

Full Length Research Paper

The role of farmer research networks' (frn) principles in influencing farmers' adoption of improved groundnut cultivars in Singida Rural District of Semi-Arid Central Tanzania

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Farmer Research Networks (FRN) is a participatory approach aimed at supporting the agroecological intensification of smallholder farming. FRN was envisaged in Latin America and Africa, however, little has been documented on how the application of FRN principles influences adoption of agricultural technologies. Guided by networking, innovation systems and Roger's theories of diffusion of innovations, this research assessed how the application of three principles, that is, 1) farmer participation, 2) usefulness of on-farm research, and 3) collaboration amongst players in networks influenced the adoption of improved groundnuts. Cross sectional mixed research methods were used. Findings show that farmers participated in forming FRN groups, the production of Quality Declared Seeds and the provision of farmer-to-farmer extension services. On-farm research was instrumental for observational and experimental research whereby farmers were able to see, learn, and adopt the innovation. Players collaborate through joint research, learning, and sharing of knowledge and resources; farmers' field days; and project meetings. It is concluded that farmers participated in conducting on-farm research and collaborated with different players in the network, indicating that FRN principles were applied to influence the adoption of improved groundnuts. The study recommends farmer participation in preliminary meetings and strengthening the linkage between farmers and more actors.

Key words: FRN principles, participation, on-farm research, collaboration, adoption of improved groundnut cultivars, Singida Tanzania.

INTRODUCTION

Farmer Research Networks (FRNs) are made up of several groups of farmers who participate in research in

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liaison with researchers and development institutions (Nelson et al., 2019). In guiding project implementation, the Crop Collaborative Research Programme (CCRP) developed a set of FRN principles comprising (i) farmer's centred approach whereby diverse farmers participate in the research process, (ii) rigorous, democratic and useful/practical research, and (iii) collaborative networks to facilitate learning and knowledge sharing (Richardson et al., 2022; Haussmann et al., 2020). For success and sustainability purposes, it is expected that key players/actors understand the principles and apply them in the FRN project implementation process.

Different scholars including Descheemaeker et al. (2021), Nelson et al. (2019) and Hassen et al. (2019) have reported on the FRN approach by pointing out the elements of participation, practical research and collaboration which are the key three principles of FRN. The first principle is about farmer centred approach which requires diverse farmers to participate in the research process so that they can learn, solve their problems and adopt agricultural innovations. Descheemaeker et al. (2021) pointed out that, the FRN approach is designed to engage farmers so that they prioritize, experiment, gather data, and understand the results. The participation of farmers in the research process carries due weight for the ownership, learning, technology adoption, diffusion, and sustainability of the programme.

The second principle is on rigorous, democratic and useful/practical research which requires the research to have beneficial importance for farmers to conduct and adopt the appropriate agricultural technologies. In this aspect, Descheemaeker et al. (2021) stated that the FRN principles are supportive in generating answers and procedures worth scaling to similar contexts since they were found through pertinent, dependable and valid research. Additionally, according to Tao et al. (2019), Nelson et al. (2019) and Hassen et al. (2019), on-farm research can be used as a problem-solving and demonstration tool, allowing farmers to use it to address issues with farm management, learn empirical lessons through observational and experimental research, and replicate it in fields with similar challenges.

The third principle is about collaborative networks that require the facilitation of learning and knowledge sharing amongst actors to adopt the appropriate agricultural technologies. According to Wenndt et al. (2021), by facilitating the exchange of information between regional and international innovation systems, the integration of participatory research inside a farmer research network (FRN) has the potential increasing its efficacy. According to Nelson and Haussmann (2019), to empower FRNs, significant institutional innovation will be required, along with changes to the relationships and roles amongst researchers, extension agents and farmers. FRN encourages collaborative networks which favour systems thinking as opposed to linear thinking. This is supported by Takahashi et al. (2019) who reported on the growing

number of research regarding social networks and farmer-to-farmer technology transfer being amongst the more effectual extension model compared to the traditional linear model widely used by the public sector. Besides, Oluwatoyin (2021) proposed the connection between researchers, innovators and farmers who are the adoption clients of agricultural innovations. Moreover, Haussman et al. (2020) reported that, in the overall FRN model, there is an organization that, whenever possible, supports the cooperative network of farmer organization (s), Non-Governmental Organizations (NGOs) and development projects, researchers/research institutions and the private sector. Local expertise, social capital and infrastructure are combined with advances in science from around the world in this network, which benefits all participants.

To further enlighten the adoption of agricultural technologies such as push-pull technology, different scholars have reported on FRN principles. The reports were centred on the interpretation, implementation and usage of the principles to guide learning and the flow of knowledge between home-grown and worldwide innovation systems (Richardson et al., 2022; Wenndt et al., 2021). Hassen et al. (2019) reported on the social value of FRN whereby the knowledge transfer resulted in the adoption of push-pull technology after the majority of farmers had participated. The study by Hassen et al. (2019) suggest that FRN promotes social interaction, which contributes to the adoption of Push-Pull Technology (PPT). It is advised that the system be spread to other farmers who are engaged in the production of sorghum as the majority of farmers who participated in the FRN have adopted the innovation. However, little has been documented regarding how FRN principles were applied to facilitate farmers' adoption of agricultural technologies. Thus, this study aimed at assessing how FRN guiding principles were applied in enabling farmers' adoption of improved groundnut cultivars in Singida region, Tanzania. Specific objectives were (1) to assess how participation influenced farmers' adoption of improved groundnut cultivars, (2) to determine the usefulness of on-farm research in influencing farmers' adoption of improved groundnut cultivars, (3) and to evaluate how collaboration amongst players in the network influenced farmers' adoption of improved groundnut cultivars. Specific questions that the study sought to answer were how the three principles of FRN, namely (1) farmer participation, (2) the usefulness of on-farm research, and (3) collaboration amongst players in the network influenced farmers' adoption of the improved groundnut cultivars.

This study was guided by networking theories of diffusion of innovations, innovation systems theory and Rodger's theory of innovations. Social network diffusion theory posits that 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, individuals were rooted in an interactive network and the belief of prospective innovation adopters is subjected to social inspiration (Beaman et al., 2021). The adoption of innovation goes beyond simple information transmission and involves amendments of decisions, discussions in a wider practice related to the socioeconomic system and an individual sincerity to influence (Deroian, 2002). Social network diffusion theory was incorporated in this study since it is in line with the FRN principles as it hypothesizes on participatory processes, collaboration, and networking. Additionally, Roger's theory was connected to FRN principles in the aspect of on-farm research, where farmers could observe, learn the advantages of innovation through on-farm trials, and weigh how simple and compatible the innovation was with their existing practices and beliefs.

According to Rogers (2003), "*innovations that offer advantages, perceived compatibility with existing practices and beliefs, low complexity, potential trialability, and observability, will have a more widespread and rapid rate of diffusion*". To clarify the concepts of adoption and diffusion as used in the theories guiding this study, Vecchio et al. (2020) stated that adoption is used interchangeably as a part or sub-process of diffusion; hence, "Diffusion is the adoption process whereby innovation is accepted across a population over time, whereas adoption is the condition whereby an individual decides to accept an innovation and integrate it into his or her life." This study has used the term "adoption" to refer to the FRN project beneficiaries' collaboratively participating in testing, learning, understanding, and practising the innovation by growing all or one of the improved groundnut cultivars, that is, *Mnanje*, *Naliendele* and *Mangaka* as amongst their agro-ecological practices.

The innovation systems approach postulates that learning in networks outspreads individual players and farmers and produces innovation. Before accepting an innovation, farmers normally learn on-farm about the performance and suitability of the innovation to farming systems and the sustainability of the inputs and market of the product (Ayele et al., 2012). The innovation system framework emphasizes the entirety of players and features essential to bring about innovation and growth (World Bank, 2007). Ayele et al. (2012) point out the key players comprising knowledge and technology providers, users of the knowledge and technology, their roles, and the interaction between players and their habits and practices that influence joint learning and innovation. Interaction and learning are dependent on players' closeness such as physical distance, and institutional environment which shapes trust-based relationships and players' characteristics to absorb new ideas. The innovation systems theory was linked to the FRN approach since it reflects more on collaboration in networks and systems thinking.

Furthermore, having the component of collaboration and/or networking, FRN group membership coupled with

FRN principles were also identified as amongst the independent variables that were conceptualized to influence the adoption of improved groundnut cultivars.

METHODOLOGY

Description of the study area

Singida Rural district has a semi-arid climatic condition. There are two seasons; the dry season, which is the longest (April to November) and the rainy season from December to March. The average rainfall is between 600 and 700 mm per annum while the average minimum temperature is 15 to 30°C (Singida District Profile, 2014). This study was conducted in Singida Rural District; Ilongero and Mtinko divisions in eight villages which are Sekoutoure, Mwakiti, Msimihi, Mdilu, Mvae, Mughanga, Minyenye and Mtinko (Figure 1). Selection of these villages was based on topographic features, climatic conditions and rainfall patterns that favour groundnut production. These villages were also selected because the improved groundnuts were introduced and promoted for adoption and diffusion through the FRN project.

Research design

A cross-sectional research design was adopted in this study whereby data were collected at a single point in time. According to Omair (2015), a cross-sectional study design enables data collection at a single moment in time and has a broad scope by incorporating many variables at once. Omair (2015) further suggests that it is more time- and money-efficient than the longitudinal design for determining relationships between variables as well as for descriptive reasons. Mixed research methods were applied to collect both quantitative and qualitative data at the same time. The mixed research methods are reported by other scholars as being advanced, perceptive and useful for the improvement of the generalizability of research (Glover et al., 2019; Polit and Beck, 2010). Additionally, Creswell (1999) stated that, in a mixed-method study, the researcher uses both qualitative and quantitative data gathering and analysis techniques in a single investigation. Objectives 1 and 3 exhibit characteristics of the qualitative research philosophy, whereas objectives 1 and 2 have some numerical descriptions falling under the quantitative research philosophical orientation. However, qualitative research was dominant over quantitative since this study aimed at assessing how FRN principles, that is, farmer participation, the usefulness of on-farm research and collaboration amongst players in networks influenced farmers' choice to adopt improved groundnut cultivars namely *Mnanje*, *Mangaka* and *Naliendele*.

Sampling procedure and sample size

Concerning quantitative data, proportionate random techniques were used to get a representative sample from the population of 1260. This study used the formula proposed by Krejcie and Morgan (1970), to determine the sample size of 212 smallholder farmers from the 8 project villages in Ilongero and Mtinko divisions, Singida Rural district.

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

where required sample size, X = z value (assumed to be 1.645 for 90% confidence level), N = population size, P = population

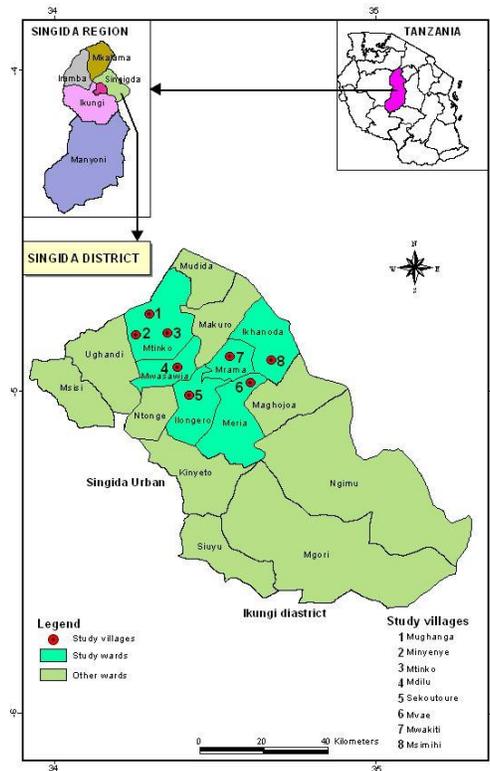


Figure 1. Map of the study area.
Source: Survey data 2022

Table 1. Sample size.

Division	Ward	List of villages	Population (N)		Sample Size (n)	
			Direct	Indirect	Direct	Indirect
Ilongero	Ilongero	Sekoutoure	50	100	8	17
		Mrama	45	90	8	15
		Ikhanoda	99	198	17	34
		Mwasawia	31	62	5	10
		Meria	84	168	14	28
Mtinko	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

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).

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

Simple random sampling was applied to select respondents from each village (direct and indirect beneficiaries). Table 1 provides the breakdown of the sample size of direct and indirect beneficiaries per village.

For the case of qualitative data, key informants (agricultural officers, agro-vet dealers, and project staff) were purposively selected for interview. The interviews were conducted with the key informants

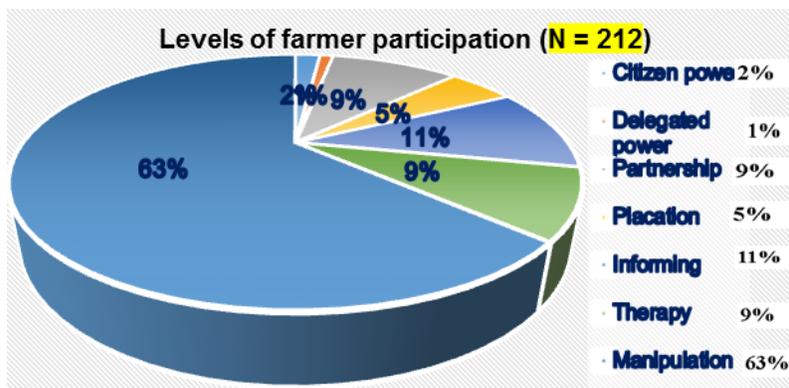


Figure 2. Levels of farmers' participation in the project launch.
Source: Survey data 2022

comprising 2 Agricultural Officers (1 at the district and 1 at the ward and village levels); 2 agro-vet dealers (1 at the district and 1 at the ward and village levels). The project staff who were interviewed included Programme Leader, Project Manager and Project Officer. Key informants were selected because of their familiarization and sufficient information they need to have concerning the project implemented in their respective areas of influence. Two groups were purposively selected for focus group discussions (FGDs) whereby each division had one group selected namely, Muungano group at Mvae village (Ilongero Division) and Mshikamano group at Mughanga village (Mtinko Division). The FGDs consisted of 8 to 12 farmers each. Key issues in FGDs and key informant interviews (KII) centred on stakeholders' understanding of FRN principles, the ways FRN principles were applied to facilitate the adoption of improved groundnut cultivars, identification of key players, their roles and interaction/collaboration in farmers' research networks.

Data collection

Primary data

Before the collection of primary data, training on data collection by using both quantitative and qualitative tools was conducted for enumerators in April 2022. Pretesting of the research tools was conducted at Mwakiti village in April 2022. From the pretesting exercise, amendment to the data collection tools was made based on the field reality. The field data collection exercise was held from April 2022 through May 2022 where both quantitative and qualitative primary data/information were collected.

Primary quantitative data such as farmers' level of participation and the extent of usefulness of crop research were collected by using semi-structured questionnaires with both closed and open-ended questions. These quantitative data were important to show the numeric/statistical figures of the study such as frequencies, percentages, mean and standard deviation.

Primary qualitative data such as farmers' feelings and opinions on why to accept or reject improved groundnut, how the farmers apply the FRN principles to facilitate the adoption of improved groundnut and how the key players collaborate/interact in farmer research networks were collected by using qualitative data collection tools such as key informant interviews, focus group discussion and observation. Checklists with open-ended questions were employed. The qualitative data were collected to provide an in-depth understanding of issues that could not be explained by statistical information.

Secondary data

A documentary review was employed to collect secondary data. The reviewed documents include information from the internet (mainly google scholar with the interval of 2017 to 2022 publications), Singida rural district socio-economic profile, FRN project design, monthly, quarterly, annual and monitoring and evaluation reports. These documents were important since they were part of the literature review which provided information on the existing situation of what has already been done and reported, the major purpose being to complement (reinforce/dispute) findings from other sources of data.

Data analysis and interpretation

Quantitative data were coded and summarized before analysis. The numeric data from the survey (questionnaires) were keyed in and analysed using Statistical Package for Social Science (SPSS) version 20 to obtain descriptive statistics (mainly frequencies and percentages). For ease of presentation, frequencies and percentages were further refined and converted into charts and/or cross-tab/pivot tables by using excel.

Qualitative information obtained from the focus group discussions and interviews particularly with the district, project officials and other key informants was translated from Kiswahili to English and was manually coded before analysis. The codes were combined to give specific themes which were analysed by using thematic analysis. Interpretations were done using themes based on patterns and trends of information gathered.

RESULTS AND DISCUSSION

Farmers' participation in the project launch and its influence on the adoption of improved groundnut cultivars

Figure 2 summarizes the findings on the level of farmer participation in the project launch. The majority (63%; N=212) responded that participants were made to believe that the project of improved groundnut cultivars was good for farmers to engage in execution (manipulation). By 11% (N=212) participants were informed through local

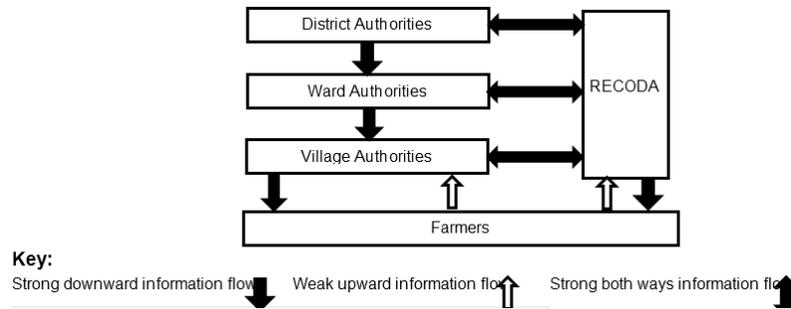


Figure 3. Project introduction process and farmers' participation.
Source: Survey data 2022

government authorities and Research Community and Organizational Development Associates (RECODA) with no negotiation meeting being held to argue about the improved groundnut projects (informing). Besides, 9% (N=212) responded that participants negotiated better ideas/shared funding that contributed to the smooth running of the improved groundnut project (partnership).

These quantitative figures provide a picture of the level of participation based on the frequency of respondents on the subject matter. However, Bigonnesse (2016) pointed out that while it was very simple to evaluate participation frequency with an attendance sheet, the quality of participation was still debatable since the frequencies alone could not provide the details. Therefore, to complement the findings, the qualitative information through Key Informant Interview and Focus Group Discussion coupled with secondary data provided the details of how farmers participated during the introduction of the project.

The entire procedure for introducing the improved groundnut cultivars in the project area is depicted in Figure 3. The procedures show that, farmers had no direct role; instead, they were represented by district and village administrations. At the district level, the project was presented to the district officials before being forwarded to the District Agricultural, Livestock, and Fisheries Officer's (DALFO) office. The project concept was presented by RECODA and debated during the meeting with DALFO's staff. The committee decided to propose villages depending on requirements. The proposed villages were accepted, and official letters were issued to the relevant ward and village officials informing them of the project. A Ward Development Committee (WADC) meeting was then organized at the ward level with participation from important leaders from the designated wards and villages. Ward executive officials, ward councillors, Village Executive Officers, village chairpersons, community development officers, and headteachers were amongst the important figures. RECODA and employees from DALFO's office presented the project idea to the participants, who all agreed to accept it and pledged to give it the necessary support.

The agenda for the village-level awareness-raising meetings was developed from this meeting. These findings are consistent with the findings from a key informant who stated:

"The meetings held at district and ward levels had not involved farmers since the process for introducing a new project required following those procedures instead of directly getting into contact with farmers. Farmers started to participate during village awareness creation meetings that were held at each of the respective proposed villages" (FRN Project Manager, RECODA Office at Ilonger Village, Singida District, 4 May 2022).

Lack of farmer participation in district and ward decision-making is detrimental to project ownership and efficient implementation. Ariti et al. (2018) made similar observations, noting a participation gap between local government entities and farmers that impeded the efficient implementation of land use policies.

The Mshikamano and Muungano FGDs stated that the village officials arranged for village meetings, to which all villagers were invited. The new idea of improved groundnut cultivars was introduced by RECODA at village sensitization workshops, along with other topics. The Tanzania Agricultural Research Institute (TARI) Naliendele produced the cultivars (namely *Mnanje*, *Mangaka* and *Naliendele*) and brought them to the project area in Singida for testing and adoption purposes, which sounded like a good idea for the farmers to embark on. Farmers took part in those meetings by showing up, listening to and following the promotional and instructional messages and dialogues, and asking questions about the RECODA-promoted improved groundnut cultivars. After each meeting, farmers were asked to form groups of their choice. Farmers who expressed interest in the project idea were registered, and with RECODA's guidance, actively participated in the group formation process. These findings imply that the processes of project introduction in the project area used both "top-down" and "bottom-up" approaches, whereby, at the district and ward levels, there was no participation of farmers, but

Table 2. Arnstein ladder of community level of participation.

Level of participation	Clarification	Implication
Citizen Power	Participants govern a programme/project to take full charge	Citizen control
Delegated Power	Participants have some degree of control/management	
Partnership	Participants negotiate better ideas/share funding	
Placation	Participants have a limited degree to influence decisions	Tokenism
Consultation	Participants' ideas/concerns not taken into account	
Informing	Participants are informed with no negotiation meeting	
Therapy	Participants are convinced that there is a problem to address	No participation
Manipulation	Participants are educated/made to believe the project is good	

Source: Conceptualized, operationalized and modified from Arnstein (1969) and Rosyida and Nasdian (2011).

at the village level, participation of farmers in the village sensitization meetings was noted. Apart from the FRN approach, RECODA implements projects by using the Rural Initiatives for Participatory Agricultural Transformation (RIPAT) model which was reported by Vesterager et al. (2017) as a combination of "top down" and "bottom up" approaches for technology transfer. Contrary to "top-down" and "bottom-up" approach, Singgalen et al. (2019) reported the existence of societal control and citizen power in all phases of development, including the project introduction phase. Elsewhere, Haussman et al. (2020) and Masambuka-Kanchewa et al. (2020) proposed a paradigm shift in which small-scale farmers were viewed as co-researchers rather than reflexive adopters or recipients of the best innovations established by scientists.

According to Arnstein (1969), full community participation was equated with citizen power. Participation was graded into levels equivalent to a ladder that could be used in the decision-making (inception phase), implementation and evaluation phases. Arnstein's ladder of community participation has been summarized in Table 2 through conceptualization, operationalization and modification as cited by Rosyida and Nasdian (2011).

Reflecting on the study findings via the Arnstein ladder of participation, it can be observed that during the project inception phase, there was a limited level of farmer participation in the aspect of development of technology or innovation. Similar observation is made by Namirembe et al. (2022) concerning the participation of farmers and other stakeholders in grounding a global tool on the principles and practice of agroecological assessments. Despite the project's initial lack of engagement, farmers were more interested in learning about innovation that resulted in its adoption after awareness-raising activities regarding improved groundnut cultivars which happened during village meetings. Through this process, farmers who were intrigued by the concept established the FRN groups, which catalysed the persuasion of other farmers to observe, learn, try out, and adopt improved groundnut cultivars.

Farmers' participation in project implementation and its influence on the adoption of improved groundnut cultivars

The findings show that there was farmers' participation during project implementation contributing to the adoption of improved groundnut cultivars. During the Mshikamano and Muungano FGDs it was observed that after the groups were formed, RECODA facilitated the training on group dynamics, leadership and group constitution. Farmers participated in attending the training, the election of group leaders, and the preparation of the group constitution. Additionally, RECODA facilitated a dialogue with the group participants to discuss the challenges farmers face concerning groundnut production and proposed ways forward to improve the situation. In the dialogue, farmers participated by identifying the challenges associated with groundnut production, including low yield from the local farmer cultivars, diseases, pests, drought and floods. This shows an element of farmers' participation which provided useful information of identifying the problems. As Cuthbertson (2019) stated, the protocol might change as a result of a group review, but at the very least it would provide useful information that would aid in designing future participation activities.

The FGDs further pointed out that, the promotion of improved groundnut cultivars inspired farmers to test them since they were reported to have higher yields and be marketable compared to the local farmer cultivars. While RECODA proposed bringing the improved groundnut cultivars for trial and adoption following confirmation, farmers proposed capacity-building programmes so that they can produce the quality declared seeds of improved groundnut cultivars rather than relying on TARI Naliendele as the source of improved groundnut seeds because Naliendele was located far away from Singida. The fruitful idea from farmers' participation was positively taken up for action by RECODA. RECODA developed a capacity-building programme for farmers to get them to produce quality-declared seeds (QDS) of

Table 3. Usefulness of research in enhancing the adoption of improved groundnut cultivars (N = 212).

FRN project group member	The usefulness of research in enhancing the adoption of improved groundnut cultivars	
	Research useful (%)	Research not useful (%)
Direct beneficiaries	69 (97.2)	2 (2.8)
Indirect beneficiaries	117 (83.0)	24 (17.0)

Source: Survey data 2022

improved groundnuts. Farmers participated in the capacity-building programmes by attending both theoretical and practical training on the production of improved groundnut QDS. These findings imply that the participatory communication led to the proposal of a capacity-building programme by farmers who later participated in its implementation. A similar observation is made by Hansen et al. (2019) who reported that farmers may relate complex climatic information to their experience and incorporate it into management decisions by using organized participatory communication procedures.

Additionally, the findings show that farmers participated in carrying out participatory research through on-farm trials and demo plots. The FGDs stated that, farmers participated in field preparation, the layout of trial plots, digging, hole-making, seed sowing at recommended spacing and conducting all crop management practices, including weeding, pest management, and disease management, by observing agroecological practices. They also participated in harvesting and weighing the yields for comparison purposes. Furthermore, farmers participated in making decisions based on the crop performance out of on-farm trials and in the production of improved groundnut quality declared seeds through demo plots and individual farmer plots. The improved groundnut quality declared seeds produced by the FRN group farmers were spread to non-group members either for sale or given out freely. Again, farmers actively participated in knowledge dissemination concerning improved groundnut cultivars. This was achieved through farmer-to-farmer extension service provision, whereby the FRN group farmers visited the non-group members and taught them about Good Agricultural Practices (GAPs) related to improved groundnut production based on their experience acquired through both theoretical and practical training offered by the FRN project. Also, non-group members were able to learn by observing both the demo and individual farmer plots. Equally, the key informant declared that farmers were actively participating in the project implementation as indicated in the following extract:

“Farmers participate in training sessions, conducting on-farm trials, transferring the knowledge gained to their fellow farmers, and producing improved groundnut, which is the new cultivar in the project area. Before the FRN

project was introduced, farmers used to produce the local groundnut cultivars, which had relatively lower yields compared to the improved ones” (District extension officer, Singida District, 3 May 2022).

The review of the project report indicated that, in the second phase of the soil amendment trial, about 86% of farmers participated in the soil health research based on their willingness to participate (FRN Quarter 1 Report, 2022). These findings indicate that there was more engagement of farmers during the implementation of the project activities compared to participation during the introduction of the improved groundnut project. This is because farmers were more familiar with the project than they were at the beginning. Participation of farmers in the research and implementation of project activities strengthens group cohesion and is healthy for the adoption, ownership, co-researching, learning, success, and sustainability of the project. As Hassen et al. (2019) reported, about 96.7% of farmers had asserted enhanced social interaction and increased technological diffusion through their engagement in research networks. Likewise, Goswami et al. (2017) insisted on livelihood and ecological sustainability through partnership with farmers in the decision-making process related to farming practices. This is consistent with social network theory, which asserts that people are embedded in interactive networks and that potential innovation adopters' beliefs are influenced by social inspiration. The adoption of innovation entails more than just disseminating information; instead, it involves changing the existing decisions, engaging in wider discussions about the socioeconomic system and showing personal sincerity in trying to make a difference (Deroian, 2002).

The usefulness of the on-farm research in enhancing the adoption of improved groundnut cultivars

From the survey, the on-farm research appeared to be useful or practical to 97.2 and 83% (N=212) of the direct and indirect project beneficiaries, respectively as summarized in Table 3. Both the direct and indirect beneficiaries had the majority score, which showed that research was useful in enhancing the adoption of improved groundnut cultivars in the project area.

Similarly, the key informant agreed that on-farm

research was useful in enhancing the adoption of improved groundnut cultivars in the project area. The extension officer was quoted saying:

“On-farm research has been so useful to farmers since they experiment together, observe, discuss, and come up with informed decisions on the appropriate innovations to adopt out of the research. Through this process, the majority of farmers in the project area have proven the Mnanje cultivar to have performed well and farmers have benefited from the sale of the improved seeds to other farmers and hence getting the cultivar spread to other villages” (District extension officer, Singida District, 3 May 2022).

In addition, it was highlighted from the Muungano focus group discussion that doing research through on-farm trials had helped spread improved groundnut cultivars. Farmers learnt about appropriate agricultural methods and how to use biological pesticides during on-farm trials. When other farmers saw the crops grown in demonstration plots, they were inspired to learn more and inquired about the source of improved groundnut seeds. Furthermore, as reported by Mshikamano FGD, the main reason why research was useful in enhancing the adoption of improved groundnut cultivars was that on-farm research provided a conducive environment to learn by seeing and practising good agricultural practices. Other reasons include learning and comparing to see the difference in yield between the local and improved cultivars, proving an appropriate technology to adopt, and creating a good environment to learn together.

These findings imply that conducting research with farmers is an important factor in developing innovations and getting those innovations widely adopted by farmers. Through on-farm research, FRN group farmers have been able to learn, produce and play a role in spreading the quality declared seeds of improved groundnut cultivars to their fellow farmers, who did not have access to them, either by sale or just giving them out for free, while teaching them how to grow the crop. By doing so, the improved groundnut cultivars were widely adopted by more farmers in the study area. Studies (Tao et al., 2019; Nelson et al., 2019; Hassen et al., 2019) indicated that on-farm research could function as a tool for problem-solving and demonstration, which could be used by farmers to solve problems related to farm management and empirically learn through observational and experimental research and replicate it in similar fields. The results support the innovation systems perspective, which holds that learning occurs in networks and spreads to individuals and farmers, resulting in 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 product, before accepting it (Ayele et al., 2012). The findings on on-farm trials also support Roger's theory of innovations, which claims that *“innovations that*

offer advantages, perceived compatibility with existing practices and beliefs, low complexity, potential trialability, and observability, will have a more widespread and rapid rate of diffusion” (Rogers 2003).

Collaboration of key players in the network of FRN and their influence on the adoption

Key players and their frequency of interaction in the FRN project

The study findings show that there was a collaboration amongst key players in the FRN network that contributed to the adoption of improved groundnut cultivars. From the Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and review of project documents, the identified key players who either regularly or seldom interacted with farmers were RECODA, extension officers, farmer groups, village leaders, middlemen, agro-input suppliers, village agro-vet dealers, and academic institutions. As summarized in Table 4, this study revealed the difference in the magnitude of interaction/collaboration amongst players in the FRN network whereby some players regularly interacted while others moderately and rarely interacted with farmers.

Mshikamano and Muungano FGDs revealed that RECODA frequently interacted with farmers once every week either for training or following-up/monitoring of the project activities (Table 4). Similar to RECODA, the FGDs reported of frequent interaction amongst the FRN farmer groups once every week to discuss matters related to project implementation. The findings suggest that the frequent interaction between farmers and RECODA contributed significantly to the spread and adoption of improved groundnut cultivars in the study area. According to Joffre et al. (2019), the adoption of practices was influenced by the increased rate of collaboration amongst participants, including those in the public and private sectors.

As pointed out by Mshikamano and Muungano FGDs, the interaction between Extension Officers and farmers was rated moderate since the Extension Officers happened to meet farmers on a monthly to quarterly basis. Equally, village leaders had moderate interaction with farmers, whereby they happened to have interacted on project-related matters in each quarter, twice to thrice a year. The FGDs also determined that the relationship between farmers and academic institutions was graded as a medium since, at a minimum, one representative from an academic institution would visit farmers for either learning or research purposes once every three months. Moderate interaction with farmers is an indicator of moderate provision of services required from the service providers. Moderate interaction implies the limited provision of extension services required by farmers. To fill in the gap Ayodele and Akindede (2018) recommended more involvement of private agencies in

Table 4. Relative frequency of interaction between farmers and key players.

Key players	Relative frequency of interaction		
	Regular	Moderate	Rare
RECODA	1 meeting per week	-	-
Action Aid	-	-	1 to 2 meetings per year
Extension officer	-	1 to 4 meetings per year	-
Farmer groups	1 meeting per week	-	-
Village leaders/LGAs	-	1 to 4 meetings per year	-
Middlemen/Traders	-	-	1 to 2 meetings per year
Agro-input suppliers/companies	-	-	1 to 2 meetings per year 1 to 2 meetings per year
Village agro-vet dealers	-	-	1 to 2 meetings per year
Academic institutions	-	1 to 4 meetings per year	-

Source: Survey data 2022

the provision of extension services.

Infrequent interaction was reported by the Mshikamano and Muungano FGDs to have been occurring between farmers and Action Aid whereby farmers appeared to mutually co-operate with Action Aid once to twice a year. Correspondingly, there was infrequent interaction between farmers and agro-input suppliers, agro-companies, and village agro-vet dealers since they mostly happened to be in touch seasonally, specifically during planting season when there was high demand for farm inputs and tools such as seeds and hand hoes. This suggests that as interactions between farmers and players such as Action Aid, Agro-vet dealers, middlemen, and other actors increase in regularity, there will be stronger networks and more possibilities for discussion of the problems each player in the network encounters. If such problems are resolved, more people would adopt improved groundnut cultivars. According to Golovina et al. (2019), farmers with stronger networks outperform their less-connected peers in terms of agricultural prosperity and financial stability.

The roles of key players in the FRN network and their influence on the adoption of improved groundnut cultivars

Table 5 provides a summary of the roles played by the key players in FRN network and their influence on the adoption of improved groundnut cultivars in the study area.

The findings summarized in Table 5 show that collaboration amongst players in the FRN network facilitated the processes that contributed to the adoption of improved groundnut cultivars. As reported by Mshikamano and Muungano FGDs, RECODA facilitated

the group formation process where farmers formed the FRN groups that enabled them to access seeds, learn, and work together in groups as opposed to individuals. RECODA transferred knowledge and resources (seeds of improved groundnuts) to farmers, and farmers practised what they learned. RECODA guided and facilitated the collaborative research process. FRN group farmers carried out participatory research through on-farm trials conducted in demo plots. The demo plots have been instrumental in attracting more farmers to adopt the improved groundnuts since farmers were able to learn by seeing and practising. In addition, through interaction between RECODA and farmers, farmers have been linked with academic institutions such as Sokoine University of Agriculture (SUA), Nelson Mandela African Institution of Science and Technology (NMAIST) and Tengeru Institute of Community Development (TICD). This linkage facilitated field-practical training programmes and research activities undertaken by students and instructors on issues related to agroecological practices, with the adoption of improved groundnut cultivars being included. This implies that the more farmers interact with the implementing organizations, the closer and more trust they build with each other, the more chances they have to participate in co-researching, the more lessons they learn together, the more actors they get connected with, and the higher the chances of adopting the innovations.

The interaction between FRN farmers and RECODA as an NGO has catalysed the adoption of improved groundnut cultivars in the study area. These findings are similar to those reported in a study by Hartmann et al. (2019), who revealed that the NGO significantly affected the community's farmers' social cohesiveness and capacity for innovation. The NGO enabled the creation of a local effective organization and assisted in bringing together farmers from various villages while also giving

Table 5. The roles of key players in the FRN and their influence on the adoption.

Key players	Major roles
RECODA	Facilitating the process of group formation Transferring knowledge and resources (seeds) to farmers, co-researching & learning Guiding/facilitating the collaborative research process Monitoring/following up on the implementation of project activities through farm visits Reporting progress of the project during stakeholders' meetings Linking farmers with academic institutions such as SUA, NMAIST and TICD
Action Aid	Transferring knowledge to farmers on agroecology and climate change Sharing the knowledge gained from FRN groups to other farmers in their areas of operations
Extension officer	Transferring knowledge/information/advisory services, co-researching & learning Provision of government directives concerning improved groundnut production Monitor the implementation of the project through farm visits Report the progress of the project to the district authorities
Farmer groups	Form groups, prepare group constitutions and elect leaders Attend training/meeting sessions organized by the group Establish demonstration and individual farmers' plots for participatory research and learning Production/multiplication of improved groundnut seeds Transfer the knowledge gained and seeds multiplied to indirect beneficiaries Conduct farm visits to indirect project beneficiaries
Village leaders/LGAs	Provision of project legal permit to operate in the area Calling for village meetings for awareness creation and Farmer Field Days Enacting by-laws for the formed groups to operate accordingly Overseeing the project operations in their respective areas of influence
Middlemen/Traders	Visiting farmers at their homesteads/villages to advertise for demand and price of groundnuts Collecting/buying groundnuts at farmgate price Transporting the collected groundnuts to other markets
Agro-input suppliers/companies	Seasonal promotion of agro-inputs and farm tools Seasonal supply of agro-inputs specifically fertilizers, pesticides and maize seeds on a mobile basis using company vehicles Seasonal supply of agricultural tools mainly hand hoes on a mobile basis using company vehicles Wholesaling of agro-inputs and farm tools to the Village Agro-vet shops
Village Agro-vet dealers	Retailing of agro-inputs and farm tools to the farmers Collecting improved groundnut from producers and retailing to other farmers (act as middlemen as well)
Academic institutions (SUA, NMAIST & TICD)	Sharing knowledge and experience through field practical training Conducting participatory research and co-learning Preparing research reports for publications

Source: Survey data 2022

them access to outside information. The findings also corroborate with innovation systems theory which states that interaction and learning are dependent on players' closeness such as physical distance, the institutional

environment which shapes trust-based relationships and players' characteristics to absorb new ideas (Ayele et al., 2012).

Additionally, the Mshikamano and Muungano FGDs

highlighted that participant interacted during the group formation process, writing of the group constitution and the election of group leaders. Participants ensured that they elected good and strong leaders who lead the groups according to the group constitution to achieve the desired goals. Through this interaction, farmers were able to establish demo and individual farmers' plots for participatory research and learning, production and multiplication of improved groundnut quality declared seeds, transfer the knowledge gained and seeds to indirect beneficiaries and conduct farm visits to the indirect project beneficiaries. The findings imply that the adoption of improved groundnut cultivars in the study area was facilitated by the frequent interaction and collaboration of FRN groups amongst themselves and indirect beneficiaries. FRN group members, being the primary recipients of the knowledge, information, and assets (improved groundnut seeds), played a key role in transferring the acquired knowledge, information, and improved groundnut quality declared seeds to the indirect beneficiaries. Similar findings are reported in a study by Hassen et al. (2019) who revealed that FRN heightened the transmission of knowledge, which led to the adoption of push-pull technology (PPT), by 97%, and enhanced social collaboration by 96%. Likewise, FRN and Farmers Research Group (FRG) were beneficial and had a substantial influence on social and other related matters as agreed by 98% of the respondents

From the KII, the FRN project staff reported that collaboration between farmers and village leaders through village meetings and farmer field days (FFDs) contributed to the adoption of improved groundnut cultivars as quoted:

"Although not conducted regularly, through village meetings and FFDs, agroecology practices and improved groundnut cultivars were promoted to a significant number of participants from different corners who happened to attend. There was the inclusion of youth and football in learning agroecology during farmer field days. Through this way of collaboration, there are increasing numbers of non-FRN members who are adopting agroecology practices and improved groundnut cultivars after seeing them in the demonstration plots and on their neighbours' farms" (FRN Project Manager, RECODA Office at Ilonger Village, Singida District, 4 May 2022).

This implies that village meetings and FFDs were instrumental in raising awareness of improved groundnut cultivars amongst farmers and by increasing the frequency of interaction through village meetings and FFDs, more clients who are in need would be reached at a reasonable cost, hence increasing the chances of the adoption of improved groundnut cultivars. The findings corroborate with the findings in a study by Emerick and Dar (2021) who revealed that field days benefited impoverished farmers more and were more cost-

effective.

Farmers interact with district agro-vet dealers for procurement of other agro-inputs. The quotation from the key informant pointed says,

"We have a big number of farmers from different corners who usually come to buy agro-inputs, mainly pesticides, fertilizers, maize seeds, and vegetable seeds, but not improved groundnut seeds because we do not sell them because they are not available. Once farmers come to buy the agro-inputs, they normally ask us questions on how to properly use the inputs, and we advise them accordingly" (District Agro-Vet Dealer, Singida District, 3 May 2022).

Furthermore, the interview with the village agro-vet dealers revealed that there was interaction with improved groundnut producers during harvesting season, whereby farmers tended to sell the seeds. The collected seeds were then sold to other farmers who needed to grow the improved nuts the next season. The quotation from the KII had this to say:

"In this area, the agro companies' vehicles do not supply groundnut seeds; instead, they supply fertilizers, pesticides, and maize seeds, which we buy wholesale and sell at retail prices. However, during the harvesting seasons, farmers who produce improved groundnut seeds on their farms tend to sell the seeds at our small agro-vet shops and the nearby open markets for cash. We tend to sell the improved groundnuts to farmers and other customers who need them at a price similar to that offered by the middlemen. Nevertheless, the supply of improved groundnut seeds is not reliable" (Ward/village Agro-Vet Dealer, Mvae Village, Singida District, May 2, 2022).

Similarly, the Mshikamano and Muungano FGDs noted that throughout harvest, middlemen engaged in active connection with farmers, frequently visit farmers' houses to purchase the improved groundnuts. These findings imply that collaboration between farmers, agro-vet dealers and middlemen was not formal but played a role in spreading the quality declared seeds of improved groundnut cultivars in the study area. Kivimaa et al. (2020) claim that to hasten transitions, transition intermediates had become potentially strong actors and entities.

In addition, the key informant reported that collaboration occurred through formal meetings, which were customarily held in the project area. These meetings included stakeholders' meetings, quarterly coordination meetings, and community of practice meetings as revealed by the FRN project staff,

"Stakeholders' meetings are the annual meetings and would have wider participation from NGOs, district

extension staff, and farmer representatives. Stakeholder meetings are more about sharing the results (not much planning) while quarterly coordination meetings are reporting, solution-seeking, and planning meetings for the implementers (a lot of planning is done here). The participants in the quarterly coordination meetings are village leaders, group leaders, extension staff, and RECODA staff” (FRN Programme Leader, RECODA Headquarters Office, Arusha, 15 August 2022).

This implies that the stakeholder and quarterly coordination meetings were the indicators of collaboration amongst actors in FRN networks, which played a role in influencing the adoption of improved groundnut cultivars in the study area through planning, sharing progress reports and seeking solutions to the problems. Through this process, other participants might improve the performance and uptake of improved groundnut cultivars by imitating the successful results made by achievers. The FRN project report (2022) indicates that, through these meetings, the local government has appreciated agroecology as a solution to the soil fertility challenges in Singida. Furthermore, the local government was aware of the spread of the improved groundnut cultivars in the project area, although they stated that availability of the improved groundnut seeds seemed to be a challenge since the demand was high after farmers had observed good performance of the crop in the study area.

FRN project staff pointed out another way of collaborating known as “community of practice” (CoP) meetings by stating that,

“Community of Practice Meeting is a kind of interaction that goes beyond country boundaries and was conducted physically and online during the corona virus disease (COVID 19) era” (FRN Programme Leader, RECODA Headquarters Office, Arusha, August 15, 2022).

This implies that, apart from interacting with local partners, FRN has a system of collaboration that opens the doors for the actors to interact globally through CoP meetings. With this form of interaction, the participants can learn globally and apply the good lessons they learn locally. According to the FRN progress report (2019), the meeting had been organized and executed with participation from transversely located CoP members interacting on agroecology conversions and research emerging from local, regional, and global trends. For instance, at the East and Southern Africa Community of Practice Annual Meeting held on September 30 through October 3, 2019, farmers’ participation in the research was reported to have contributed to improved productivity through a combination of actions and activities; and to some extent, farmer capacity to undertake research had increased, and the farmers see the network as an instrument for learning. As reported by Nicklin et al. (2021), through social learning, the communities of

practice of the McKnight programme have given a range of actors in Africa and the Andes a place to build their adaptability concerning food system research and action.

Conclusion

The synthesis of the research findings leads to the conclusion that farmers participated in conducting participatory on-farm research and collaborated with different players in the FRN network, indicating that FRN guiding principles were applied to influence the adoption of improved groundnut cultivars in Singida Rural District. Reflecting on each principle, the participation of farmers has been evident, although there was more engagement of farmers during the implementation of the project activities compared to the level of participation during the initial stages of the introduction of improved groundnut cultivars in the project area. Farmers participated in forming FRN groups, production of QDS of improved groundnut cultivars and provision of farmer-to-farmer extension services through farmers’ visits, and transfer of knowledge and assets (seeds), which contributed to the adoption of improved groundnut cultivars in the study area.

The study also revealed that participatory on-farm research was useful in enhancing the adoption of improved groundnut cultivars in the study area. The on-farm trials being undertaken have empirically been instrumental for observational and experimental research whereby farmers have been able to see, learn, and adopt the innovation by growing and spreading the improved groundnut cultivars, unlike the case before the inception of the project.

This study has furthermore observed evidence of collaboration and interaction amongst players in FRN networks, though differing in the magnitude of interaction. Some players regularly interact with farmers, while others only moderately and rarely interact with them. The major ways of interaction were noted to include joint research, learning, and sharing of knowledge and resources; village meetings; farmers’ field days; stakeholder meetings; quarterly coordination meetings; and community of practice meetings. In one way or another, this collaboration, coupled with the participation of farmers in carrying out participatory on-farm research, has played a role in enhancing the adoption of improved groundnut cultivars in the study area.

RECOMMENDATIONS

Based on the research findings, hereunder are some recommendations worth noting:

(1) RECODA and local government authorities (district, ward, and village) may make sure that deliberate efforts

are made to ensure that during the project inception phase, farmers participate by negotiating project ideas during the preliminary meetings that are held at the district and ward levels. Instead of being represented by the DALFO's office and local government authorities alone, there may be representatives of farmers in those preliminary meetings.

(2) RECODA may include other actors in FRN networks who can also contribute to the value addition of improved groundnut cultivars. Such actors include consumers, processors, traders, transporters, quality controllers, political authorities, media, financial institutions, researchers, breeders/pre-basic seed producers, basic/foundation seed producers, and certified seed producers. QDS producers, export aggregators etc.

(3) RECODA may make sure collaboration is strengthened more by having regular farmers' interactions with more players in a network of the improved groundnut value chains while observing agroecological practices sensitive to sustainable energy and environmental protection.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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