



Farmer Research Networks and Dissemination of Agroecological Knowledge and Practices in Singida District of Tanzania

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The paper explores different methods used by Farmer Research Networks (FRNs) to disseminate agroecological knowledge and practices in Singida District, Tanzania. The study used cross-sectional research design, using a qualitative research approach. Data were collected from 75 participants of focus group discussions, 19 key informants, 26 in-depth interviewees and personal

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observations. The data collected were analysed using thematic analysis, a structured method to identify patterns and themes based on the study topic. The use of natural pesticides (bio-pesticides), use of organic fertilizer (mainly compost), intercropping, crop rotation, mixed cropping, nine seed planting methods, Zambian hoe, soil conservation techniques (mainly mulching), timely planting as well as application of recommended spacing are common and major practices in Singida district. FRNs used farmer field schools (FFSs), village government meetings, demonstration plots, farmer-to-farmer knowledge sharing, and community groups as the main methods for disseminating agroecology knowledge and practices to farmers. These methods create a wide awareness of agroecological knowledge and practices among farmers in the study villages. It is recommended that local government authorities and development organisations should utilize FRNs to disseminate agroecological evidence-based knowledge and practices to farmers and scale up the utilization of the FRN approach to communicate and disseminate recommended agroecological and agricultural practices for sustainable farming and food systems in Tanzania.

Keywords: *Farmer research networks; agroecological knowledge; agroecological practices; dissemination methods.*

1. INTRODUCTION

Around the globe, agriculture plays important roles in food and nutrition security, economic development and poverty reduction. It is estimated that 64% to 83% of the human population in sub-Saharan Africa depends on agriculture, and these are mainly smallholder farmers (FAO, 2020). The nature of the farming system is based on growing mixed crops, animal production, trees and shrubs for improving sustainability of ecosystems to provide economic (income and food security), healthy food (safe and nutrition security) and environmental benefits to farmers, community and the nation. In practice, however, many farming systems move away from these ecological benefits, because the smallholder farmers often face numerous challenges including land degradation, low soil fertility, climate change and variability, fragmented market and limited access to agricultural inputs (Siyao, 2012; Dawson et al., 2016). These challenges are compounded by insufficient extension services, which hinder the adoption of research best knowledge and practices. Dawson et al. (2016) argue that limited extension agents and outreach services hinder dissemination and communication of research outcomes to end users. Deficient and ineffective ways of exchange or dissemination of research innovations (knowledge and practices) to end users (farmers) impede attainment of this ecologically ideal situation (agroecological intensification), which would improve ecosystems, biodiversity and social, economic, and environment and sustainability, especially in many developing nations in Africa.

The FRNs have emerged as one of the potential solutions to bridge the channel gaps of

dissemination, adoption and implementation of the agroecological practices (Dawson et al., 2016; CCRP, 2018; Nelson et al., 2019; Richardson et al., 2022). Academic literature disclosed that the FRN emerged in 2014, and was first established by the McKnight Foundation. By 2019, over 30 FRN projects had been implemented, involving researchers, farmer groups, and other stakeholders, with participation ranging from a few dozens to thousands of farmers (CCRP, 2018). According to Nelson et al. (2019), the FRNs are collaborative associations of farmer groups, researcher and development organizations that aim to provide access to technical, institutional, and financial support while facilitating the exchange of information and data.

The FRNs have been recognized as a promising alternative mechanism for enhancing adoption of agroecology knowledge and practices to smallholder farmers in Africa including Tanzania (Dawson et al., 2016; Richardson et al., 2022; Chilewa et al., 2023). This is because the FRNs embraced participatory approaches to research and found appropriate solutions to address the challenges faced by smallholder farmers, particularly in the area of agroecological intensification (AEI) within the context of agroecology. In the FRN, farmers are engaged in knowledge co-creation based on their contextual ideal of their environment to come up with appropriate solutions for agroecological intensification (Nelson et al., 2019). Agroecology is defined here as the science of applying ecological concepts and principles to manage interactions between plants, animals, humans and the environment for sustainable food systems (Gliessman, 2018). Likewise,

application of agroecological research innovations fosters adaptation and is resilient to climate change and variability. The FRN principles namely farmer participation (the way they work with farmers), on-farm research, and collaboration among stakeholders drive this initiative's success (Giller et al., 2021; Richardson et al., 2022)

In Tanzania, Research, Community, and Organizational Development Association (RECODA), a Non-Governmental Organization (NGO); in collaboration with Local Government Authorities (LGAs), Universities (Sokoine University of Agriculture and Nelson Mandela Institute of Science and Technology), Tanzania Research Institutions, Sustainable Agriculture in Tanzania (SAT) and other partner organizations; is dedicated to promote multi-disciplinary research to provide solutions to challenges facing low crop yields and environmental degradation using agroecological farming systems.

The overall objective of these development agents is to co-create agroecological knowledge and practices taking following necessary steps from research, production trials to communication and dissemination of the best outcomes using creative, locally driven approaches to meet particular requirements of smallholder farmers (Kanjana et al., 2022 & Chilewa et al., 2023). Farmers actively participate in research and teamwork within the FRN Project to pinpoint major issues, such as root causes of poor yields, pest and disease occurrence, systems change, and then develop practical solutions based on their locally available materials. In Singida region, the RECODA project has been deployed by members of FRN to ensure that other farmers get reliable agroecology research knowledge and practices to improve soil health, yields, ecosystems and food systems for the benefit of farmers and communities.

Yet, similar to other forms of sustainable agriculture, dissemination and communication of agroecology knowledge and practices is slow (Toensmeier & Herren, 2016); hence attainment of agroecological intensification is likely to take a long period of time, while climate change intensity is increasingly impacting negatively species, richness and abundance in agricultural landscapes, leading to unsustainable food systems. Scientific research on emerging and promised benefits of FRNs, and the potentiality

of the interplay between FRN principles and agroecology intensification for sustainable food systems worldwide is diverse (Sinclair et al., 2019; Chilewa et al., 2023). Besides, some studies have focused on the status and factors that explain farmers' willingness or obstructions to adopt and implement agroecological farming. Several studies have determined the contribution of implementing agroecological practices to food availability, food and income security by comparing between FRN and Non-FRN members and shown a double increase in crop yields (IPES-Food, 2016; Nelson et al., 2019, Kanjanja et al., 2023).

On the other side, different scholars have published various methods used to disseminate innovation in agriculture; for example, Agricultural Technology Transfer Hub (AgriTech) is an important contemporary channel of dissemination of agricultural innovations including improved seeds/seedlings, managing soil and water, controlling pests and diseases, and post-harvest technology (Adam et al., 2025); while other studies (FAO, 2016; Mapiye et al., 2021; Sutherland & Marchand, 2021; Richardson et al., 2022; ASFEC, 2023; Iyabano et al., 2023; SWISSAID, 2023; URT, 2023) examined the role of participatory methods in the dissemination of agroecological practices. Yet, there are knowledge and practice gaps; what is missing in the field of FRN research is a clear understanding of the actual roles played by FRNs to communicate and disseminate agroecology knowledge and practices to their fellow farmers, particularly late adopters. Despite the lack of information on agroecological knowledge and practices, several farmers who have already implemented agroecological practices have completely transformed their lives. They now have abundant food for their households, and by selling the surplus, they have increased their income (Kanjana et al., 2023). This paper fills in these research knowledge gaps using a case study of Tanzania.

The paper used qualitative data which were collected in Singida district in 2024 answering two basic research questions: (i) What are the specific agroecological knowledge and practices disseminated by FRN members to their fellow farmers, and (ii) How and what specific methods do FRNs use to disseminate agroecological knowledge and practices to their fellow farmers? By providing answers to these research questions, This study aims to explore FRN dissemination mechanisms for knowledge

transfer, identify specific practices and provide agroecological policy recommendations to enhance their contribution to sustainable agriculture (Sinclair et al., 2019; Richardson et al., 2022; Chilewa et al., 2023). The reminder of this paper unfolds as follows. In section two, we define our key conceptual and theoretical frameworks; in Section 3, we describe the research methods applied in qualitative data collection; in Section 4, we present our findings and discussion; and in the last section (Section 4), we wrap up the paper by giving conclusions and recommendations.

2. KEY CONCEPTS AND THEORETICAL FRAMEWORK

2.1 Definitions of Key Concepts

Agroecology refers to a farming-system that is based on “various ecological processes and ecosystem services such as nutrient cycling, biological nitrogen fixation, natural regulation of pests, soil and water conservation, biodiversity conservation, and carbon sequestration” (Wezel et al., 2014) with the goal of improving ecosystems, agricultural productivity for a sustainable food system and economic development as well conserving the environment. Agroecological knowledge is the combination of scientific knowledge with the local knowledge of farmers and other producers to create sustainable solutions to food and agricultural challenges.

Agroecological practices refers to practices of agroecological farming are biodiversity (mixed cropping, intercropping, crop diversification), usage of biological (bio)-inputs (fertilizer and pesticide), mulching to enhance water conservation, no or limited tillage, and among others (Sinclair F et al., 2019; IPES-Food, 2016; Nelson et al., 2019). Generally, agroecological farming aims to reduce environmental impacts of agriculture while meeting the growing demand for food, conserving water and land, and act as a strategy for climate adaption and resilience.

Dissemination of information or knowledge is the act or process of spreading or communicating information or knowledge to a large audience, essentially making it accessible to end users via various methods/channels, either printed dissemination materials or publications, workshops, media, and digital platforms, guaranteeing that the information will be accessible, comprehended, and used

effectively by the intended receivers (Rogers, 2003).

2.2 Theoretical Framework

This paper examines how members of the FRNs communicate and disseminate agroecological practices and information to their fellow farmers. To explore this linkage, the study was guided by the Diffusion of Innovation (DoI) theory that was developed by Everett M. Rogers in 1962 and revised in 2003, and a model developed by Sen (2005) to explain the process of information communication. According to Rodgers (2003), an innovation is “an idea, practice, or object perceived as new by an individual or other units of adoption”. Both the DoI theory and the model revealed that an idea or information or knowledge communication and dissemination process commence when the sender is stuck by an idea. This idea or knowledge is then expected to be disseminated to the end users, in this case the farmers. However, to disseminate such information or knowledge and practices and reach the intended audience, there must be dissemination methods or strategies or channels, and these should be properly selected. According to Sen (2005, dissemination methods/strategies are important for informing farmers about new ideas “know how” to realize agricultural productivity and production. Rodgers (2003), developed the diffusion of innovation theory, which provides a fundamental framework for comprehending how agricultural information and practices are disseminated using different channels. The DoI theory identifies four elements influencing the spread of innovations: technological characteristics, communication channels, time, and social systems.

Drawing on RECODA’s work, and in particular focusing on dissemination and diffusion rather than on adoption of knowledge, FRNs are sources of ideas, and their role is to communicate what they know to their fellow farmers using different channels or methods (Nelson et al., 2019; Chilewa et al., 2023). The choice of the dissemination methods depends on the choice of the sender, which in this case are FRNs. The receivers of the knowledge and practices are farmers who had not been reached by the extension agents or staff of development organizations. The study also found out how agroecological knowledge and skills had been transmitted to farmers by FRNs in Singida district. Also, the study assessed the extension methods used to disseminate that knowledge to farmers.

3. METHODOLOGY

3.1 Description of the Study Area and Sampling Procedures

The study was conducted between February and April 2024 in Singida district, Singida Region, Tanzania. The district was purposively selected because it was a part of long-term FRN-RECODA's Project's commitment and partners to pilot the FRNs approach in six wards and nine villages, which collectively encompass 18 FRNs. Based on this initiative, most farmers who were members of FRNs were using the AE knowledge and practices on their farm plots and were engaged in disseminating the innovations to their fellow farmers within and outside their villages. In terms of weather, the district is characterized by semi-arid conditions. It receives short rains with an average of 600 to 700 millimetres per annum, normally from December to March each year. According to Tanzania's population and housing census (2022) data, the district has 284,895 people (142,933 being female and 141,962 being male) (NBS, 2022). The majority of the

population depend on agriculture as their main economic activity, but it characterized by food shortage due to unreliable rains, farm land deterioration, and incidents of pests and diseases which affect agricultural crops and livestock (Chilewa et al., 2023). Farmers grow maize, millet, sorghum, beans as the main food crops, while sunflower, onions, and vegetables are key cash crops. In addition, farmers raise cattle, goats, and poultry.

A multistage sampling approach was employed to select both the wards and villages involved in the FRN initiative. In the first stage, five wards as indicated in Fig. 1 (Ilongero, Mrama, Ikhanoda, Mwasauya, and Merya) were purposively selected from a total of six wards due to their road accessibility, especially during the rainfall season. In the second stage, one village in each ward; Sekoutoure (Ilongero ward), Mwakiti (Mrama ward), Msimihi (Ikhanoda ward), Mdilu (Mwasauya ward) and Mvae (Merya ward); was purposively selected due to their interests and being active in knowledge co-creation and engagement with the RECODA-FRN Project.

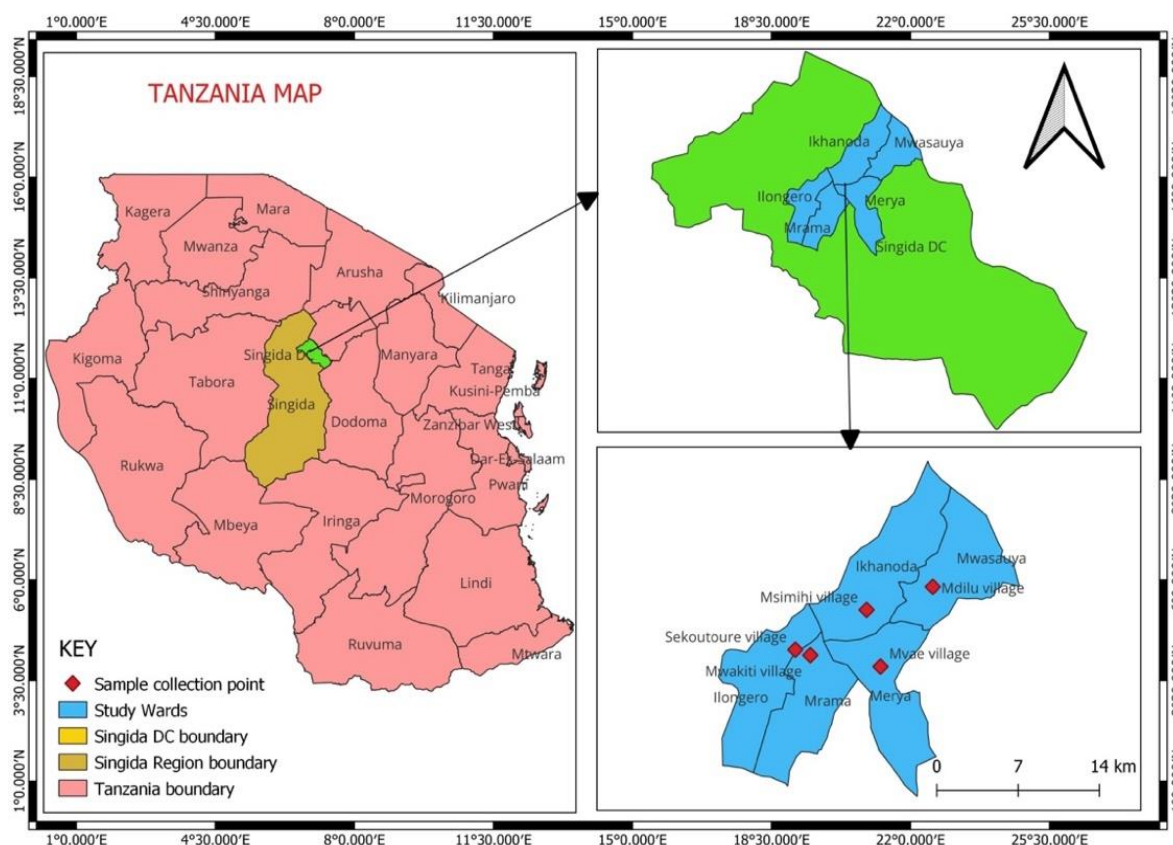


Fig. 1. Map showing the location of the study area

Source: GIS (2024)

3.2 Research Design and Sample Size

Cross-sectional research designed was used in this study because it allows data to be collected at a single point in time in a given population (Kothari, 2009; Cresswell, 2024). In addition, the design allows the determination of relationships between variables; it saves time; and it is cost-effective in data gathering (Cummings, 2018). Five FRNs, one in each village, were purposively selected to participate in Focus Group Discussions (FGD). A total of 75 farmers (77% female) participated in 5 FGDs (Table 1).

Further, 19 key informants were purposively selected in the study villages for in-depth interviews. These included: lead farmers, village and ward agricultural extension officers, and community leaders. The selection was guided by age, sex and experience in the fields of agriculture and social issues, and they were interviewed using a semi-structure checklist to gain relevant insights and understanding of information about the research topic. Besides, in-depth interviews were conducted with 26 lead farmers to gather individualized experiences pertaining to the interactions with the FRNs during the dissemination of AE knowledge and practices. Additionally, direct observation was done to gain an understanding of the practical application of agroecological intensification. The strategic decision to employ purposive sampling was instrumental in enhancing the relevance, efficiency, and validity of the data collected, thereby ensuring the study's robustness.

3.3 Data Collection Methods and Analysis

This study employed a qualitative research methodology which was informed by the constructivist philosophy. Constructivism's central idea is that learners build new knowledge upon the foundation of previous learning (Cresswell, 2024). Data collection was executed through participatory rural appraisal techniques, incorporating FGDs, KIs, in-depth interviews, and direct observation, guided by checklists. These diverse techniques were useful for data triangulation (Cresswell, 2024).

The qualitative data that were collected were analysed using thematic analysis, a structured method for identifying patterns and themes in textual data. This involved recording, writing, and translating qualitative information collected during the FGDs, KIs, and in-depth interviews.

Then, extracting themes that were related to the topic under discussion, and organising insights were done, enabling the authors to draw coherent conclusions.

4. RESULTS AND DISCUSSION

4.1 Agroecological Knowledge and Practices Disseminated by FRNs in the Study Areas

This section characterizes different AE knowledge and practices which existed in the study areas and the methods used by FRNs to disseminate them. On one side, the findings show that the common AE knowledge and practices included: composting, nine seed method, crop rotation, intercropping, ridge closure and terracing, Zambian hoe, and sustainable pest management. These kinds of knowledge and practices were reported by FGD participants, KI respondents as well as in-depth interviewees. In addition to these, findings from the key informant revealed that knowledge of proper and timely planting of crops was also advocated and disseminated by the FRNs in the study areas.

It was also reported by participants in FGDs that *"Members of the FRNs received training on nine-seed farming, a technique that involves digging holes and planting nine maize seeds per hole. Another method employed is the use of the Zambian hoe, where a hole is dug one foot deep, and three seeds are planted in each hole after inserting the hoe. Farmers reported that both planting methods are highly effective in retaining soil moisture. Even in conditions of limited rainfall, these techniques help crops thrive by ensuring they can access the stored moisture in the soil."* (FGD in Mvae, April 18, 2024 & RECODA staff, April 30, 2024).

The same FGD participants added:

"....apart from that... we have knowledge and skills on compost fertilizer production, which has significant benefit in soil health improvement and is cost-effective because it uses materials readily available in our village as well at our homesteads. Moreover, it reduces dependence on industrial fertilizers, which are so expensive that most of us cannot afford buying them." (FGD participants in Mvae, April 18, 2024).

Table 1. Villages and numbers of participants in FGDs

S. No.	Village	Number of participants	
		Female	Male
1	Mvae	10	7
2	Mdilu	8	5
3	Sekoutoure	12	1
4	Msimihi	15	1
5	Mwakiti	13	3
	Total	58	17

Source: Field Survey, 2024

Other relevant stories were testified in other study villages. For example, *participants in another FGD said: "... we were taught about compost fertilizer; previously we did not know that compost is made by collecting fresh and dry leaves, piling them together, sprinkling water on them, and later turning them..."* (FGD participants in Msimihi, April 16, 2024).

A similar finding was also reported as follows: *"... we are well informed about ridge farming that is essential in water conservation and prevention of soil erosion. We build ridges to prevent water from flowing away, helping retain moisture for the crops, and this helps us to have good harvests compared to others who do not have such knowledge..."* (FGD participants in Mvae village, April 18, 2024).

On the other side, findings from the key informants revealed that: intercropping, crop rotation, mixed cropping and mulching were common agroecology practices in the study villages. The findings are in the line with information provided by and extension officer, who testified that:

"... crop yields through intercropping, crop rotation and mixed cropping practices are increasingly being disseminated in villages with and without FRN and are now widely adopted due to their ability to increase crop diversification and reduce risks of crop production failure..." (Ward Extension Officer, Mwakiti village, April 24, 2024). In addition, one in-depth interviewee narrated the following: *"... last year (2023), I successfully harvested maize, cowpeas and sunflower on the same piece of farm plot, while enhancing soil fertility to subsequent increase crop yields..."* (Female farmer, Mwakiti village, April 15, 2024)

These findings concur with those by Yeleliere et al. (2022), who also noted that leguminous crops, crop rotation, and mixed cropping are essential

and recommended their use to improve soil health through nitrogen fixation and ecosystem services. Further, the authors, show that these practices together with mulching are effective in water retention and yield improvement. Similarly, Giller et al. (2021), affirm that the use of compost and organic fertilizers on crops have been reported to have ability to conserve soil and improve soil health.

4.2 Communal Methods Used in Disseminating Agroecological Knowledge and Practices in the Study Areas

This section presents and discusses different methods used by FRNs to disseminate the AE knowledge and practices. These methods include: Farmer field school (FFS), Village government meeting (VGM), Farmer-to-Farmer knowledge sharing (FFKS), Community Groups (CGs), Demonstration Farms (DF), Individual Farmer Follow Up (IFF), and Mobile Phone (MP) (Table 2).

4.2.1 Farmer Field Schools (FFS)

The findings presented in Table 2 show that FRNs used a number of methods in communication and dissemination of AE knowledge and practices. However, the four methods which scored high in pairwise ranking and scoring were farmer field school (29%), village government meetings (24%), demonstration farm (19%), and farmer-to-farmer knowledge sharing (14%). The four methods were followed by community groups (10%) and individual farmer follow up (IFF) (5%), while mobile phone scored zero, which means that it was not a common or an appropriate means used in communication knowledge of agroecology in Singida district (Table 2). The reasons to prioritize these methods are that they are highly effective and hence provide hands-on learning and practical demonstrations, which are essential for knowledge retention.

Table 2. Pair wise ranking on different methods used for dissemination of agroecological knowledge and practices in the study areas

Methods	Farmer Field School	Village Government Meeting	Demonstration Farms	Individual Farmer Follow Up	Farmer-to-Farmer knowledge sharing	Community Group	Mobile Phone	Score
Farmer Field School		Farmer Field School	Farmer Field School	Farmer Field School	Farmer Field School	Farmer Field School	Farmer Field School	6
Village Government meeting			Village Government Meeting	Village Government Meeting	Village Government Meeting	Village Government Meeting	Village Government Meeting	5
Demonstration Farm				Demonstration Farm	Demonstration Farm	Demonstration Farm	Demonstration Farm	4
Individual Farmer Follow up					Farmer-to-Farmer knowledge sharing	Community Groups	Individual Farmer Follow up	1
Farmer-to-Farmer knowledge sharing						Farmer-to-Farmer knowledge sharing	Farmer-to-Farmer knowledge sharing	3
Community Groups							Community Groups	2
Mobile Phone								0
Total								21

Source: Field Survey, 2024

Table 3. Results of the Pair-wise Ranking Presented in Table 2

Method	Score	%	Rank	Reason
Farmer Field School	6	29	1	Highly effective and provides hands-on learning and practical demonstrations, which are essential for knowledge retention
Village Government meetings	5	24	2	Highly effective because they reach many people at once, allowing them to quickly become aware of what is happening regarding agroecology
Demonstration Farm	4	19	3	Effective for showing real results, but sometimes is underutilized or not available every year
Individual Farmer Follow up	1	5	6	Allows for tailored advice, but is time-consuming and cannot reach many farmers
Farmer-to-Farmer knowledge sharing	3	14	4	Fosters trust, as farmers are often more receptive to learning from their peers who face similar challenges.
Community Groups	2	10	5	Localized and accessible, but has a limited reach compared to larger village meetings.
Mobile Phone	0	100	7	Used for sharing market information but limited in disseminating technical knowledge.

Source: Field Survey, 2024

According to the findings, the FFS was the most used method for communication and dissemination used by FRNs in the study areas. This is because, "... FFS utilize demonstration farms as learning tools ..." (FGD participants in Msimihi village, April 16, 2024). The use of demonstration plots is done in a participatory manner; "... each member actively participates in observation and research to see the results of agroecological practices in action." .." (FGD, Mdilu village, April 24, 2024). They added that they normally called upon their fellow farmers before they harvested to come and see the progress of the plants on the farms. In this way their fellow farmers observed, asked questions and learned during the discussions. This means that, by conducting field experiments and participating in discussions and observation throughout the cropping or livestock production cycle, farmers were actively engaged in hands on learning and acquired skills necessary for evidenced-based decision making.

Those findings are in line with what was reported by an uninvited female farmer during an FGD in Mdilu village:

"... to be honest, the FRNs are doing a great job. As soon as they received the training, they initiate an FFS demonstration plot and begin inviting fellow villagers farmers who are non-FRNs—to see and learn from the demonstration plot. Through the demonstration plot, other FRN farmers and non-FRN farmers, observe and compare which plot is performing well and which has more yields. They explain what they have done, and we learn directly from them. For instance, they can invite all the villagers interested in learning, and those who attend gain knowledge, becoming teachers themselves to other farmers who did not participate in the training..."

These narratives imply that the level of engagement of the FRNs was excellent, and the use of FFS was very useful in dissemination agricultural knowledge. Through the FFS approach, almost every farmer interested in agroecology had been reached by FRNs for training. It was also necessary to learn how they ensured ongoing support and follow-up with farmers after the initial dissemination of AE knowledge and practices. One of them narrated the following:

"... We continue to provide training and advice to farmers whenever needed. We visit

farmers' fields to ensure that their farming practices align with the training they received during FFS. Also, we encouraged them to form farmer groups, which have proven to help them synthesize what they acquired during the trainings (An in-depth interviewee, Sekoutoure village, April 17, 2024).

In addition, qualitative findings showed that the majority of farmers had gained ability to implement newly acquired techniques after observing their practical applications. Similarly, a study by Stone (2026) showed that farmers who had attended FFS highlighted the significance of practical experiences in their learning processes. This shows that the FFS approach fosters collaboration among farmers, enabling them to collectively address challenges and learn from one another, which promotes a shared responsibility (Pretty et al., 2010). Scholars such as Chilewa et al. (2023) and Guo et al. (2015), had similar findings; they highlighted that the FFS framework within FRNs is instrumental in co-creating and disseminating AE knowledge and practices, as farmers test, evaluate and adjust methods to fit their local context in collaboration with researchers and peers. FFS positively enhances farmers' knowledge, skills, and decision-making capabilities among farmers. This participatory model not only empowers farmers to adopt sustainable practices but also fosters their creativity.

4.2.2 Village Government Meetings (VGM)

Comparing the agroecological knowledge and practices dissemination methods presented in Table 2, the use of village government meetings was ranked the second. The reason behind is because this method is a golden chance; it gives an opportunity to share information and experiences of the benefits of AE knowledge and practices during a village government's assembly; it is an effective means because many people are reached at once, allowing them to quickly become aware of what is happening, regarding AE. About this method, participants in an FGD said:

"...village meetings allow us to reach more farmers at once, and we can address their questions immediately..." (FGD in Sekoutoure village, April 18, 2024).

It was also reported during the FGD that more often, in village meetings, there was an agenda to discuss AE. When the meeting reaches the

agenda, it will be addressed by a representative from the FRNs. In this way, the members of FRNs used this chance to disseminate AE knowledge and practices to the farmers by creating awareness to those who attended. These findings corroborate ones by Chilewa et al. (2023), who reported the typical role of the FRNs, as assigned by RECODA, as to disseminate knowledge about AE. One of the ways to disseminate this knowledge is through these meetings.

The findings are in line with Jakku et al. (2019) and Annosi et al. (2020) who contend that workshops and group meetings have significant advantages in fostering participatory learning among farmers. They further argue that participatory environment not only enhances communication and the dissemination of AE knowledge and practices but also enhances ability of farmers to co-create knowledge and skills as farmers function as both instructors and learners in the whole process of AEI. According to Chilewa et al., 2023, such collaborative learning also enhances the diffusion and adoption of sustainable agricultural practices. However, limited time allocated for discussions during village meetings often leads to hurried conversations, as expressed by participants during FGD.

4.2.3 Demonstration plots

Demonstration plot is a mechanism that enables farmers to learn by seeing, that is observing what is happening when different agroecological practices are applied in the field plot. It provides a practical, hands-on learning experience and, allowing farmers to observe and directly apply agroecological practices (FAO, 2018). It was informed during the FGDs in the study villages that demonstration plots serve as a crucial instrument for disseminating AE knowledge in farming systems.

The plots facilitate direct observation of plot management and performance, especially in crop rotation, intercropping, composting, and bio-pesticides materials. Key informants and focus group discussions among farmers underscore the significance of these plots in convincing sceptical farmers of AE benefits. About the importance of demonstration plots, during an FGD, the participants said: *"... invited farmers during field days ... come and see what is happening in the field, and most of them question the agronomic practices applied in a plot..."* (FGD of Msimihi village, April 24, 2024).

A participant gave the following remark;

"... I'm not a member of the FRNs but, truly, the FRNs are doing well because as soon as the members received training, they start demonstration farms. They invite other farmers to participate; they go and learn in those plots. The farmers observe and indicate which plots are good, which plots have been successful; they tell us 'We did this and this, and this plot turned out like this,' and we learn directly from that. For example, they can invite all the villagers here who are willing to learn; they will come and learn, and those who have learned become teachers for their peers who have not participated in those trainings. So, participation is good, and now almost all of us have spread knowledge from trainings due to these farmer groups...." (In-depth interview, Mdilu village, April 14, 2024).

Those results are similar to ones reported by FAO (2008) that, demonstration plots, as articulated in the conservation agriculture toolbox, play a critical role in disseminating agricultural practices. These plots provide farmers with direct observation of the benefits of AE techniques, such as enhanced yields and improved soil health. This finding is similar to one by Sseguya et al. (2021) who reported that demonstration plots bridge research and practical application by showcasing the feasibility of innovative techniques in real-world settings. These findings demonstrate the importance of maintaining demonstration plots in AE farming to enhance adoption and implementation of AE practices like intercropping and nine seed holes.

The picture below shows FRN; they disseminate agroecological practices, which is making compost manure by using the demonstration method for the farmers in Sekoutoure village.

4.2.4 Farmer-to-farmer knowledge sharing

Farmer-to farmer knowledge sharing was the ranked the fourth among the methods used for dissemination of agroecological knowledge and practices. The qualitative findings show that FRNs working with farmers had created a network of farmers who could learn from each other and share their experiences, leading to a more widespread adoption of AE practices. Likewise, during FGDs in Mdilu Village, participants discussed that farmer-to-farmer knowledge sharing was among the methods they

used to disseminate AE knowledge and practices to the farmers. About this, participants in an FGD were quoted as saying:

"...Thank you, to the other farmers, there are times when we, as a group, call them. Those of us who have already been educated then educate them as well. We hold a meeting and invite them about twice a year in each sub-village to educate them and exchange knowledge. For example, now that we have learned how to make natural pesticides, we have discovered that wild cannabis is a good pesticide to spray on crops. This is similar to the farming method we are discussing, which involves planting nine seeds. So, when we are trained, we also train others. For instance, I practise this at home, and other farmers come to learn from me. I teach them how to mix compost fertilizer. That is how we educate those who follow us ..." (FGD participants, Mdilu village, April 24, 2024).

"...through a single farmer, you can find them in the fields, talk to them, and educate them, especially during planting season. You can guide them to use correct methods instead of the ones they are used to—for example, advising them to abandon traditional farming practices ..." (FGD participants, Sekoutoure village, April 18, 2024).

Participants in another FGD said:

"... another key way to encourage farmers to learn is by making an effort to implement what we have been taught. This allows our neighbours and the surrounding community to learn from us based on what we practise in our groups. Therefore, FRNs must put in enough effort to produce their own crops so that when other farmers pass by, they can notice the difference. They might wonder; we live in the same area and experience the same rainfall, but why is this farmer getting better yields? This curiosity will drive them to seek knowledge and adopt better farming practices ..." (FGD participants, Mvae village, April 19, 2024).

The finding implies that this method fosters trust, as farmers are often more receptive to learning from their peers who face similar challenges. The result is in line with one of a study by Taylor & Bhasme (2018), who reported that the "farmer-

to-farmer" approach is an extension method, which involves farmers sharing their knowledge and experiences with other farmers. The findings are also similar to those reported by Izuchukwu (2023) that farmer-to-farmer networks are an effective means of sharing agricultural knowledge and encouraging sustainable farming practices. These connections enable farmers to engage with one another, benefit from shared experiences, and obtain pertinent information to improve their agricultural methods. As a result, there is an increase in agricultural productivity, a decrease in environmental harm, and strengthened food security.

4.2.5 Use of Community Groups (CGs)

The use of CGs was ranked number five among the methods used for dissemination of agroecological knowledge and practices. Among the seven methods identified, this was reported to be a moderately useful channel in communicating and disseminating agroecological knowledge and practices (Table 3). Findings from key informant interviewees showed that FRN members regarded CGs as effective in providing links between farmers and agricultural experts. About this, participants in an FGD said:

"...since the FRNs are locally available and accessible, they are very important in promoting peer-to-peer learning and bringing solutions to the challenges we face in agriculture..." (FGD participants, Mvae village, April 19, 2024).

CGs are used as entry points for knowledge dissemination and generation. They are also important in finding collective and common solutions at the farm level, although they have its of reach more farmers compared to village meeting.

One of the community groups in the study area was a dominant microfinance serving groups, and played a significant role in bringing together farmers for credit and savings. Participants in an FGD narrated about it as follows: "We, members of the FRNs, are also members in the microfinance serving groups; hence, we share with them necessary agricultural information, especially on agroecological practices..." (Participants in an FGD, Mvae village, April 19, 2024). Thus, an FRN member is tasked with educating community groups. It was reported that although FRN members were few, they

reached a larger population of smallholder farmers through CGs. These findings imply that a certain number of farmers relied on the information provided by CGs and therefore, the CGs needed to be supported by local government authorities and development projects/programmes. This is attributed to the facts that they were playing an important role of serving the farmers with suitable agricultural information that could otherwise be provided by the government. It was observed that the CGs were effective in disseminating agricultural research information to farmers. Dawson et al. (2016) found CGs as crucial in disseminating agricultural information.

5. CONCLUSION AND RECOMMENDATIONS

From the evidence gathered in this study, it can be concluded that knowledge of proper and timely planting and management of agricultural crops as well as utilization of compost, nine seeds method, crop rotation, intercropping, ridge closure, terracing, the use of the Zambian hoe, and bio-inputs are the major agroecology knowledge and practices in the area of study. The FRNs are crucial in building knowledge and promoting agroecology intensification and transformation towards ensuring food security and sustainable food systems in Singida District.

Farmer field schools, village meetings, demonstration plots, farmer-to farmer knowledge sharing, and community groups are most common and are effective methods in sharing of knowledge and practices of agroecology in the study areas. These methods enhance sharing of knowledge and experiences between members of FRNs and other farmers in the study villages. The uses of village meetings and community groups strengthen the knowledge and practices dissemination in the stud areas. Generally, FRNs in the study district, utilize participatory and farmer-centred approaches, which prove to be suitable means for disseminating research-based knowledge, technology and practices that will contribute to improving agricultural and economic development.

Based on the study key messages and conclusions, the following recommendations are put forward. First, it is recommended that local government authorities should use FRNs in disseminating agroecological evidence-based knowledge and practices to farmers. Second, it is

recommended the utilization of the FRN approach should be expanded to support and optimize the adoption of sustainable practices among diverse farming communities. This calls for the need to strengthen FRNs through a series of capacity building sessions in order to enhance their knowledge and skills to enhance widespread agroecological knowledge and practices. Such sessions will ensure that FRNs continue to support farmers in understanding adoption of sustainable practices, thereby contributing to resilient agriculture and improved livelihoods.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author(s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators were used during the writing or editing of this manuscript.

CONSENT

In compliance with global or academic norms, the authors sought and obtained written consent of the respondents.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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