Factors Influencing the Adoption of Improved Groundnut Cultivars amongst Smallholder Farmers in Singida Tanzania

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Abstract

Groundnut is amongst the global important food and cash crops; irrespective of its importance, studies report its low adoption. Amongst the reported adoption factors were age, gender, education, group membership and seed availability. Nevertheless, there is insufficient documentation on the influence of these factors on the adoption of groundnut amongst beneficiaries of Singida Rural Farmer Research Networks (FRNs). Innovation systems, networks and Roger's theories of diffusion of innovations guided this study to establish the determinants of the adoption of improved groundnut cultivars amongst these target groups. Specifically, the study (1) assessed the adoption of improved groundnuts in relation to farmers' socio-economic characteristics; (2) determined the factors that influenced the adoption of improved groundnuts and (3) examined farmers' adoption perception towards access to services, technological characteristics and the institutional environment. Cross-sectional design and mixed research methods were used. The socioeconomic characteristics of farmers were compared using Chi-square test cross-tabulations. The binary logistic regression model was used to determine factors influencing the adoption of improved groundnut cultivars. A Likert scale was used to assess the farmers' perceptions towards the adoption of improved groundnut cultivars in relation to access to services, technological characteristics and the institutional environment. Findings show that socioeconomic characteristics such as age, sex, marital status, education level and income had no significant influence on the adoption of improved groundnuts. The adoption of improved groundnuts was significantly influenced by three factors: FRN group membership, seed accessibility and technological characteristics which include adaptive to agroecological zones, high yields, early maturity, drought tolerance, pests and disease resistance. The majority of farmers had a positive perception towards access to services, technological characteristics and the institutional environment for the adoption of improved groundnut cultivars. In this regard, sensitization for more farmers to join groups and enhancement of timely seed availability and accessibility of improved groundnut cultivars are recommended.

Keywords: Adoption, Improved groundnut cultivars, Farmer Research Networks, RECODA, CCRP, Singida Tanzania

Introduction

Groundnut (*Arachis hypogaea* L.) is a leguminous crop known by different names such as earthnut, peanut, monkey nut or goobers. Scholars (i.e., Abady *et al.,* 2019; Shasani *et al.,* 2020; Mwatawala & Kyaruzi 2019) consider groundnut as amongst the important food and cash crops grown in almost all of the world's tropical and subtropical countries. In Africa, the major groundnut-producing countries are Nigeria, Sudan, Tanzania, Chad, Senegal and Cameroon (Mwakimata, 2018). The major groundnut production regions in Tanzania include Shinyanga, Tabora, Dodoma, Mbeya and Mtwara regions (Daudi *et al.,* 2018).

According to the United Republic of Tanzania (URT) (2016), Singida is a semi-arid region and amongst the top ten rated regions with the potential for groundnut production in terms of quantity (tonnes) and harvested area (ha) in Tanzania. Thus, groundnut can have a significant contribution to increased income, food and

nutritional security for farmers in Tanzania, if it is widely adopted to improve their productivity. Despite its potential, the study by Sawe *et al.* (2018) revealed that groundnut is amongst the crops characterised by low tolerant capacity in semi-arid areas; hence it records a decline in terms of yields trends by 1.97 pe cent. According to FRN Project Report (2018), the change in rainfall patterns and distribution has affected the production of groundnuts. Groundnut is not a new crop in Singida, however, due to changes in the rainfall pattern, its production has been declining. To address the challenge of declining trends in groundnut production yields, Research Community and Organizational Development Associates (RECODA) implemented a project titled "Farmer Research Networks' Participation in Agro-Ecological Intensification for Improved Soil Health, Productivity, Nutrition and the Development of Legume Seed Systems in Singida" (FRN, 2018). Farmer research networks (FRN) are associations of farmers who collaborate with researchers and development organizations to do research (Nelson *et al.,* 2019). The Crop Collaborative Research Programme (CCRP) created a set of farmer research network (FRN) principles to serve as a roadmap for project execution. The fundamental ideas include (i) a farmer-centred strategy in which a variety of farmers take part in the entire research process; (ii) rigorous, democratic and practical/useful research and (iii) collaborative networks to promote learning and information sharing (Richardson *et al.,* 2021; Haussman *et al.,* 2020).

Under the Crop Collaborative Research Programme (CCRP), which is funded by the McKnight Foundation, the FRN project was implemented to address the effects of climate change on groundnut and other crops. Specifically, the project promoted the adoption and use of drought-tolerant crop cultivars (groundnuts, bambara nuts, lablabs and pigeon peas) and technologies that harness rainwater harvesting and moisture conservation (FRN, 2018). The FRN project's goal was to boost sustainable food production and farm productivity emanating from improved soil health practices, leading to food security and increased income, which would increase household resilience. One of the FRN project's specific objectives was to develop seed systems for legumes, specifically groundnuts, bambara nuts, lablabs, and pigeon peas, to establish how a seed system enhances productivity and diet diversification (FRN, 2018).

The FRN project also aimed to address the unavailability of seeds of improved groundnut cultivars because, being a new crop, the availability of seeds of improved groundnut cultivars was not assured in the project area, despite that Singida was reported as amongst the top ten groundnut producers in Tanzania (URT, 2016). RECODA procured the seeds of improved groundnut cultivars from the Tanzania Agricultural Research Institute (TARI)-Naliendele, which were introduced for trying out in the project area (Lukurugu *et al.,* 2021). After procurement, RECODA, through the FRN project facilitated the availability of seeds of improved groundnut cultivars, whereby 112.5 kg of seeds of improved groundnut cultivars were distributed to 420 beneficiary farmers in eight project villages. These 420 beneficiary farmers who received seeds of the improved groundnut cultivars were expected to multiply them for spreading out to at least 1260 target beneficiary farmers in the project area, who would further diffuse the innovation to their fellow indirect beneficiary farmers in their respective and neighbouring villages (FRN, 2018).

Konja (2020) pointed out the recently developed interest by a diversity of professionals in conducting adoption studies on new agricultural technologies in groundnut production. Irrespective of its importance, different studies report low adoption rates of improved groundnut cultivars. For instance, Lukurugu *et al.* (2021) identified low adoption of improved groundnut cultivars in the Tanzanian southern zone, while Takahashi *et al.* (2019) reported a low adoption rate of improved agricultural technologies such as improved groundnut cultivars. Similarly, Gorfad *et al.* (2018) reported the existence of a wide adoption gap between farmer practices versus improved innovations including improved groundnut cultivars that were developed by scientists from agricultural Universities. It is worth noting that an innovation, including improved groundnut

cultivars, should solve identified problems, and researchers should be aware that an innovation is not adopted because of its technical advantages alone (Orr, 2018).

According to the FRN progress report (2018), an assessment was done to determine the adoption of improved pigeon peas, which established an adoption rate of 80 per cent. In this assessment, no documentation was done about the adoption of improved groundnut cultivars. The project assessment report proposed further research on the adoption and suitability of the improved groundnuts in Singida. On the other hand, Simtowe *et al.* (2019), as cited by Lee (2020), identified the factors that affected the adoption of improved groundnut cultivars in Uganda which included the size of the household, higher income, receipt of extra information on cultivars and more usage of hired labour and manure. The factors that influenced the adoption of improved groundnut cultivars in Tanzania were age, gender, education, land ownership, group membership, farm size, experience, grain price, seed availability and seed cost (Mwalongo *et al.,* 2020). Nevertheless, there is insufficient documentation on the influence of these factors on the adoption of improved groundnut cultivars by amongst FRN beneficiary farmers in Singida Rural District.

This study aimed at establishing the factors which influenced the adoption of improved groundnut cultivars amongst FRN beneficiaries. The specific study objectives were (i) to assess the adoption status of improved groundnut cultivars in connection to farmers' socio-economic characteristics (ii) to determine the factors influencing the adoption of improved groundnut cultivars in the study area and (iii) to examine the perception of farmers towards the adoption of improved groundnut cultivars regarding access to services, technological characteristics and institutional environment.

Theoretical framework

Networking theories of innovation diffusion, innovation systems theory and Rodger's theory of innovations served as the foundation for this study. According to the social network diffusion theory, the adoption of new technologies by farmers typically follows a complex contagion pattern and is based on a variety of sources of information (Beaman *et al.,* 2021). Additionally, people are embedded in an interactive network, and potential innovators' attitudes are influenced by social inspiration. The adoption of innovation entails more than just the dissemination of information; it also involves changes to decisions, conversations in a wider context pertaining to the socioeconomic system and the sincerity of an individual to exert influence (Deroian, 2002). Since social network diffusion theory makes assumptions about networking, collaboration and participatory processes, it was incorporated into this research because it is consistent with FRN principles. Social network diffusion theory was used to identify the independent variables used in this study, including multiple sources of information, a broader spectrum of external skills, an on-farm learning environment and multiple connections to seeds that were conceptualized as determinants of the adoption of improved groundnut cultivars.

In addition, Roger's theory was related to FRN principles in the area of on-farm research, where farmers could watch, learn about the benefits of innovation through on-farm experiments and assess how easy and compatible the innovation was with their current practices and beliefs. As Rogers (2003) observes, innovations with benefits, perceived compatibility with current practices and beliefs, low complexity, possible trialability and observability will spread more quickly. In order to make the terms "adoption" and "diffusion" clearer as they are used in the theories that underpin this study, Vecchio *et al.* (2020) noted that "adoption is the condition whereby an individual decides to accept an innovation and integrate it into his or her life, whereas diffusion is the process by which innovation is adopted across a population over time." The term "adoption" used in this study refers to the collaborative testing, learning, understanding and application of the innovation by the FRN project beneficiaries through the cultivation of all or a single improved groundnut cultivar, namely Mnanje, Naliendele and Mangaka, as part of their agro-ecological practices.

According to the innovation systems

perspective, learning occurs in networks and spreads to individuals and farmers, leading to innovation. Farmers typically learn on the farm about the performance and applicability of the innovation to farming systems, as well as the sustainability of the inputs and market for the produce, before accepting it (Ayele *et al.,* 2012). The diversity of players and characteristics necessary to promote innovation and growth are highlighted by the innovation system framework (World Bank, 2007). Ayele *et al.* (2012) identify the essential players, which include knowledge and technology suppliers and users, as well as their roles, interactions with one another, and routines and behaviours that affect collaborative learning and innovation. Players' proximity, such as physical separation, the institutional setting, which moulds relationships based on trust and the ability to assimilate new information are factors that affect interaction and learning. The FRN approach and the innovation systems theory were related because the latter focuses more on network cooperation and systems thinking. The innovation system approach was used to identify the independent variables such as demand-driven innovation, suitability of innovation, sustainability of inputs, market of the product, on-farm learning, providers of knowledge and technology, users of knowledge and technology and institutional environment, which were conceptualized to influence the adoption of improved groundnut cultivars.

Methodology

Study Area

Singida Rural District lies between 30 and 70 latitudes south of the Equator and 340 and 350 Longitudes East of Greenwich. A semiarid climate prevails in Singida Rural District. There are two seasons: the dry season which is the longest (April to November), and the rainy season (December to March). The annual average precipitation is between 600 and 700 mm, while the minimum temperature ranges from 15 to 30°C (Singida District Profile, 2015). Topographically, Singida District, which is in the east of the Great Rift Valley, is a significant scarp that can reach heights of 180 metres. These climatic and topographical features favour groundnut cultivation. The enormous outcrops, or six rocky peaks (tors), of granite and metamorphic rocks that can be found in Singida District are a notable aspect of the land escarpment. These outcrops, often referred to as inselbergs, are the remains of ancient land surfaces that have in the nearby areas been eroded to create a vast, gently undulating pen plain (Singida District Profile, 2015). Furthermore, according to the Singida District Profile (2015), the Nyaturu, Sukuma, Taturu, Barbaig, Hadzabe and Kimbu are the primary indigenous ethnic groups in the district. The Barbaig, Hadzabe, and Kimbu constitute a sizeable minority. Compared to other tribes, the Nyaturu people make up the largest ethnic group in the district. Singida Rural District was chosen because its topographical characteristics, climatic factors and rainfall patterns favour the production of groundnut.

The FRN Project Report (2018) states that variations in the distribution and pattern of rainfall have an impact on groundnut yield. Although groundnuts are not a new crop in Singida, variations in rainfall distribution are causing a decline in output. Prior work

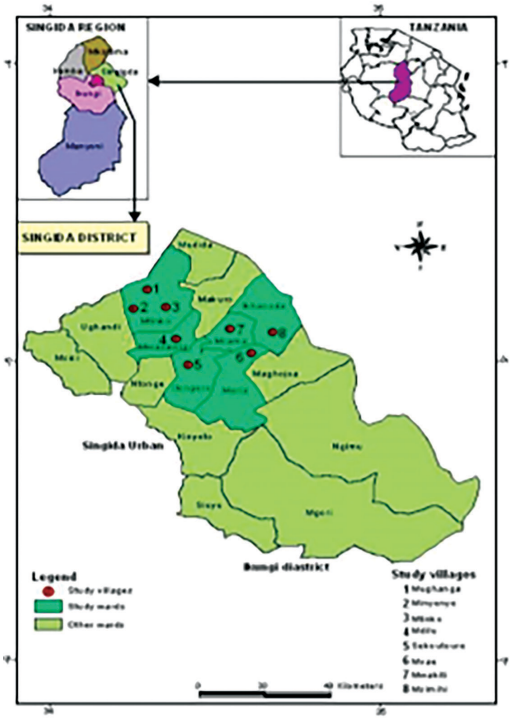

Figure 1: Map of the study area
Source: Survey data 2022

conducted by one of the main partners in the FRN project in Tanzania, Research Community and Organizational Development Associates (RECODA), suggested that improved groundnut cultivars could be successful in Singida Rural District.

Research Design

This study used a cross-sectional research design, in which information was gathered all at once. As Omair (2015) observes, a cross-sectional research design has a broad scope because it incorporates numerous variables at once and allows for data collection at a single point in time. The author further observes that the design is more cost and time-effective than the longitudinal approach when looking for relationships between variables and for descriptive purposes. Both quantitative and qualitative data were gathered concurrently using mixed research techniques. Mixed research methods have been cited by Glover *et al.* (2019) and Polit and Beck (2010) as being cutting-edge, perceptive and helpful for enhancing the generalizability of research. Additionally, according to Creswell (1999), a mixed-method study employs both qualitative and quantitative data collection and analysis methods in a single inquiry. In the context of this study, while the qualitative research focused on how FRN group membership was governed by FRN principles with an emphasis on participation, the practicality of on-farm research, networking and collaboration, quantitative research techniques were used to identify the factors that statistically influenced the adoption of improved groundnut cultivars, specifically Mnanje, Mangaka and Naliendele. Therefore, mixed methods complimented each other, whereby quantitative research provided numeric data while qualitative research provided information that deepened understanding of the situations that numerical data could not adequately illustrate.

Sampling procedure and sample size

The study population consisted of 1260 target beneficiary farmers from eight project villages in Ilongero and Mtinko Divisions of Singida Rural District (420 direct beneficiaries and 840 indirect beneficiaries). Eight villages—Sekoutoure, Mwakiti, Msimihi, Mdilu, Mvae, Mughanga, Minyenye and Mtinko—in the Ilongero and Mtinko Divisions of Singida Rural District participated in this study (Fig. 1). These villages were chosen based on topographical characteristics, climatic factors and rainfall patterns that favour the production of groundnut. Additionally, the FRN initiative introduced and promoted improved groundnuts for adoption and diffusion in these villages. In order to obtain a representative sample of the population for quantitative data, random sampling procedures were applied. The sample size for smallholder farmers' direct and indirect beneficiaries from the 8 villages in the Ilongero and Mtinko Divisions of Singida Rural District was calculated using the formula used by Krejcie and Morgan (1970).

$$n = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

Where: n = required sample size, X = z value (assumed to be 1.645 for 95% confidence level), N = Population size, P = Population proportion (assumed to be 0.5 since this would provide the maximum sample size), d = degree of accuracy (5%), expressed as a proportion (0.05).

$$n = \frac{1.64^2 x 1260 x 0.5 x 0.5}{0.05^2 x (1260-1) + (1.64^2 x 0.5 x 0.5)} = 212$$

Simple random sampling was applied to select respondents from each village (direct and indirect beneficiaries).

Proportionate Formula Random Sampling Procedure

Direct Beneficiaries (FRN group members):

n = (420/1260)*212 = 70.67 approximately 71

n1= (50/420)*71 = 8, n2 = 8, n3 = 17, n4 = 5, n5 = 14, n6 = 5, n7 = 6, n8 = 8

Indirect Beneficiaries (Non-group members):

n = (840/1260)*212 = 141

n1= (100/840)*141 = 17, n2 = 15, n3 = 34, n4 = 10, n5 = 28, n6 = 10, n7 = 12, n8 = 15

Table 1 provides a breakdown of the sample size of direct and indirect beneficiaries per village.

Key informants who provided qualitative data were specifically chosen for interviewing.

Table 1: Sample size

Division	Ward	List of villages	Population (N)		Sample Size (n)	
			Direct	Indirect	Direct	Indirect
1. Ilongero	1. Ilongero	Sekoutoure	50	100	8	17
	2. Mrama	Mwakiti	45	90	8	15
	3. Ikhanoda	Msimihi	99	198	17	34
	4. Mwasawia	Mdilu	31	62	5	10
	5. Meria	Mvae	84	168	14	28
2. Mtinko	6. Mtinko	Mughanga	29	58	5	10
		Minyenye	37	74	6	12
		Mtinko	45	90	8	15
TOTAL			**420**	**840**	**71**	**141**
GRAND TOTAL			**1,260**		**212**	

Source: Survey data 2022

The major informants were District Agricultural Extension Officers and project employees. Key informants were picked based on their positions about the initiative and the information they had access to in their respective spheres of influence. Two groups the Mshikamano group in Mughanga village (Mtinko Division) and the Muungano group in Mvae village (Ilongero Division) were purposefully chosen based on their divisions to participate in focus group discussions (FGDs). FGDs were made up of 8 and 12 farmers from Mshikamano and Muungano groups respectively. The composition of 8 and 12 farmers in the FGD was according to the suggestion by Nyumba *et al.,* (2018) who suggested that, the group gets difficult to lead when it has more than 12 participants, and it may split up into two or even three smaller groups, each conducting its own separate debate. The main topics discussed in FGDs and KII were on understanding how farmer traits, technological traits, and factors including informational and socioeconomic factors influenced the adoption of improved groundnut cultivars in the research area.

Data collection

Enumerators were trained in data collection using both quantitative and qualitative instruments in April 2022, before the collection of primary data. In April 2022, the data collection tools underwent preliminary testing in the community of Mwakiti. The data-gathering methods were modified in light of the outcomes of the pretesting exercise. Between April and May 2022, the field data collection operation was conducted to gather both primary quantitative and qualitative data.

Semi-structured copies of a questionnaire with both closed- and open-ended questions were used to collect primary quantitative data on factors such as age, sex, marital status, level of education, primary source(s) of income, technological characteristics, seed accessibility, FRN group membership status and institutional characteristics. These numerical statistics were crucial for illustrating the study's numerical and statistical numbers, such as frequencies, percentages, means and standard deviations.

Primary qualitative data were gathered using qualitative data collection methods such as key informant interviews, focus group discussions and observation. The collected data focused on farmers' feelings and opinions on why to accept or reject improved groundnut cultivars as well as how farmer characteristics, technological characteristics, institutional characteristics and information factors affected the adoption of improved groundnut cultivars. Checklists with open-ended questions were used. Qualitative data were collected to fully understand situations that statistical data could not sufficiently depict.

The secondary data were gathered through a documentary review. The online sources of knowledge (mainly Google Scholar with the

interval of 2017 to 2022 publications), the socioeconomic profile of the Singida Rural District, the FRN project design, and monthly, quarterly, yearly, monitoring and evaluation reports were amongst the materials which were studied. Since these were part of the literature review and included details on what had already been done and reported, these documents were significant since their main goal was to complement (or refute) the conclusions drawn from other data sources.

Data analysis and interpretation

Prior to the analysis, quantitative data were coded and summarized. The Statistical Package for Social Science (SPSS) version 20 was used to input and evaluate the survey's numerical data (questionnaires) in order to provide descriptive statistics (mainly frequencies and percentages). Frequencies and percentages were further adjusted and transformed into cross-tab and pivot tables for simplicity of presentation.

The adoption was measured based on the operational definition used in this study. Respondents who reported to have either grown all or one of the improved groundnut cultivars (i.e., Mnanje, Mangaka and Naliendele) (1 = Yes) in a questionnaire were considered to have adopted them, while those who reported not to have grown the cultivars (0 = No) were treated as not having adopted them. Independent variables such as FRN group membership and seed accessibility were captured from the questionnaire responses, where 1 was coded for group members and 0 for non-group members; similarly, 1 was coded for respondents who had access to improved groundnut seeds and 0 was for respondents who had no access to improved groundnut seeds. Technological characteristics and institutional characteristics were captured from respondents' perceptions and were transformed and categorized into two by calculating the mean, whereby 1 was coded for positive perception and 0 for negative perception.

The socioeconomic traits of farmers who adopted and did not adopt the improved groundnut cultivars were compared using Chi-square test cross-tabulations. A Likert scale was used to assess the farmers' perceptions of the adoption of improved groundnut cultivars in relation to access to services, technological characteristics and the institutional environment. The binary logistic regression model was used to determine factors influencing smallholder farmers' adoption of improved groundnut cultivars. The following adopted equation is the binary logistic regression model according to Astari (2019).

$$logit(\pi) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p$$

Whereby,

$\beta 0, \beta 1, \ldots,$ = Regression parameters; $X1, X2, \ldots,$ Xp = Independent variables

π= Probability of adoption

$X1$ = Respondent's age (the age of respondent in years)

$X2$ = Respondent's sex (1= male, 0= female)

$X3$ = Education (1 = primary education, 0 = other level of education)

$X4$ = Marital status (1=married, 0= otherwise)

$X5$ = Major source of income (1 = agriculture, 0 = others)

$X6$ = Technological characteristics (1= positive perception, 0 = negative technological perception)

$X7$ = Seed accessibility (1 = accessible, 0 = not accessible)

$X8$ = FRN group membership (1= group member, 0 = non-group member)

$X9$ = Institutional characteristics (1 = positive institutional perception, 0 = negative perception)

Before the analysis, the qualitative data from the focus group discussions and interviews, particularly with the district, project officials, and other key informants, were translated from Kiswahili to English and then coded. Specific themes were created by combining the codes, and these topics were then subjected to thematic analysis. Themes based on similar patterns and trends in the data were used to interpret the data.

Results and discussion

Socioeconomic characteristics and adoption of improved groundnut cultivars

Table 2 presents the comparative adoption status amongst farmers based on their socio-economic characteristics. The Chi-square tests show the P values as follows: age (P= 0.128),

sex (P=0.427), marital status (P=0.226), an education level (P=0.414) and major sources of income (P=0.708) indicating that there is no statistical significance concerning farmers' socio-economic characteristics and the adoption of improved groundnut cultivars. This implies that there is no significant difference between those who adopted and those who did not adopt improved groundnut cultivars. Thus, social economic characteristics (i.e., age, sex, marital status, education and income) did not influence the adoption of improved groundnut cultivars in the project area.

However, from the descriptive statistics, the following are the study findings: In terms of age groups, 60.8 per cent adopted the innovation while 39.2 per cent did not adopt it. The majority of adopters were middle-aged people between the ages of 36 and 65 years (65.7%), followed by 51.6 per cent young people of between 18 and 35 years of age. The elderly group above 65 years that adopted improved groundnuts constitutes 50 per cent. Similar findings are reported in a study by Lindsjö *et al.,* (2020) who revealed that the majority (72.4%) of respondents were aged between 36 to 64 years. This is consistent with what is reported by Mwalongo *et al.,* (2020) who revealed that farmers aged between 35 to 50 years have adopted the improved cultivars of groundnuts. These findings imply that the age category of 36 to 65 years constitutes middle-aged adult farmers who are socially responsible and mature enough to decide to participate, conduct on-farm trials, interact in networks and adopt appropriate innovations that are economically useful.

Gender-wise, the group of adopters constituted 60.8 per cent while the non-adopters were 39.2 per cent for both males and females. However, the majority of adopters were females, accounting for 63.8 per cent with males accounting for 58.5 per cent. The analysed information from Mshikamano group disclosed that, in Singida, groundnuts are considered women's crops to assure the availability of household cooking oil as one of the main ingredients in meal preparation, while men are the decision-makers on land use and concentrate more on the production of cash crops mainly sunflower. These findings are in contrast to the findings in a study by Banla *et al.,* (2018), who found that 62.2 per cent of males as opposed to 37.8 per cent of females were participating in groundnut farming in three regions of Togo. Likewise, Mwalongo *et al.,* (2020) reported more males adopting the improved groundnut cultivars than is the case with females, due to higher position of the former in decision-making about the allocation of household resources. This implies that there is still gender inequality in matters related to decision-making over resource allocation for groundnut production and hence influences its adoption by gender.

In terms of marital status, there were 60.8 per cent adopters and 39.2 per cent non-adopters amongst the married and single respondents. Amongst the group of adopters, the majority (62.4%) of the respondents were married, followed by 50.0 per cent who were single. Other scholars also found that new technologies in production were more widely adopted by married farmers than was the case with unmarried farmers (Konja, 2022; Kalinda *et al.,* 2014). The findings imply that married farmers are relatively settled with established permanent settlements and are responsible for taking care of their family members; hence, they are more likely to adopt any technology that sounds useful to them.

In terms of education, primary school leavers, secondary school alumni, and those who never attended formal school education have 60.8 and 39.2 per cent of adopters and non-adopters respectively. From amongst the group of adopters, the majority (62.5%) had attained primary education, followed by 52.6 per cent who were secondary school alumni and 44.4 per cent who had never attended formal schooling. Complementary to these findings, the analysed qualitative information from the Muungano FGD revealed that the majority of those who participated in groundnut production were primary school leavers. The analysed information showed that those who attained secondary and tertiary education were fast adopters, but they were few in the village since the majority of them normally did not engage in farming activities as they were more focused on looking for employment opportunities created by other sectors of the economy. These

results support those reported by Lee (2020), who stated that, amongst other factors, the adopters of innovations were more educated and informed than the non-adopters. Similarly, Daudi *et al.* (2018) reported that the low levels of education and literacy limited the adoption of agricultural technologies by farmers. These results suggest that formal education matters in influencing adoption and that the more educated a person becomes, the more he or she is likely to become aware of and adopt new technology.

As far as major sources of income are concerned, there were 60.8 per cent adopters amongst farmers, employees, petty business persons and livestock keepers and 39.2 per cent non-adopters. The majority (62.0%) of adopters depended on agriculture/farming, as their main source of income. Other scholars (Suleiman, 2018; Mwaisakila & Matemani, 2021) have stated that agriculture is the backbone of the Tanzanian economy, contributing approximately 30 per cent of the total GDP, employing 65-70 per cent of the population and accounting for approximately 75 per cent of rural income. Similarly, Ahmed *et al.* (2020) observed that agriculture was a livelihood practised by about 85 per cent of household heads. This reality informs us that agriculture is the main source of income amongst farmers, and there is a need to optimize income through the adoption of improved technologies. The adoption of improved groundnut cultivars is part of agricultural development, which, when internalized, will ultimately contribute to the increase of the Tanzanian Gross Domestic Product (GDP).

Table 2: Comparison of farmers' socio-economic characteristics and adoption of improved groundnut cultivars (N=212)

Socio-economic characteristics		Adoption Status			Pearson Chi-Square
		Adopted	Not adopted	Total	
Age Groups	18 - 35 years	32 (51.6%)	30 (48.4%)	62 (100%)	0.128
	36 - 65 years	92 (65.7%)	48 (34.3%)	140 (100%)	
	Above 65 years	5 (50.0%)	5 (50.0%)	10 (100%)	
	Total	**129 (60.8%)**	**83 (39.2%)**	**212 (100%)**	
Respondent's sex	Male	69 (58.5%)	49 (41.5%)	118 (100%)	0.427
	Female	60 (63.8%)	34 (36.2%)	94 (100%)	
	Total	**129 (60.8%)**	**83 (39.2%)**	**212 (100%)**	
Marital status	Married	116 (62.4%)	70 (37.6%)	186 (100%)	0.226
	Single	13 (50.0%)	13 (50.0%)	26 (100%)	
	Total	**129 (60.8%)**	**83 (39.2%)**	**212 (100%)**	
Education Level	Primary	115 (62.5%)	69 (37.5%)	184 (100%)	0.414
	Secondary	10 (52.6%)	9 (47.4%)	19 (100%)	
	Never attended school	4 (44.4%)	5 (55.6%)	9 (100%)	
	Total	**129 (60.8%)**	**83 (39.2%)**	**212 (100%)**	
The major source of income	Agriculture/Farming	119 (62.0%)	73 (38.0%)	192 (100%)	0.708
	Employment	3 (50.0%)	3 (50.0%)	6 (100%)	
	Petty business	3 (42.9%)	4 (57.1%)	7 (100%)	
	Livestock keeping	4 (57.1%)	3 (42.9%)	7 (100%)	
	Total	**129 (60.8%)**	**83 (39.2%)**	**212 (100%)**	

Source: Survey data 2022

Factors influencing the adoption of improved groundnut cultivars

The binary logistic regression was used to determine factors influencing smallholder farmers' adoption of improved groundnut cultivars. Table 3 shows that the value of the log-likelihood is 79.555, while the Nagelkerke R square is 0.833, which indicates that the model explained about 83.3 per cent of the variation in the dependent variable. The higher Nagelkerke R square suggests that the model fitted to the data has high explanatory power for the joint association of the factors influencing the adoption of improved groundnut cultivars in the study area.

Furthermore, the results show that the mode fitted the data well at p = 0.00. This indicates that the variables were good at predicting the likelihood of smallholder farmers' adoption of improved groundnut cultivars.

Table 3: Model Summary: Omnibus Tests of Model Coefficients

Step	-2 Log likelihood		Cox & Snell R Square	Nagelkerke R Square
1	79.555a		0.610	0.833
	Chi-square		df	Sig. (p-value)
Step 1	Step	199.370	9	0.000
	Block	199.370	9	0.000
	Model	199.370	9	0.000

Source: Survey data 2022

While the adoption of improved groundnut cultivars was the dependent variable, the independent variables used in the regression model were age, sex, education, marital status, major source of income, technological characteristics, seed accessibility, FRN project group membership and institutional characteristics. The study results in Table 4 indicate that out of nine independent variables, three variables, namely FRN group membership, seed accessibility and technological characteristics, had a significant influence on the dependent variable (adoption of improved groundnut cultivars).

The study findings (Table 4) show that FRN group membership was significant at p less than 0.05. The findings imply that FRN group membership status (direct beneficiaries) increases the likelihood of adopting the improved groundnut cultivars by 6.28 units. To their credit, the information analysed from both the Muungano and Mshikamano FGDs showed that, compared to non-FRN group members, the FRN group members interacted more with the project facilitators and extension workers, who offered training, information and other extension services. Also, the seeds of improved groundnut cultivars were first provided through the channels of active group membership status. The non-FRN group members had indirect access to seeds of improved groundnut and extension-related services. Similar to these findings, Kimaru-Muchai *et al.* (2020) used binary logistic regression, which showed that membership in a social group was amongst the factors that influenced the adoption of Zaipit technologies in drier upper Eastern Kenya. Furthermore, Israr and Khan (2019) confirmed that membership in a farm service centre influenced the adoption of improved wheat seed innovations in Khyber Pakhtunkhwa using a binary logistic regression model.

The findings show that seed accessibility was highly significant at p less than 0.05 The findings imply that an increase in seed accessibility increases the likelihood of adopting improved groundnut cultivars by 114.12 units (Table 4). The direct beneficiaries of the project who belong to FRN groups had more access to seeds of improved groundnut cultivars compared to indirect beneficiaries. The information sourced from KII indicate that, the FRN project facilitated the availability of improved groundnut seeds for the selected FRN group members to multiply and spread. In the process of seed distribution, FRN group members were given priority due to their group membership status. During the interview, one key informant said,

"The priority in seed distribution of the

improved groundnut cultivars was given to the active direct beneficiaries of the project/ FRN group members" (FRN Project Officer, RECODA Office at Ilongero village, Singida District, 4 May 2022).

Similar findings were reported by Selahkwe *et al.* (2021), who used a logistic regression model to arrive at the results, which showed that farmers who were supplied with improved seeds from non-governmental organizations had a higher probability of adopting the innovation than the non-recipients. Again, Lee (2020) stated that if seed accessibility was ensured coupled with awareness creation, the adoption rate was likely to have increased to 30 per cent.

Table 4 displays the research findings, which revealed that perception of technological characteristics (i.e., adaptive to agroecological zones, high yields, early maturity, drought tolerance, pests and diseases resistance) were highly significant at p less than 0.05. This implies that changing the status of the technological characteristics of improved groundnut cultivars from undesirable (such as low yield, late maturity and drought intolerance) to desirable (such as high yield, early maturity and drought tolerance) increases the likelihood that farmers will adopt improved groundnut cultivars by 14.93 units. The key informant complimented by pointing out the aspect of high yield being the driving factor that contributed to the adoption of improved groundnut cultivars as follows:

"Prior to the FRN initiative, farmers produced local groundnut cultivars, which had substantially lower yields than the improved cultivars they are now widely adopting"(District agricultural extension officer, Singida District, 3 May 2022).

Additionally, a farmer from Mvae village declared to have had harvested higher yields from improved groundnut cultivars than the local groundnut cultivars:

"After I learned from the trial plot how to produce improved groundnut cultivars, I practiced the knowledge in my plot where I grew Mnanje by observing correct spacing and timely weeding as we were taught by our project facilitators. I managed to harvest 10 bags of improved groundnut cultivars on 1 acre. Before that, I was harvesting an average of 2 bags of local groundnut cultivars in the same acre" (Joseph Mwiru Muna, a farmer from Mvae village, Singida District, May 2, 2022).

It was further noted from the analysis of the Muungano and Mshikamano FGDs which showed that improved groundnut cultivars such as Mnanje had some relatively unique characteristics over local farmer cultivars. The key features of Mnanje that were pointed out by participants in FGDs as being preferable to farmers and buyers in the market include its high yield, vigour and large grain size, attractive reddish colour, a large amount of oil once pressed and good taste when eaten in all forms, that is raw, cooked, roasted or boiled. The literature states that Mnanje 2009 has unique characteristics that attract customers in the market, including its highest oil content (51%), highest iron composition (65.4 mg/kg), and sweetness when eaten in raw or in cooked form (Lukurugu *et al.,* 2021). The findings are also similar to Mehmood and Khan (2021), who found that the majority of farmers in the Potwar Plateau of Pakistan considered improved groundnut cultivars as better than the traditional or local cultivars in terms of yield, pod size and marketing.

Farmers' perception on the adoption of improved groundnut cultivars

Farmers' perception towards access to services

The study findings in Table 5 indicate that farmers had a positive perception towards access to services for the adoption of improved groundnut cultivars since mean score was used as a decision rule whereby the mean score of 2 and above was judged as positive perception and the mean score of less than 2 was judged as negative perception. For instance, farmers agreed that multiple connections to improved groundnut seeds affected the adoption of improved groundnut cultivars. "I am sure that multiple connections to improved groundnut seeds influence the adoption of improved groundnut cultivars" had a mean score of 2.81 and 84.9%. Oluwatoyin (2021) suggested a solution to the constraints of the adoption associated with availability, accessibility and affordability. Furthermore, access to credit

Table 4: Factors influencing the adoption of improved groundnuts cultivars (N=212)

Independent Variables	B	S.E.	Wald	df	Sig. (p-value)	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Constant	-2.752	2.197	1.570	1	0.210	0.064		
Respondent's age	-0.373	0.695	0.288	1	0.592	0.689	0.177	2.689
Respondent's sex	0.059	0.609	0.009	1	0.923	1.060	0.321	3.501
Education	-1.604	1.561	1.056	1	0.304	0.201	0.009	4.287
Marital Status	0.854	1.119	0.583	1	0.445	2.350	0.262	21.050
Major sources of income	0.970	1.086	0.797	1	0.372	2.637	0.314	22.179
Technological characteristics	2.703	0.653	17.148	1	0.000	14.930	4.153	53.671
Seed accessibility	4.737	0.881	28.941	1	0.000	114.123	20.315	641.108
FRN project group membership	1.837	0.816	5.076	1	0.024	6.280	1.270	31.057
Institutional characteristics	0.291	0.629	0.214	1	0.643	1.338	0.390	4.588

Source: Survey data 2022

services was agreed by 82.5% of farmers that it influences the adoption of improved groundnut cultivars. The perception statement *"I am sure that access to credit services influences the adoption of improved groundnut cultivars"* had a mean score of 2.76. Similarly, Chandio and Jiang (2018) stated that the availability of credits was a determinant for the adoption of improved wheat cultivars in Pakistan. The perception statement *"I am sure that access to post-harvest infrastructure influences the adoption of improved groundnut cultivars"* had a mean score of 2.60. By 67.0%, farmers agreed that access to post-harvest infrastructure influenced the adoption of improved groundnut cultivars. Kumara *et al.,* (2018) reported that the majority of farmers have been constrained by a lack of seed storage. Multiple connections to improved groundnut seeds, amongst other factors facilitated farmers' access to quality seeds, which was similarly stated by Vabi *et al.* (2018) to have influenced decisions to adopt improved groundnut innovations. Likewise, access to on-farm learning, access to information and a broader spectrum of external skills regarding improved groundnut cultivars from multiple sources were agreed upon by 87.7, 84.9 and 78.8 per cent of farmers (with mean scores of 2.82, 2.81 and 2.73) respectively, to influence the adoption of improved groundnut cultivars. The literature shows that learning innovations are a complex process that requires farmers to have access to information from multiple sources for them to adopt technologies (Beaman *et al.,* 2018; Fisher *et al.,* 2018; Lee 2020; and Puozaa *et al.,* 2021). These findings corroborate with social network diffusion theory, which posits that diffusion follows a complex contagion pattern whereby farmers tend to adopt a new technology provided that information about that technology comes from multiple sources (Beaman *et al.,* 2021). These findings suggest that access to services such as multiple connections to seeds, on-farm learning, a broader spectrum of external skills and information, credit and post-harvest infrastructure are potential influencing factors towards the adoption of improved groundnut cultivars.

Farmers' perception towards technological characteristics of an innovation

The mean scores of 2 and above indicate that farmers had a positive perception towards the technological characteristics of improved groundnut cultivars, regardless of a negative perception of introduction of improved groundnut cultivars as demand driven technology which had a mean score of less than 2 (Table 6). To support this, the analysis from the Muungano and Mshikamano FGDs showed that

Table 5: Farmers' perception towards access to services (N=212)

Statements	Agree %	Neutral %	Disagree %	Mean
I am sure that multiple connections to improved groundnut seeds influence the adoption of improved groundnut cultivars	84.9	11.3	3.8	2.81
I am sure that access to on-farm learning regarding improved groundnut cultivars influences its adoption	87.7	6.6	5.7	2.82
I am sure that access to information regarding improved groundnut cultivars from multiple sources influences its adoption	84.9	10.8	4.2	2.81
I am sure that a broader spectrum of external skills concerned with improved groundnut cultivars influences its adoption	78.8	15.6	5.7	2.73
I am sure that access to credit services influences the adoption of improved groundnut cultivars	82.5	10.8	6.6	2.76
I am sure that access to post-harvest infrastructure influences the adoption of improved groundnut cultivars	67.0	25.9	7.1	2.60

Source: Survey data 2022

they had preferred improved groundnut cultivars to traditional farmer cultivars. The information sourced from both FGDs further shows that, after they participated in testing through on-farm trials, the demand for improved groundnut cultivars rose as a result of the good performance of the crop in terms of high yield, sweet taste, drought tolerance, pests and diseases resistance, early maturity, adaptive to the environment and marketability. These findings support Roger's theory of innovations related to FRN principles in the components of participation and usefulness of on-farm research, where farmers could watch, learn about the benefits of innovation through on-farm experiments, and assess how easy and compatible the innovation was with their current practices and beliefs. Rogers (2003) asserts that innovations with benefits, perceived compatibility with current practices and beliefs, low complexity, possible trialability and observability will spread more quickly. The findings are also in line with the innovation systems perspective, which states that learning occurs in networks and spreads to individuals and farmers, leading to innovation. Farmers typically learn on the farm about the performance and applicability of the innovation to farming systems, as well as the sustainability of the inputs and market for the produce, before accepting it (Ayele *et al.,* 2012).

To complement the study findings by taking the example of yield, the key informant stated:

"Before the introduction of improved groundnut cultivars, farmers used to harvest an average of 1 to 2 bags of unshelled local groundnut cultivars per acre, but after project interventions, they can harvest an average of 7 to 10 bags of unshelled improved groundnut cultivars per acre. This has motivated farmers to prefer improved groundnut cultivars to local farmer cultivars" (FRN Project Officer, RECODA Office at Ilongero village, Singida District, 4 May 2022).

Other studies also revealed similar results. Akpo *et al.* (2021) reported that farmers preferred improved groundnut cultivars to the traditional ones. Daudi *et al.* (2018) and Mwalongo *et al.* (2020) reported on the superior qualities of improved groundnut cultivars over the local cultivars in the aspects of drought tolerance, pest and disease resistance, early maturity, high yield, big grain size, attractive grain colour, good taste, high oil content and a good market price. These findings suggest

that technological characteristics such as the adaptation to agroecological zones, drought tolerance, pest and disease resistance, early maturity and higher yields are preferable to farmers and hence have a positive influence on the adoption of improved groundnut cultivars.

However, the statement *"I am certain that improved groundnut cultivars were introduced as a demand-driven technology"* had a mean score of 1.44 indicating that 75.5% farmers disagreed and hence had a negative perception that improved groundnut cultivars were introduced as demand-driven technology. The results show that there was low farmer involvement in the development of innovations from the beginning thus, farmers did not consider themselves as part of the process of developing demand-driven technologies. To support this, the information sourced from Muungano and Mshikamano FGDs stated that before the introduction of the FRN project, farmers used to grow the traditional groundnut cultivars, and due to a lack of information, it was initially not their demand to grow improved groundnut cultivars. The FGDs stated that it was RECODA that introduced the idea of improved groundnut cultivars developed by Tanzania Agricultural Research Institute (TARI) Naliendele and brought to the project area in Singida for testing and adoption purposes. The literature shows that while the FRN approach emphasizes participation, the usefulness of on-farm research, and collaboration amongst stakeholders in the network (Richardson *et al.,* 2021; Haussman *et al.,* 2020), the improved groundnut seeds were initially produced by breeders and then passed to farmers for production of quality declared seeds (QDS) through farmer research groups, non-governmental organizations, and individual seed entrepreneurs (Akpo *et al.,* 2021; Lukurugu *et al.,* 2021). The findings imply that farmers had a negative perception towards developing demand-driven innovations since improved groundnut cultivars were initially not their idea, regardless of their later being preferred and adopted after participation in learning, testing, successful demonstrations, implementation and good performance from the on-farm trials.

Farmers' perception towards the institutional environment

The mean scores of 2 and above show that farmers had a positive perception of the institutional environment for the adoption of improved groundnut cultivars indicating that institutional environment such as markets, agro-input suppliers, credit facilities, subsidies and extension services were important for the adoption of improved groundnuts (Table 7). According to literature (Orr, 2018), amongst the key determinants of efficacious adoption are efficient institutions, demanding markets and

Table 6: Farmers' perception towards technological characteristics (N=212)

Statements	Agree%	Neutral%	Disagree%	Mean
I am certain that improved groundnut cultivars are adaptive to our agro-ecological zones	66.5	10.4	23.1	2.43
I am certain that improved groundnut cultivars are more drought tolerant than local cultivars	58.5	17.0	24.5	2.34
I am certain that improved groundnut cultivars are more pests and diseases resistant than local cultivars	44.3	25.9	29.7	2.15
I am certain that improved groundnut cultivars mature earlier than local cultivars	66.5	10.4	23.1	2.43
I am certain that improved groundnut cultivars have higher yields than local cultivars	67.9	8.5	23.6	2.44
I am certain that farmers prefer improved groundnut cultivars to local cultivars	71.2	7.1	21.7	2.50
I am certain that improved groundnut cultivars were introduced as a demand-driven technology	19.3	5.2	75.5	1.44

Source: Survey data 2022

favourable policies.

The findings further revealed that 85.4 per cent of farmers agreed that the availability of markets influences the adoption of improved groundnut cultivars whereby the statement "I have no doubt that availability of markets affects the adoption of improved groundnut cultivars'' had a score of 2.75. To complement this, the analysed information from both Muungano and Mshikamano FGDs showed that there was a reliable market for improved groundnut cultivars in the study area, but the seed availability of improved groundnut cultivars was limited. Those farmers who multiplied the seeds of improved groundnut cultivars usually provided the seeds to their fellow farmers free of charge, and those who sold the seeds normally sold them to their fellow farmers, middlemen and agro vet shops. With regard to market availability, the literature states that proximity to the market increases farmers' adoption (Orr, 2018), and a strong export market is amongst the adoption drivers (Ojiewo *et al.,* 2020). The findings imply that the availability of markets is essential for enhanced interaction between breeders, traders, transporters, farmers and agro-input suppliers, hence increasing the chances of the adoption of improved groundnut cultivars.

It was perceived positively by 81.6% farmers who agreed with the statement that *"I have no doubt that availability of agro-input suppliers affects the adoption of improved groundnut cultivars"* with a mean score of 2.72. Additionally, the information analysed from Muungano and Mshikamano FGDs showed that the seeds of improved groundnut cultivars were mainly supplied by the FRN project and RECODA. Both FGDs stated that the agro-companies had supplied farm inputs and tools such as seeds and hand hoes, during planting seasons by using their trucks. Nevertheless, the maize seeds were the major types of seeds that were mostly supplied by the agro-companies in the project area, not the groundnut seeds. Rutsaert *et al.,* (2021) reported that nearly 30 per cent of farmers travelled more than 60 minutes to look for at least one nearby agro-dealer, irrespective of the high number of agro-dealers. This implies that the availability of agro-input suppliers is still limited while is essential for enhancing interaction amongst players in networks and, hence, influencing the adoption of improved groundnut cultivars.

Furthermore, respondents perceived positively by agreeing with the statements that they had no doubt that the availability of credit facilities (78.8%), subsidies (87.3%) and extension services (81.6%) affected the adoption of improved groundnut cultivars with the mean scores of 2.68, 2.79 and 2.72 respectively. The analysis of information from the Muungano and Mshikamano FGDs showed that farmers accessed credit through village savings and loans associations (VSLAs), which is one of the interventions being introduced by the project. The participants further stated that they accessed

Table 7: Farmers' perception towards the institutional environment (N=212)

Statement	Agree	Neutral	Disagree	Mean
I have no doubt that availability of markets affects the adoption of improved groundnut cultivars	85.4	4.7	9.9	2.75
I have no doubt that availability of agro-input suppliers affects the adoption of improved groundnut cultivars	81.6	8.5	9.9	2.72
I have no doubt that availability of credit facilities affects the adoption of improved groundnut cultivars	78.8	10.8	10.4	2.68
I have no doubt that availability of subsidies affects the adoption of improved groundnut cultivars	87.3	4.7	8.0	2.79
I have no doubt that availability of extension services affects the adoption of improved groundnut cultivars	81.6	9.0	9.4	2.72

Source: Survey data 2022

fertilizer and sunflower seeds as subsidies from the government. The major extension service providers mentioned by the FGD participants were RECODA and government extension workers. According to literature, (i.e., Chandio and Jiang, 2018; Oluwatoyin, 2021), credit availability was a significant determinant of the adoption of improved agricultural technologies. Additionally, Shiferaw *et al.,* (2015, as cited by Takahashi *et al.,* 2018), reported that a lack of credits, seed supply, and technological information lowered the adoption of improved groundnut cultivars. According to Liu *et al.* (2020), fair subsidies boost agricultural enterprises and farmers' participation in the innovation diffusion process enthusiasm. In the instance of the adoption of improved varieties, Norton and Alwang (2020) pointed out that extension services could take the place of education. These findings suggest that the availability of credit facilities, subsidies and extension services is essential for interaction amongst players in FRN networks and hence influencing the adoption of improved groundnut cultivars.

Conclusion and Recommendations

From the research findings, the following conclusions and recommendations can be drawn: Socioeconomic characteristics such as age, sex, marital status, education level and income did not influence the adoption of improved groundnut cultivars in the project area. The adoption of improved groundnut cultivars was significantly influenced by three factors: FRN group membership, seed accessibility and technological characteristics which include adaptation to agroecological zones, high yields, early maturity, drought tolerance, pests and disease resistance. In comparison to farmers who had a negative perception, the majority of farmers had a positive perception of access to services, technological characteristics and the institutional environment for the adoption of improved groundnut cultivars.

The findings support the theories that guided this study. FRN principles were observed by FRN group members through their participation in carrying out on-farm trials and collaboration with other players in the networks. FRN members participated in project implementation that facilitated the adoption of improved groundnut cultivars. This is in line with the social network diffusion theory, which posits that people are embedded in an interactive network, and potential innovators' attitudes are influenced by social inspiration since diffusion follows a complex contagion pattern whereby farmers tend to adopt a new technology provided that the basis of information about that technology comes from multiple sources. Furthermore, FRN group members conducted on-farm research and learnt about and later on practised good agroecological practices about the cultivation of improved groundnut cultivars that support the innovation systems and Roger's theory of innovations. The innovation systems perspective postulates that learning occurs in networks and spreads to individuals and farmers, leading to innovation, whereby farmers typically learn on the farm about the performance and applicability of the innovation to farming systems, as well as the sustainability of the inputs and market for the produce, before accepting it. Similarly, Roger's innovation theory asserts that innovations with benefits, perceived compatibility with current practices and beliefs, low complexity, possible trialability, and observability will spread more quickly.

RECODA, the local government authorities in Singida rural district, and other development stakeholders should sensitize more farmers to form and join groups for them to get more access to education, information, agricultural inputs, credits, on-farm learning, a broader spectrum of external skills, networking and collaboration amongst different stakeholders and hence pave the way for wider adoption of agricultural innovations.

RECODA, the local government authorities in Singida rural district, and other development actors should ensure that improved groundnut seeds with the characteristics preferred by farmers are readily available and easily accessible on time to widen the adoption spectrum of improved groundnut cultivars.

RECODA, the local government authorities in Singida rural district, and other development stakeholders should take advantage of farmers' positive perceptions of access to services,

technological characteristics, and institutional environments to promote improved groundnut cultivars so that they are widely adopted by many more farmers.

References

Abady, S., Shimelis, H., & Janila, P. (2019). Farmers' perceived constraints to groundnut production, their variety choice and preferred traits in eastern Ethiopia: implications for drought-tolerance breeding. *Journal of Crop Improvement,* 33(4), 505-521. Retrieved from [https://www.tandfonline.com/doi/abs/10.1080/15427528.2019.1625836] site visited on 11/2/2021

Ahmed, B., Echekwu, C.A., Mohammed, S.G., Ojiewo, C., Ajeigbe, H., Vabi, M.B., & Nwahia, O.C. (2020). Analysis of Adoption of Improved Groundnut Varieties in the Tropical Legume Project (TL III) States in Nigeria. Agricultural Sciences, 11(02), 143-156.Retrieved from [http://oar.icrisat.org/11721/] site visited on 2/8/2022

Akpo, E., Ojiewo, C.O., Kapran, I., Omoigui, L.O., Diama, A., & Varshney, R.K. (2021). Enhancing Smallholder Farmers' Access to Seed of Improved Legume Varieties Through Multi-stakeholder Platforms: Learning from the TLIII project Experiences in Sub-Saharan Africa and South Asia (p. 205). Springer Nature.

Astari, D.W. (2019, October). Analysis of Factors Affecting the Health Insurance Ownership with Binary Logistic Regression Model. In *Journal of Physics:* Conference Series 1320(1), p. 012011. IOP Publishing.

Banla, E.M., Dzidzienyo, D.K., Beatrice, I.E., Offei, S.K., Tongoona, P., & Desmae, H. (2018). Groundnut production constraints and farmers' trait preferences: a pre-breeding study in Togo. *Journal of Ethnobiology and Ethnomedicine,* 14(1), 1-14.

Beaman, L.A., BenYishay, A., Magruder, J., & Mobarak, A.M. (2018). Can network theory-based targeting increase technology adoption? NBER Working Paper 24912.

Beaman, L., and Dillon, A. (2018). Diffusion of agricultural information within social networks: Evidence on gender inequalities from Mali. *Journal of Development Economics,* 133, 147–61.

Beaman, L., BenYishay, A., Magruder, J., & Mobarak, A.M. (2021). Can network theory-based targeting increase technology adoption? American Economic Review, 111(6), 1918-43.

Chandio, A.A., and Jiang, Y. (2018). Factors influencing the adoption of improved wheat varieties by rural households in Sindh Pakistan.AIMS Agriculture and Food 3(3):216-228.

Creswell, J.W. (1999). Mixed-method research: Introduction and application. In Handbook of educational policy (pp. 455-472). Academic press.

Daudi, H., Shimelis, H., Laing, M., Okori, P., & Mponda, O. (2018). Groundnut production constraints, farming systems, and farmer-preferred traits in Tanzania. *Journal of Crop Improvement,* 32(6), 812-828.

Deroian, F., (2002). Formation of social networks and diffusion of innovations. Research Policy 31, 835e846.

Fisher, M., Holden, S.T., Thierfelder, C., & Katengeza, S.P. (2018). Awareness and adoption of conservation agriculture in Malawi: what difference can farmer-to-farmer extension make? *International Journal of Agricultural Sustainability,* 16 (3), 310–25.

FRN Project Report, (2018). Project Progress and Results.

Glover, D., Sumberg, J., Ton, G., Andersson, J., & Badstue, L. (2019). Rethinking technological change in smallholder agriculture. Outlook on Agriculture, 48(3), 169-180.

Gorfad, P.S., Chovatia, J.V., & Kalsariya, B.N. (2018). Adoption of improved groundnut production technology by groundnut growers. *Guj. J. Ext. Edu,* 29(2), 201-202. Retrieved from [https://www.gjoee.org/papers/947.pdf] site visited on 2/8/2022

Haussmann, B.I., Aminou, A.M., Descheemeaker, K., Weltzien, E., Some, B., Richardson, M., & Coe, R. (2020). Tackling Key Issues for Smallholder Farmers: The Farmer Research Network

(FRN) Approach. In Sorghum in the 21st Century: Food–Fodder–Feed–Fuel for a Rapidly Changing World (pp. 315-329). Springer, Singapore.

Israr, M., & Khan, N. (2019). The role of the farm service centre (FSC) in the adoption of improved wheat seed technology in Khyber Pakhtunkhwa: A logistic regression analysis. *Sarhad Journal of Agriculture,* 35(4), 1351-1356.

Kalinda, T., G. Tembo, & E. Kuntashula. (2014). Adoption of improved maize seed varieties in Southern Zambia. *Asian Journal of Agricultural Sciences* 6 (1): 33–39.

Kimaru-Muchai, S.W., Ngetich, F.K., Baaru, M., & Mucheru-Muna, M.W. (2020). Adoption and utilisation of Zai pits for improved farm productivity in drier upper Eastern Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* (JARTS), 121(1), 13-22.

Konja, D.T. (2022). Technology Adoption and Output Difference Amongst Groundnut Farmers in Northern Ghana. *The European Journal of Development Research,* 34(1), 303-320.

Krejcie, R.V., & Morgan, D.W. (1970). Determining Sample Size for Research Activities.Educational and Psychological Measurement, 30(3), 607–610.

Krejcie, R.V., & Morgan, D.W. (1970). Determining sample size for research activities. Educational and psychological measurement, 30(3), 607-610.

Kumara C.D, Herridge D, Yi SS, *et al.* (2018) ImpactAssessment of the Village Seed Bank (VSB) Program forChickpea, Groundnut and Pigeonpea in the Central Dry Zone of Myanmar, Focusing on the Production, Distribution, Productivity and Profitability of Seed of Improved Cultivars.Patancher: International Crops Research Institute for the Semi-Arid Tropics, pp. 40. ISBN 978-93-86527-01-1.

Lee, H. (2020). The current status and constraints of drought-tolerant maize adoption in Uganda. *The Open Agriculture Journal,* 14(1).

Lindsjö, K., Djurfeldt, A.A., Isinika, A.C., & Msuya, E. (2020). Youths' participation in agricultural intensification in Tanzania. AIMS.

Liu, L., Zhu, Y. & Guo, S., (2020). The evolutionary game analysis of multiple stakeholders in the low-carbon agricultural innovation diffusion. Complexity, 2020, 1-12.

Lukurugu, G.A., Mponda, O.K., Akpo, E., Monyo, E.S., Nzunda, J., Daudi, H., Joseph, A., Mlimbila, H.G., Ndolelwa, D. & Mkandawile, C., (2021). Groundnut Seed Production and Distribution Through Multi-Stakeholder Platforms in Southern Region of Tanzania. In Enhancing Smallholder Farmers' Access to Seed of Improved Legume Cultivars Through Multi-stakeholder Platforms (pp. 9-30). Springer, Singapore.

Lukurugu, G.A., Mponda, O.K., Akpo, E., Monyo, E.S., Nzunda, J., Daudi, H., Joseph, A., Mlimbila, H.G., Ndolelwa, D. & Mkandawile, C., (2021). Groundnut Seed Production and Distribution Through Multi-Stakeholder Platforms in Southern Region of Tanzania. In Enhancing Smallholder Farmers' Access to Seed of Improved Legume Cultivars Through Multi stakeholder Platforms (pp. 9-30). Springer, Singapore.

Mehmood, K., Rehman, A., & Khan, A. (2021). Farmers' Perceptions, Awareness and Adoption of Improved Groundnut Varieties in Potwar Plateau of Pakistan. *Sarhad Journal of Agriculture,* 37(4).

Mwaisakila, S.R., & Matemani, J.K. (2021). Tanzania Towards Industrialization; Kilimo Kwanza Policy Towards Economic Growth and Self-Sustaining. *Jurnal Magister Administrasi Publik* (JMAP), 1(2), 92-101.

Mwakimata, R.G., (2018). Gendered yield gap analysis in groundnut production in Tanzania: social and economic implications (Doctoral dissertation, Sokoine University of Agriculture).

Mwalongo, S., Akpo, E., Lukurugu, G.A., Muricho, G., Vernooy, R., Minja, A., Ojiewo, C., Njuguna, E., Otieno, G. & Varshney, R., (2020). Factors Influencing Preferences and Adoption of Improved Groundnut Cultivars amongst Farmers in

Tanzania. Agronomy, 10(9), p.1271.

Mwatawala, H.W., & Kyaruzi, P.P. (2019). An Exploration of Factors Affecting Groundnut Production in Central Tanzania: Empirical Evidence from Kongwa District, Dodoma Region. *International Journal of Progressive Sciences and Technologies,* 14(1), 120-130.

Nelson, R., Coe, R., & Haussmann, B.I. (2019). Farmer research networks as a strategy for matching diverse options and contexts in smallholder agriculture. Experimental Agriculture, 55(S1), 125-144.

Norton, G.W., & Alwang, J. (2020). Changes in agricultural extension and implications for farmer adoption of new practices. Applied Economic Perspectives and Policy, 42(1), 8-20.

Nyumba, O., Wilson, T., Derrick, K., C.J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods in Ecology and evolution, 9(1), 20-32.

Ojiewo, C.O., Omoigui, L.O., Pasupuleti, J., & Lenné, J.M. (2020). Grain legume seed systems for smallholder farmers: Perspectives on successful innovations. Outlook on Agriculture, 49(4), 286-292.

Oluwatoyin, B.C. (2021). Factors influencing adoption of improved maize seed varieties amongst smallholder farmers in Kaduna State, Nigeria. *Journal of Agricultural Extension and Rural Development,* 13(2), 107-114. Retrieved from [https://academicjournals.org/journal/JAERD/article-full-text-pdf/D9E5EF666959] site visited on 2/8/2022

Omair, A. (2015). Selecting the appropriate study design for your research: Descriptive study designs. *Journal of health specialties,* 3(3), 153.

Orr. A., (2018). Markets, institutions and policies: a perspective on the adoption of agricultural innovations. Outlook on Agriculture47: 81–86.

Polit, D.F., & Beck, C.T. (2010). Generalization in quantitative and qualitative research: Myths and strategies. *International Journal of Nursing Studies,* 47(11), 1451-1458.

Puozaa, D.K., Jinbaani, A.N., Adogoba, D.S., Busagri, D., Rasheed, M.A., Issah, A.R., & Oteng-Frimpong, R. (2021). Enhancing access to quality seed of improved groundnut varieties through multi-stakeholder platforms in Northern Ghana. In Enhancing Smallholder Farmers' Access to Seed of Improved Legume Varieties Through Multi-Stakeholder Platforms (pp. 65-79).

Richardson, M., Coe, R., Descheemaeker, K., Haussmann, B., Wellard, K., Moore, M., & Nelson, R. (2021). Farmer research networks in principle and practice. *International Journal of Agricultural Sustainability,* 1-18.

Rogers, E.M., (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Rutsaert, P., Chamberlin, J., Oluoch, K.O.A., Kitoto, V. O., & Donovan, J. (2021). The geography of agricultural input markets in rural Tanzania. *Food Security,* 13(6), 1379-1391.

Sawe, J., Mungâ, C.G., & Kimaro, G.F. (2018). The impacts of climate change and variability on crop farming systems in Semi-Arid Central Tanzania: The case of Manyoni District in Singida Region. *African Journal of Environmental Science and Technology,* 12(9), 323-334.

Selahkwe, C., Nformi, M.I., Lengah, T.N., Nchanji, E.B., & Fotang, C. (2021). Factors That Determine the Adoption of Improved Irish Potato Technologies by Farmers in the Western Region of Cameroon. *Agricultural Sciences,* 12(12), 1404-1413.

Shasani, S., Banerjee, P.K., De, H.K. & Panda, S., (2020). Constraints in Adoption of Groundnut Cultivation Technology by the Farmers of Odisha. *Indian Journal of Extension Education,* 56(2), pp.39-44.

Shiferaw, B., Kebede, T., Kassie, M.,& Fisher, M. (2015). Market imperfections, access to information and technology adoption in Uganda: Challenges of overcoming multiple constraints. *Agricultural Economics,* 46 (4), 475–88.

Simtowe F., Amondo E., Marenya P., Rahut D., Sonder K., & Erenstein O. (2019). Impacts of drought-tolerant maize varieties

on productivity, risk, and resource use: Evidence from Uganda. Land Use Policy; 88104091

Singida district council profile, (2015). Retrieved from [https://singidadc.go.tz/storage/app/media/SINGIDA%20DC%20SOCIO-ECONOMIC%20PROFILE.pdf] site visited on 23/5/2023.

Suleiman, R. (2018). Local and regional variations in conditions for agriculture and food security in Tanzania.

Takahashi, K., Muraoka, R., & Ōtsuka, K. (2019). Technology adoption, impact, and extension in developing countries' agriculture: a review of the recent literature.

URT, (2016). Annual Agriculture Sample Survey. Initial Report [https://www.nbs.go.tz/nbs/takwimu/Agriculture/2016_17_AASS_%20report.pdf] site visited on 18/9/2021.

Vabi, M.B., Sadiq, S.A., Mustaph, A., Suleiman, A., Affognon, H.D., Ajeigbe, H.A., & Kasim, A.A. (2019). Patterns and drivers of the adoption of improved groundnut technologies in North-western Nigeria. *African Journal of Agriculture,* 6(1), 1-16. Retrieved from [http://oar.icrisat.org/11081/] site visited on 2/8/2021

Vecchio, Y., Agnusdei, G.P., Miglietta, P.P., & Capitanio, F. (2020). Adoption of precision farming tools: the case of Italian farmers. *International Journal of Environmental Research and Public Health,* 17(3), 869.

World Bank, (2007). Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems. Washington DC.