/perceptions is highly unlikely to occur by chance. Furthermore, the high factor mean score of 0.562 indicates that an increase in income level has a substantial positive impact on the awareness and perceptions of diversified legumes. This suggests that as the income level of smallholder farmers increases, their understanding and perception of diversified legumes also

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improve significantly. According to Mhango *et al.* [24] income level of smallholder farmers is positively related to their understanding and perception of diversified legumes. Moreover, a study by found that farmers who participated in multiple output markets, including legume markets, reported higher income and better food security than non-participants. Furthermore, a study by Vanlauwe *et al.* [28] concluded that farmers put more value on short-term benefits of legumes, including food and income, than long-term benefits such as natural resource management. This finding indicates that smallholder farmers who have high incomes are more likely to diversify than the ones with low incomes.

The findings in Table IV also show that the statement; legume harvest is high has a significant influence on smallholder farmer's awareness and perception of diversified legumes ($p<0.05$). Furthermore, the statement had a factor mean score of 0.718 in explaining the smallholder farmer's perception and awareness on diversified legumes. These results imply that the statement "legume harvest is high" has a statistically significant influence on the awareness and perception of diversified legumes among smallholder farmers. The p-value of less than 0.05 suggests that the relationship between the statement and the awareness/perception of diversified legumes is unlikely to occur by chance. Additionally, the high factor mean score of 0.718 indicates that the statement "legume harvest is high" is strongly associated with and explains a significant portion of the smallholder farmers' perception and awareness of diversified legumes. This suggests that when smallholder farmers perceive that their legume harvest is high, it positively affects their understanding and perception of diversified legumes. The results are in line with other studies that suggested that smallholder farmers' understanding, and perception of diversified legumes are positively affected by high legume harvests [4].

Lastly, the statement legume is more profitable was also used to assess its influence on smallholder farmers' perceptions and awareness of diversified legumes. The results show that the statement had a significant influence on the awareness/perception of smallholder farmers ($p<0.05$). Moreover, the result shows a factor mean score of 0.277. The findings suggest that the claim that "legume is more profitable" has a statistically significant impact on smallholder farmers' awareness and perception of diverse legumes.

Additionally, the statement "legume is more profitable" appears to positively influence smallholder farmers' perceptions of and familiarity with a variety of legumes, according to the factor mean score of 0.277. This shows that farmers' comprehension and perception of varied legumes are positively impacted when they believe legumes to be more profitable. According to Muoni *et al.* [4], farmers put more value on the short-term benefits of legumes, including food and income, than on long-term benefits, such as natural resource management. Another study by Ferreira *et al.* [30] found that legumes' low profitability for farmers may be attributed to a lack of public and private investments in breeding programs and legume-adapted technology for planting, managing, harvesting, processing, and storing when compared to cereals. Therefore, farmers' understanding, and perception of diversified legumes are influenced by economic factors such as profitability.

V. Conclusions and Recommendations

Findings of this study based on the analysis indicate that several factors have proven the statements; "easy to cultivate", fair distribution of seed, food availability, increased income level, and legume harvest high had a significant influence on the awareness and perception of diversified legumes among smallholder farmers. However, the factor of "enough information" was not significant but had a positive influence on farmers' awareness and perceptions of diversified legumes. Therefore, efforts should be made to enhance information dissemination, including the use of various platforms such as farmer field days, community workshops, radio programs, and mobile technology. Addressing this issue by improving access to information and increasing awareness campaigns could be beneficial in promoting the adoption and positive perception of diversified legume production among smallholder farmers. Also, the significant influence of fair distribution of seed on farmers' awareness and perception of diversified legumes suggests the importance of ensuring equitable access to quality seeds. Stakeholders, including government agencies, NGOs (FRN project), and seed companies, should collaborate to develop and implement fair distribution systems that prioritize smallholder farmers. This can involve establishing seed banks, promoting community-based seed production, and providing transparent and inclusive mechanisms for seed access and distribution.

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

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CHAPTER FOUR

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Major Findings

The following is a condensed overview of the key results and discoveries from the study, presented in a chronological order as outlined in the manuscripts provided. The summary aims to highlight the major findings in a clear and concise manner, while also providing a logical flow of information that mirrors the order of presentation in the original manuscripts.

4.4.1 To determine the extent and factors of adoption of diversified legumes among smallholder farmers in the study area

This objective aimed at determining the extent and factors of adoption of diversified legumes among smallholder farmers in the study area. Whereas, the findings showed that age, education, farm size, major occupation, experience, land size, access to credit and motivation were significantly associated with adoption of diversified legume production. The adoption of varied legume production in the research area was found to be statistically significantly influenced by the farmers' age, education level, farm size, main occupation, experience, land size, availability to credit, and motivation. It is further stated that non-adopters of diverse legumes encounter a number of difficulties, such as missing RECODA FRN project training and education sessions and not being aware of the advantages of diversifying their crops.

4.4.2 To assess smallholder farmer’s awareness and attitude towards diversified legumes

This objective aimed at determining the smallholder farmer’s awareness and attitudes towards diversified legume. Therefore, the objective analysed the perception awareness and effects of Awareness of and Attitude towards Diversified Legumes Production on Management practices of diversified legumes production in the study area. The findings of the study revealed that several factors significantly influenced smallholder farmers; awareness and perception of diversified legumes.

These factors included ease of cultivation, fair distribution of seeds, food availability and increase in income level, high legume harvest, and higher profitability of legumes. Furthermore, the statement enough of information did not show statistical significance. However, it exhibited a positive association.

4.5 Conclusions

This study aimed to determine the Impact of FRN Project on Diversified Legumes (Pigeon Peas, Groundnuts and Bambara Nuts) Among Smallholder Farmers in Singida Region, Tanzania. The Study Has Provided Valuable Insights into The Factors and Their Extent of adoption of diversified legumes among smallholder farmers in the study area. The analysis revealed several factors that were significantly associated with adoption of diversified legume production including age, education, farm size, major occupation, experience, land size, access to credit, and motivation.

Furthermore, in the case of awareness and its effects towards diversified legume production and management practices the results showed that several factors significantly influenced smallholder farmers; awareness and perception of diversified legumes. These factors included ease of cultivation, fair distribution of seeds, food availability, increase in income level, high legume harvest, and higher profitability of legumes.

4.6 Recommendations

Based on the findings of the study, several recommendations can be made;

i. The central government should increase investment in the agricultural sector through providing incentives and subsidies to smallholder legume farmers and other stakeholders.
ii. The RECODA FRN projects should increase educational training sessions and extension services to smallholder farmers in order to motivate them to adopt diversified legume production to increase food security.

iii. To further support smallholder farmers in adopting and benefiting from diversified legume production, there is a need for increased research and investment in legume crops by different stakeholders. This includes breeding programs focused on developing high-yielding and resilient varieties suitable for local conditions, as well as the development and dissemination of improved agronomic practices and post-harvest technologies. Public and private sector collaborations should be encouraged to facilitate knowledge exchange, technology transfer, and investment in legume-related research and development.

APPENDICES

Appendix 1: Farmers' Survey

A. Social-economic profile of respondents

(Tick that is appropriate)

1. Age:

Age Group	Code	Tick
15 - 24	1	
25 - 55	2	
55 - 65	3	
66 - Above	4	

2. Gender:

Sex	Code	Tick
Female	1	
Male	2	

3. Marital Status:

Status	Code	Tick
Married	1	
Not Married	0	

4. Education Level:

Level	Code	Tick
Primary	1	
Secondary	2	
High School / VTC	3	
Diploma	4	
Degree	5	
Masters / PhD	6	

5. Farm Size:

Numbers of ha	Code	Tick
Less than 1	1	
1 - 2	2	
3 - 5	3	
More than 5	4	

B; Extent and factors for adoption

6. What type of crops do you grow most in your farm?

Number of years	Code	Tick
Cereals	1	
Legumes	2	
Vegetables	3	
Other	4	

7. Have you been growing diversifies legumes in your farm?

Type	Code	Tick
Yes	1	
No	0	

8. What type of diversified legume do you cultivate?

	Code	Tick
Groundnuts	1	
Pigeon pea	2	
Bambara nuts	3	
Other	4	

9. For how long have you been growing diversifies legumes?

Type	Code	Tick
Less than 1 season	1	
2 seasons	2	
More than 2 years	3	

9. What has been the purpose of growing diversified legumes?

Type	Code	Tick
Home use	1	
Commercial purposes	0	

10. What pushed you into growing diversified legumes?

Type	Code	Tick
Nutritional value	1	
Soil fertility reason	2	
Influence of the FNR project	3	
Other reason	4	

11. Do you know about diversified legumes seed varieties?

	Code	Tick
Media (radio, magazines etc)	1	
Agriculture related Projects	2	
Services from extension officer	3	
Agro-vets	4	
Other	5	

C; Profitability of adoption

12. What has been the average crop harvest on groundnuts for the last three seasons?

Amount in tons	**Code**	**Tick**
Less than 1	1	
Averagely 1	2	
More than 1	3	

13. For the previous harvest, have you been selling the amount of diversified legumes harvest?

	Code	**Tick**
Yes	**1**	
No	**0**	

14. What is the average income obtained when the harvest was sold?

……

15. What was the first priority when using the obtained income obtained?

	Code	Tick
Food	1	
Clothing	2	
Treatment	3	
Housing	4	
School fees	5	
Savings	6	
Others	7	

16. What other non-monetary profits had the cultivation of diversified legumes brought to you and your household?

……

17. What are you opinions regarding the cultivation of diversified legumes?

……

Appendix 2: Key Informant Interview Checklist
FRN Project implementers

1. What are the objectives of FNR project in this region?
2. How far have the objectives mentioned been met?
3. Why were pigeon peas, Bambara nuts and groundnuts a focus of FNR project?
4. Do you this the establishment of these legumes have been successfully adopted?
5. What are the indicators that these mentioned crops have been adopted?
6. What do you think were the factors that pushed farmers to adopt the crops and the technologies that come with the cultivation of the crops?
7. Can you link the adoption of the diversified legumes linked with the project and the social economic statuses of the farmers engaged with the project?
8. Can you tell how the FNR project ensures that farmers are sustainably engaged with the project?
9. To ensure increased adoption, what do you think need to be done from the farmers' side and the government as far as diversified legumes is concerned?
10. What are the challenges that you think the adoption of diversified faces from both ends, project implementers and farmers?

Village/Ward Extension Officers

1. Can you tell me the nature of you farmers and the crops they are more engaged with in your jurisdiction?
2. How big is the number involved in diversified legumes from the total number of farmers you offer service to?
3. Do you think this number of farmers is the result of the FNR project?
4. What do you know about the FNR project and how have you been involved?

5. Has the project played a role in the adoption of diversified legumes in the village/ward?

6. What are the socio-economic advantages that farmers involved in the FNR project have over those that are not?
7. What need to be done to increase adoption of diversified legumes?
8. What do you think is the farmers' perception toward diversified legumes?
9. What are the challenges facing implementers and extension officer hence hindering adoption of diversified legumes?

Kuhusu Tasnifu Hii

Utafiti huu ulifanyika mkoani Singida, katika taarafa za Mtinko na Ilongero nchini Tanzania, ili kubaini matokeo ya mradi wa mtandao wa utafiti kwa wakulima(FRN) kwenye uzalishaji wa mikunde mbalimbali (DLP) pia kuchunguza uelewa na mtazamo wa wakulima kuhusu uzalishaji huo. Ililazimu kufanyika utafiti huu mkoani Singida kutokana na uwepo wa ukubalikaji (utekelezaji) mdogo wa DLP miongoni wakulima wadogo wadogo katika eneo hilo. Aidha, taarifa kwaajili ya utafiti huu mfano zinazohusu sifa za mkulima husika, namna za uzalishaji, gharama, mavuno na mauzo ya mikunde zilikusanywa kupitia mahojiano ya ana kwa ana na wakulima hao. Utafiti uligundua kwamba uzoefu wa kulima, uwepo wa mikopo, motisha kwa mkulima husika, elimu vilichangia kuongeza uwezekano wa mkulima kutekeleza DLP. Utafiti pia uligundua kwamba urahisi wa ulimaji, usambazaji wa haki wa mbegu, mavuno na tija ya mikunde ilishawishi mtazamo kuhusu DLP. Utafiti unapendekeza mikakati kadhaa katika kushawishi utekelezaji wa DLP miongoni mwa wakulima ikiwemo watendaji wa FRN kuwapa mafunzo ya kutosha kuhusu umuhimu wa DLP. Pia, inapendekezwa kuwepo na usambazaji wa haki wa mbegu za mikunde ili kushawishi mtazamo chanya wa wakulima kuhusiana na DLP.