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# Contribution of Agroecological Practices to Household Food Availability: A Case Study of Singida District

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**Abstract**

Globally, there are urgent calls for transformation of agriculture and food systems to address food unavailability, food insecurity and environmental challenges. Agroecological practices have been promoted as one of the solutions, which have potential to address these challenges. Nonetheless, there is limited evidence regarding the question whether agroecology can indeed enhance food availability among smallholder farmers in Sub-Saharan Africa, Tanzania inclusive. Thus, the study was conducted to examines how the implementation of agroecological practices contribute to achieving food availability at household level by comparing between farmers who are members of Farmer Research Network (FRN) (implementers) and non-FRN farmers (non-implementers) using a case of Singida district. The study employed a cross-sectional research design, and an integration of both quantitative and qualitative data collection and analysis methods. Interviews involved a total of 160 respondents who were randomly selected from household sampling frameworks. Focus group discussions (FGDs) and in-depth interviews were conducted to gather complementary data. On one hand, quantitative data were analyzed using Statistical Package for Social Sciences (SPSS) software whereby descriptive statistics and an inferential statistic (multiple linear regression) were determined. On the other hand, qualitative data were analyzed using thematic content analysis. The findings revealed, more than half (68%) and 15% of FRN farmers were in the medium and high categories of implementation of agroecological practices, contrary to non-FRN farmers, the majority (76%) were in low and none in high categories respectively. Based on alaysed data, the most common applied practices by both FRN and non-FRN farmers were: (i) the use of organic fertilizers (farm yard manure and compost manure (96%); (ii) intercropping (88%); (iii) crop rotation (82%); and integration of crop and livestock (79%). In addition, results indicate a significant association between the level of implementation of agroecological practices and food availability (p-value = 0.000). FRNs' farmers were food secure as compared to non-FRN farmers just due to campaign and capacity building training offered to them. There is a need for a capacity development program to speed up agroecological intensification for sustainable food systems. Thus, it is very essential for public and private organizations to develop capacity building strategies or programmes to impart farmers with knowledge and skills on agroecological revolution.

**Keywords:** agroecological practices, contribution, food availability, household

## 1. Introduction

In the context of Africa, even with growing rates of population increase and rapid urbanization, about 80 percent of Africa's food is still produced by smallholder farmers, in highly diverse farming systems. Agriculture plays a critical role in the food systems supply chain, unfortunately continues to face serious challenges among them being climate change (extended periods of drought), degraded soils, and unaffordable inputs that has shaken the global food supply chain. Production and productivity of the already stretched land resources have consistently declined and getting worse (Therond et al., 2017) unless the trend is reversed. Industrial agriculture is also responsible for soil exhaustion, biodiversity loss and reduces crop diversifications, hence posing challenges to food availability and food security, subsequent to hunger, malnutrition and health complications (D'Annolfo et al., 2017;Gallardo-López et al., 2018; Palomo-Campesino et al., 2018). Reflecting that industrial agriculture is not functioning effectively. Business as usual in the food system particularly agriculture, is no longer an option (Oteros-Rozas et al., 2019).

Agroecology offers solutions that not only will reverse the situation but most importantly will create a balance between social, economic, political and environmental benefits (Parmentier, 2014; Wezel et al., 2020). According to Francis (2016), agroecology consists of principles and concepts designed to optimize interactions between plants, animals, human beings and the environment, cognizant of the socio-economic aspects required for a sustainable and fair food availability. Therefore, a thoughtful transformation is necessary at farm level to address the persistent problems of food unavailability and insecurity.

Literature reviews revealed that many governments of Sub-Saharan African (SSA) countries continues to promote agroecological farming as an alternative to industrial agriculture since because it has a number of benefits comprising land restoration, maintain or increase soil fertility and conserve moisture (Wezel et al., 2014; Maggio et al., 2019; Wezel et al., 2020). The benefits are normally observed through implementation of a number of agroecological practices such as crop diversification; intercropping, use of animal manure, compost, and plant residues rather than synthetic fertilizers); minimal or no tillage; crop rotation, application of cover crops and mulch, as well as terraces and contour ridges. Also, the use of bio-pesticide, natural predator, and repellent plants to prevent and control pests (disease, bird and insect) in cropz, fisher folks and livestock production systems. Embracing agroecological practices is one of the strategies to raise agricultural productivity and increase food availability among smallholder farmers who depend on agriculture in Tanzania. The small-scale production is the foremost source of food supply, which on average accounts for about 95% of food availability (Assenga & Kayunze, 2016).

In Singida region, where this study was conducted, more than 75% are small scale farmers (Iraoya & Isinika, 2022). Local government authority in collaboration with the Farmer Research Network (FRN) project, which is under Research Community and Organisational Development Association (RECODA) facilitated implementation of agroecological practices in Singida district. Since 2000, the FRN project provides various support to farmers in terms of capacity building, extension and advisory services, access to agricultural inputs and credits, with aims to help farmers adopt and implement agroecological practices. In this admiration, more than 4 000 farmers in Singida district were trained on principles and elements of agroecology, as well as on techniques of agroecology transformation including hand on skills on integration of legumes with cereals crops; application of bio-fertilizers (farmyard, compost and green manure), bio-pesticides, land/soil conservation cover cropping, mulching and use of nine seeded holes in maize production (Chilewa et al., 2023). However, implementation of the agroecological practices in the district has not been straightforward; it has often resulted in indifferent and unexpected outcomes. Additionally, even among farmers who have implemented agroecological methods, disparities exist, as there are variations in terms of the type and scale of practising agroecological practices (Kingu, 2020). While there is evidence that many FRN farmers are implementing agroecological practices, little is known about the extent of implementation and its contribution to food availability at household level (Mockshell & Villarino, 2018). This paper, therefore, assesses whether implementation of agroecological practices has any contribution to food availability at household level by comparing FRN and non-FRN farmers in the Singida district.

Some of the analysed cases show agroecological practices have the ability to increase farm productivity and yield stability to 50% and above while reducing the need for external agricultural inputs (D'Annolfo et al., 2017; Maggio et al., 2019). Trail et al. (2016) found that inter-cropping and crop rotation increased millet yield and legume yield by 60% and 36%, respectively. Similarly, Miyashita and Kayunze (2016) reported that a suite of soil management practices (cover crops, terracing, mulching, crop rotation, intercropping, and the use of organic fertilizer has the ability to increase yields by 11% or more for crops like maize, sunflower, and cowpea, and more than 50% for vegetable crops compared to conventional agriculture production. Lyons et al. (2014) found soil conservation practices doubled maize yields from 1.3 to 2.6 t/ha and bean yields from 0.7 to 1.7 t/ha over a sample of 6,000 respondents. In addition, more than 50% of yields in fields were realized when farmers used practices of legume diversification, crop rotation, no-till, and agroforestry system (Arslan et al., 2017). On the other side, Tapsoba et al. (2023) reported that the application of organic fertilizers and terracing to control soil erosion had raised yields from 0.7 tonnes/ha to 1.2 tonnes/ha. Méndez et al. (2013) argued that although agroecology has many benefits, it still lacks sufficient evidence on its contributions to food availability and security.

According to Napoli et al. (2011) food security has four parameters namely availability, access, utilization, and stability. Availability addresses sufficient quantities of food for an active and healthy life. Access to food guarantees that one has physical and economic access to food in terms of income, markets, and prices.

Utilization refers to the nutrition status of individuals by diet diversity and intra-household distribution. The stability of food considers the reliability of those three dimensions throughout (Napoli et al., 2011). Therefore, the study from which this paper emanates assessed the extent of implementation of agroecological practices and how the practices contribute to food availability among farmers in Singida district. Explanation, prediction, and interpretation of the study were built through the theory of planned behaviour advocated by Ajzen (1991). Hence, the evidence-based findings generated from the study are useful in policy and strategy formulation to address specific challenges facing farmers as they strive to adopt the agroecology principles and elements recommended by FAO. Policy messages from this study would also contribute to the implementation of the Sustainable Development Goals (SDGs) of ending hunger, food and nutrition insecurity and poverty by 2030.

## 2. Theoretical Framework

The theory of planned behaviour (TPB) provides assumptions on how to understand the level of implementation of agricultural technologies. This theory was proposed by Ajzen (1991) as an extension of the theory of reasoned action developed by Fishbein and Ajzen (1977). The theory is designed to predict and explain human behaviour through personal and social factors. Based on theory assumption, the level of implementation of agroecological practices among smallholder farmers was conceived to be an important step towards food availability, and ultimately, food security. Generally, the planned behaviour theory emphasizes that in order for a human being to take action on something, it depends on an individual's behaviour, which is consistent with the assumption of this study. The study assumed that one of the determinants for smallholder farmers to implement any agricultural technology or practice is their behaviour or intention to accept or reject it after reasoning the benefit behind the technology. The assumption is that when farmers are trained in agroecological practices, they change their attitudes and behavioural perception. This means that farmers who were trained are impacted with knowledge and skills that can influence them to implement agroecological practices efficiently. This can have positive effects on crop productivity and yield. Therefore, the independent variables provided by this theory were adopted for the conceptual framework. A dependent variable, *i.e.*, food availability in terms of the quantity of food produced was assumed to be affected by the level of agroecological practices implemented by farmers. The dependent variable (the outcome), is determined by farmers' attitudes, subjective norms, and perceptions toward the implementation of agroecological practices.

## 3. Method

### *3.1 Description of the Study Area*

The study was conducted in Singida district located in Singida region, Tanzania. The district is situated within the semi-arid central zone of Tanzania, with latitudes 3°52′ and 7°34′ and between longitudes 33°27′ and 35°26′ East of Greenwich, and has a total area of 3,387 km$^2$. The district experiences a low and short rain season between December and March. The district was selected for this study because it is one of the initial areas where the FRN project operated since 2002. The precipitation regime in the district follows a unimodal rainfall pattern ranging from 600 to 700 mm received for a period between December and March. Food and nutrition insecurity is prevalent in the region, for example in 2016, 49% of households had low household dietary diversity (Kanjanja et al., 2022). According to the 2022 population census (URT, 2022), the district has a total population of 284,895 people (141 962 M and 142 933 F), with an average household size of 5.3 people (URT, 2023). Agricultural and livestock activities are the primary livelihood activities, with households cultivating an average of 2.15 acres (32). Farmers also engage in processing, petty business, and fishing activities. The major crops are maize, sorghum, pearl millet, groundnuts, and beans for food, while sunflower and onion are grown for both cash crop (mainly) and food crop. The livestock raised are cattle, goats, sheep, donkeys, and local chickens. Four villages were purposely selected to include varied socio-economic and land resource endowment characteristics of the farmers and the study areas.

### *3.2 Research Design, Sampling Procedure, and Sample Size*

The study used a cross-sectional research design whereby primary data were collected from farmers at one point in time. The design was selected because has the ability to provide a comprehensive picture of the problem being investigated (Clark & Ivankova, 2015), is a suitable approach for determining the relationship between and among variables in a specific time, and is an economy in terms of time and financial resources (Clarke & Visser, 2019). The study employed multistage sampling techniques. The first step involved the purposive selection of Singida district because it is the working site of the FRN project. The second step involved the selection of one division (Ilongero), out of two divisions. The Ilongero division was selected based on the fact that the FRN project operates in this division. The third step involved purposive selection of four wards; two wards Merya and Mrama from the project site and the other two wards-Maghojoa and Ntonge outside the project site. One village from each ward was purposely selected, Mwakiti and Mvae representing the FRN working site, and Ghata and Ntonge non-FRN site. Lastly, the household heads (respondents) were randomly selected. The fourth stage involved random selection of households from each village. The sample size was selected based on the formular developed by Kothari (2004) for a study with an unknown (infinite) population:

$$no = \frac{Z^2 Pq}{e^2} \quad (1)$$

where,

no = the sample size needed if the population is unknown; e = the margin error (desired level of precision); P = proportion estimated for the population; q = 1 – p, and Z = the confidence level at 95% (standard value of 1.96).

Z = 1.96, P = 0.5, q = 0.5, e = 0.0775, thus, no = $(1.96^2 \times 0.5 \times 0.5)/0.0775^2$ = 159.9~160.

*3.3 Data Collection Methods*

Primary quantitative data were collected through a structured questionnaire with open and close-ended questions. Prior to the actual survey, a pre-test was done for 24 respondents (12 FRN and 12 Non-FRN farmers) selected in the villages not included in the study, but with similar field conditions. Thereafter, the tool was modified accordingly. The questionnaire helped us to collect information on livelihood activities, type of crops grown, quantity of yield harvested, sold, and consumed per household/respondent. Qualitative data were gathered through Focus Group Discussions (FGD and key informant interviews (KIIs). Four FGDs, one per village were conducted. The number of FGD participants ranged between 8 and 12. Consideration was made for sex (female and male), experience in FRN, and a clear understanding of agroecological farming. The KIIs were used to collect qualitative information to supplement the information obtained through the survey as well for the triangularization process. A total of nine key informants were selected purposefully based on their experience, expertise, and involvement in the implementation of agroecological practices.

*3.4 Data Processing and Analysis*

Descriptive statistics such as percentages, means, and frequencies were computed to describe the extent of agroecological practices implemented. Inferential statistics were computed to make inferences about the population and gauge the status of food availability. Index scales were developed to gauge the level of food availability per household. To capture the amount of food availability, the respondents were asked to mention the amount harvested in the 2019/2020 of each food crop in the cropping per kilogrammes (kg). In this study, "food availability" is referred to as the amount of food available in a household. Some of the households had zero agricultural produce (which means nothing harvested). This is likely possible because the study villages are located in a semi-arid area, where climate change vagaries are already happening. Respondents who did not have a cultivation area, particularly during the cropping season in which the data was collected, were excluded from the analysis.

The number of food crops available for consumption was computed as the difference between the food crops harvested and the amount sold. Other externalities such as post-harvest losses, food supplied or received as gifts, and amount stored as source of seed from next cropping season were held constant. Thereafter, the amount in kg for each food crop harvested was converted into kilocalories (kCal) to get the amount of energy available for each crop. KCal shows the energy available for each crop because each food crop has different kilocalories (Tanzania Food Composition Tables, 2008). All food crops in terms of kilocalories were added up together to obtain a total amount of kilocalories per household (composite index). To calculate the amount of food available per person per year, the total food available was divided by the number of people (family size) at household level. This methodological approach was adapted as recommended by other scholars (*e.g.*, the World Food Programme [WFP], 1997). According to WFP (1997), 2 100 kCal was used as an average energy requirement per person/day. On average, each person requires 766 500 kCal per year (*i.e.*, 2,100 × 365 days). The amount available per person was then compared to the recommended amount of food per year in terms of kilocalories. Based on that 2 100 kCal, three categories of food availability were established. A household with food availability less than 766 500 kCal was classified as having inadequate food availability; a household with food availability between 766 500 kCal and 985 500 kCal was classified as having adequate food availability; a household with food availability greater than 985 500 kCal was classified as having adequate and surplus food availability. A Chi-square test was then performed to determine whether there is a link between the extent to which agroecological practices are implemented and food availability.

## 4. Results

### *4.1 Extent of Implementation of Agroecological Practices*

According to our data analysis approach, three categories of status of implementation of agroecological practices were determined based on the intensity. Farmers who implement agroecological practices range 0-4 were categorized into a low category of implementers; 5-8 medium implementers and 9-11 high implementers. Findings revealed that among the FRN farmers, more than half (68%) were in the medium category, and few 15% and 16% were in high and low categories respectively. Whereas for Non-FRN farmers, the majority (76%) were in the low category of implementation and the rest 24% were in the medium category. Suprisingly none of them was in the high category as indicated in Figure 1.

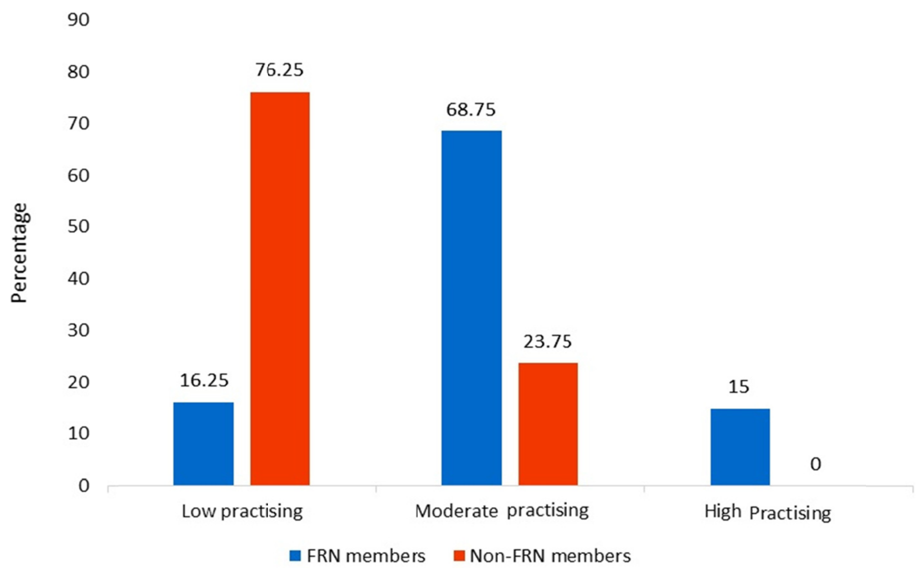


Figure 1. Extent of implementation of agroecological practices among FRN and Non-FRN farmers

### *4.2 Common Agroecological Practices Implemented in the Study Areas*

A practice-wise analysis was carried out to examine and understand different agroecological practices which are mostly implemented by farmers in the study villages and probably why. Table 1 presents the distribution of responses to the agroecological practices commonly implemented by FRN and non-FRN farmers. The most common practices were: (i) the use of organic fertilizers including farm yard manure (FYM) and compost manure (96%); (ii) intercropping (88%); (iii) crop rotation (82%); and crop and livestock integration (79%).

Table 1. Type of agroecological practices implemented by FRN and non-FRN farmers

| Agroecology practices | Membership category | | Total (%) |
|---|---|---|---|
| | FRN member (n =80) | Non-FRN member (n = 80) | |
| Organic fertilizers | 78 (97.5) | 76(95.0) | 154(96.0) |
| Intercropping | 78 (97.5) | 62 (77.5) | 140(88.0) |
| Crop rotation | 72 (90.0) | 59 (73.8) | 131(82.0) |
| Crop and livestock integration | 65 (81.2) | 61 (76.2) | 126(79.0) |
| Cover crops and mulching | 45 (56.2) | 23 (28.8) | 68(42.5) |
| Crop diversification | 40 (50) | 19 (23.8) | 59(37.0) |
| Control pests using natural herbs | 53 (66.2) | 0 (0.0) | 53(33.0) |
| Nine seeded holes | 51 (63.8) | 0 (0.0) | 51(32.0) |
| Mixed cropping | 21 (26.2) | 5 (6.2) | 26(16.3) |
| Chaka hoe | 19 (23.8) | 0 (0.0) | 19(12.0) |
| Agroforestry | 1 (1.2) | 0 (0.0) | 1(0.6) |
| Total | 80 | 80 | 160 |

*Note*. The numbers in the brackets represent percentages. Percentages exceed 100 because the analysis used was multiple responses and did not necessarily add to 100%.

### *4.3 Status of Food Availability among FRN and non-FRN Households*

The results in Table 2 present the status of food availability at household level by comparing between FRN and non-FRN households. More than half (74%) of the FRN households were food secure as opposed to 23% of non-FRN households. Moreover, households with surplus food were relatively few (13% and 8%) for the FRN and non-FRN households respectively. The findings imply that farmers who were members of FRN were better off in terms of food availability and likely food security compared to their fellow farmers.

Table 2. Status of food availability between FRN and non-FRN households

| Kilocalories available per year per person | Household membership | | Chi-Square | Df | Sig |
|---|---|---|---|---|---|
| | FRN | Non-FRN | | | |
| Inadequate food availability | 11(13.8) | 56 (70.0) | | | |
| adequate food availability | 59 (73.8) | 18 (22.5) | 53.055 | 2 | 0.000 |
| Surplus food availability | 10 (12.5) | 6 (7.5) | | | |

### *4.4 Contribution of Agroecological Practices to Household Food Availability*

The statistical summary of the Chi-square analysis of food availability is presented in Table 3 below. The Table shows a significant association between the level of implementation of agroecological practices and food availability at p-value = 0.000. Implying that as households increase the number of agroecological practices in the farm there is high chance of being food secure. This means more crop yields, and subsequently more food available at their household level.

Table 3. Contribution of agroecological practices to household food availability

| Household membership | Food availability level (kCal/person) | Agroecology practicing level | | | Chi-Square | Sig. level |
|---|---|---|---|---|---|---|
| | | Low | Moderate | High | | |
| FRN member | Inadequate | 3 (23.1) | 3 (5.5) | 0(0) | 28.474 | 0.000 |
| | Adequate | 9 (69.2) | 48 (87.3) | 5 (41.7) | | |
| | Surplus | 1(7.7) | 4 (7.3) | 7 (58.3) | | |
| Non-FRN member | Inadequate | 56 (91.8) | 4 (21.1) | 0 (0.0) | 60.059 | 0.000 |
| | Adequate | 5 (8.2) | 9 (47.3) | 0 (0.0) | | |
| | Surplus | 0 (0.0) | 6 (31.6) | 0 (0.0) | | |

*Note.* Numbers outside and inside the brackets are frequency and percentage, respectively.

## 5. Discussion

### *5.1 Status of Implementation of Agroecological Practices in the Study Area*

Comparison of the results on the levels of implementation of agroecological practices by FRN and Non-FRN farmers revealed that, the majority of FRN farmers were in the medium and high categories, as opposed to non-FRN farmers; almost all were in the low category. Suprisingly none of them were in the high category. This finding is in agreement with focus group discussion findings. This difference may be due to effects of active participation of farmers who are members of FRNs in the project interventions compared to non-FRN farmers (Figure 1). Based on the analysis, significant differences exist in the way farmers perceive the importance and the need to implement agroecological practices. The FRN farmers were imparted with knowledge and hands on skills on how to implement the agroecological practices, and they were aware of benefits associated with agroecological farming. It was widely said, the FRN members were capacitated through a series of training provided by the FRN project. This finding is online with Constantine et al. (2021), who reported that the capacity of smallholder farmers to adapt or implement recommended practices differ from one another based on the level of understanding in terms of knowledge and skills, and other factors such as age, income level, and social capital. The social capital interactions and networking among farmers within or between villages or between farmers and extension agents play an important function in enhancing knowledge and sharing experience in farming activities. Participants of the FGD reported that through training were able to understand the benefits associated with agroecology as science, practices and movement. This suggests a high disparity in knowledge and skills among the FRN and Non-FRN farmers in Singida district.

"*... we were able to understand the benefits associated with agroecology as science, practices and movement...*" narrated by one of the respondents in FGD in Mvae village. As a science FRN research activities came up with a vivid example on how intercropping of leguminous (cowpeas and pigeon peas in particular) with maize improved both maize and cowpeas yields.

This kind of intercropping system enhances soil fertility, conserves moisture, and promotes biodiversity. For example, cowpeas fix atmospheric nitrogen, enriching soil and providing essential nutrients to both cowpeas and maize. Besides, the cowpeas serve as a mulch, maintaining soil moisture and supporting maize plant health. As noted by this mutualistic relationship not only improves agricultural productivity but also promotes sustainable management of land. Thus, implementation of varieties of agroecology practices significantly contribute to resilience and eco-friendly farming systems. This is in agreement with Oteros-Rozas et al. (2019), and Kangmennaang et al. (2017). This trend has been also observed in other African countries such as Malawi, Kenya and Nigeria (Chappell et al., 2018). In the context of Tanzania, semi-arid area, where Singida is situated, has harsh climatic conditions including unreliable rainfall and prolonged drought period, that significantly contribute to low yielding and environmental unsustainability, implementation of agroecology practices reduce the impacts of climate change. The regions located in arid and semi-arid agro-ecological zones are more vulnerable than those with moderate climate. Thus, intercropping, crop rotation, mulch, cover crop and use of organic fertilizers have the ability to improve crop yields and subsequently increase food availability at household level. The findings are in line with (Constantine et al., 2021) who reported that farmers who were trained in Mvomero and Masasi districts were good implementers of agroecological practices compared to their fellow farmers who were not trained.

### *5.2 Common Agroecological Practices Implemented by FRN and Non-FRN Farmers*

Historically, FYM has long been used by farmers in Tanzania and elsewhere in Sub-Saharan Africa (SSA) to add fertility and nutrients to soil, leading to better agricultural yields and improved soil quality. FYM is a type of organic material that may be utilized as an organic source of nutrients in soil. Among the common practices implemented by both FRN and non-FRN farmers in Singida region was the application of organic fertilizer. The FGD findings also indicated that the use of animal manure scored the highest marks (69) followed by compost (21%). The compost was made up with crop residue, green plant, ashes, animal waste, and water. These mixtures were left for at least one month to allow the materials to decompose and produce organic matter. The reasons behind both FRN and non-FRN farmers to rely on organic fertilizer is that: these materials are inexpensive and have the ability to restore soil health and soil moisture.

Soil structure and biomass are both enhanced by the addition of FYM (Ouda & Mahadeen, 2008). Likewise, FYM and mulch are good sources of soil organic carbon, nitrogen, phosphorus, and potassium levels all improve soil's chemical characteristics (Ouda & Mahadeen, 2008). As a result, adopting a nutrient delivery system that combines integrated utilization is crucial to improve crop production in Singida region. It is also very important if we are to reduce our reliance on synthetic fertilizers and protect our environment while maintaining agricultural productivity (Ouda & Mahadeen, 2008). Miyashita and Kayunze (2016) supported that soil organic management practices such as application of animal manure, mulching or soil cover crop and intercropping have significant contribution to increased soil health and crop yields, and thus they need to be adopted in farming systems. These practices eventually heighten food security, and increase adaptive capacity/resilience of farmers in Singida semi-arid area.

Intercropping was another practice adopted by the majority of the household interviewed. Both FRN and Non FRN farmers reported understanding the potential benefits of intercropping into two folds. First, when leguminous crops are used, they have ability to fix nitrogen into soil, hence improving productivity. Secondly, it has the ability to reduce risk associated with total failure of one crop. Farmers consider intercropping as a way to reduce the risk of total crop loss in the event of either prolonged drought, or flood or short rains. Thus, increases chances of food availability and reduces the risk of household food insecurity. It emerged, during FGD at Mvae village, that intercropping increased crop yields and reduced production costs, especially labour cost. Likewise, crop rotation was found to be widely implemented by the majority of farming households (82% and 74% for FRN and non-FRN households respectively). It was learned that farmers clearly understood the advantages of crop rotations. During FGD in Ntonge village, farmers reported having observed that crop rotation was responsible for reduced crop disease incidences. These practices are termed "common practices" because they seem to be mostly practiced by both groups, FRN and non-FRN farmers. It was named as common practices because normally farmers in the study areas traditionally used it regardless of being trained or not. FRN farmers applied agroecology principles while farming in their farms. FRN farmers also adopted nine-seed holes technique, Chaka hoe (Zambian hoe), and pest and disease control using bio-inputs.

This means that FRN farmers were familiar with different types of agroecological practices compared to non-FRN households. And they were more likely to apply a wide range of agroecological practices compared to non-FRN households who had never received training. Know-how and hand-on skills influenced implementation of agroecological practices, and were of importance in agricultural transformation from conventional to agroecological farming for sustainable food systems. The study findings are in agreements with Udimal et al. (2017), and Schoonhoven and Runhaar (2018) who emphasise that training farmers is essential for agricultural development. Similarly Kangmennaang et al. (2017) and Chappell et al. (2018) studies revealed that farmers who implemented agroecological practices in Malawi and Senegal had higher crop yields and were food secure in terms of food availability than their counterparts. Nevertheless, the finding is contrary to Méndez et al. (2013), who reported low yield gains when a farmer uses organic and ecological farming compared to industrial farming. This is likely because of the low amount and rate of using organic fertilizers that were observed among farmers in Singida district.

### *5.3 Contribution of Agroecological Practices to Foold Availability at Household Level*

The synthesis of qualitative findings from the FGD in Mwakiti village show that the implementation of agroecological practices plays a major role in soil health improvement, and moisture conservation. High crop yield, reduced soil erosion, reduced land degradation, and biodiversity conservation were the multiple benefits associated with the implementation of agroecological practices in the study areas. This is in agreement with Ayivor et al. (2015) whose study in Ghana asserted increased crop productivity and yield gains associated with implementation of agroecological practices, and successively increased food availability at the household level. Evidence shows that agroecology farming reduces the risk of crop failure due to crop diversification (*ibid*), and is likely to increase income level.

On the other hand, Athanasio et al. (2016), and Limbu et al. (2017) revealed that a farm well diversified and integrated with livestock components has ability to double crop production of various crop varieties, hence contributing significantly to food availability at the household level. Moreover, this is contrary to Alare et al. (2018) reported no association between the use of agroecological practices and improvement of food availability. Based on the findings from this study, there is a causal relationship between implementing agroecological practices and the amount of food produced and available for the household members in Singida district.

## 6. Conclusion and Recommendations

This paper examined the extent of implementation of agroecological practices and their contribution to food availability at the household level by comparing between the FRN and non-FRN households. The basis for such a comparison is that the FRN-RECODA project development framework promotes the application of principles and elements of agroecology. Thus, we assumed that FRN farmers would be in a higher category of implementation of agroecological practices and thus would benefit more in terms of food availability, and subsequent food security. We found that the FRN household heads were at a moderate level of implementation of agroecological practices, whereas the non-FRN household heads were at a low level. Food availability was associated with the level of implementation of agroecological practices. FRN farmers respondents were food secure in comparison with their counterparts. The more farmers implemented agroecological practices, the more the household had more food. We argue that agricultural programs should address food insecurity by emphasizing the adoption and implementation of agroecological practices. Also, there is a need for the FRN project in collaboration with the local government authority to scale up its interventions to reach more farmers including farmers outside the FRN project villages.

**References**


Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Alare, R. S., Owusu, E. H., & Owusu, K. (2018). Climate smart agriculture practices in semi-arid Northern Ghana: Implications for sustainable livelihoods. *Journal of Sustainable Development, 11*(5), 57. https://doi.org/10.5539/jsd.v11n5p57

Arslan, A., Belotti, F., & Lipper, L. (2017). Smallholder productivity and weather shocks: Adoption and impact of widely promoted agricultural practices in Tanzania. *Food Policy, 69*, 68-81. https://doi.org/10.1016/j.foodpol.2017.03.005

Assenga, E. A., & Kayunze, K. A. (2016). Food security incidences based on dietary energy consumption, dietary diversity and household food insecurity access scale in Chamwino District, Tanzania. *International Journal of Asian Social Science, 6*(11), 644-658. https://doi.org/10.18488/journal.1/2016.6.11/1.11.644.658

Athanasio, S. M., Mary Alphonce, K.-M., Hieromin Amon, L., Huruma Fredrick, M., Masanja Charles, J., Limbu, S. M., … Amon, P, S. (2016). *Fish polyculture system integrated with vegetable farming improves yield and economic benefits of small-scale farmers*.

Ayivor, J. S., Pabi, O., Ofori, B. D., Yirenya-Taiwiah, D. R., & Gordon, C. (2015). Agro-diversity in the forest-savannah transition zone of Ghana: A strategy for food security against climatic and socio-economic stressors. *Environment and Natural Resources Research, 6*(1), 1. https://doi.org/10.5539/enrr.v6n1p1

Chappell, M. J., Bernhart, A., Bachmann, L., Gonçalves, A. L., Seck, S., Nandul, P., & dos Santos, A. C. (2018). *Agroecology as a pathway towards sustainable food systems*.

Chilewa, H. S., Martin, R., & Ntumva, M. (2023). *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*.

Clark, V. L. P., & Ivankova, N. V. (2015). *Mixed methods research: A guide to the field* (Vol. 3). Sage Publications.

Clarke, E., & Visser, J. (2019). Pragmatic research methodology in education: Possibilities and pitfalls. *International Journal of Research & Method in Education, 42*(5), 455-469. https://doi.org/10.1080/1743727X.2018.1524866

Constantine, J., Sibuga, K. P., Shitindi, M. J., & Hilberk, A. (2021). Awareness and application of existing agroecological practices by small holder farmers in Mvomero and Masasi Districts-Tanzania. *Journal of Agricultural Science, 13*(1), 30. https://doi.org/10.5539/jas.v13n1p30

D'Annolfo, R., Gemmill-Herren, B., Graeub, B., & Garibaldi, L. A. (2017). A review of social and economic performance of agroecology. *International Journal of Agricultural Sustainability, 15*(6), 632-644. https://doi.org/10.1080/14735903.2017.1398123

Fishbein, M., & Ajzen, I. (1977). *Belief, attitude, intention, and behavior: An introduction to theory and research*.

Francis, C. (2016). Agroecology: the Ecology of Sustainable Food Systems. *NACTA Journal, 60*(4), 454.

Gallardo-López, F., Hernández-Chontal, M. A., Cisneros-Saguilán, P., & Linares-Gabriel, A. (2018). Development of the concept of agroecology in Europe: A review. *Sustainability, 10*(4), 1210. https://doi.org/10.3390/su10041210

Iraoya, A. O., & Isinika, A. C. (2022). Income diversification and agricultural intensification of rural households in Nigeria: Synergies and tradeoffs. *Journal of African Development, 23*(1), 112-131. https://doi.org/10.5325/jafrideve.23.1.0112

Kangmennaang, J., Kerr, R. B., Lupafya, E., Dakishoni, L., Katundu, M., & Luginaah, I. (2017). Impact of a participatory agroecological development project on household wealth and food security in Malawi. *Food Security, 9*, 561-576. https://doi.org/10.1007/s12571-017-0669-z

Kanjanja, S. M., Mosha, D. B., & Haule, S. C. (2022). Determinants of the implementation of agroecological practices among smallholder farmers in Singida district, Tanzania. *European Journal of Agriculture and Food Sciences, 4*(5), 152-159. https://doi.org/10.24018/ejfood.2022.4.5.571

Kingu, H. (2020). Role of Institutions in Household Food Security in Tanzania: A Case of Singida Region. *Tengeru Community Development Journal, 7*(1), 1-18.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*: New Age International.

Limbu, S. M., Shoko, A. P., Lamtane, H. A., Kishe-Machumu, M. A., Joram, M. C., Mbonde, A. S., … Mgaya, Y. D. (2017). Fish polyculture system integrated with vegetable farming improves yield and economic benefits of small-scale farmers. *Aquaculture Research, 48*, 3631-3644. https://doi.org/10.1111/are.13188

Lyons, K., Richards, C., & Westoby, P. (2014). *The darker side of green: Plantation forestry and carbon violence in Uganda*.

Maggio, A., Scapolo, F., van Criekinge, T., & Serraj, R. (2019). Global drivers and megatrends in agri-food systems. *Agriculture & food systems to 2050: Global trends, challenges and opportunities* (pp. 47-83). World Scientific. https://doi.org/10.1142/9789813278356_0002

Méndez, V. E., Bacon, C. M., & Cohen, R. (2013). Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems, 37*(1), 3-18. https://doi.org/10.1080/10440046.2012.736926

Miyashita, C., & Kayunze, K. A. (2016). Can organic farming be an alternative to improve well-being of smallholder farmers in disadvantaged areas? A case study of Morogoro region, Tanzania. *International Journal of Environmental and Rural Development, 7*(1), 160-166.

Mockshell, J., & Villarino, M. E. J. (2018). Agroecological intensification: Potential and limitations to achieving food security and sustainability. *Reference Module in Food Science.* https://doi.org/10.1016/B978-0-08-100596-5.22211-7

Napoli, M., De Muro, P., & Mazziotta, M. (2011). Towards a food insecurity Multidimensional Index (FIMI). *Master in Human Development and Food Security, 10*.

Oteros-Rozas, E., Ravera, F., & García-Llorente, M. (2019). How does agroecology contribute to the transitions towards social-ecological sustainability? *Sustainability, 11*(16), 4372. https://doi.org/10.3390/su11164372

Ouda, B. A., & Mahadeen, A. Y. (2008). Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). *International Journal of Agriculture and Biology, 10*(6), 627-632.

Palomo-Campesino, S., González, J. A., & García-Llorente, M. (2018). Exploring the connections between agroecological practices and ecosystem services: A systematic literature review. *Sustainability, 10*(12), 4339. https://doi.org/10.3390/su10124339

Schoonhoven, Y., & Runhaar, H. (2018). Conditions for the adoption of agro-ecological farming practices: A holistic framework illustrated with the case of almond farming in Andalusia. *International Journal of Agricultural Sustainability, 16*(6), 442-454. https://doi.org/10.1080/14735903.2018.1537664

Tapsoba, P. K., Aoudji, A. K., Ouédraogo, F., Dassekpo, I. S., Kestemont, M.-P., Konkobo, M. K., & Achigan-Dako, E. G. (2023). Understanding the behavioral drivers of smallholder agro-ecological practice adoption in Benin and Burkina Faso. *Farming System, 1*(2), 100023. https://doi.org/10.1016/j.farsys.2023.100023

Therond, O., Duru, M., Roger-Estrade, J., & Richard, G. (2017). A new analytical framework of farming system and agriculture model diversities. A review. *Agronomy for Sustainable Development, 37*, 1-24. https://doi.org/10.1007/s13593-017-0429-7

Trail, P., Abaye, O., Thomason, W. E., Thompson, T. L., Gueye, F., Diedhiou, I., … Faye, A. (2016). Evaluating intercropping (living cover) and mulching (desiccated cover) practices for increasing millet yields in Senegal. *Agronomy Journal, 108*(4), 1742-1752. https://doi.org/10.2134/agronj2015.0422

Udimal, T. B., Jincai, Z., Mensah, O. S., & Caesar, A. E. (2017). Factors influencing the agricultural technology adoption: The case of improved rice varieties (Nerica) in the Northern Region, Ghana. *Journal of Economics and Sustainable Development, 8*(8), 137-148.

Wezel, A., Casagrande, M., Celette, F., Vian, J.-F., Ferrer, A., & Peigné, J. (2014). Agroecological practices for sustainable agriculture: A review. *Agronomy for Sustainable Development, 34*(1), 1-20. https://doi.org/10.1007/s13593-013-0180-7

Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems: A review. *Agronomy for Sustainable Development, 40*, 1-13. https://doi.org/10.1007/s13593-020-00646-z

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**Authors Contributions**

Dr. Sylvester C. Haule and Dr. Devotha B. Mosha were responsible for study design and revising. Ms. Sauda M. Kanjanja was responsible for data collection, processing and analysis. Ms. Sauda drafted the manuscript and Dr. Haule and Dr Mosha revised it. The first contributed more the two authors because it was part and percel for her Master Degree Programme. All authours work on reviewers' comments, read and approved the final munuscript.

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