CONTRIBUTION OF AGROECOLOGICAL PRACTICES TO HOUSEHOLD FOOD AVAILABILITY: EXPERIENCE FROM FARMER RESEARCH NET-WORK (FRN) PROJECT IN SINGIDA DISTRICT

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL EDUCATION AND EXTENSION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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EXTENDED ABSTRACT

This study assessed the contributions of agroecological practices to household food availability in Singida district. Specifically, the study intended to: (i) determine the extent of implementation of agroecological practices among FRN farmers and non-FRN farmers in Singida district; (ii) examine the contribution of agroecological practices to household food availability by comparing FRN and non-FRN farmers; (iii) assess farmers' perceptions towards implementation of agroecological practices as a means of improving food availability; and (iv) determine factors influencing farmers in implementing agroecological practices in the study district. Using the "With and Without" approach, a sample size of 160 respondents was selected, 80 from two villages where farmers were trained on agroecological practices (the "With FRN group") and the other 80 from two villages where farmers were not trained on agroecological practices (the "Without FRN group"). Both quantitative and qualitative primary data were collected for triangulation purposes. A structured questionnaire was administered to 160 household respondents and a checklist used in and in-depth interviews with eight key informants (KIIs). Besides, four Focus Group Discussions (FGDs), one in each village were conducted. Quantitative data was analysed through the Statistical Package for Social Sciences (SPSS) computer soft were, while qualitative data analysed using content analysis.

Descriptive statistics involving the calculation of means, frequencies and percentages were computed. A chi-square test was used to determine associations between the extent of implementation of agroecological practices and membership of the household in the FRN. A multiple linear regression model was used to determine possible determinants influencing the implementation of agroecological practices. Content analysis was used to Analyse qualitative data.

The findings showed that the overall extent of implementation of agroecological practices was moderated (73.8%). Most FRN farmers had more food than non-FRN farmers because they were trained in agroecological practices and imparted knowledge and skills that influenced FRN farmers to implement the practices, eventually contributing to increased crop yield and thus food availability in households. The finding from the Chi-square Test revealed that the implementation of agroecological practices had a significant contribution to households (p-value = 0.000). The FRN farmers had adequate food available to their families than non-FRN farmers. In terms of perception, farmers had a positive perception towards the implementation of agroecological practices as a technology to enhance food availability. In contrary, farmers had a negative perception of the ease of implementation of agroecological practices, indicated that it was a cumbersome task to practice some agroecological technologies such as contour ridges and nine seeded holes. Furthermore, the findings of the multiple regression model indicated that household income, training on agroecological practices, age, benefits from practising agroecology, land ownership, farm distance and education level of the household head had significantly influenced the implementation of agroecological practices at a p-value = 0.05 level of significance.

Based on the findings, the study concluded that farmers in the study district implementation of agroecological practices at moderate level. This was likely due to the intensiveness of most agroecological practices; however, the FRN project's training influenced smallholder farmers to implement agroecology. Also, agroecological practices have a significant contribution to household food availability. Farmers who were moderately involved in the implementation of agroecological practices had adequate food availability. The positive perception of farmers towards agroecological practices to enhance food availability is an indication that farmers have the possibility to be familiar with and implement agroecological practices so as to improve soil fertility and increase crop productivity, thus leading

to food availability. The study also concludes that household income, training attainment, benefits obtained from practising agroecology, land ownership and the education level of the household head are important determinants for agroecological practices implementation in Singida district. As these factors increase, the implementation of agroecological practices also increases. While the age of the household head and farm distance had an inverse relationship, as the farmer aged, the implementation of agroecological practices decreased. Also, the longer the distance in which the farm is located, the more difficult it is to implement agroecology. Therefore, farmers whose farms are located far from homesteads find it difficult to implement agroecology since it is easy to manage them.

The study recommends that the FRN project, in collaboration with other development agents, should put more emphasis on promoting agroecological practices in order to increase the level of their implementation. This can be done in different ways, including the provision of specialised equipment to reduce the intensiveness of some of the practices and other inputs. Because agroecological practices contribute significantly to household food availability, farmers who implemented agroecological practices had adequate food availability compared to their counterparts. Therefore, there is a need to scale up training agroecological practices to reach a wider community, including farmers outside FRN villages. Farmers had a positive perception of the implementation of agroecological practices, so local government authorities and other stakeholders should promote agroecological practices transformation to encourage farmers to continue implementing agroecological practices. The Government and other stakeholders should insist more on improving training services to increase the implementation of agroecological practices. Training will help to increase farmers' awareness, knowledge and benefits associated with implementing agroecology. Also, the study recommends diversification of income sources on the farmers' side by engaging in both on-farm and off-farm activities such as petty business to

increase income, which in turn will enable them to invest in the implementation of agroecology practices.

DECLARATION

I, **SAUDA MBWIGA KANJANJA**, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

This dissertation is dedicated to the Almighty God for his guidance and grace throughout my academic pursuit and my parents; my beloved mother, Faines Matingo (who pass way a day before my submission on this dissertation) and my father Mbwiga Kanjanja, for their prayers and support during my study period.

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LIST OF ABBREVIATION

AE	Agroecological
AEI	Agroecological Intensification
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
FRN	Farmers Research Networks
GIS	Geographic Information System
HLPE	High Level Panel of Experts
Kcal	Kilocalories
KG	Kilograms
KII	Key Informant Interview
NGOs	Non-Governmental Organizations
RECODA	Research Community and Organizational Development Association
SAT	Sustainable Agriculture in Tanzania
SNAL	Sokoine National Agriculture Library
SPSS	Statistical Package for Social Sciences
TWN	Third World Network
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
WFP	World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agroecology has been recognised by governments, Non-Governmental Organisations (NGOs) and other development agencies worldwide as a sustainable agricultural development pathway (Parmentier, 2014; FAO, 2018; Teixeira *et al.*, 2018; HLPE, 2019). This is particularly so since the 2008 financial and food price crises, which is reflected in the United Nations (UN)'s Food and Agriculture Organizations (FAO) that call for a new paradigm for a sustainable agricultural system (FAO, 2018).

Agroecology farming is promoted as a means to achieve sustainable food systems due to its capacity to provide solutions to industrial agricultural challenges. According to Polomo-Campesino *et al*. (2018), the emergence of industrial agriculture in the 1940s and 1950s, which spread globally between the 1960s and 1970s, superseded the agricultural system, which was primarily dependent on the natural ecosystems and biological processes. In most cases, the purpose of industrial agriculture is to increase yield to a maximum level while using a high level of synthetic pesticides and fertilisers as well as improved seed varieties (Therond *et al.*, 2017; Polomo-Campesino *et al*., 2018). The use of industrial inputs has detrimental impacts on the environment, economic and social development. Among others, the impacts are biodiversity loss, water contamination, reduction in soil fertility, hence poor crop productivity and health problems caused by exposure to pesticides (Third World Network (TWN), 2015; Gallardo-López *et al*., 2018).

Evidence shows that agroecology has the potential to provide solutions to agricultural challenges. Agroecology is a set of principles, practices and concepts that aim to optimise interactions between plants, animals, humans and the environment while taking into ac-

count the socioeconomic aspects needed for a sustainable and equitable agri-food system solution to agricultural challenges (Oteros-Rozas *et al.*, 2019). Examples of agroecological practices include intercropping, crop rotation, biological control of pests, mulching, and the use of organic fertiliser (Mockshell and Villarino, 2018). Agroecology, in general, proposes a comprehensive system centred on smallholder farmers, leveraging their collective knowledge to identify problems, innovate for specific ecological and cultural contexts and develop long-term solutions for transformational change (Wezel, 2015).

As noted by Mdee *et al*. (2018), agroecological farming has the potential to increase crop production at a low cost as it does not depend on external inputs while ensuring food availability and security. For example, evidence indicates that intercropping millet and legumes have the ability to increase millet yield by about 60% (Trail *et al*., 2016). Mulching leads to increased millet yield by about 70% compared to a millet field without mulching (Trail *et al*., 2016). In addition, a study by Levard and Mathieu (2018) showed that the application of organic fertilisers and practising anti-erosion practices plus organic fertiliser raised yields to about 1.2 tonnes/ha, up from 0.7 tonnes/ha. In realising such benefits, the Government of Tanzania, in collaboration with NGOs, particularly the Research Community and Organisational Development Association (RECODA), promoted the implementation of agroecological practices and principles in Singida district and other regions of Tanzania. RECODA has been working with smallholder farmers organised into Farmers Research Networks (FRN) in Singida district since 2000, with the focus on enabling farmers to identify challenges in agricultural production and search for innovative solutions based on agroecology principles using the Farmer Field Schools (FFS) approach. The aim is to address the challenges and increase crop yields and subsequently enhance food availability to reduce food and nutrition insecurity (RECODA, 2014). The FRN-RE-

CODA project is implemented in four wards and nine villages and it has 18 FRNs, comprising a total of 344 farmers.

This study applies a particular understanding of the notion of "food security" as access to nutritious and sufficient food and is often considered a major element of human development (Mkonda and Xinhua, 2017). Food security is typically measured based on the dimensions of availability, access, utilisation and stability whereas, agroecological practices have the potential to contribute to all these dimensions (Gliessman, 2015). However, the researchers focused on the component of food availability, which is all about the availability of an adequate amount of food produced domestically with or without employing agroecological practices with suitable quality (Mockshell and Villarino, 2018). This study, therefore, assessed the contribution of agroecological practices on food availability by comparing the FRN and Non-FRN households in the study area.

1.2 Problem Statement

Embracing agroecological practices is one of the strategies to raise agricultural productivity and increase food availability among smallholder farmers who depend on the agricultural sector. In Tanzania, small-scale production is the foremost source of food supply (Saruni and Mutayoba, 2018), which on average accounts for about 95% of food availability (URT, 2017a).

However, agricultural farming in Singida district is still encountering challenges, as yields are still low and are, affected by prolonged drought and rainfall shortages attributed to climate change and variability. To address the climate change impacts, smallholder farmers practise agroecological practices to improve soil fertility status and make improvements for better crop yield. Even among farmers who have implemented agroecological meth-

ods, disparities exist, as there are variations in terms of the type and scale of practising agroecological practices (Kingu, 2020).

The implementation of agroecological practices in Singida district has been promoted by the government of Tanzania and the FRN RECODA project since 2000 (RECODA, 2014), whose aim is to increase crop yields and ensure food security. The project provides support to FRN participating farmers in terms of capacity building, agricultural inputs and facilitating farmers' access to credit to enable them to implement agroecological practices. However, implementation of the agroecological practices has not been straightforward; it has often resulted in indifferent and unexpected outcomes. Food unavailability remains a concern among smallholder farmers in the district. The study, therefore, seeks to document whether implementation of agroecological practices has any contribution to improving food availability by comparing implementers and non-implementers of the agroecological practices.

Several studies have been conducted to assess the importance of agroecological practices on land management, including soil fertility improvement and some include that of Oteros-Rozas *et al*. (2019), who assessed the contribution of agroecological practices to socio-ecological sustainability. Sinclair *et al.* (2019) assessed the contributions of agroecological approaches to global and climate change adaptation and mitigation, whereas Mdee *et al*. (2018) assessed the application levels of agroecological practices in Tanzania. A more recent study by Constantine *et al*. (2020) determined the level of awareness and application of agroecological practices by smallholder farmers. However, the determinants and extent of the adoption of agroecological practices and their influence on household food availability, which justify their critical contribution to food security, have not been

adequately explored. Therefore, this study has been intended to fill in these knowledge gaps.

1.3 Justification of Study

Agroecological practices have been promoted by governments and other development agencies as a means to improve farmers' livelihoods through food and nutritional security improvements and income generation while continuously conserving the natural ecosystem (Bellamy and Ioris, 2017). Understanding the potential of agroecological practices to address the problem of low agricultural productivity caused by unreliable rainfall, pest and disease, inefficient agricultural input use, and poor land management could provide evidence for policymakers on how sustainable food systems can be enhanced. Hence, it was expected that the study findings would provide evidence that could be used in policy and strategies formulation to address specific challenges facing farmers as they strive to adopt the agroecological elements recommended by FAO. This is also important in improving food production while lowering adverse environmental impacts. The policy messages from this study would also contribute to the implementation of the Sustainable Development Goals (SDGs) of ending hunger and achieving food and nutrition security by 2030.

1.4 Objectives of the Study

1.4.1 Overall objective

The overall objective of this study was to assess the extent of the implementation of agroecological practices and its contribution to food availability among farmers in Singida district.

1.4.2 Specific objectives

Specifically, the study intended to:

i. Determine the extent of implementation of agroecological practices among FRN and non-FRN farmers in Singida district.
ii. Examine the contributions of agroecological practices to household food availability by comparing results between FRN and non-FRN farmers.
iii. Assess farmers' perceptions towards the implementation of agroecological practices as a means to enhance food availability.
iv. Determine factors influencing farmers to implement agroecological practices.

1.4.3 Research questions

The following questions were adopted:

i. To what extent have farmers implemented agroecological practices in Singida district?
ii. (a) Does the implementation of agroecological practices contribute to food availability? (b) Is there any difference in the status of food availability between FRN and non-FRN farmers?
iii. What are the farmers' perceptions towards the implementation of agroecological practices in the study area?
iv. What are the social and economic factors that influence farmers to implement agroecological practices in the study area?

1.5 Definition of the Key Concepts

1.5.1 Agroecology

Different scholars have defined the concept of agroecology differently since there is no clear definition despite its long history (Wezel *et al*., 2009; Gliessman, 2015). Since its emergence in the early 20th century, there has been an evolution of definitions and interpretations of agroecology. The common definition applied by many institutions and coun-

tries has three keywords: scientific discipline, social movement, and practices (Wezel *et al*., 2015). As a science, agroecology is defined as the holistic study of agroecosystems that aims to apply ecological concepts and principles to sustainable food systems design and management (Gliesman, 2015). As a set of practices, agroecology aims to enhance resilience in ecological, social-economic and sustainable farming system by minimising the use of synthetic external inputs. As a social movement, it promotes sustainable agricultural practices and their relationship with society by addressing current calamities such as climate change, food insecurity and malnutrition (Wezel *et al*., 2020).

1.5.2 Agroecological practices

Agroecological practices are defined as agronomic practices that aim to produce high yields through the best use of ecological and ecosystem services without depending on external synthetic fertilisers and pesticides (Silic, 2014; Wezel *et al.*, 2020). Agricultural practices which are considered agroecological include organic fertilisation; biological control of pests; crop rotation; conservation tillage; mixed cropping; and intercropping are widely practised (Wezel *et al.*, 2014; Palamo-Campesino *et al.*, 2018). Other practices include cover crops and mulching, green manure, agroforestry, crop and livestock integration, water harvesting, and appropriate fallow periods (TWN, 2015; Chappell *et al*., 2018). In most cases, agroecological farming emphasises diversification as a way to increase food availability (Sinclair *et al.*, 2019). This is in contrast to conventional agriculture, which normally emphasizes monocropping.

1.5.3 Crop diversification

Crop diversification refers to the practice of growing more than one variety of crops belonging to the same or different species in a given area through diversifying crop rotations, intercropping, and agroforestry (Wezel *et al*., 2015). However, experience from the literat-

ure shows that a diversified cropping system is disadvantaged due to high labour costs in terms of labour for land tillage, management, and harvesting, so farmers are discouraged from practising (Durham and Mizik, 2021).

1.5.4 Intercropping

Intercropping is defined as the agricultural practice of growing more than one crop in the same place at the same time (Bybee-Finley and Ryan, 2018). Intercropping as an agroecological practice has beneficial effects on agriculture as it offers more harvest compared to single-crop produce; nutrients are used efficiently; it helps in weed suppression; and it ensures crop stability (Ayivor *et al.,* 2016). Planting only nutrient-consuming crops such as fruiting vegetables depletes nutrition, especially nitrogen, while mixing with low nutrient-consuming crops such as cereals and nitrogen-fixing legumes will be good for soil fertility (Duchene *et al.,* 2017).

1.5.5 Cover crops and mulching

Cover crops such as grasses and legumes are grown to cover soil primarily to improve the physical, chemical, and biological characteristics of the soil. The cover crops improve soil health and structure, hence allowing better micro-biotic activities, reducing soil erosion as it builds a stronger structure, reducing weed infestation, increasing water infiltration rate, and promoting pest suppression (Gu and Annex, 2015). Some cover crops are proven to contain twice the nitrogen of compost. Therefore, cover crops are used to avoid nitrogen deficiency. Besides, nitrogen from cover crops does not run off easily and is not leached out like inorganic nitrogen fertilisers do, hence reducing the risk of water contamination (Wezel *et al*., 2015).

1.5.6 Rotating crops

Rotating crops is the tendency of planting different crop species in a field each season. Biological and physical benefits of crop rotation include the improvement of soil quality by reducing soil erosion and reducing pest and disease infestation since it can control host-specific pests which specialise in a particular species (Hyran *et al*., 2018). However, it becomes difficult for farmers with a shortage of land to rotate crops, so monoculture remains the only option regardless of its effect on the soil.

1.5.7 Agroecology and a related system of farming practices

Agroecology as a concept is related to organic farming and conservation agriculture as they all focus on providing environmental conservation, sustainable agriculture, and enhancing food security. However, agroecology differs from organic farming and conservation agriculture, and the main differentiating aspect is that it develops agroecosystems with minimal dependence on external inputs (Mockshell and Villarino, 2018). Agroecology offers the use of Integrated Pest Management (IPM) and the minimum use of inorganic fertilizers. In contrast, organic farming has clear and rigorous regulations, standards and restrictions, including no use of synthetic pesticides and fertilizers, processing aids and additives and no genetically modified organisms or products (Migliorini and Wezel, 2018). Conservation Agriculture (CA) is a farming system that can prevent loss of arable land while regenerating degraded lands. It promotes maintenance of permanent soil cover, minimal soil disturbance, and diversification of plant species (Pittelkow *et al.,* 2015; Mockshell and Villarino, 2018). Unlike organic and agroecological farming, conservation farming allows the use of external inputs (inorganic fertilizer, genetically modified crops and industrial pesticides. There are no stand-alone practices of agroecology that are not practiced by organic farming and conservation agriculture. A practice to be considered an

agroecological practice depends on the extent to which it is used in agroecological processes as opposed to external inputs (Sinclair *et al.*, 2019).

1.5.8 Food security

Several authors have defined food security as a complex concept in different ways. According to FAO (1996), food security is access for all people at all times to enough food for an active, healthy life. The World Food Summit (1996) states that food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food security has four parameters commonly used to measure food security, 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. This is described in terms of incomes, markets, and prices. Utilization refers to the nutrition status of individuals by diet diversity and intra-household distribution. The stability of food considers the stability of those three dimensions throughout (Napoli *et al*., 2011). This specific study focused on food availability.

1.5.9 Food availability

Food availability refers to the physical availability of adequate amounts of food of suitable quality, produced domestically at a given time and place (Fraanje and Lee-Gammage, 2018). It focuses on the physical existence of adequate food, be it from its own production, purchases from markets, or transfer (FAO, 2006). Food availability means that food is physically present because it has been grown, manufactured, imported, or transported. Adequate food reflects both the quality and quantity of food that is enough to meet daily re-

quirements by providing all essential nutrients for all members of the household or society (Napoli *et al*., 2011). Farming households' food availability is determined by the main crops grown. Moreover, several factors can affect household food availability, such as little acreage and over-dependence on rainfall, which correspond to a greater likelihood of household food availability (Ngongi *et al*., 2014).

1.6 Empirical review

1.6.1 Link between agroecology and food availability

Given the growing global interest in agroecology, there is a recognised need to understand how it may contribute to household food availability. Silici (2014) reported that agroecological practices support food sovereignty by enabling farmers to boost and diversify their production, stabilise yields and decrease dependency on expensive and often hard-to-access inputs. It will be evident that farming households dealing with agroecological farming have various crops produced on their farms and that the yields of individual crops in agroecological fields are lower when compared to conventional farming, but the total agriculture output is larger due to diversification (Silici, 2014; Chappell *et al*., 2018). Keeping in mind that crop diversification is likely to improve food availability in both quantity and diversity, for example, Amouzou *et al*. (2018) showed that there's an increase in yield from 14.5 to 16.0 t/ha when the farmer intercropped and by 36% through crop rotation. The use of organic manure boosts maize yield from 2.02t/ha to 4.58t/ha (Wainaina *et al.*, 2018). Similarly, through intercropping, farmers experienced an increase in crop yield of an average of 14.5 to 16.0 t/ha and by 36% through crop rotation (Amouzou *et al*., 2018). In addition, agroecology through the integration of nutrient management maintains and adjusts soil fertility and plant nutrient supply at an optimum level, which boosts crop productivity. Likewise, the implementation of nine seeded holes increased maize yield two times compared to the traditional method (Keya *et al*., 2021). Despite this information,

little is known about the link between the implementation of agroecological practices and food availability at the household level. Therefore, this study attempted to fill this gap by examining the contributions of agroecological practices to households' food availability in Singida district and factors affecting farmers in implementing agroecological practices.

1.6.2 Farmers' perception towards the implementation of practices

Ochola *et al.* (2013) found that farmers perceive agroecological practices positively as they offer multiple benefits, including pest and disease management, enhanced productivity, soil fertility improvement, and ecological adaptability and most farmers are aware of and motivated to apply them. Hence, practices such as crop rotation and intercropping improve soil nutrients and interrupt the life cycle of pests. They are, therefore, suitable for crop management.

Farmers' perceptions of sustainable farming systems influence their intention to implement their practices (Creemers *et al*., 2019). It is perceived that agroecology means less productivity compared to conventional agriculture, which tends to produce relatively reliable, immediate, and observable results (Isgren, 2016; Durham and Mizik, 2021). On the other hand, most farmers perceive agroecological practices as the normal farming approach (Wezel *et al*., 2014), hence little attention is paid to agroecological practices. Moreover, agroecology is perceived to be knowledge, management, and labour-intensive (Silic, 2014; Durham and Mizik, 2021). This is due to the high requirement for labour and time, as it does not use mechanised machines like conventional farming. Therefore, poor and marginalised farmers may find it difficult to implement agroecological systems due to inadequate resources that limit access to knowledge.

1.6.3 Factors influencing the implementation of agroecological practices

A number of studies have addressed important factors influencing the adoption decision behaviour of smallholder farm households toward various agroecological practices. For instance, the studies by Wainaina *et al.* (2018) and Schoonhoven and Runhaar (2018) revealed that policies, socioeconomic, farmers' knowledge and information factors have an influence on the adoption of agroecological practices. In fact, agricultural laws and policies that support agriculture modernization rather than environmental conservation affect the implementation of agroecological practices (Isgren, 2016). Socioeconomic factors, such as land ownership, experience and knowledge obtained through training, have an influence on households' decisions to adopt agroecological practices in Tanzania and Nigeria, respectively (Tey *et al.,* 2017; Oyetunde-Usman *et al.,* 2021). Limited demand for agroecological products associated with poor investment and lack of financial abilities also hinders farmers from adopting agroecological practices (Schoonhoven and Runhaar, 2018).

Environmental factors such as topography, farm location such as proximity to the liver, mountain, sea, forest and agroecological variations, on the other hand, influence farmers' decision to practise agroecology (Oyetunde-Usman, 2021). For example, when the farm is close to a large estate, it is difficult to implement agroecology because chemicals from adjacent farms tend to spread to the nearby farm, affecting water, soil and air quality, as well as biological control of pests, Likewise, agronomic benefits to soil health such as soil organic matter maintenance, soil erosion, control and weed suppression through cover crops drive farmers to implement agroecological practices (Tey *et al.*, 2017).

1.7 Theoretical Framework

The study used the Theory of Planned Behaviour (TPB) to understand the level of implementation of agroecological practices among smallholder farmers. The level of implementation was conceived to be an important step towards food availability and, ultimately, food security. The theory of planned behaviour was proposed by Ajzen (1991) as an extension of the theory of reasoned action developed by Ajzen and Fishbein in 1975. The theory is designed to predict and explain human behaviour through personal and social factors. Its emphasis on the main factor in determining an individual's behaviour is consistent with the assumption of this study because for smallholder farmers to implement any agricultural technology or practice depends on their behaviour or intention to accept or reject it after reasoning the benefit behind the technology.

Therefore, the independent variables provided by this theory were adopted for the conceptual framework. The concept of food availability as a dependent variable in terms of the amount of food produced was considered to be affected by the level of agroecological practices implemented by farmers. The dependent variable, which is the outcome, is determined by farmers' attitudes, subjective norms, and perceptions regarding the implementation of agroecological practices.

1.8 Conceptual Framework

This study conceptualises that for the household to be food secure in terms of available food, it needs to implement agroecological practices at a certain level. The implementation of agroecological practices is thus an important step towards food availability. According to the theory of planned behaviour, the main factor in determining an individual's behaviour is their intention. Thus, the implementation of agroecological practices for smallholder farmers depends on their intention to accept or reject the implementation of agroe-

cological practices based on knowledge gained through training. Socioeconomic characteristics of individuals serve as background influences on their attitudes and perceived behaviour towards implementation (at varying levels), which in turn have an influence on food availability. The assumption is that the high level of implementation can lead to increased productivity and subsequent adequate food availability. While the medium and low levels of implementation of agroecological practices are likely to lead to moderate and low food availability respectively.

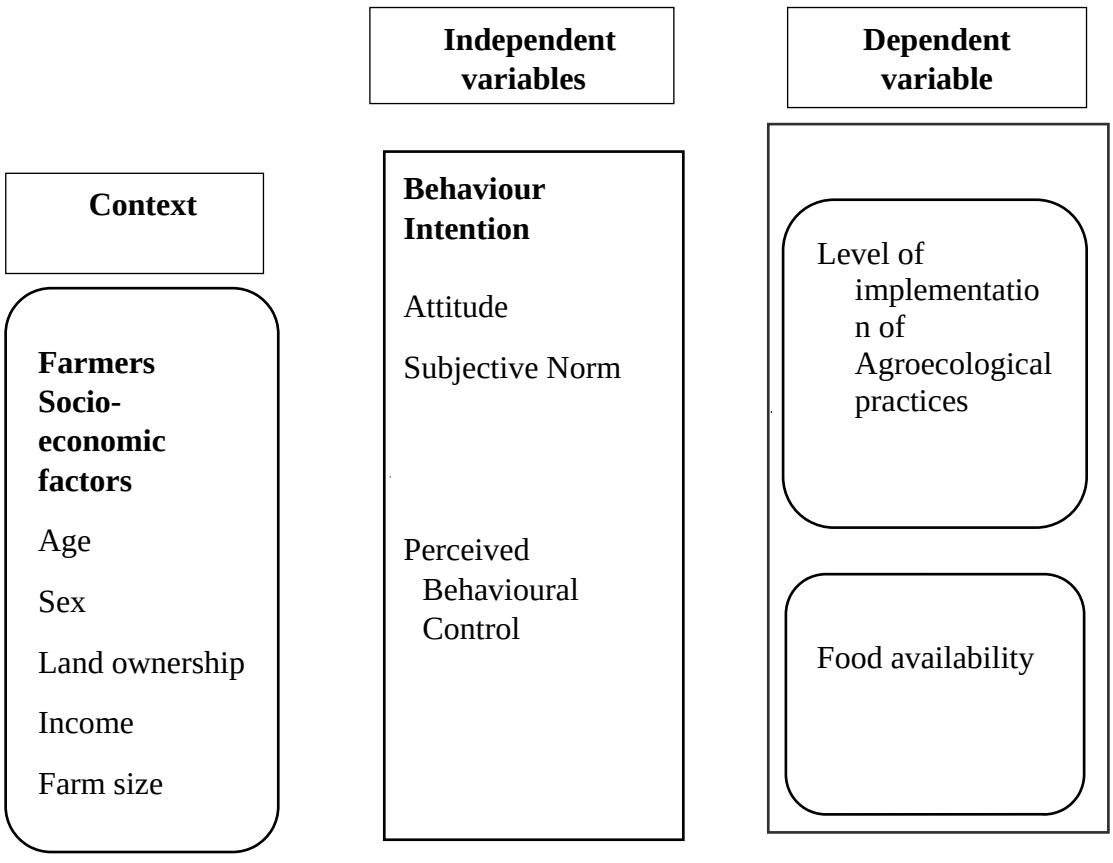

Figure 1.1: The theoretical framework of the study

1.9 Research Methodology

1.9.1 Description of the study area

The study was conducted in Singida ddistrict which is located in Singida Region, in Tanzania. The district lies between latitudes 3^0 52' and 7^0 34'and between longitudes 33^0 27'

and 35^0 26' East of Greenwich with a total area of 3 387 km^2. It lies in a semi-arid area and therefore experiences a low and short rain season between December and March. It receives an average rainfall ranging from 600 mm to 700 mm per annum. Administratively, the district has 3 divisions, 21 wards, 84 villages, and 439 hamlets. Based on the projected population in 2017, the district has 255 324 (URT, 2017b).

Singida district was selected for this study because it is the place where the FRN RECODA project is being executed. The project provides various capacity building through training on agroecological practices that aim to improve soil fertility and subsequently increase crop yield and food availability. The project is being implemented in nine wards and nine villages. The study included both FRN and non-FRN members in four wards, namely Mrama, Ntonge, Maghojoa and Ilongero. The wards were chosen for comparison because farmers in Mrama and Ilongero wards were implementing agroecology and had been trained by the FRN project, while farmers in Ntonge and Maghojoa wards were not included in the FRN programme.

The majority of farmers are crop growers and livestock keepers, raising cattle, goats, sheep, donkeys, and local chickens. In addition, other farmers engaged in processing, petty business, and fishing. We found that maize, sorghum, pearl millet, sunflower, groundnuts and beans are the main food crops, while sunflower and onions are the cash crops.

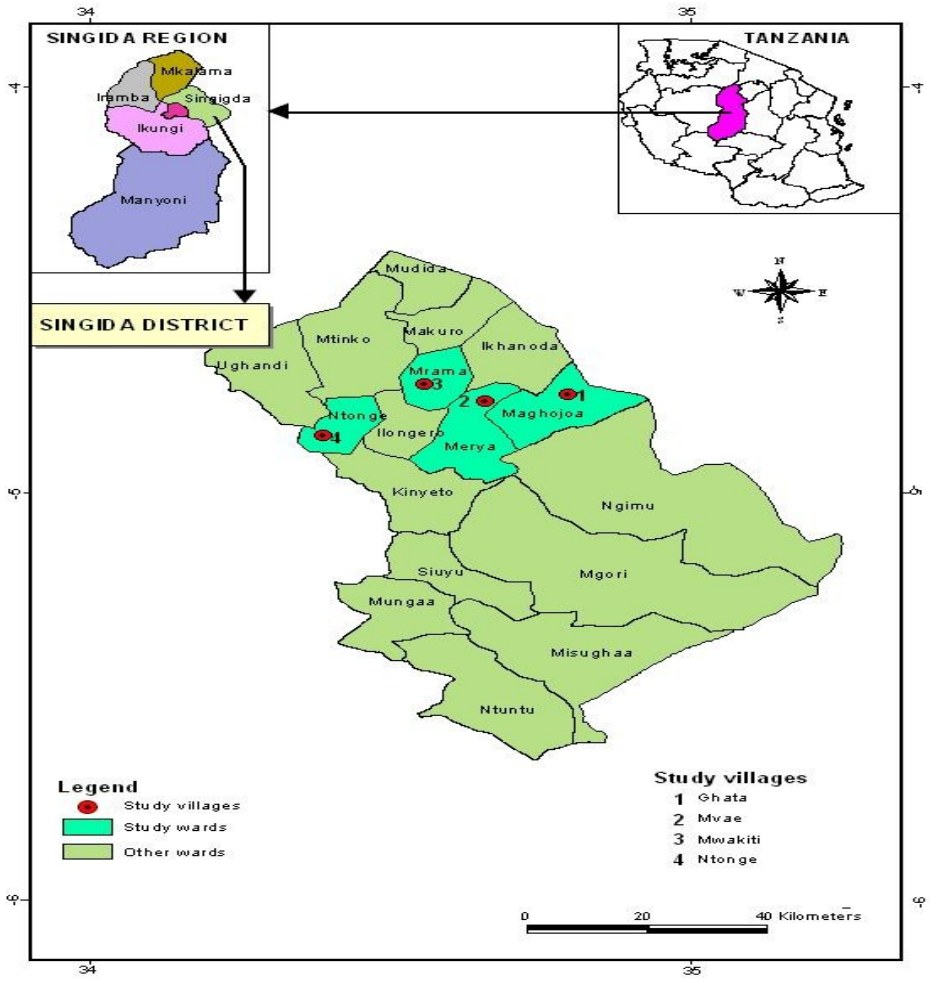

Figure 1.2: A map showing the study area's location. Source: GIS (2021)

1.9.2 Research design

The study employed the "With and Without" approach to examine the contribution of agroecological practices in enhancing food availability among farmers. In this case, the "With the Group", those who were practising agroecology, were compared to the "Without Group" those who were not practising. Those who are practising agroecology were members of the FRN project and were trained, while the other group were non-FRN project members and were not trained. The with and without approach was preferred over the "Before and After" because of the drawback of comparing households over different rainy seasons, whereby the differences would have been due to differences in rainfall other than the practices. As a result, data were collected for a single cropping season, with the as-

sumption that differences in yields were caused by one's involvement or lack thereof in agroecology, and that environmental conditions were similar in all study villages. The study populations were both beneficiaries and non-beneficiaries of the FRN project.

1.9.3 Sampling techniques and sample size

A multistage purposeful sampling procedure was applied to select one division, wards and villages. The first stage was the selection of one division among the two divisions where the FRN project operates. The selection takes into consideration the distribution of wards that are within the project area and wards that are outside the project area. The second stage involved the purposive selection of four wards; two wards within the FRN project area and the other two in a non-FRN project area. The third stage involved selecting one village at random from the two FRN ward project areas and purposefully selecting two villages from a non-FRN project area, for a total of four villages. The fourth stage involved the random selection of 40 households from each village using a lottery system. An attempt was made to represent all the sub-villages in each village. The formula by Kothari (2004) was used for determining an unknown population size as well as a sample size of 160 respondents.

A sample size was determined by a single formula as indicated below:

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

This formula is for a sample size for a study with an unknown (infinite) population size.

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; $no = \frac{1.96^2 * 0.5 * 0.5}{0.0775^2}$ = 159.9 ~ 160.

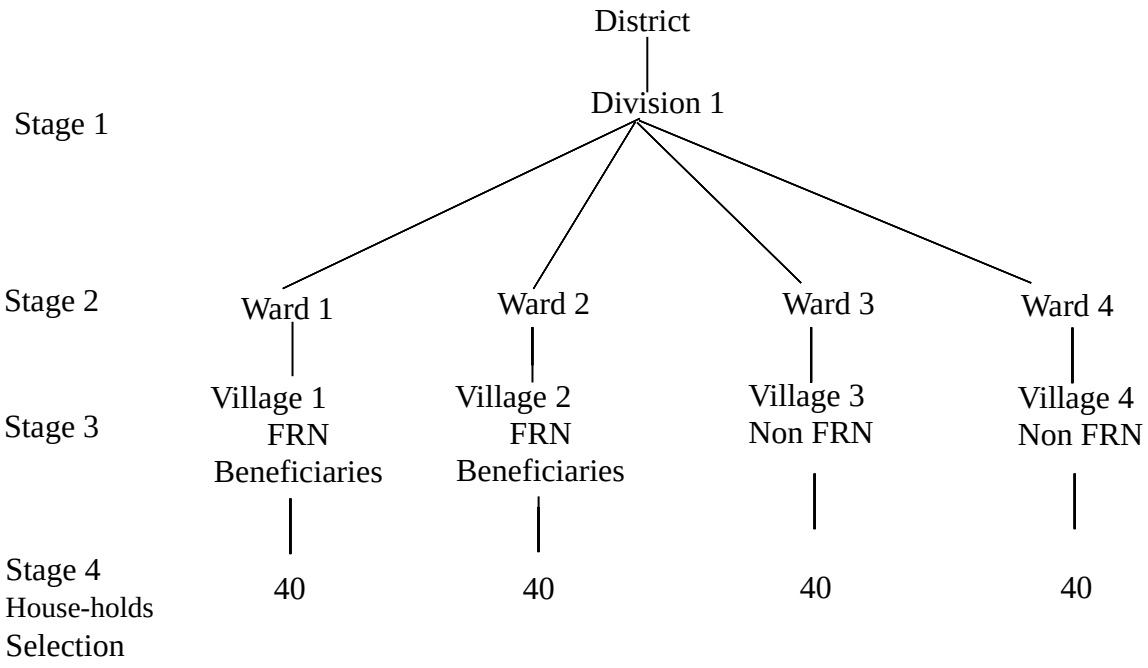

Figure 1.3: Multistage purposeful sampling procedure

1.9.4 Data collection

In this study, both quantitative and qualitative primary data were collected for triangulation purposes. A structured questionnaire with open-and closed-ended questions was used to collect quantitative data. The questionnaire was initially prepared in English and later translated into Kiswahili for effective administration. Before the actual household survey, the researcher pretested the tool with 12 respondents, 12 each from FRN and non-FRN villages outside the study sites, but they were under similar field conditions. Thereafter, the tool was modified accordingly. The tool captured various socio-economic characteristics of the respondents; the extent of implementation of agroecological practices and their con-

tributions to food availability; farmers' perceptions of agroecology and the factors influencing the implementation of agroecological practices.

Focus group discussions (FGDs) and key informant interviews (KIIs) were used to collect qualitative data in each study village. One FGD per village was conducted. The FGDs participants range from 8 to 12. Consideration was made for sex (female and male), experience and a clear understanding of agroecology farming. The key informants consist of two leaders from the FRN project, two ward agricultural extension officers and four village leaders. They provide overview information about the status and constraints of the implementation of agroecological practices at the study sites. An interview guide guided the interview with the key informants. Secondary data on agroecological practices and the factors influencing their implementation were gathered from a variety of sources, including project and government reports, journals and the Sokoine National Agriculture Library (SNAL). The intention of consulting archival material was to get a picture of the uniqueness of the current factors that influence the implementation of agricultural and related farming systems.

1.9.5 Data processing and analysis

Statistical Package for Social Sciences (SPSS) version 25.0 computer software was used to summarize, code and analyse quantitative data. On one hand, descriptive statistics (percentages, means and frequencies) were computed for objectives one and three. On the other hand, inferential statistics were performed. For example, the Chi-square test for objectives one and two index scales were developed to gauge the extent of implementation of agroecological practices for objective one; to measure the level of food availability per household for objective two; and to gauge respondents' perceptions of agroecological practices for objective three. In addition, a multiple linear regression (MLR) model was

employed to determine factors influencing the implementation of agroecological practices. The multiple linear regression equation used was as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta n Xn + \varepsilon$, ……..(2)

Where:

Y = the number of agroecological practices implemented by farmers

B = Regression coefficients.

β_0 = Intercept

X_1 …Xn are explanatory variables: sex (0 = Female 1 = Male); level of education (0 = No education, 1 = 7 years, 2 = 11 years, 3 = , 13 years 4 = 1year, 5 = 12 years, 6 = 12 years, 7 =16 years); Age (Number of years); Household size (Number of people per household); Land ownership for agricultural activities (1 = Yes, 0 = No); Land size used for food crop production (Number of acres); Benefits obtained from practising agroecology (1 = Yes, 0 = No); Training attended on agroecological practices (1 = Yes, 0 = No); Household income (1=Yes, 0=No) ε = error term.

Content analysis was used to analyse qualitative data and emerging themes from FGDs and KIIs were identified, described, and discussed. The content analysis involved transcription, translation of the content, and the development of themes. In the theme development process, the listing and categorization of different types of information were first done. Then the listed information was reviewed to see the relationship with the study. Then the relevant information was analysed into themes, which were reported as research findings.

1.10 Limitations of the Study

The first limitation of this study is that it looked at the availability of an adequate amount of food produced domestically with or without employing agroecological practices. The

findings may not be very accurate to draw conclusions on food availability in households since the data of harvested crops was taken for only one year of harvest. This might not be precise for comparison, so there is a need for further research to compare harvests for two to three consecutive years of production and measure productivity per unit area. The second limitation was the nature of the respondents in the household survey. It was difficult to obtain accurate information from respondents who are non-FRN members due to a lack of knowledge about record keeping. The unit of measurement also differed from a researcher's understanding. Through observation, it was easy to know the real amount that farmers meant, especially for poor harvested crops.

1.11 Organisation of the Dissertation

This dissertation is organised into four chapters: **Chapter One** "Introduction," sets the stage. It reviews relevant concepts and the theoretical and empirical foundations of this study. It also provides a problem statement, justification, the general and specific objectives, and research questions. The chapter further presents the research conceptual framework, research methodology, and study limitations.

Chapter two presents manuscript number one, which stems from objectives one and two and is titled: "Contribution of Agroecological Practices to Household Food Availability: A Case Study of Singida District." **Chapter Three** presents Manuscript Number Two, which assesses farmers' perceptions towards the implementation of agroecological practices to enhance food availability. **Chapter four** presents a published paper emanating from objective four, titled "Determinants of Implementation of Agroecological Practices among Smallholder Farmers in Singida District." **Chapter five** highlights a general discussion of the study findings. It presents key messages emanating from each specific objective.

Chapter six which is the last chapter of this dissertation, comprises of two sections: conclusion and recommendation. In the conclusion section, key lessons learned or implic-

ations of the study are presented. Section two provides recommendations that are proposed to be addressed by different actors at the study sites as well as at regional and national levels.

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CHAPTER TWO

PAPER ONE

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

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Abstract

The study was carried out to assess the extent of implementation of agroecological practices and their contribution to food availability at the household level. The comparison was made between the FRN participating households, who are the implementers of agroecological practices and non-FRN participating households (non-implementers) in Singida district, where the FRN project operates. Using a cross-sectional research design, 160 smallholder household heads were randomly selected and surveyed. A structured questionnaire was administered to household respondents; an interview guide for key informants was conducted; a checklist for the focus group discussion was prepared. Descriptive statistics (involving the calculation of means, frequencies and percentages) and multiple linear re-

gression were performed for quantitative data analysis. Thematic analysis was used to analyse qualitative data. The study revealed that most FRN-participating households had adequate food availability. The knowledge and skills gained through training on agroecological practices influenced FRN participating farmers to implement more agroecological practices compared to their counterparts. The implementation contributed to increased crop productivity and subsequent food availability in households. The study, therefore, concludes that the more farmers implement agroecological practices, the more likely the availability of food at the household level. There is a need for various stakeholders (public and private organizations) to come up with long-term strategies that will emphasise the adoption of agroecological farming in areas impacted by climate change and soil degradation.

Keywords: Agroecological practices, Contribution, Food availability, Households

2.1 Introduction

The emergence of industrial agriculture in the 1950s and its eventual diffusion worldwide superseded the agricultural system, which primarily depended on the natural ecosystem and biological processes (Palomo-Campesino *et al.,* 2018). It replaced traditional farming, especially in areas that were dominated by large-scale farming, while in areas where they normally practised on a small scale, they continued with their traditional farming. Industrial agriculture focuses on increasing yield per unit area through agricultural intensification. It is characterised by the extreme use of inorganic fertilizers, synthetic pesticides, and hybrid or at best-improved seeds, and in some cases, replacing the use of organic fertilizers, cultural methods of weed and pest control, and use of traditional seeds. Evidence shows that industrial agriculture is responsible for reducing the diversification of crops grown (Therond *et al.,* 2017) and affecting land productivity within a short time (Oteros-Rozas *et al*., 2019). It is associated with several benefits, including high yield, standard produce, and easy management since it allows mechanization.

Despite these benefits of industrial agriculture in the short run, in the long run, it faces substantial negative environmental and social-economic consequences, including land degradation, reduction in soil fertility, and health problems caused by exposure to pesticides in the majority of small-scale farmers (Gallardo-López *et al.,* 2018). Socio-economically, it created classes between farmers with the ability to purchase expensive external inputs and those who could not afford to buy those technologies (parmentier, 2014; Palomo-Campesino *et al.* 2018).

The evidence clearly shows that land degradation and soil exhaustion are linked to industrial agriculture, which in turn leads to low crop productivity and food and nutrition insecurity (FEWSNET, 2012). In recent decades, agroecological practices have been promoted

as an alternative to industrial agriculture because they can restore or maintain soil fertility and increase crop yield without or with little effect (Wezel, 2015; FAO, 2018).

This study defines agroecology as the application of agronomic practices which aim to produce high yields through the best use of ecosystem services without depending on external synthetic fertilisers and pesticides while protecting the environment (Silic, 2014; Wezel *et al.,* 2020). These practices include no or minimum tillage; intercropping' crop rotation; cover cropping; mulching; terracing and contour ridges; and incorporation of organic fertilisers and pesticides (Silic, 2014; Mockshell and Villarino, 2018; Oteros-Rozas *et al*., 2019; Wezel *et al.,* 2020). Agroecological farming also includes crop-livestock integration and crop diversification.

According to Gliessman (2015) agroecological practices can improve agricultural productivity and yields of many crop commodities by 50% or above while protecting the environment and restoring degraded agroecosystems. In their study, Trail *et al.* (2016) found that inter-cropping and crop rotation increased millet yield and legume yield by 60% and 36%, respectively. Similarly, Miyashita (2006) reported that a suite of soil management practices (cover crops, terracing, mulching, crop rotation, intercropping, and organic fertilizer) led to improvements in yields for all cultivated crops, with 11% higher maize yields, 11% higher cow pea yields and 56% higher pumpkin yields compared to crops under conventional production. Likewise, the Oakland Institute (2014) reported that 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 realised when farmers used practices of legume diversification, crop rotation, no-till and agroforestry, compared to fields where they had not applied these practices (Arslan *et al.*, 2017). Furthermore, Levard and Mathieu (2018) reported that the application of or-

ganic fertilizers and terracing to control soil erosion had raised yields from 0.7 tonnes/ha to 1.2 tonnes/ha.

In Tanzania, agroecology has been proposed as an alternative to industrial agriculture since the 2000s. Investment in agroecology is considered a necessity for sustainable and inclusive food systems. The government of Tanzania, in collaboration with Non-Government Organisations (NGOs) and other development agencies, promotes the adoption and implementation of agroecological practices in various regions. The Research Community and Organisational Development Association (RECODA) is one of the NGOs implementing agroecological practices through the Farmer Research Network (FRN) project. The project is being implemented in Singida district which is located in Singida Region Tanzania. The FRN project has trained more than 4000 farmers in the principles and practices of agroecological farming, including integration of leguminous plants (such as pigeon peas, groundnuts, and chickpeas) with cereals (maize, sorghum) to enhance nitrogen fixation; application of farmyard and compost manure to increase soil fertility; cover crops and mulching to protect topsoil from wind and water erosion and conserve soil moisture; and nine seeded holes to conserve moisture and enhance aeration (RECODA, 2014) The current study aimed at understanding the extent of implementation of agroecological practices by smallholder farmers and how these practices contributed to food availability in the study area. Using the Theory of Planned Behaviour by Ajzen (1991), the study examined the extent of implementation agroecological practices and their contribution to household food availability.

2.2 Theoretical Framework

The study used the Theory of Planned Behaviour (TPB) to understand the level of implementation of agroecological practices among smallholder farmers. The level of imple-

mentation was conceived to be an important step towards food availability, and ultimately, food security. The theory was proposed by Ajzen (1991) as an extension of the theory of reasoned action developed by Fishbein and Ajzen (1975). The theory is designed to predict and explain human behaviour through personal and social factors. Its emphasis on the main factor in determining an individual's behaviour is consistentwith the assumption of this study because for smallholder farmers to implement any agricultural technology or practice depends on their behaviour or intention to accept or reject it after reasoning the benefit behind the technology. The assumption is that when farmers are trained about agroecological practices, they change their attitude 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. The concept of food availability as a dependent variable in terms of the amount of food produced was considered to be affected by the level of agroecological practices implemented by farmers. The dependent variable, which is the outcome, is determined by farmers' attitudes, subjective norms, and perceptions toward the implementation of agroecological practices.

2.3 Conceptual Framework

This study assumes that for the household to be food secure in terms of available food, it needs to implement agroecological practices at a certain level. The implementation of agroecological practices is thus an important step toward food availability. According to the theory of planned behaviour, the main factor in determining an individual's behaviour is their intention. Thus, the implementation of agroecological practices for smallholder farmers depends on their intention to accept or reject the implementation of agroecological practices based on knowledge gained through training. Socioeconomic characteristics of

individuals serve as background influences on their attitudes and perceived behaviour towards implementation (at varying levels), which in turn has an influence on food availability. The assumption is that the high level of implementation can lead to increased productivity and subsequent adequate food availability. While medium and low levels of agroecological practice implementation are likely to result in moderate and low food availability, respectively (Figure 2.1).

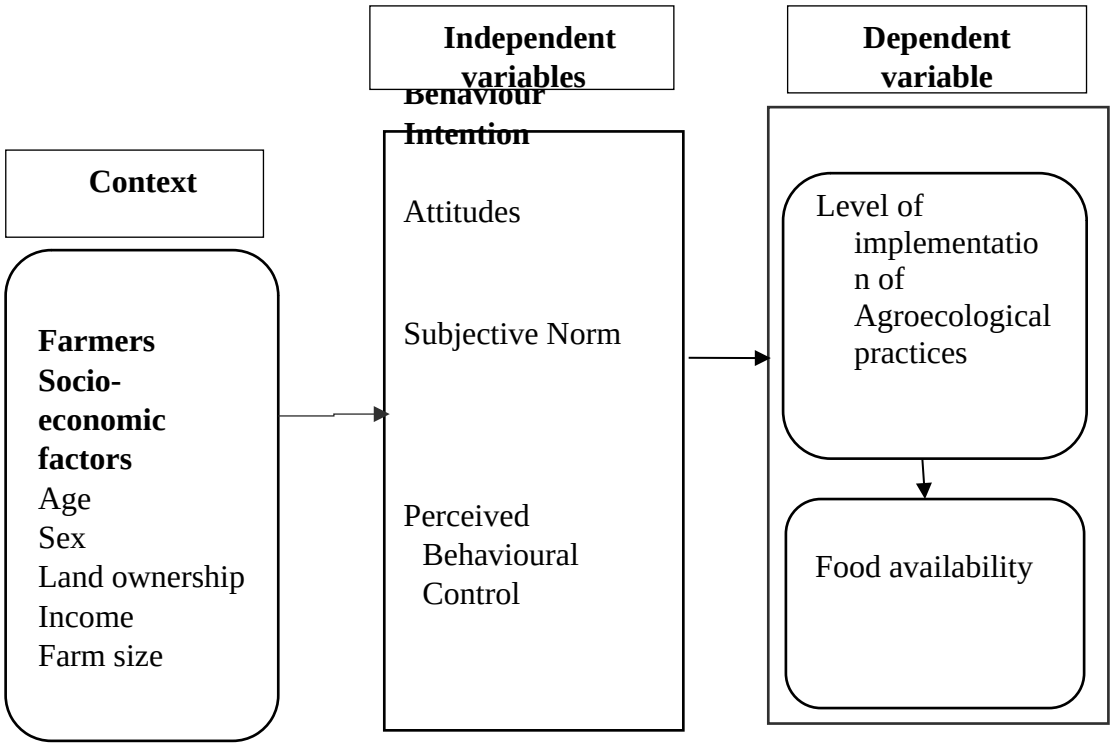

Figure 2.1: Conceptual framework of the study

2.4 Research Methodology

2.4.1 Study area

The study was conducted in Singida District, Singida Region. The district is located in the semi-arid zone of Tanzania. The district lies between latitudes 30 52' and 70 34' and between longitudes 330 27' and 350 26' east of Greenwich, with a total area of 3 387 km2. The precipitation regime in the district is unimodal, receiving one season of rainfall per

year with low levels of rainfall ranging from 600 to 700 mm falling between December and March. The low amount of rainfall contributes to low production and subsequent food and nutrition insecurity. The choice of Singida district as a study area was due to its involvement in the FRN project, which was aimed at training and motivating smallholder farmers into practicing agroecology.

The livelihoods of smallholder farmers consist primarily of diversified agricultural systems (crops and livestock keeping). They tend to be more at the subsistence level than the commercial farming level (Isinika *et al.,* 2021). Farmers also engage in processing, petty business, and fishing activities. The prevailing crops are maize, sorghum, pearl millet, groundnuts, and beans for food, while sunflower and onion are mainly income sources. Livestock raised includes cattle, goats, sheep, donkeys, and local chickens. According to the 2012 Tanzania National Census, the population of Singida district was 225 521, but the projected population in 2017 was 255 324 (URT, 2017). Moreover, the study was specifically conducted in four villages that were purposely selected to represent the diverse socio-economic and land resource endowment characteristics of the farmers and the study areas, respectively (Figure 2.2).

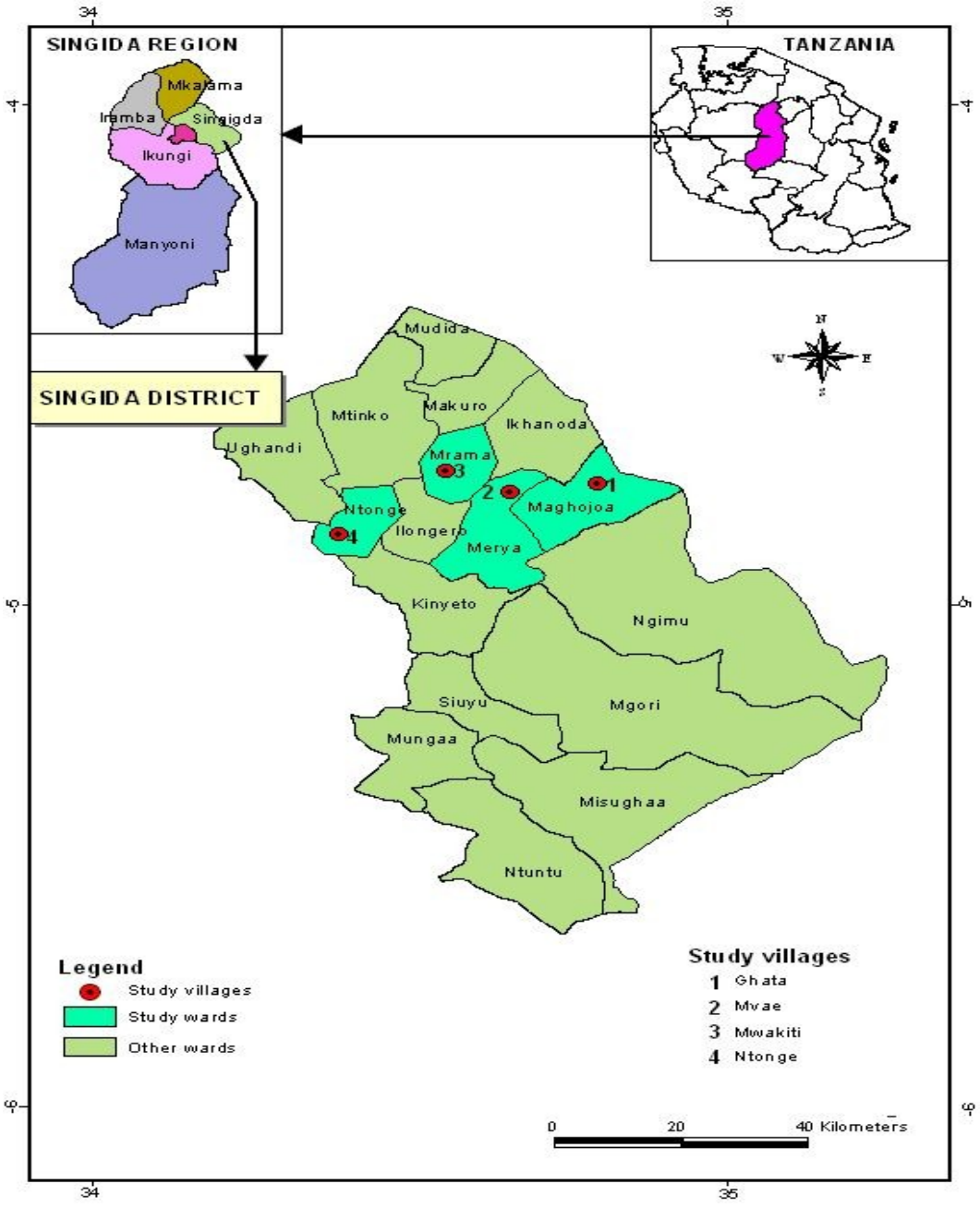

Figure 2.2: Map showing the location of the study area Source: GIS (2021)

2.4.2 Research design, sampling procedure and sample size

The study used a cross-sectional research design. Primary data was collected from farmers at one point in time. The design was selected because it can provide a comprehensive picture of the problem being investigated (Clark and Ivankova, 2016), is a suitable approach for determining the relationship between and among variables at a specific time, and is

economical in terms of time and financial resources (Cresswell, 2014). The study employed purposive, multistage and simple random sampling techniques as detailed hereunder.

Firstly, Singida district was purposively selected since it is the working site of the FRN project. Secondly, the Ilongero division was selected out of the two divisions implementing the FRN project. Thirdly, Merya and Mrama wards (within the FRN site) and Maghojoa and Ntonge wards (outside the FRN project) were selected purposively. Fourth, it involved randomly selecting two villages, Mwakiti and Mvae villages, to represent FRN working sites and purposefully selecting Ghata and Ntonge as non-FRN villages. The non-FRN villages are purposively selected in order to get the villages that are adjacent to the randomly selected FRN villages so as to obtain the study villages from the same agroecological zone. Lastly, the household heads (respondents) were randomly drawn from the sampling frame project register for FRN and the village register for non-FRN household heads. In each village, 40 household heads were randomly selected using a lottery system in which an attempt was made to represent all the village hamlets in each village. According to NBS (2014), a household is a group of individuals who share the same center under the responsibility of a head whose authority is recognised by all the members. As indicated hereunder, the formula by Kothari (2004) for an unknown population size was used to determine a sample size of 160 respondents.

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

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; $no = \frac{1.96^2 * 0.5 * 0.5}{0.0775^2}$ = 159.9 ~ 160.

To get a distribution of sample size for each village, a method of proportional allocation was used under which the size of the sample from each stratum is kept proportional to the size of the strata (Kothari, 2004). And the formula for proportional allocation is given below:

$$ni = np,$$

Where; *ni* is the sample from each stratum, *p* is proportion, *n* is the sample size.

Thus; *n* = 160, *p* = 0.25 (the proportional of 4 villages = ¼) Then, *ni* = 160*0.25 = 40.

2.4.3 Data collection methods

Primarily, data related to the level of implementation of agroecological practices was collected. Since the implementation of agroecological practices was to be associated with food availability, data related to household food availability was also collected. Both quantitative and qualitative primary data were collected. A structured questionnaire with open and close-ended questions was used to collect quantitative data. Specifically, data on the extent of agroecological practices implementation and their contribution to food availability was collected. In addition, data related to livelihood activities carried out by farmers, crops grown, and yields harvested, sold and consumed were collected. Before the actual data collection, a pretest was done for 12 respondents from FRN villages who were not selected for the study and the other 12 respondents were selected from non-FRN villages but they were under similar field conditions. Thereafter, the tool was modified accordingly. Focus group discussions (FGDs) and key informant interviews (KIIs) were

used to collect qualitative data. One FGD per village was conducted – making a total of four. The number of FGD participants ranged between 8 and 12. The purpose of conducting FGD was to get information about the agroecological practices that were implemented by farmers in the area and their contributions to crop yield and food availability. The first FGD was conducted in an FRN village with twelve participants (4 males and 8 females) and the second FGD was conducted in another FRN village with ten participants (4 males and 6 females). The third FGD was conducted in a non-FRN village with eight participants (3 females and 5 males), and the last was also in a non-FRN village with ten participants (3 females and 7 males). Consideration was made for sex (females and males), experience in FRN, and a clear understanding of agroecological farming. The KIIs were used to collect qualitative data to supplement those obtained through the survey as well as for triangularization purposes using an interview guide. A total of nine key informants were selected purposefully based on their experience, expertise and involvement in the implementation of agroecological practices. These were two FRN project leaders: one project coordinator; one training officer; two Ward Agricultural Extension Officers; and village leaders from surveyed villages. They were interviewed to validate information about the extent of implementation of agroecological practices and their associated benefits. They also provided information on the contribution of agroecological practices to food availability at the household level.

2.4.4 Data processing and analysis

Descriptive statistics such as percentages, means, frequencies, and inferential statistics were performed. 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 house-

hold. To capture the amount of food availability, the respondents were asked to mention the amount of each food crop harvested in the 2019/2020 cropping year in bags or tins and thereafter converted to kilogrammes (kg). In this study, “food availability” is referred to as the amount of food available in a household. 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 sold amount. Other externalities such as post-harvest losses, food received as gifts, trading, and saving crops for seeds were held constant. Thereafter, the amount in kg for each food crop harvested was converted into kilocalories (kCal) to get the common energy available for each crop. KCal shows the energy available for each crop because each food crop has different kilocalories (Tanzania Food Composition Tables, 008). All food crops in terms of kilocalories were added up together to obtain a total amount of kilocalories per household (composite index). Then the amount of food available per household was divided by the number of family members (family size) to obtain the available food per person per year. This methodological approach was adapted as recommended by other scholars (e.g., the World Food Programme [WFP]). 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 x 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.

2.5 Results and Discussion

2.5.1 Extent of implementation of agroecological practices

Levels of implementation were considered high, medium, or low. High implementation levels were considered for farmers implementing nine to eleven practices, whereas those implementing one to four practices were categorised as low implementers. Results indicated that among the FRN participating farmers, 15% were in the high implementation category, 68% were in the medium category, and 16% were in the low implementation category. On the other hand, for the non-FRN participating farmers, 24% were medium implemented, 76% were low implemented, and none of them was in the high category (Figure 2.3). The results indicate that the majority (83%) of FRN-participating farmers fall in either the medium or high implementation level category, whereas the majority (76%) of non-FRN-participating farmers fall into the low implementation category. Focus Group Discussions showed similar findings. FGD participants at Mvae village reported the difference in agroecological intensification between the FRNs and non-FRNs groups. Participation in the FRN project research activities is linked to farmers' adoption of agroecological practices.

FRN farmers implemented more agroecological practices than their fellow non-FRN farmers. This likely contributed to the training offered by the FRN project. The project has been providing training to farmers on various agroecological practices, principles and ele-

ments. This helped to create knowledge, skills, and awareness for participating farmers. Therefore, the obtained knowledge led FRN participating farmers to adopt and implement more practices than non-trained farmers. The training also helped farmers to understand the advantages and disadvantages of agroecology, making it easier for them to transform into a farming system that is more sustainable than farmers who had never been trained. The findings are in line with Constantine *et al.* (2020) who reported that farmers in Mvomero and Masasi districts implemented more agroecological practices compared to their counterparts (non-trained farmers).

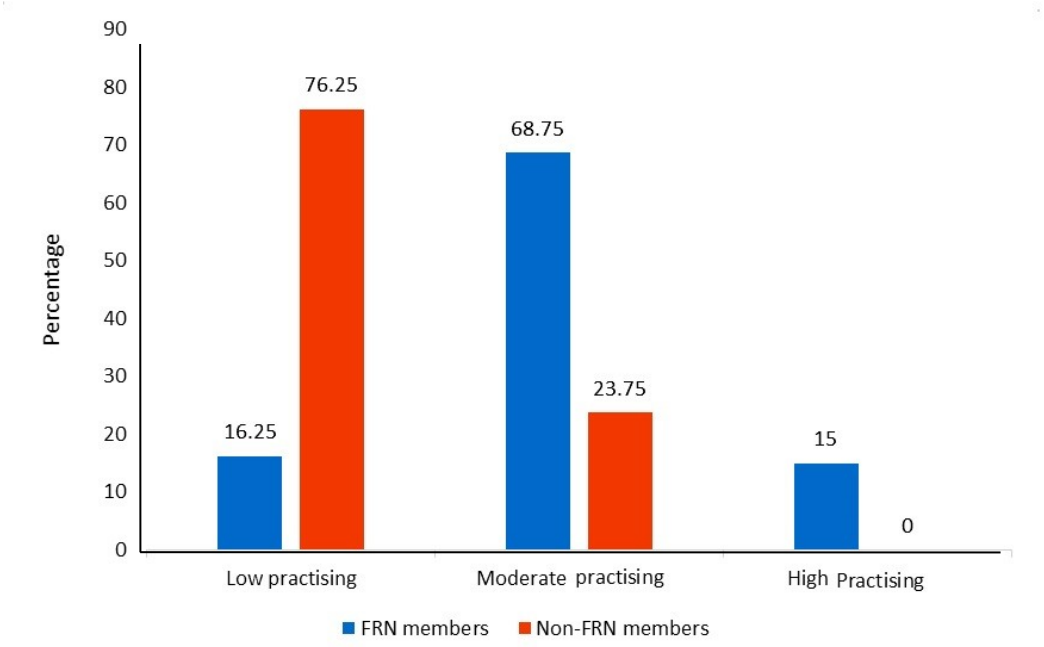

Figure 2.3: Extent of implementation of agroecological practices among FRN and Non-FRN farmers

2.5.2 Common agroecological practices implemented by the respondents in the study area

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 prob-

ably why. Table 2.1 presents the distribution of responses to the agroecological practices commonly implemented by FRN and non-FRN framers.

The most common practices were; (i) the use of organic fertilisers including farm yard manure (FYM) and compost manure (96%), (ii) intercropping (88%), (iii) crop rotation (82%), and crop and livestock integration (79%). In terms of fertiliser, this means organic fertiliser is mostly used compared to inorganic fertilizer. This is likely because the project promotes agroecological farming to restore soil fertility and hence increase crop productivity. Similarly, the FGD findings showed that an application of farm yard manure (FYM) and compost manure ranked the highest, the first and second types, respectively. The compost manure consists of crop residues, green plants, ashes, animal wastes and water. They are left for at least one month to make sure the materials are well rotten. Generally, the results in Table 2.1 indicate very marginal differences in the implementation of common agroecological practices between the supported (FRNs) and non-supported (non-FRNs) respondents. This is likely because the beneficiaries and non-beneficiaries are living and farming in the same agroecological location where they are facing similar challenges, for instance, low soil fertility, low crop productivity, and low yields; therefore, they are looking for appropriate solutions to address the challenges.

Different forms of intercropping (row, mixed and relay intercropping) were found to be commonly implemented by the majority of farmers of both groups, participating and non-participating FRN farmers (Table 2.1). This implies that farmers understand the potential benefits of intercropping in increasing crop yield and reducing the risk of total crop failure. It emerged, during FGD at one of the villages, those farmers associate increased crop yields with planting more than one crop on one plot at the same time (intercropping). Farmers were also found to consider intercropping as a way to reduce the risk of total crop loss in the event of unfavourable weather. Crop rotation was also found to be widely used

by the majority of farming households, (82% and 74% for FRN and non-FRN households respectively). It was learned that farmers are aware of and understand 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 practised by both groups, participating and non-participating FRN farmers. During FGD, farmers reported that they normally use those practices as their traditional farming practices regardless of training. The majority of non-participating FRN farmers were found to implement agroecological practices at a low level. Four practices were identified: use of organic fertilizer, intercropping, crop and livestock integration, and crop rotation are among those they implement without following its principles since they are not trained. This is why they were practising a low level. FRN farmers apply the principles when implementing because they are knowledgeable about them and they apply more than common practice.

Table 2.1: 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%.

In addition to the common agroecological practices, FRN participating farmers have been observed to implement, at varying levels, other agroecological practices such as nine-seeded holes, Chaka hoe (Zambian hoe) and pest and disease control using plant-based substances, as shown in Table 2.1. These practices were not traditional; they had been introduced by the FRN project, and farmers were trained and started to implement them based on the knowledge provided, indicating that FRN households were familiar with different types of agroecological practices compared to non-FRN households. Based on this finding, FRN households are more likely to apply a wide range of agroecological practices compared to non-FRN households who had never received training. This implies that knowledge and skills obtained from training and subsequent adoption of agroecological practices are important in agroecological transformation. The findings are similar to those of Udimal *et al.* (2017) and Schoonhovena and Runhaar (2018), who also found that training is one of the basic conditions for information dissemination and adoption of any technology.

2.5.3 Status of food availability among FRN and Non-FRNs households

The results in Table 2.2 present the status of food availability among FRN and non-FRN households in the study villages. The results show that about 74% of the FRN households had adequate food compared to non-FRN households (23%). Moreover, households with surplus food were relatively few, at 13% and 8% for the FRN and non-FRN households, respectively. The findings imply that FRN-participating households were better off than non-FRN households in terms of food availability and likely food security.

Observations from two FGDs involving farmers participating in FRN indicated that they had adequate food for home consumption from the previous growing season. On the other hand, results from the two FGDs involving farmers who are non-FRN participating house-

holds indicated that their households had not had adequate food from the same growing season. One of the FRN participating farmers said:

"Since implementing agroecological practices on my farm, I've had more food available." Now I can cultivate and harvest maize, sorghum, sunflower, beans and chicken peas more than in the past five years. I have adequate food throughout the year."

As for the farmers who used nine seeded holes, for example, one FGD participant claimed to have been able to increase maize yields from 3 bags per acre (300 kgs) to 20 bags/acre (20 000 kgs/acre). The implementation of agroecological practices such as nine seeded holes and chaka hoe helped farmers to increase crop production, especially for maize, since the study area is located in semi-arid conditions where they experience variability in rainfall and relatively low. Therefore, these technologies play a great role as they enhance moisture storage and soil fertility improvement (Keya *et al.*, 2021). It was also reported during the FGD in Mvae village that pigeon peas, lablab and cowpeas are new crops introduced by the FRN project that boost productivity and yields of other crops, hence contributing to adequate food availability. Furthermore, the findings revealed that although both FRN and non-FRN farmers used organic fertilisers, did intercropping, crop rotation, and crop and livestock integration, the status of food availability differed. This is likely because FRN households were knowledgeable about the right way of using agroecological practices and principles, implying that farmers have changed their attitudes and perceptions towards agroecological farming. The results show that non-FRN-participating farmers harvested an inadequate amount of food, probably because they practised agroecology at a low level and they implemented without following the principles since they had never been trained.

The study findings are consistent with those of Kangmennaang *et al.* (2017) and Chappell *et al*. (2018), who found that farmers who implemented agroecological practices in Malawi and Senegal had higher crop yields and were more food secure in terms of food availability than their counterparts. However, these findings are contrary to Meemken and Qaim (2018), who find low yield when a farmer uses organic farming compared to yield obtained from industrial agriculture because of the synthetic agro-inputs. This is also likely because of an appropriate way of using organic fertiliser.

Table 2.2: 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)			

2.5.4 Contribution of agroecological practices to household food availability

The Chi-square results show a significant association between the level of implementation of agroecological practices and food availability (p-value = 0.000) (Table 2.3). This implies that the more farmers implement agroecological practices the greater the chance for them to have enough food available for their households. In comparison between FRN and non-FRN participating respondents, the FRN had more adequate food available to their families than non-FRN households. This is possible because the FRN was at a moderate level of implementation of agroecological practices compared to the low level of non-FRN.

Based on these findings, the FRN RECODA project intervention in the agroecological farming system is likely to have a great contribution to food availability in Singida district.

Therefore, Singida local government authorities need to emphasise and promote the adoption and implementation of agroecological practices and elements to increase crop productivity and subsequent food availability at the household level. The knowledge and skills gained by the FRN household are essential for agricultural transformation from low to higher crop yields. The practical implication of these findings for other agricultural practitioners is that there is a need to promote the implementation of best agroecological practices.

Table 2.3: Contribution of agroecological practices to household food availability

Household membership	Food availability level kCal/person	Agroecology practicing level				
		Low	Moderate	High	Chi-Square	Sig. level
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

Likewise, from the synthesis of qualitative results during the FGD in Mwakiti village, the implementation of agroecological practices plays a major role in soil fertility improvement, which enhances crop productivity and ultimately increases food availability and security. Mixed cropping and integrated crop and livestock keeping were also said to contribute to crop diversification. It was learned during the discussions that farmers were able to harvest several crops at once, for example, maize, sunflower and pigeon peas, on the same piece of land.

This is an outcome of the intercropping intervention introduced by the FRN RECODA project. Farmers also reported multiple benefits associated with the implementation of

agroecological practices including high crop yield, reduced soil erosion, reduced land degradation and biodiversity conservation.

These findings are similar to Ayivor *et al*. (2016), whose study in Ghana reported that practising agroecological practices increases crop productivity and yields, and subsequently food availability at the household level. The authors further declared that agroecology farming reduces the risk of crop failure due to crop diversification. Diversification at the farm level is also likely to increase income after selling the surplus. Moreover, this is contrary to some research which indicates that sustainable means of agriculture production systems produce less compared to the conventional farming system. For example, Alare *et al*. (2018) reported no association between the use of agroecological practices and food availability improvement. Likewise, Limbu *et al.* (2017) found that diversifying farming with integrated livestock production increased the variety and quantity of food available for consumption.

The study can conclude that there is a causal relationship between implementing agroecological practices and amount or level of food available for the household. Level of implementation is concluded to be associated with whether the head or any member of the household being involved or participating in FRN. Therefore, training provided to FRN farmers has changed their perceptions and attitudes towards agroecology. Previously, farmers perceived agroecological practices just like any other farming system. However, after receiving the training, they had different views. The training helped FRN participating farmers with knowledge and awareness-creation. Farmers' positive perception and attitude towards agroecology changed their behaviour and hence they implemented practices that increased food availability more than their counterparts did. On the other hand, non-FRN participating farmers were not aware of agroecology since they were not trained.

Their perceptions and attitudes did not change; they implemented agroecological practices at a low level, resulting in inadequate food availability.

2.6 Conclusion and Recommendations

This paper examined the extent of implementation of agroecological practices and their contribution to food availability at the household level in Singida district, Tanzania. To examine the links between the extent of implementation of agroecological practices and their contribution to food availability. The comparison was made between the FRN households who were trained in agroecological practices and implemented them on their farms and non-FRN households (non-implementers). 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 the higher category of implementation of agroecological practices and thus would benefit more in terms of food availability and probably food security. We found that the FRN household heads were at a moderate level of agroecological practices implementation, whereas the non-FRN household heads were at a low level. Food availability was associated with the level of implementation of agroecological practices. FRN household heads were food secure, particularly in terms of food availability, because they were knowledgeable and skilled in agroecological principles and practices. The study, therefore, concludes that the more farmers implement agroecological practices, the more likely the availability of food at household level. This is due to multiple crops being grown on the same piece of land as well as improved soil fertility through the use of organic fertilisers and mixed cropping. There is a need for the FRN project and local government to continue the emphasis on farmers' implementation of agroecological practices and scale up their interventions to reach a wider community, including farmers outside the FRN villages. There is also a need for various stakeholders (public and private organizations) to come up with long-term

strategies that will emphasise the adoption of agroecological farming in areas impacted by climate change and soil degradation.

Acknowledgments

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CHAPTER THREE

PAPER TWO

3.0 Farmers' Perceptions towards the Implementation of Agroecological Practices for Enhanced Food Availability

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Abstract

The paper debates farmers' perceptions towards the implementation of agroecological practices to enhance food availability in Singida district in Tanzania. Data was collected using a questionnaire survey, where 160 farming households were randomly selected from 4 villages. A Likert scale type of rating question was used to assess farmers' perceptions toward choices for the implementation of agroecological practices. Results showed that about (64%) of the farmers had a positive perception of the reputation of implementing agroecological practices toward enhancing food availability at the household level. This is an indication that farmers recognise the contribution of agroecological practices to household food availability. Farmers were interested in implementing agroecological practices because of their multiple benefits in improving crop production while conserving the environment. Furthermore, the study found that more than half (.53%) of farmers had a neg-

ative perception of the perceived ease of use of agroecological practices, which was most likely due to perceived difficulties and labour intensity in implementing some agroecological practices. Qualitative findings revealed that farmers in the study area develop a strategy of working in collaborative farming groups to address labour intensity challenges. Farmers had a positive perception of the implementation of agroecological practices, so local government authorities and other stakeholders should promote the agroecological transformation to encourage farmers to continue implementing agroecological practices.

Key words: Agroecological practices, Food availability, Perception, Smallholder farmers

3.1 Introduction

Agroecology seems to be the most promising means for increasing agricultural production as well as an accessible and appropriate strategy for poor resource farmers. It involves the application of ecological principles to the design and management of agriculture and food systems, basically to create a sustainable farming environment and maintain biodiversity (Wezel *et al.,* 2015; TWN, 2015). Recently, agroecology has been supported by various stakeholders, development organisations and NGOs based on its potential for improving crop production while conserving nature (Parmentier, 2014; FAO, 2018; HLPE, 2019). Agroecological practices intend to minimise the usage of external inputs while producing a high yield through the best use of internal recycled inputs. Some of the practices which are commonly implemented are minimum or no tillage, biological management of pests, integrated nutrient management, cover crops, mulching and crop-livestock integration (Silic, 2014; Wezel *et al.,* 2014; Palamo-Campesino *et al.,* 2018). Farmers can choose to use all or just a few of these practices, depending on their willingness and ability. Agroecological practices and approaches are guided by agroecological principles such as nutrient recycling, which aims to maximise the use of nutrients generated on farm; diversifica-

tion through the use of local crop varieties and livestock breeds for adaptation to changing environmental conditions; biodiversity enhancement; synergy and favourable soil conditions for soil health, animal health and participation (Silic, 2014; Wezel *et al.*, 2020). Therefore, farming practice may also apply some or all of the agroecological principles. However, its appropriate management is intensive in terms of labour, skills and knowledge.

Studies show that implementation of agroecology contributes to food availability as it encourages diversification in production, which eventually leads to a large total output (Silic, 2014; TWN, 2015; Kerr *et al.*, 2021). The rising agricultural challenges, especially extreme weather conditions that cause a rise in temperature and drought in many countries, have already threatened food production (Oteros-Rozas *et al.*, 2019). Therefore, there is a need to shift into agroecological farming which does not deplete the environment, leading to environmental sustainability and has shown better resilience. This will improve the agricultural output for smallholder farmers and increase food availability.

Agroecology has shown several environmental and social benefits apart from increasing food production. For example, increasing diversification through intercropping, crop and livestock integration, and agroforestry improves the resilience of the farming system, which in turn reduces the risk of pests (TWN, 2015). Other practices such as crop rotations, cover crops, and application of manure improve soil fertility and increase water holding capacity, helping to avoid soil erosion. In addition, the application of manure and crop residue improves the soil quality as the level of organic matter increases, which helps to mitigate climate change variability by sequencing carbon into the soil (Therond *et al.*, 2017). Increases in crop yield and stability, lowers production costs by discouraging the

use of external inputs, and leads to an increase in ecosystem services (Ponsian *et al*. (2015).

Because of the abovementioned benefits of agroecology, it is important to support and promote it by creating policies that will enable its implementation, provision of extension services, availability of fair markets for selling agroecological products and promoting farmer-to-farmer networks. This will help to scale up agroecology among farmers (TWN, 2015). Given the knowledge-intensive nature of agroecology, capacity building through training and outreach to farmers is critical for its widespread adoption. Therefore, awareness creation and regular support are necessary to ensure its uptake. Consequently, this will allow them to shift from the conventional farming system, which uses expensive inputs which are not easily accessible and harm the environment.

The Farmer Research Network (FRN) project, under the Research Community and Organisational Development Association (RECODA), has been providing training programmes and demonstrating the long-term viability of agroecological practices to smallholder farmers in Singida district. FRN also supports farmers by providing credit to run other non-farm activities and farm inputs such as seeds and farm equipment.

Several studies examined farmers' perceptions of specific agroecological practices, such as Majbar *et al.* (2021), who investigated farmers' perceptions and willingness to contribute to environmental sustainability through compost production and use. Souza *et al*. (2018) reported that farmers perceive that the use of agroecological practices, such as green manure improves soil and crop health, allowing the farmer to shift from using industrial fertilisers and agrochemicals in the study which assessed farmers' perceptions on the use of green manure. According to Mamo and Bahiy (2019), farmers in Ethiopia perceive ma-

nure use to be complex and labour-intensive; however, they prefer to use it for soil and yield improvement. Another study by Hayran *et al*. (2018) assessed farmers' perceptions with regard to sustainable agricultural practices. The current study aimed to assess farmers' perceptions towards the implementation of agroecological practices to enhance food availability, which has been little documented by previous studies.

3.2 Methodology

3.2.1 Description of the study area

The study was carried out in Singida district Singida region. The region is located in the central part of Tanzania. The district lies between latitudes 3^0 52 ' and 7^0 34 'and between longitudes 33^0 27 ' and 35^0 26 ' East of Greenwich with a total area of 3 387 km^2. The district lies in a semi-arid area and experiences low rainfall and a short rainy season from December to March. It receives an average rainfall ranging from 600 mm to 700 mm per annum. Administratively, the district has 3 divisions, 21 wards, 84 villages, and 439 hamlets. According to the 2012 Tanzania National Census, the population of Singida district was 225 521, but the projected population in 2017 was 255 324 (URT, 2017).

The main economic activities in the district are crop production and livestock keeping. People also engage in processing, petty business, and fishing. The main animals raised are cattle, goats, sheep, donkeys, and local chickens. Maize, sorghum, pearl millet, sunflower, groundnuts and beans are the main crops produced in the study area for food, while sunflower and onions are the main cash crops grown.

The district was selected for this study because it is the place where the FRN project was being implemented. The project aimed to identify solutions to low productivity caused by soil infertility and mono-cropping that contribute to food insecurity. The FRN project has

been building capacity for farmers through training on various agroecological practices for the purpose of improving soil fertility and subsequently increasing food production. Therefore, the presence of farmers who were trained and practising agroecology was an important reason for the selection of the study area.

The project is being implemented in nine wards and nine villages. The study included both FRN and non-FRN members in four wards, namely Mrama, Ntonge, Maghojoa and Ilongero. The wards were chosen for comparison because farmers in Mrama and Ilongero wards were implementing agroecology and had been trained by the FRN project, while farmers in Ntonge and Maghojoa wards were not included in the FRN programme.

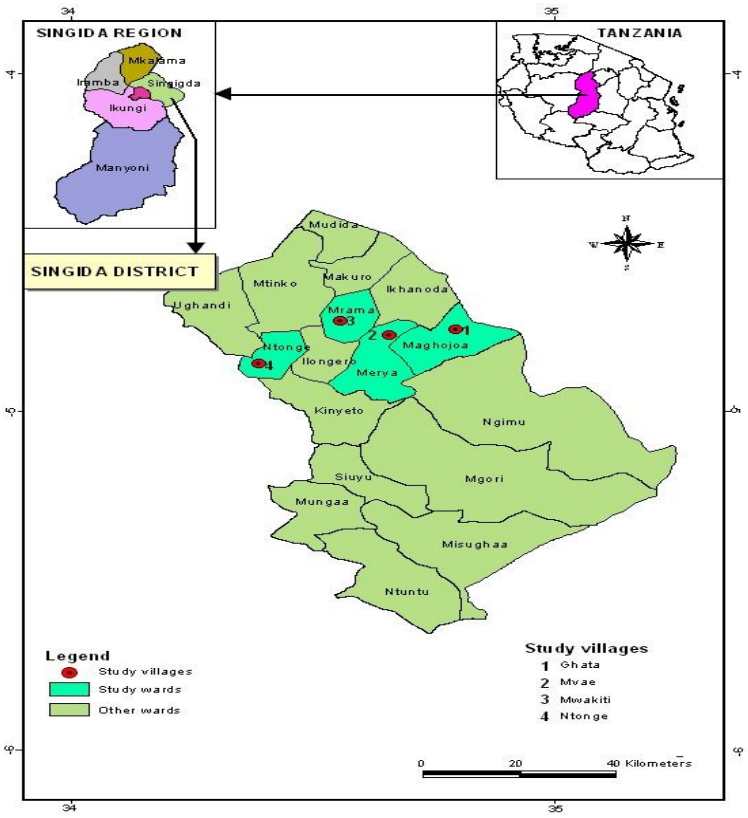

Figure 3.1: Map showing the location of the study area
Source: GIS (2021)

3.2.2 Research design

The study used a cross-sectional research design whereby primary data was collected from farmers at one point in time. A cross-sectional research design was used because it provides a comprehensive picture of the problem being investigated (Clark and Ivankova, 2016). It is also good for determining the relationship between and among variables at a specific time. It is economical in terms of time and financial resources (Creswell and Clark, 2011).

3.2.3 Study population, sample and sampling procedure

The study population comprised smallholder farmers, including both beneficiaries and non-beneficiaries of the FRN project. The sampling frame for FRN was a list of household heads from the project, while for non-FRN farmers it was a list of households provided by the village chairperson.

A multistage purposeful sampling procedure was applied to select one division, wards, and villages. The first stage involved the selection of one division among the two divisions where the FRN project operates. The selection took into consideration the distribution of wards which are within the project area and wards that are outside the project area. The second stage involved the purposive selection of four wards; two wards within the FRN project area and the other two in a non-FRN project area. The third stage involved the random selection of two villages representing the FRN working site and purposive selection of the other two villages for non-FRN villages, making four villages. The fourth stage entailed the simple random selection of 40 households from two FRN villages, making a total of 80 households. With regard to non-FRN villages, 40 households were selected from each village, making a total of 80 households. A household was the unit of analysis.

Sample size was determined using the formula proposed by Kothari (2004) as indicated below:

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

This formula is for a sample size for a study with an unknown (infinite) population size.

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; $no = \frac{1.96^2 * 0.5 * 0.5}{0.0775^2}$ = 159.9 ~ 160.

Therefore, a total sample of 160 households was randomly selected for interview, resulting in an equal distribution of 40 households from each village. Moreover, key informants who were project leaders, village leaders and extension officers were purposively selected.

3.2.4 Data collection

In this study, both quantitative and qualitative primary data were collected for triangulation purposes. A structured questionnaire with open and closed-ended questions (Likert scale type) was used to collect quantitative data. The questionnaire was initially prepared in English and later translated into Kiswahili for effective administration. Before the actual household survey, the researcher pretested the tool with 12 respondents, 12 each from FRN and non-FRN villages outside the study sites, but they were under similar field conditions. Thereafter, the tool was modified accordingly. The tool collected various information on farmers' perceptions of agroecology as a means improving food availability.

Focus group discussions (FGDs) and key informant interviews (KIIs) were used to collect qualitative data in each study village. One FGD per village was conducted. The FGDs participants range from 8 to 12. Consideration was made for sex (female and male), experience and a clear understanding of agroecology farming. The key informants consist of two leaders from the FRN project, two ward agricultural extension officers, and four village leaders. They provide information about their perceptions of agroecological practices and their benefits. An interview guide guided the interview with the key informants.

3.2.5 Data processing and analysis

A Statistical Package for Social Sciences (SPSS) version 25.0 computer programme was used to analyse quantitative data. Descriptive statistics such as percentages and frequencies were calculated and presented in bar and pie charts.

To assess farmers' perceptions towards the implementation of agroecological practices for enhanced food availability, the Likert scale type of rating questions was used. Fourteen statements about agroecological practices for enhanced food availability were asked, while for perceived easy to use practices, 12 statements were asked. The respondents were required to indicate whether they strongly agree (SA), agree (A), neutral (N), disagree (D) or strongly disagree (SD) with each of the statements. Thereafter, the results were computed into three levels from the established five levels. Thus, "Strongly Agree" and "Agree" were grouped as "Agree" and scored (3), Neutral remained the same with a score of (2) while "Strongly Disagree" and "Disagree" were combined into "Disagree" and had a score of 1.

Therefore, the three categories used were: Agree, Neutral and Disagree. Agreed items were treated as positive perceptions towards agroecological practices for enhanced food

availability and disagreements were treated as negative perceptions, while the neutral item showed that farmers had no decision. In the analysis, several assumptions were made. For farmers' overall perceptions, it was said that when a respondent agreed with all 14 practice statements, they would score 42 (i.e., 14 x 3). If one disagreed with all the 14 practice statements, one would score 14 (i.e., 14 x 1) and if a respondent was undecided or neutral with all the 14 practice statements, then he/she would score 28 (i.e., 14 x 2). Thereafter, the scores were combined to give a scale of 14-42. Then, scores below 27 were considered as a reflection of a negative perception meaning agroecology does not enhance food availability, while a score of 28 represented a neutral perception and scores above 28 represented a positive perception that agroecology enhances food availability, as presented in Figure 5.3.

For farmers' perceptions of the ease of implementation of agroecological practices, 12 statements were asked of the respondents if one disagreed with each of the 12 practice statements, then one would score 12 (i.e., 12 x 1). When respondents agreed towards each of the 12 statements, they would score 36 (i.e., 12 x 3) and if one was neutral to all 12 practice statements, then one would score 24 (i.e. 12 x 2). Thereafter, the scores were combined to make a score range of 12-36. Then scores below 24 were considered as a reflection of negative perception, or not easy to use; 24 scores were considered neutral perception; scores above 24 were considered as a reflection of positive perception or easy-to-use agroecological practices as presented in Figure 5.4.

3.3 Results and Discussion

3.3.1 Overall perceptions to enhanced food availability at household Level

Figure 3.3 depicts the findings regarding farmers' perceptions of agroecology as a means of increasing food availability. The results showed that 64% of the respondents perceived agroecological practices as enhancing food availability, while 25% of the respondents did

not perceive agroecological practices as enhancing food availability at a household level and only 11% of the respondents had a neutral perception. This means that the majority of farmers had a positive perception towards agroecological practices enhancing food availability. The positive perception is an indication that farmers recognise the contribution of agroecological practices to household food availability and is probably associated with the other benefits that farmers get through practising agroecology. During FGD with farmers in Mvae village, it was learned that agroecological practices have several environmental benefits, including improving soil fertility, preventing the growth of weeds and reducing pests and disease, as well as increasing crop yields and preventing soil erosion.

The study findings suggested that farmers' positive perception was influenced by the aforementioned multiple benefits offered by practising agroecology. These findings are in line with the findings by Paracchin *et al.* (2020), who found that farmers had a positive perception towards agroecological practices in a study they did in Benin. The positive perception was particularly due to yield improvement, which led to food availability for farmers' households.

Likewise, Hayran *et al*. (2018) pointed out that farmers in Turkey had a positive perception towards sustainable agricultural practices. The reason pointed out by the authors was due to the benefits associated with the use of sustainable practices including efficiency, nutrient recycling and an increase in crop productivity. The positive perception was also based on the benefits of natural resource protection and the avoidance of negative impacts on the environment (Hayran *et al*., 2018).

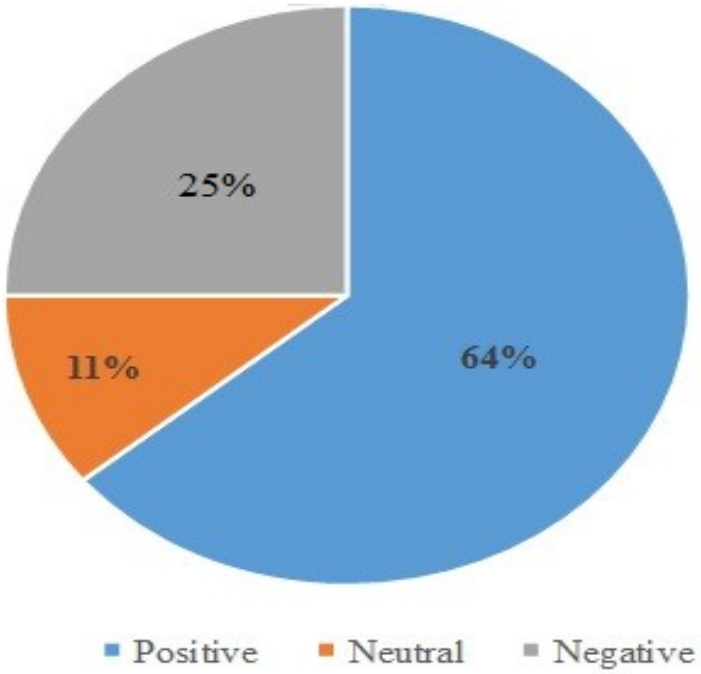

Figure 3.2: Respondents' overall perceptions on agroecological practices to enhance food availability

Furthermore, a statement-by-statement analysis was conducted to determine the mean score of each statement. The mean score was obtained by adding the weights given to each statement by respondents, divided by the total number of respondents for each statement. Based on the mean score obtained, position rankings were allocated.

The study findings (Table 3.1) showed that the statement which received the highest rating, with a mean score of 2.97, was "*Crops and livestock integration increase crop productivity.*"

This was contributed by benefits obtained by farmers from integrating crops and livestock. Crop and livestock integration led to the availability of crop residues and animal manure for nutrient recycling and improved soil fertility, as reported by one KII during an interview which was conducted at Mvae village on April 21, 2021.

The second highest-rated statement was "*Crop diversification enhances food availability,"* which scored 2.92. This was followed by a statement which scored 2.91 and read as follows: "*Crop rotation improves soil nutrients and hence increases crop productivity, which in turn enhances food availability."* The fourth highest-rated statement scored 2.90 and read, "*Intercropping allows efficient use of space, leading to increased crop production."*

The higher rating of these practices probably contributed to their benefits in improving crop yield. A study by Chappell *et al*. (2018) reported that crop diversification, which is comprised of crop rotation, intercropping and crop and livestock integration, led to an improvement in crop yield. In addition, Hayran *et al*. (2018) reported that crop rotation and intercropping practices improve soil quality by reducing pest and disease infestation and soil erosion, resulting in increased crop yield.

Table 3.1: Respondents' statements wise score on perceptions of agroecological practices to enhance food availability

Statement	A=3	N=2	D=1	TS	MS	RANK
Crop and livestock integration increases crop productivity.	158(98.8)	1(0.6)	1(0.6)	476	2.97	1
Crop diversification enhances food availability	148(92.5)	11(6.9)	1(0.6)	467	2.92	2
Crop rotation increases nutrients	151(94.4)	4(2.5)	5(3.1)	466	2.91	3

and interrupts pest life cycle						
Intercropping allows efficient use of space	151(94.4)	3(1.9)	6(3.8)	465	2.91	4
Cover crops and mulching provide nutrients to the soil	137(85.6)	9(5.6)	14(8.8)	443	2.77	5
Inadequate knowledge leads to poor practice of agroecology	116(72.5)	40(25.0)	4(2.5)	432	2.73	6
Proper crop choice and rotation practices stabilize crop yield	124(77.5)	23(14.4)	13(8.1)	431	2.69	7
Minimum tillage inhibits root penetration hence poor crop	128(80.0)	8(5.0)	24(15.0)	424	2.65	8
Mixed intercropping increases crop competition	102(63.7)	14(8.8)	44(27.5)	378	2.36	9
Relay intercropping mitigates competition risk for the main crop	77(48.1)	47(29.4)	36(22.5)	361	2.26	10
Integration of crops with timber and fruit trees increases production	53(33.1)	13(8.1)	94(58.8)	279	1.74	11
Agroforestry decreases crop yields due to crop competition	25(15.6)	48(30.0)	87(54.4)	258	1.61	12
Application of crop residue on the farm triggers pests	37(23.1)	20(12.5)	103(64.4)	254	1.59	13
Agroecological farming produces a low yield	22(13.8)	18(11.25)	120(75.)	222	1.38	14

Moreover, the study findings showed that the majority of respondents highly disagreed with the statement that "*Integration of food crops with timber, fruit, or nut trees increases food availability"* with a score of 1.74. Also, the respondents disagreed with the statement that "*Agroforestry decreases crop yield due to competition for resources"* with a score of 1.61. Likewise, respondents disagreed with the statement that "*Application of crop residues triggers pests and diseases hence reducing production,"* with a score of 1.59. Lastly, the respondents disagreed with a practice statement that said *"Agroecological farming produces low yield compared to conventional farming"* with a score of 1.73. These practices were least ranked because they may be less important to farmers com-

pared to their expectations and also due to inadequate knowledge and awareness of those practices. Knowledge and skills about sustainable agricultural methods are definitely important as it increases farmers' ability to get information and improve awareness about the practices. As informed by Schoonhovena and Runhaar (2018), information about the benefits of agroecological practices enables farmers to increase awareness and understand the practices. Being exposed to different sources of information could bring changes to farmers' perceptions of farming practices and influence their implementation (Girmachew *et al.,* 2020).

Generally, farmers appeared to have a positive perception towards agroecological practices that enhance food availability. The positive perception is important as it determines farmers' commitment to promoting and implementing agroecological practices so as to increase crop productivity. Farmers were aware of the role of agroecology in solving environmental problems and reducing production risks that led to food availability.

3.3.2 Farmers' Perceptions of the ease of implementation of agroecological practices

The results based on the analysis of the perceptions of the ease of use of agroecological practices using 12 statements indicated that 53% of the respondents perceived that agroecological practices were not easy to use and 41.5% perceived that they were easy to use. A few (5.5%) had a neutral perception (Figure 3.4). The study findings imply that more than half of farmers had a negative perception of the ease of use of agroecological practices. The negative perception of the respondents was due to their feelings of difficulties in applying agroecological practices. This is probably attributed to high labour requirements and the amount of time needed. During FGD, the participants agreed that:

> *"Applying mulch or constructing ridges in the farm to control soil erosion and conserve water, as advised by agroecology experts, takes time, especially if you*

don't have enough labour or income to hire labour." It was also agreed that... *"In the nine-seeded hole practice, you can't dig holes in a large farm and look after them when you are alone"* (FGD, Mwakiti village, 17 April, 2021).

These results agree with a study by Vermue (2017), who reported that farmers perceive agroecological practices as a complex farming system. Also, a study by Durham and Mizik (2021) showed that the majority of farmers in Senegal perceived that the implementation of agroecology was labour-intensive. However, as mentioned above, farmers in the study area, despite perceiving labour intensiveness, implemented agroecological practices since they have large family sizes, making labour available for their farming and also because the implementation of agroecology enhances food availability. The study's findings are similar to the findings of a study done by Oyetund-Usman (2021), who found that the majority of farmers practising agroecology had large families and relied on family labour supply.

This is also supported by Ullah *et al.* (2018), who reported that the probability of implementation of sustainable practices is high in households of large size since they provide labour for farming activities and reduce the need for hiring extra labour. On the other hand, Teixeira *et al*. (2018) reported that farmers with small families had to hire extra labour to meet the demands of implementing agroecology. Yet it is the emphasis that for a farmer to practice agroecology he/she needs support from other people.

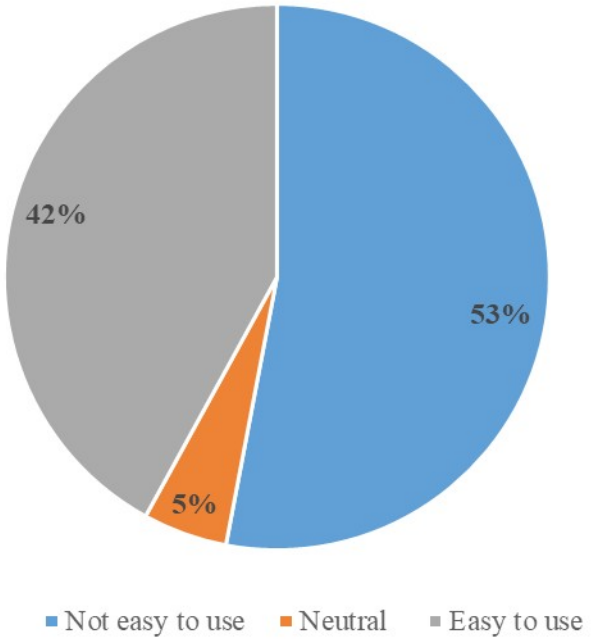

Figure 3.3: Respondents' of the ease of implementation of agroecological practices

A statement-wise analysis was done to gain more insights into farmers' perception of the perceived ease of use of agroecological practices. The results in Table 3.2 show that the statement with the highest mean score was "*Organic fertiliser reduces the use of synthetic fertilizers"* with a score of 2.97. This indicates that farmers prefer to use organic fertiliser as a means of improving soil fertility while reducing the cost of buying inorganic fertilizer. During field visits, it was observed that in areas where the soil was bad, whether pure stone or very sandy, the incorporation of organic manure helped to improve soil quality with high levels of organic matter. In addition, during the FGD held at Mvae village on April 20, 2021, the participants agreed that:

> *"The soil in their area is very sandy. Therefore, application of animal and compost manure to a large extent has helped us to improve the soil to become more productive"*.

Also, one KII (Ward Agricultural Officer) said that:

"...our farmers prefer to use organic manure because they can't afford the price of inorganic fertiliser, which is approximately eighty thousand per bag of 50 kilograms."

These findings were consistent with those of Durham and Mizik (2021), who found that the costs of inputs in organic farming are lower compared to the costs of inputs in conventional farming. This is because agroecological farming limits the use of synthetic inputs. Alemayehu *et al*. (2020) added that organic fertilisers increase soil water retention, offer a good drainage, help to avoid land degradation, and offer a better response to drought and floods.

The second statement with a high score (2.91) was "*Planting cover crops and applying mulch help to suppress weeds on the farm."* This indicates that farmers had knowledge about the benefits of mulching and had the potential to plant cover crops on their farms. Also, it was revealed during FGD at Mwakiti village, which was conducted on April 17, 2021, that the participants said that they had been trained about cover crops and their benefits, and they had been introduced to crops which were not grown in their areas, such as lablab and cowpea, which help to prevent soil erosion and conserve moisture. Similarly, Gu and Anex (2015) found that cover crops and mulching have benefits such as efficiency in nutrient recycling, reducing soil erosion and pest suppression.

Table 3.2: Respondent's statements wise score on Perceived ease use of agro-ecological practices

Statement	Agree	Neutral	Disagree	TS	MS	Rank
Organic fertilization reduces use of synthetic fertilizers	157(98.1)	2(1.3)	1(0.6)	476	2.97	1
Agroecological practices are not labour intensive	46(28.7)	8(5.0))	106(66.3	260	1.62	8
Organic fertilizer is bulky hence difficult to transport	125(78.1)	2(1.3)	33(20.6)	412	2.57	3
Adoption of agroecological practices need investment costs	30(18.75)	9(6)	121(76))	229	1.43	11
Biological control of pests is not difficult	50(31.3	11(6.9)	99(61.9))	271	1.69	6
Cover crops and mulching are easy ways to suppress weeds	151(94.37)	4(2.5)	5(3.13)	466	2.91	2
Agroforestry is not intensive	30(18.75)	16(10)	114(71.25)	236	1.47	9
Agroecological practices are simple cropping system	49(30.63)	13(8.12)	98(61.25)	271	1.69	4
Natural pesticides for pest control are not easily available	27(16.88)	12(7.5)	121(75.62)	226	1.41	12
Integration of different crops in rotations require high skills	51(31.9)	9(5.6)	100(62.5)	271	1.69	5
Zero tillage requires machinery to open furrows for seeding	49(30.6)	11(6.9)	100(62.5)	269	1.68	7
Difficult to manage different crops in the same field	32(20.5)	8(5.0)	120(75.0)	232	1.45	10

Looking into the statements with the least scores, according to the study findings in Table 10, the statement *"Agroforestry systems do not require high labour and management"* received a score of 1.47 and ranked 9th. *"It is not easy to manage different crops in the same field due to dissimilar requirements,"* scored 1.45 and ranked 10th, followed by "*Zero tillage requires specific machinery for cutting and opening furrows for seeding.*" "*Adoption of agroecological practices requires high investment costs,"* scored 1.443 and ranked the 11th, and "*Natural pesticides for weed, pest, and disease control are not difficult to prepare and not easily available,*" scored 1.42 and ranked the 12th. These practices received low scores, which may be due to a lack of experience for farmers since they are not implemented to a large extent. As supported by Bongole *et al.* (2020), experience plays a significant role in the implementation of Climate Smart Agriculture practices (CSA). He

further explains that farmers with high experience have accumulated skills and knowledge that influence them to increase the usage of practices. Amare and Simene (2017) emphasise that experience increases the likelihood of farmers implementing conservation practices and enables farmers to perceive and understand the impact of the farming practices.

To conclude, the majority of farmers had a negative perception of the perceived ease of use of agroecological practices, owing to the high labour and knowledge requirements, as well as investment in their implementation. This led farmers to say that they were not easy to use. However, farmers in the study areas were implementing agroecological practices by working in collaborative groups. Also, some had large family sizes, which supplied labour through hiring extra labour. In addition, the study showed that farmers were interested in implementing agroecological practices as a way of improving crops.

3.4 Conclusion and Recommendations

The study results showed that farmers had a positive perception towards agroecological practices to enhance food availability. The positive perception was influenced by the multiple benefits offered by agroecological practices. Benefits such as suppressing the spread of pests, soil fertility improvement, improving agroecological services, which in turn improve crop productivity, leading to food availability. Besides those benefits, farmers perceive that agroecological practices are not easy to use. This is most likely due to perceived difficulties in implementing some of the practices, as agroecology is both knowledge- and labour-intensive. The study recommends that it is necessary to promote and motivate farmers to implement agroecological practices so as to increase crop productivity and reduce environmental problems.

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CHAPTER FOUR

PAPER THREE

RESEARCH ARTICLE

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Determinants of the Implementation of Agroecological Practices among Smallholder Farmers in Singida District, Tanzania

Sauda M. Kanjanja, Devotha B. Mosha, and Sylvester C. Haule

ABSTRACT

Agroecological farming is considered to be among the suitable approach toward sustainable food systems and environmental conservation. Characteristically agroecology is at a low cost as it does not depend on expensive external inputs. Similar to other forms of more sustainable agriculture, implementation of its practices is generally low. There is scant information regarding the causes for its low implementation. This paper, therefore, looks into the determinants of the implementation of agroecological practices among smallholder farmers in Singida District, Tanzania. Specifically, the study uses data from the household surveys, focus group discussions, and key informants' interviews. The study employed both descriptive and inferential analysis to establish determinants of the adoption of agroecological practices. A multiple linear regression model was employed to analyze the factors for the decision to use agroecological practices, using cross-sectional data from 160 randomly selected households. Thematic analysis was used to analyze qualitative data. The study findings indicate that the dominant agroecological practices are the application of organic fertilizers (such as farm yard manure, composite and green manure), intercropping, and crop rotation. The results, also show income, education level of the household head, distance from homestead to the farm, training on agroecology, and land ownership was found to be associated with the implementation decision of agroecological practices by farming households. Besides, about 75% of farmers who decide to implement agroecology practices were those who had access to training support from FRN project. Based on the study findings, The Government and other stakeholders should insist more on improving training services to increase the implementation of agroecological practices. Also, the study recommends diversification of income sources on the farmers' side by engaging in both on-farm and off-farm activities such as petty business to increase income which in turn will enable them to invest in the implementation of agroecology practices.

Keywords: Agroecological practices, Determinants, Implementation, Smallholder farmers.

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I. Introduction

The multi-dimensional role of agroecology in reducing hunger and poverty is well acknowledged worldwide. Agroecology refers to a farming practice that relies on ecosystem services rather than on external inputs. [1], [2]. Increased use of external agricultural inputs has multiple detrimental consequences for the environment. For example, it is known that excessive use of industrial fertilizers and agrochemicals reduces the environmental quality, soil infertility as well as loss of biodiversity. Consequently, soil infertility leads to low crop yields, a reduction in livestock and poultry production, and a result decrease in community income, which threaten livelihood generation, especially for small-scale farmers. The challenge of soil fertility exhaustion and ecosystem deterioration have encouraged governments, farmers, and scientists to explore alternative agronomic agricultural practices that have fewer negative effects on agro-ecosystems.

Agroecology is considered one of the strategies that enhance sustainability in farming [3]. Several governments and NGOs around the world are promoting agroecological farming. Agroecological practices and principles, for instance, are applied in large-scale farms in America and Europe as means to restore soil fertility and management of the environment, as it is been proven to have the ability to restorative land and vegetation in some countries [4].In Africa, agroecology has been practiced mostly in West African countries (Mali, Ghana, Burkina Faso, Benin, Togo, and Niger, and Eastern African countries (largely Tanzania, Kenya, Malawi, Zimbabwe, and Madagascar) primally by small-scale farmers [5]. The purpose of implementing agroecological practices in Africa hinges on increasing agricultural crop yields and livestock products to meet food and nutrition security for the family and local market demand for an income source. In Tanzania, agroecological (AE) practices were first introduced in Mvomero, Bagamoyo, Masasi, Morogoro, and Singida districts by the Government,

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in collaboration with non-government organizations (NGOs) such as Research Community and Organisational Development Association (RECODA), Sustainable Agriculture in Tanzania (SAT), Participatory Ecological Land Use Management (PELUM) Tanzania and SWISS AID, and other development partners. The goals of promoting agroecological practices are improving the livelihood generation of farmers and other stakeholders along its value chain through increasing yields of crops and livestock products, improving farm-product quality while at the same time achieving more environment-friendly crop production that maintains ecosystems.

Agroecological farming has been defined as a complex activity because it embedded various components including the 10 FAO agroecology elements, and principles. According to [1], agroecological farming is holistic and 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 storage". It has the potential to improve ecosystems and bring food, nutrition, and income security to farming households [6], [7]. Various literature for instance [8], [9] show that embracing agroecological practices help to mitigate the impact of climate change. Moreover, for farmers to benefit from agroecological practices, they need to adopt and implement them.

Since 2015, the Farmer Research Network (FRN)-RECODA project has trained about 2000 farmers on different agroecological practices include: mixed cropping, crop rotation, integrated pest and disease management, application of inorganic fertilizers (animal composite and green manures), unlimited or no-tillage using farmer field school (FFS) approach. The project also supports farmers in forming FRN groups for the easiest accessing credit – loans, and agricultural inputs and technologies that subsequently facilitate the adoption and implementation of agroecological practices. Yet, similar to other forms of more sustainable agriculture, implementation of agroecological farming is low [10]–[12].

Scientific research on factors that explains farmers' willingness or barriers to adopting AE practices is diverse. Several studies have focused on farmers' motivation to adopt AE practices, and this can be influenced by such factors as information about the benefits of agroecology [13]. Other studies focused on analyzing the effectiveness of governance arrangements (institutional factors) in contributing to more adoption of ecological-friendly AE practices [14]. And there are studies in most African countries that documented the influences of the social context of farmers on their willingness to implement agricultural practices [15] and the larger system that governs agri-food chains [16]. A set of empirical studies has focused on solving agricultural problems by analyzing the components that influence the adoption of multiple agricultural practices at the farm level. Reference [17], has come up with four important components characteristics of the farm, resource limitations, social capital, and economic factors. Nevertheless, what is missing is a holistic framework that integrates personal and economic contextual factors that explain limited transitions towards agroecological farming and how these factors are related. In the study area where AE has been promoted, no clear explanations as to what socio-economic factors influence the implementation of AE practices in the Singida district. This paper aims to fill this knowledge gap.

II. Methodology

A. Area of the Study

The study was conducted in the Singida district, Singida region. The district is located in the central part of Tanzania which is a semi-arid condition. It lies between latitudes 30 52′ and 70 34′ and between longitudes 330 27′ and 350 26′ East of Greenwich and covers a total area of 3,387 km^2. Administratively, the district comprises 3 divisions, 21 wards, 84 villages, and 439 hamlets. Its population was 225 521 in 2012, while the projected population was 255 324 in 2017 [18]. The precipitation regime is annual, with low levels of rainfall ranging from 600 to 700 mm per annum falling between December and March. The livelihoods of smallholder farmers consist primarily of diversified agricultural systems (cop and livestock keeping). They tend to be more at the subsistence than the commercial farming level [19]. Farmers also engage in processing, petty business, and fishing activities. The prevailing crops are maize, sorghum, pearl millet, groundnuts, and beans for food, while sunflowers and onions are the main income source. The livestock raised are cattle, goats, sheep, donkeys, and local chickens.

Singida district was purposively selected because is the place where the FRN-RECODA project is implemented. Farmers in some of the wards have trained in agroecological practices and principles through Farmer Research Network (FRN) approach. Four villages were purposely selected to represent diverse socio-economic and land resource endowment characteristics of the farmers and the study areas. (Fig. 1.).

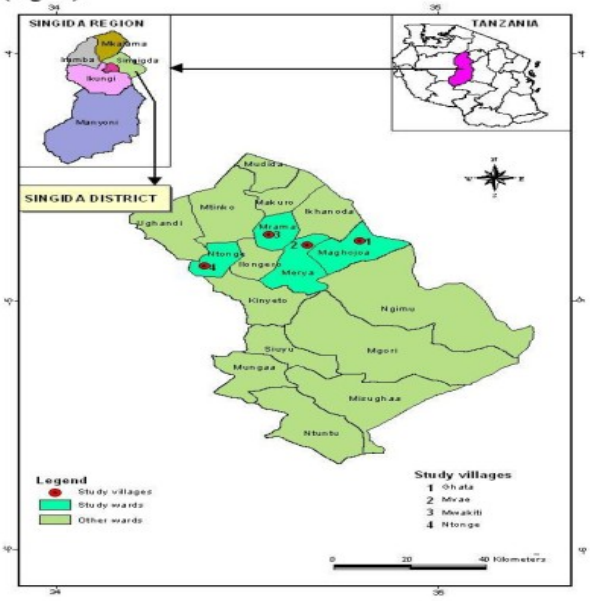

Fig. 1. Map showing the location of the study area Source: GIS (2021).

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B. Research Design, Study Population, 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. A cross-sectional research design was used because it provides a comprehensive picture of the problem being investigated [20]. It is also good for determining the relationship between and among variables at a specific time. It is economical in terms of time and financial resources [21].

The study's population was farmers both beneficiaries and non-beneficiaries of the FRN project. The study employed a multistage sampling technique. In the first stage, the Singida district was purposively selected among the six districts in the Singida region on the fact that it is a working area of the FRN –RECODA project promoting agroecological practices through intensification and transformation for food systems security. In the second stage, one division out of two divisions was selected. The selected division was Ilongero, which was also purposively selected because is where the FRN project operates. The selection takes into consideration the distribution of wards that are within the project area and wards out of the project area. In the third stage, four wards, two wards within the FRN project area and the other two in the non-FRN project area were selected. The selected wards in the FNR area were Merya and Mrama and Maghojoa and Ntonge wards were selected outside the FRN wards. In the fourth stage, one village from each ward was purposively selected, making a total of four villages namely Mwakiti and Mvae representing FRN villages, and Ghata and Ntonge representing non-FRN villages.

The sampling unit was a household, and the respondents were heads of households. According to o the National Bureau of Statistics (NBS), and this study, a household is a group of individuals who share the same center, under the responsibility of a head whose authority is recognized by all the members [22]. Lastly, the household heads (respondents) were randomly drawn from the sampling frames namely the project register for FRN and the village register for non-FRN household heads. In each village, 40 household heads were randomly selected using a lottery system in which an attempt was made to represent all the village hamlets in each village. The [23] formula for unknown population size was used to determine a sample size of 160 respondents. The sample size was:

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

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;
Z – the confidence level at 95% (standard value of 1.96).

Z=1.96

P=0.5

q=0.5

e=0.0775

Thus,

$$no = \frac{1.96^2 * 0.5 * 0.5}{0.0775^2} = 159.9 \sim 160$$

C. Data Collection Methods

In this study, both quantitative and qualitative primary data were collected for triangulation purposes. Quantitative data were collected using a structured questionnaire with open and close-ended questions. The questionnaire was initially prepared in English and later translated into Kiswahili for effective administration. Before the actual household survey, the researcher pretested the tool on 12 respondents, 12 each from FRN and non-FRN villages outside the study sites, but they are under similar field conditions. Thereafter, a tool was modified accordingly. The tool captured various socio-economic characteristics of the respondents and the factors influencing the implementation of agroecological practices.

Qualitative data were collected using Focus Group Discussion (FGD) in each study village and key informant interviews (KIIs). One FGD per village was conducted. The FGDs participants range from 8 to 12. Consideration was made for sex (female and male), experience, and a clear understanding of agroecology farming. The key informants consist of two leaders from the FRN project, two ward agricultural extension officers, and four village leaders. They provide overview information about the status, and constraints of the implementation of agroecological practices at the study sites. The interview with the key informants was guided by an interview guide.

Relevant secondary data about AE practices and influential factors hindering its implementation were collected from sources including project and government reports, journals, and Sokoine National Agriculture Library (SNAL). The intention of consulting archival; the material was to get a picture of the uniqueness of the current factors that influence the implementation of agricultural and related farming systems.

D. Data Processing and Analysis

Data were verified, coded, entered, and analyzed using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel computer software. Descriptive statistics such as percentages means, frequencies, and inferential statistics were performed. A multiple linear regression (MLR) model was employed to determine factors influencing farmers to implement agroecological practices. Below is the MLR model equation used.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \quad (2)$$

where
Y – Number of agroecological practices implemented by farmers;
B – Regression coefficients ;
β_0 – Intercept.
$X_1 \ldots X_n$ – explanatory variables: sex (0=Female, 1=Male); level of education (0=No education, 1=7 years, 2=11 years , 3=13 years, 4=1 year, 5=12 years , 6=12 years, 7=16 years); Age (Number of years); Size of the household (Number of people per household); Land ownership for agricultural

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activities (1=Yes, 0=No); Land size used for food crops production (Number of acres); Benefits obtained from practicing agroecology (1=Yes, 0=No); Training attended on agroecological practices (1=Yes, 0=No); Household income (1=Yes, 0=No) ε=error term.

Qualitative data from FGDs and KIIs were analysed through content analysis. The analysis involved transcription, translation of the content, and development of themes. In the theme development process, listing and categorization of different types of information were first done. Then the listed information was reviewed to see the relationship with the study. Then the relevant information was analyzed into themes, and the developed themes were reported as research findings.

III. Results And Discussion

A. Socio-Economic Characteristics of Respondents

Table I presents descriptive statistics of the socio-economic characteristics of surveyed households. Nearly three-quarters (71%) of the respondents engaged in FRN villages were female and a few (29%) were male. This is contrary to non-FRN respondents, where more than half (64%) of respondents were male, and few (36%) were female. This means, that the proportion of females who practiced agroecological practices was higher than their counterparts' men. The high participation of women farmers reflecting women are early adopters or risk-takers than men probably because of their multitasks at the household and community levels, hence ready to clasp any opportunity come across.

The respondents had various ages as Table I indicates. Many (63%) of the FRN respondents were in the age category ranging from 18 to 30 years, 32% from 31 to 40 years, and 35%. The trend is similar to those of whom 35% and 31% of respondents were in age categories from 18 to 30 years, and between 31and 40 years respectively. Respondents with age above 50 were 31% of FRN and non-FRN farmers respectively. The findings mean many of the heads of households are in an active age group (18–50). The energetic people are likely an important element or factor that influences the implementation of agroecological practices since intensive labor is required. Some studies in Tanzania also observed the same - active age of household contributes to labor in agricultural production and commercialization [24], [25].

On marital status, the majority (92.5% and 87.5% of FRN and Non-FRN respondents, respectively) were married. The study finding implies that households with married heads are more likely to implement agroecology than households with unmarried heads. During FGD at Mwakiti village, it was revealed that married people were more willing to implement agroecological practices than single ones because of the availability of manpower. The reason married people were more willing to adopt agroecological practices than single ones is likely because agroecological intensification and transformation are labor intensity. Thus, households comprising both wife and husband have adequate farm labor supply compared to single-parent households. This is like [26] study findings in Mufindi district, which argue high labor source has significantly affected the adoption of agricultural innovations. The results show that the majority (89.4%) of the head of households had attained primary education (Table I). This means, they were able to read and write, probably this might have a positive influence on the adoption of agroecology practices. The FGD findings from Mwakiti village support this finding-the married couples were more willing to implement agroecological practices than single ones likely because of manpower availability.

Table I: Social Economic Characteristics of Respondents in Singida Region (N=60)

Variable	Category	FRN Members		Non-FRN Members	
		Frequency	%	Frequency	%
Age of HH	18–30 years	50	63.0	9	11.3
	31–40 years	26	32.5	15	18.8
	41–50 years	25	31.3	24	30.0
	51 and above years	24	30.0	32	40.0
Sex of the HH	Male	23	28.8	51	63.8
	Female	57	71.3	29	36.3
Marital Status	Single	1	1.3	2	2.5
	Married	74	92.5	70	87.5
	Divorced	2	2.5	1	1.3
	Separated /widow/widower	3	3.8	7	8.8
Economic activity	Crop production	16	20.0	18	22.5
	Livestock keeping	1	1.3	1	1.3
	Livestock and crop production	63	78.8	61	76.3
Level of education	No-formal education	8	10.1	4	5.0
	Primary education	69	86.3	74	92.5
	Secondary education	3	3.8	1	1.3
	Certificate	0	0.0	1	1.3
Farm size (acres)	1–5 acres	50	62.5	46	57.5
	6–10 acres	25	31.3	24	30.0
	11 and above acres	5	6.3	10	12.5
Farm distance	Below 5 km=Nearby home	67	83.75	65	81.25
	5–10 km = far from home	8	10	9	11.25
	10 km and above = very far	5	6.25	6	7.5
Land ownership	Yes	77	96.2	78	97.5
	No	3	3.8	2	2.5
Income per month	50 001–200 000	53	66.25	56	70
	200 001–350 000	17	21.25	12	15
	350 001–500 000	7	8.75	8	10
	500 000 and above	3	5.75	4	5
Household size	1–4 members	10	12.5	14	17.5
	5–8 members	46	57.5	44	55
	9 and above members	24	30	22	27.5

In terms of the level of education, the majority (86%) attained primary education, 3.8% attained secondary education and 10% had no education for FRN farmers. While for non FRN farmers majority 92% attained primary education, 1.3% secondary education, and a certificate while 4% had no education (Table I). This means, that more than half of household heads can read, write and follow agroecology training instructions and likely had a positive influence on the adoption of agroecology practices. The findings of the study are in agreement with [27] who found that majority of household head farmers in Masasi and Mvomero districts have primary education.

Furthermore, the results show almost three-quarters (77.5%) of the respondents are engaged in crop and livestock production, and few (21.3%) both in FRN and Non-FRN,

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were engaged in crop production alone. This means that mixing livestock and crop production is a key economic activity for both income and food security in the study area. The size of the farm per household range between 2–5 acres. This reflects [19] that showed farmers in the Singida region are producing for subsistence rather than for commercial. The average household size was seven (7) members, concur with [12] who reported that the average household size in Nigeria had eight members. The author adds that larger family sizes are a feature of most farming households in developing countries and signify possibilities of family labor.

In terms of household size, the majority of respondents (57.5% and 55% of FRN and non-FRN respectively) had 5–8 family members, the rest had either four or fewer or above 9 members (Table I). This indicates a typical large family setting, implying the availability of family labor who are important in farming activities especially the implementation of agroecological practices. The results concur with [12] who reported that the average household size in Nigeria had eight members. The author adds that larger family sizes are a feature of most farming households in developing countries and signify possibilities of family labor. On land ownership, the majority (96.2% and 97% of FRN and of non FRN respectively) own land.

Furthermore, the study results show that about 84% and 81% of FRN and non-FRN respondents respectively had farms located nearby their homes (Table I). This might be one of the factors that enhance implement agroecological practices. The results further show that farmers had various income levels. Many of both FRN and non-FRN farmers' income levels range between Tshs 50 001 and 200 000, while about 5% had income above Tshs 500 000 per year. This income is relatively low compared to farmers in other areas. The low income is likely either to hinder the implementation of agroecological practices due to a lack of funds to hire labor since agroecology is labor intensive or enhance its implementation because is a means of crop diversification to meet food and income security.

B. Type of Agroecological Practices Implemented by Farmers in the Study Sites

The study results (Table II) show that almost all FRN (98%) and non-FRN (95%) respondents used organic fertilizers to improve soil fertility. This means the use of organic fertilizers is higher than the use of inorganic fertilizers. According to the FGD findings, and application of farm yard manure (FYM) scores the highest rank (1st), followed by compost manure use (2nd). The composite manure comprises crop residues, green plants, ashes, and animal wastes – well rotten to provide organic matter. Likewise, the majority (97% of the FRNs), and (78% of non-FRN) of the respondents practiced intercropping.

The above conforms to what FGD findings all villages revealed – planting more than one crop on one plot and at the same time increasing crop yields, and security of crop fails. In addition, crop rotation is wide used by the majority of farming households (82% and 74% for FRN and non-FRN households respectively) Table II. The study findings imply that farmers understood the potential benefits associated with intercropping and crop rotation. The findings conform to what [16] and [28] reported that intercropping and crop rotation is an important role in soil fertility restoration and breaking down the life cycle of pests leading to low disease incidents.

TABLE II: 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

In addition to the above findings, the nine seeded hoes, Chaka hoe (Zambian hoe), and the use of natural botanicals were agroecological practices practiced by the FRN farmers only (Table II) because there were trained. Reflecting that FRN households are more likely to apply a wide range of agroecological practices compared to non-FRN households who had never received training. The findings confirmed the findings by [29] and [2] who found that one of the conditions for the adoption of any technology is the availability of information to the expected adopters through training. Furthermore, results indicate that agroforestry was poorly implemented by only 1.3%, for both FRN and non-FRN farmers (Table II). The small percentage could be associated with inadequate knowledge of benefits and skills about the practice on the farmers' side. During FGD, non-FRN participants failed to explain what agroforestry is all about, suggesting that they were unaware of it as well benefits associated with it. The findings conform to [27] results of those farmers in Mvomero and Masasi districts poorly implemented agroforestry practices due to inadequate knowledge about the practices.

C. Determinants of the Implementation of Agroecological Practices among Smallholder Farmers in the Singida District

Ten variables were subjected to the multiple linear regression model to assess their influence on the implementation of agroecological practices among smallholder farmers in the Singida district. The selection of variables was based on theoretical explanation and the result of various empirical studies. These variables are income of the household, age of household head, sex of household head, household size, benefits from practicing AE, training on AE practices, land tenure (ownership), land size, farm size, and education level of the household head. The multiple linear regression model results indicate that the amount of income in the household, knowledge obtained through capacity-building pieces of training, age, benefits from practicing AE, land ownership, farm distance, and level of education of the household heads had a significant effect on the

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implementation of agroecological practices in the study area (Table III).

1) Household income level

Study findings in Table III show that household income level had a positive beta-coefficient of 0.002, implying statistically significant by 0.008 at p<0.05 level. This means one unit change in household income will lead to a 0.002 unit increase in the implementation of agroecological practices on average. Therefore, the total income earned by a household per year determines the likelihood of agroecological practices implementation among FRN smallholder farmers. This implies that households with a high-income level have a greater chance of investing in agroecology. Besides, a higher income level enhances access to agroecological inputs and hiring labor for agroecology implementation. The findings conform to FGD results in the FRN villages that adequate income enhanced the implementation of agroecological practices. The income is used to purchase and transport FYM and hire labor. The study findings are in line with [12] reported the same the higher the income of a farming household the more the possibility to implement agricultural practices.

2) Training in agroecological practices

The findings show that respondents' training attended on agroecological knowledge was 0.002 significant by 0.002 (at p<0.05) and positively related to the adoption or implementation of agroecological practices with a beta coefficient of 1.259 (Table III). This means that a one-unit change in the level of knowledge of agroecology increases the likelihood of implementing agroecological practices on average by 1.259 units. This implies that there is an increase in the implementation of agroecological practices as the farmer attains more training. During the FGDs with farmers in Mwakiti village, one of the participants narrated that "*…The fundamental ingredient that leads most of us in the village to implement agroecology is because of the knowledge and skills imparted by extension officers from the FRN project. This is contrary to the past, where we didn't do since we had no such knowledge and skills on the practices…*" After probing further during FGD it was narrated that the training program designed and conducted by RECODA can change the behavior and attitude of farmers towards the transformation of a farming system through intensification of agroecological practices.

1) Age of household head

The age of the household head had a negative beta coefficient of 0.347 and was statistically significant by 0.004 (at p<0.05). This means a one-unit increase in the age of the household head is likely to decrease 0.347 units of implementation of agroecological practices on average. This implies that older farmers are less likely to implement agroecological practices than young farmers. This is attributed to the fact that as the farmer gets older, he/she loses energy, and the ability to engage in agroecology farming which is labor-intensive decreases. The findings conform to what [30] reported – the age of household heads influences the implementation of agroecological land management practices in Ethiopia negatively. The study results contrast with [31], [3] who found the age of a farmer is one determinant of agroecological practices implementation.

2) Level of education

The level of education of household heads was significant (p<0.05) and positively associated with the high adoption of agroecological practices with an odds ratio of 0.002 (Table III). This means that one unit increase in the level of education increases the likelihood of implementing agroecological practices on average by 1.259 units. Thus, the more the farmer becomes educated, the more likely he/she is to learn and practiced new agricultural practices because education is a key to knowledge generation. The results imitate key informants' findings that "…educated farmers were willing to implement new interventions". The results conform to [32], [27], and [33] results that educated farmers were likely to pay attention to any interventions that prove to have positive effects to increase crop yields.

3) Land ownership

The study findings show a significant association between land ownership and implementation of agroecological practices by 0.002 (at p<0.05) (Table III). This means as farmers who own land are likely to engage in agroecological farming. Farmers who own land probably are willing to invest in agroecological practices as they are sure of getting benefits that mostly come out after a long time for some practices such as fallow, agroforestry, and landscaping management compared to farmers with hired land may not be motivated to invest on practices which they have no assurance of its benefits. These study findings are consistence with [34] results reported that land ownership is a fundamental aspect to encourage farmers to practice agroforestry and agronomical practices in Kenya.

TABLE III: FACTORS INFLUENCING FARMERS IN THE IMPLEMENTATION OF AGROECOLOGICAL PRACTICES AT THE SIGNIFICANCE LEVEL OF (95%)

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	7.390	1.499		4.928	0**		
Age of HH	-0.347	0.119	-0.194	-2.903	0.004**	0.941	1.063
Marital status	0.318	1.004	0.021	0.317	0.752	0.943	1.061
Source of income	-0.496	0.303	-0.113	-1.636	0.104	0.873	1.146
Household income	0.002	0	-0.205	-2.711	0.008**	0.731	1.368
Farm distance	-2.751	0.345	-0.626	-7.977	0.002**	0.681	1.468
Sex of household head	0.513	0.313	0.118	1.638	0.104	0.810	1.235
Household size	0.023	0.057	0.029	0.411	0.682	0.843	1.186
Education level of HH	0.092	0.032	0.192	2.895	0.0004**	0.954	1.048
Training on AE practices	1.259	0.404	0.273	3.118	0.002**	0.547	1.829
Benefits from practicing AE	4.967	0	0.163	1.750	0.082*	0.691	1.448
Land ownership	1.239	0.304	0.273	3.118	0.002**	0.547	1.829
Farm size for food crops	0.031	0.089	0.025	0.345	0.730	0.819	1.220

Dependent Variable: Implementation of agroecological practices (Unstandardized R^2=0.455.
Note:*=means significant at 5 % level; HH=household head; AE=agroecology.

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4) Farm distance

Study findings show that farm distance had a negative beta coefficient of 0.626 and was statistically significant by 0.003 at $p<0.05$. This means that for every unit increase in farm distance the implementation of agroecological practices decreases by 0.626 units, reflecting that the longer the distance from homestead to farm, the less the motivation farmer had in agroecology implementation. The observation also supported qualitative findings and [35] whereby it has been reported that farm distance has a significant effect on the implementation of agroecological practices.

5) Benefits from practicing AE

The results in Table III indicate that the benefits associated with practicing agroecology influence farmers to apply the practices by 0.107 units. This means that as farmers got more benefits from AE practices, they would be more motivated to implement them. During FGD with farmers and key informant interviews with experts in the study area indicated that AE practices have many benefits to farmers in their environment because is an environmentally friendly farming system as well as the increase in food production, yield stability, and reduction in the cost of production. These findings are supported by [36] who found that agroecological approaches are very potential in addressing farmers' multiple requirements.

IV. Conclusions

This paper has assessed the determinants of the implementation of agroecological practices in the Singida district in Tanzania. Ten socio-economic variables were evaluated namely income of the household, farmer's perception of agroecology practices, training attained on agroecological principles and practices: age of household head, sex of household head, household size; marital status; income source, household income; distance from homestead to the farm; education level of household head; land ownership, and farmland size. The results show income, education level of the household head, distance from homestead to the farm, and land ownership determines the implementation of agroecological practices. In addition, the common practices farmers implemented were: the application of organic fertilizers, intercropping, and crop rotation. However, the high acceptance of more than a three quarter (75%) of the farmers practicing agroecological practices were those who were trained by the FRN project. Generally, we recommended that the government and other stakeholders should insist more on improving training services to increase the rate of adoption. The FRN project, the local government authority in Singida, and other stakeholders along the value chain of crop production should continue to promote the implementation of agroecology farming and the formation of FRN to enhance engagement in agricultural technology implementation. Farmers in the Singida district should be sensitized to increase both farm and on-farm alternative sources of income because doing so can help them to get extra income which can be used to hire labor and transport FYM to increase the implementation of agroecological practices.

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Conflict of Interest

Authors declare that they do not have any conflict of interest.

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CHAPTER FIVE

5.0 GENERAL DISCUSSION

5.1 Introduction

This chapter presents general discussion of the study findings based on specific objectives. The study has four objectives, first objective determined the extent of implementation of agroecological practices among FRN and Non-FRN farmers in Singida district. Second objective examined the contribution of agroecological practices to household food availability by comparing between FRN and non-FRN farmers. Third objective assessed farmers' perception towards implementation of agroecological practices as a means to enhance food availability. Lastly, the study looked on the factors influencing farmers to implement agroecological practices.

5.2 Overall Synthesis

Objective one of the studies was to determine the extent of implementation of agroecological practices among smallholder farmers in Singida district. Levels of implementation were considered high, medium, or low. The overall level of implementation of agroecological practices was medium for the majority of FRN-participating farmers. On the other hand, more than three quarters (76.25%) of non-FRN participating farmers were at a low level of implementation of agroecological practices and about 24 % were in the medium category. FRN farmers implemented more agroecological practices than their fellow non-FRN participating farmers did. This is likely contributed by the training offered by the FRN project. The project has been providing training to farmers on various agroecological practices, their principles and elements; this has helped to create knowledge, skills and awareness for participating farmers. Therefore, the obtained knowledge led FRN participating farmers to adopt and implement more practices than non-trained farmers. The train-

ing also helped farmers to understand the advantages and disadvantages of agroecology, making it easier for them to make decisions and transform to a farming system that is more sustainable than farmers who had never been trained. The findings are supported by Constantine *et al.* (2020), who reported that trained farmers in Mvomero and Masasi Districts implemented more agroecological practices than their counterparts (non-trained farmers).

FRN and non-FRN farmers in both groups were found to implement some agroecological practices, including (i) the use of organic fertilisers such as farm yard manure (FYM) and compost manure (96%), (ii) intercropping (88%), (iii) crop rotation (82%) and crop and livestock integration (79%). In terms of fertilizer, this means organic fertiliser is mostly used compared to inorganic fertilizer. This is likely because the project promotes agroecological farming to restore soil fertility and thereby increase crop productivity. Farmers' implementation of intercropping is an indication that farmers understand the potential benefits of intercropping in increasing crop yield and stability by planting more than one crop on one plot at the same time. Crop rotation is widely used by the majority of farming households, implying that farmers are aware of and understand the effects of growing the same crops every season, such as soil infertility and recurrent crop diseases; hence, they rotate crops to reduce the effects.

These practices are termed "common practices" because they seem to be mostly practised by both groups, participating and non-participating FRN farmers, and are used as their traditional farming practices regardless of training. In addition, non-participating FRN farmers were found to implement agroecological practices at a low level by the majority. They applied only these four practices: use of organic fertiliser, intercropping, crop and livestock integration and crop rotation and they implemented them without following their

principles since they were not trained. This is the reason for implementing at a low level. On the contrary, FRN farmers applied the agroecological practices because they were trained and knowledgeable about them and they applied them beyond their common practice.

Some agroecological practices were found to be applied by only FRN participating farmers such as nine-seeded holes, Chaka hoe (Zambian hoe), and control of pests and diseases by means of plant-based substances. These practices were not traditional one; they had been introduced by the FRN project and farmers were trained and started to implement them based on the knowledge provided. Based on this finding, FRN households are more likely to apply a wide range of agroecological practices compared to non-FRN households that had never received training. This implies that knowledge and skills obtained from training and subsequent adoption of agroecological practices are important in agroecological transformation. The findings are similar to those of Udimal *et al.* (2017) and Schoonhovena and Runhaar (2018), who found that training is one of the basic conditions for information dissemination and adoption of any technology.

Also, the study assessed the status of food availability among FRN and non-FRN households in the study villages. The study found that FRN households were better off than non-FRN households in terms of food availability and food security. Despite the fact that both FRN and non-FRN farmers implemented agroecological practices such as the use of organic fertilisers, intercropping, crop rotation and crop and livestock integration, results show that they differed in the status of food availability. The results show that non-FRN participating farmers harvested an inadequate amount of food, probably because they practise agroecology at a low level and they implemented without following the principles since they had never trained. The capacity-building training provided by the FRN project

had a positive influence on the adoption of agroecological practices that increased crop diversification and food availability.

The study findings are consistent with that of Kangmennaang *et al.* (2017) who revealed that farmers who implemented agroecological practices in Malawi and Senegal had higher crop yields and were more food secure in terms of food availability, than their counterparts. However, these findings are contrary to Meemken and Qaim (2018), who revealed low yield when a farmer used organic farming compared to yield obtained from industrial agriculture because of the synthetic agro-inputs. This is also likely because of an appropriate way of using organic fertilizer.

The significant association between the level of implementation of agroecological practices and food availability implies that the more farmers implement agroecological practices the greater the chance for them to have enough food available for their families. In a comparison between FRN and non-FRN respondents, the FRN participating households had more adequate food available to their families than non-FRN households. This is likely because the FRN participating farmers were at a medium level of implementation of agroecological practices compared to the low level of the majority of non-FRN participating farmers. These findings confirm that of Chappell *et al.* (2018). who reported that the implementation of agroecological practices increases crop yield.

These findings are similar to Ayivor *et al*. (2016), whose study in Ghana reported that practising agroecological practices increases crop productivity and yields, and subsequently food availability at the household level. The authors further declared that agroecological farming reduces the risk of crop failure due to crop diversification. Diversification at the farm level is also likely to increase income after selling the surplus.

The third objective of the study assessed farmers' perceptions towards the implementation of agroecological practices to enhance food availability. The study found that the majority of farmers had a positive perception towards agroecological practices that enhance food availability. The positive perception is an indication that farmers recognise the contribution of agroecological practices to household food availability and is probably associated with the other benefits that farmers get through practising agroecology. Farmers revealed several environmental benefits contributed by agroecological practices including improving soil fertility, preventing the growth of weeds, and reducing pests and disease, as well as increasing crop yields and preventing soil erosion. The study findings suggested that farmers' positive perception was influenced by the aforementioned multiple benefits offered by practising agroecology. These findings are consistent with those of Parachini *et al.* (2020), who found that farmers had a positive perception towards agroecological practices in a study they did in BeninThe findings, however, revealed that more than half of the farmers had a negative perception of the ease of use of agroecological practices. The respondents' negative perception were due to their perceived difficulties in applying some agroecological practices. This is probably attributed to high labour requirements and the amount of time needed. Yet, farmers in the study area, despite perceiving labour intensiveness, implemented agroecological practices since they have large family sizes, making labour available for their farming. and also understood the benefits of implementing agroecology. These results agree with a study by Vermue (2017), who reported that farmers perceive agroecological practices as a complex farming system. Also, a study by Durham and Mizik (2021) showed that the majority of farmers in Senegal perceived that the implementation of agroecology was labour-intensive.

Furthermore, the study determined the factors influencing farmers to implement agroecological practices. The multiple linear regression model results indicate that the amount of

income in the household, knowledge obtained through capacity-building through training, age, level of education of the household heads, land ownership, farm distance and benefits obtained from practising agroecology had a significant effect on the implementation of agroecological practices in the study area. Household income, training on agroecology, level of education, land ownership and benefits obtained from agroecology positively influenced farmers to implement agroecology. The total income earned by a household per year determines the likelihood of agroecological practices being implemented among smallholder farmers. This implies that households with a high-income level have a greater chance of investing in agroecology. Besides, a higher income level enhances access to agroecological inputs and hires labour for agroecology implementation. In addition, as farmers attain more training on agroecological practices the possibility to implement agroecology also increases since training plays a major role in creating awareness and knowledge. Land ownership is likely to influence farmers to engage in agroecological farming as they are sure of getting benefits that mostly come out after a long time for some practices such as fallow, agroforestry and landscaping management.

Compared to farmers with hired land, they may not be motivated to invest in practices for which they have no assurance of receiving benefits. The benefits that farmers obtain from implementing agroecology and the increase in the level of education motivate them to proceed with the practices. The age of the household head and farm distance negatively influenced farmers to implement agroecological practices, implying that older farmers are less likely to implement agroecological practices than young farmers. This is attributed to the fact that as the farmer gets older, he/she loses energy and the ability to engage in in labour-intensive agroecological farming. The findings conform to what Nigussie *et al.* (2017) reported: the age of household heads influences the implementation of agroecological land management practices in Ethiopia negatively. In terms of farm distance, the res-

ults show that the greater the distance from the homestead to the farm, the less motivated the farmer was to implement agroecology.

Generally, this part provides the linkage between the specific objectives of the study as follows; the overall level of implementation of agroecological practices was moderate for FRN farmers. For the status of food availability, FRN farmers who were at a moderate level of implementation of agroecological practices had adequate food availability for their households compared to non-FRN farmers who implemented agroecology at a low level. Since farmers have a positive perception towards agroecological practices to enhance food availability, there is a great possibility for them to implement them regardless of their intensity. In addition, farmers implemented agroecology, which led to food availability because of training provided by the FRN project, and most of them own land for agricultural activities**.** Therefore, in order to promote agroecology training is very important aspects as it will enable change farmers attitude as well as supporting farmers in knowledge and skills creation.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The first objective describes the extent of the implementation of agroecological practices among farmers in Singida District. Farmers from FRNs implemented agroecological practices at a moderate level, which is an indication of the commitment of farmers compared to non-FRN farmers, who were at a lower scale of implementation. Many farmers adopted one or two practises solely because they were simple to implement. The majority of farmers in both FRN and non-FRN groups applied organic fertilizers, intercropping, crop rotation and integration of crop and livestock components.

The techniques of the nine-seeded holes - *chaka* hoe, commonly known as Zambian hoe - and the application of biopesticides (botanical materials) were practised by FRN farmers only. The reason is that these two techniques need training on how best to use them. That is why non-FRN farmers did not implement them because they did not know how to prepare and use them. Notably, the adoption and implementation of agroecological practices necessitate the acquisition of knowledge and skills following capacity building. Thus, there is a need to train farmers on agroecological practices for wider implementation and scaling up of the technology.

Based on the second study objective, it could be concluded that FRN farmers are more food secure than non-FRN farmers. The plausible explanations for this adequacy are related to the moderate implementation of agroecological practices. In other words, the implementation of agroecological practices had a significant contribution to household food availability. The third objective was that farmers have a positive perception of agroecological practices to improve food availability at the household level. However, this was contrary in terms of the perceptions of the ease of implementation of agroecological practices

on the farms, as farmers had a negative perception. The perceived negative perception was associated with labour intensity and the need for knowledge and skills before the implementation of agroecological practices.

For the last objective, we conclude that household income, training attainment, land ownership, benefits obtained from practising agroecology, education level of the household head and distance to the farm are important determinants for the implementation of agroecological practices in Singida District. With the exception of the last, as these factors increase, so does the likelihood of farmers implementing agroecological practices, whereas the farther the farm is located from the homestead, the lower the likelihood of farmers implementing agroecological practices.

6.2 Recommendations

Based on the above conclusions, the following recommendations are made:

The FRN project, in collaboration with other development agents, should promote agroecological practices and evidence-based results to increase the level of implementation in the study district. There is a need for the government to support farmers with high technology to reduce labour intensity. As the implementation of agroecological practices has a significant contribution to food availability, the FRN project needs to scale up to reach a wider community, including non-FRN farmers. Furthermore, because farmers have a positive perception of the benefits of implementing agroecological practices, there is a need for local government authorities (LGAs) and other stakeholders to promote agroecology narratives to develop strategies for transitioning from conventional agricultural to agroecological farming. There is also a need for the LGA in Singida District to provide training to farmers to increase farmers' awareness, knowledge, and skills on how to implement agroecological practices.

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APPENDICES

Appendix 1: Questionnaire for MSc. study

Contribution of Agroecological Practices to Households Food availability: Experience from Farmers Research Network Project in Singida District

Dear respondent,

This questionnaire is for MSc. study whose purpose is to assess the contribution of agro-ecological practices to household food security: Experience from Farmers Research Network Project in Singida District Council. You have been selected to participate by giving sincere views on this issue. I, therefore, kindly request your participation. Feel free to give your opinions. Your response will be treated with confidentiality.

A. Name of enumerator……Phone number……...

B. Date of interview……..

C. Questionnaire identification number

District	Division	Ward	Village	Group name

Section 00: Demographic Information

1. Gender Male [ ] Female [ ]

2. Are you the head of the household? Yes [ ] No [ ]

3. If No, Relationship with household head…….

4. Age of household head in years……..……

5. What is your marital status?

Single [ ] Married [ ] Divorced [ ] Separated [ ] Widow/widower [ ]

6. Do you have children? Yes [ ] No [ ] If yes, how many are they?

1.2 Children [ ] 3-4 children [ ] 5-6 Children [ ] More than 6 Children [ ]

7. How many members in your household? ……

8. Number of dependants (household members under 18 years and those incapacitated for any reason) ……

9. What is your occupation?

i. Crop farming activities only [ ]

ii. Livestock keeping activities only [ ]

iii. Livestock and crop production activities [ ]

iv. Government employee [ ]

v. Private employee [ ]

vi. Trading [ ]

10. Other, specify (mention)……

What are your major sources of income? (Rank 3 sources, 1=most impontant,2=important, 3= moderate)

i. Selling crop produce only [ ]

ii. Selling livestock product and by product only [ ]

iii. Selling crop produce and livestock product [ ]

iv. Salary [ ]

v. Petty business [ ]

vi. Others (specify)……

11. What is the highest level of education of household head?

i. No education [ ] v. Adult education [ ]

ii.	Standard 7	[ ]	vi. Certificate	[ ]
iii.	Form IV	[ ]	vii. Diploma	[ ]
iv.	Form VI	[ ]	viii. University	[ ]

12. Do you own land for agricultural activities?

Yes [ ] No [ ]

13. If yes, how many plots? …….. What is the size each plots in acres?

……

14. If no where do you get land for agriculture? ……..

15. What is the total size of your land is under cultivation in previous year? ……

16. What is the total size of your land used for food crops production? …….

Section 01: Agroecological Practices Implemented by Farmers in Singida District

17. Have you ever heard about agroecological practices?

Yes [ ] No [ ]

18. If yes, where did you hear about agroecological practices?

i.	Fellow farmers	[ ]
ii.	FRN	[ ]
iii.	Relatives	[ ]
iv.	Media (radio, TV) Magazine	[ ]
v.	Extension agent	[ ]
vi.	Others NGOs/Project	[ ]

19. If yes, in 1 above, could you briefly explain what does ‘agroecological practice mean for you? .....

21. The following are among of the agroecological practices, which agroecological practices do you practice in your field? (You can tick more than one where appropriate)

i. Inter-cropping [ ] ii. Mixed cropping [ ]

iii. Crop and livestock integration [ ] iv. Crop rotation [ ]

v. Crop diversification [ ] vi. Cover crops and mulching [ ]

vii. Agroforestry [ ] viii. Nine seeded hole [ ]

ix. *Chaka* hoe [ ] x. Organic pest management [ ]

xi. Organic fertilization [ ] xii. All of the above [ ]

22. Have you ever attended any training on agroecological practices?

Yes [ ] No [ ]

23. If yes who offered the training?

1. Extension officer [ ]
2. FRN [ ]
3. NGO/project [ ]
4. Farmers association [ ]
5. Research institute [ ]
6. Media (radio, TV) magazine [ ]
7. Others (specify)

……

24. What type of agroecological practices have you learned?

i. Intercropping [ ] ii. Mixed cropping [ ]

iii. Crop and livestock integration [ ] iv. Crop rotation [ ]

v. Crop diversification [ ] vi. Cover crops and mulching [ ]

vii. Agroforestry [ ] viii. Nine seeded hole [ ]

ix. *Chaka* hoe [ ] x. Organic pest management [ ]

xi. Organic fertilization [ ] xii. All of the above [ ]

25. If you are a member of FRN, which agroecological practices do you practice? (You can tick more than one where appropriate). *If not a member of FRN please skip this question*

i. Intercropping [ ] ii. Mixed cropping [ ]

iii. Crop and livestock integration [ ] iv. Crop rotation [ ]

v. Crop diversification [ ] vi. Cover crops and mulching [ ]

vii. Agroforestry [ ] viii. Nine seeded hole [ ]

ix .Chaka hoe [ ] x. Organic pest management [ ]

xi. Organic fertilization [ ] xii. All of the above [ ]

26. What are the crops you normally grow and practice used for each crop?

Type of crop	**No. of parcel per crop**	**Practice per parcel**		**Reason for the practice**
		No. of par-cel	**Practice**	

Key to practices:1= monocropping,2= mixed cropping,3= intercropping, 4=crop rotation, 5=crop diversification, 6=cover crops and 7= mulching, agroforestry

27. For how long have you been practicing agroecology?

i. Less than one year [ ]

ii. One – 2years [ ]

iii. Three - 4years [ ]

iv. More than four years [ ]

28. How do you conserve/restore soil fertility in your field? (You can tick more than one where appropriate)

i. Fertilizations (chemical and non-chemicals fertilizers) [ ]

ii. Crop rotation [ ]

iii. Intercropping [ ]

iv. Conservation tillage [ ]

v. Other

(specify): .....

29. Which kind of fertilizers do you use?

i. Inorganic fertilizers (Chemical fertilizers) [ ]

ii. Organic fertilizers (animal manure, green manure, compost) [ ]

iii. Both [ ]

30. Which type of organic fertilizers do you use? (You can tick more than one where appropriate)

i. Farm yard manure (mixture of animal manure, urine, bedding material, fodder residues and domestic waste like ashes)

[ ]

ii. Compost manure (well-rotted dry crop residue, green plants, ashes, animal waste and water) [ ]

iii. Animal manure (consist of animal wastes) [ ]

iv. Green manure (Type of crops cultivated primarily to enrich the soil with nutrients and organic matter through ploughing into the soil while still green)[ ]

v. None [ ]

vi. Other (specify): .....

31. How do you manage insect pests and diseases? (You can tick more than one where appropriate)

i. Biological (control of pest using other organism) [ ]

ii. Chemical pesticides [ ]

iii. Cultural methods (crop rotation, pruning, scouting, cleaning farm, resistance varieties/cultivars) [ ]

iv. Natural treatment (such as neem oil extracted from seed and leaves) [ ]

v. Mechanical and physical controls (i.e. use of traps - for pest animals and insects; [ ]

vi. None [ ]

vii. Other methods (specify).....

32. How do you manage weeds? (You can tick more than one where appropriate)

i. By burning plant residues after harvesting. [ ]

ii. By grazing through animals [ ]

iii. By mechanical weeding (tillage, mowing and/or manual). [ ]

iv. By cultural (crop rotation, intercropping, cover crops, mulches) [ ]

v. By chemical herbicides, [ ]

vi. Other

(specify): .....

33. Are there any benefits you get from practising agroecology?

Yes [ ] No [ ]

34. If yes, please mention at least three benefits of agroecological practices?

i. …… ii …….

iii.…… iv…….

Section 02: Status of Food Availability between FRNs Farmers Practicing Agroecological Practices and Non-FRNs

35. Where do you obtain food for your household?

i. Buying [ ]

ii. Self-production [ ]

iii. From relatives [ ]

iv. Food aid (from NGOs, Government) [ ]

v. Self-production and buying [ ]

vi. Other specify …….

36. In the table below provide the information on crops which are main source of food for your household (list according to priorities)

No	**Food Crop**	**Area (acre)**	**Seed type**	**Crop uses**	**Amount har-vested (Kgs)**	**Amount sold (Kgs)**	**Amount re-ceived (Kgs)**	**Amount con-sumed (Kgs)**	**Amount stored (Kgs)**
i.									
ii.									
iii.									
iv.									

Key: seed type 1=local seed, 2= hybrid seed

Crop uses, 1food consumption, 2= selling, 3= both

37. Apart from own production, did you receive food from any other sources last year?

Yes [ ] No [ ]

38. If yes from which source and how much?

Source of food received	**Amount received (Kgs)**
Bought	
Relatives	
Food aid (from NGOs, Government)	
Other (specify)	

39. Which source provides you food often and what is the reason. (Rank according to frequencies). Tick one response for each source

Source of food received	**Extent of receiving**	**Reason**
Bought	Often	
	Sometime	
	Rarely	
Relatives	Often	
	Sometime	
	Rarely	
Food aid (from NGOs, Government)	Often	
	Sometime	
	Rarely	
Other (specify)		

40. What are the storage facilities do you use after harvest your crops? (You can tick more than one where appropriate)

i. Metal cans/ drums [ ]

ii. Polythene/ Plastic sacks [ ]

iii. Improved granaries (wooden wall) [ ]

iv. Traditional granaries (cylindrical shape) [ ]

v. Purdue Improved Crop Storage (PICS) [ ]

vi. Others structures ……

41. How do you treat your crops before storage?

i. Storage chemicals (pesticides) [ ] ii. Traditional (botanicals, ashes) [ ]

iii. Both chemical and traditional [ ] iv. None [ ]

42. Before storing new harvested crop, how much food was available in your store?

Type of Crop	**Amount of stored**
Maize	
Sorghum	
Beans	
Pigeon pea	
Cowpea	
Bambaranut	
Grand nut	
Millet	
Others specify	

43. For how long the food stored can serve your household after harvesting?

i. Three months [ ] ii. Six months [ ]

iii. Nine months [ ] iv. Twelve months [ ]

v. Twenty four months [ ] vi. Others specify……

44. Do you think agroecological practices contribute to household availability?

Yes [ ] No [ ]

45. Please give reasons for your response

……

……..

46. Have your household received loan or credit from any financial institution/ organization/ association?

Yes [ ] No [ ]

47. If yes, from which organization your household received loan or credit? (Mention)

……

48. What was the purpose of the credit received?

i. Agriculture activities [ ]

ii. Buying food [ ]

iii. Other uses specify……

49. What are the off-farm activities and the average earning carried during the past 12 months and its contribution to food availability?

Activities	**Average earning**	**% Contributed to food availability**

Section 03: Farmers Perception towards Agroecological Practices to enhance food availability

50. Reasons for Practicing Specific/ Each Practice

Please put the number under the word that best reflects your feeling to each statement on the following rating scale: **Strong Agree (SA)=5 Agree (A)=4 Neutral (N)=3; Disagree (D)=2 Strong Disagree (SD)=1**

Statement	**SA**	**A**	**N**	**D**		**SD**
Inadequate knowledge about agroecological practices leading to food unavailability						
Crop diversification allow the integration of more						

diverse cultivars or crops which enhance food availability						
Crops and livestock integration allows availability of organic manure for soil fertilization which increases crop productivity.						
Crop rotation improve soil nutrient and interrupt life cycle of pest and disease hence enhance food availability						
Cover crops and mulching reduce soil erosion and provide nutrients to the soil which lead to increase crop production.						
Minimum tillage inhibits root penetration hence poor crop production leading to food unavailability						
Intercropping allows efficiency use of space which enhance proper plant population in the farm leading to increase crop production						
Integration of food crops with timber, fruit or nut trees, increase land productivity which enhance food availability						
Agroforestry decrease crop yields due to crop competition for light, nutrients, and water with trees						
Relay intercropping mitigate competition risk for main crop hence increase productivity.						
Crop choice and rotation practices stabilize crop						

yield leading to food availability						
Mixed intercropping increase crop competition hence reduce yield.						
Agro-ecological farming produce low yield compared to conventional farming						
Application of crop residue in the farm trigger pest and disease which harm crops, hence reduce crop production leading to food unavailability						

51. Perceived Usefulness of Each Practice

Please put the number under the word that best reflects your feeling to each statement on the following rating scale: **Strong Agree (SA)=5 Agree (A)=4 Neutral (N)=3 Disagree (D)=2 Strong Disagree (SD)=1**

Statement	**SA**	**A**	**U**	**N**	**SD**
Agroecological practices is too labour intensive					
Agroecological practices is simple cropping system					
Adoption of agro-ecological practices requires high investment costs					
Natural pesticides for weed, pest and disease control are difficult to prepare and not easily available					
Agroforestry systems need higher management and higher labour demand.					
It is difficult to manage more than one crop in the same field due to difference in crop requirements					
Zero tillage requires specific machinery for cutting and					

opening furrows for seeding which is costly.					
Organic fertilization reduces use of synthetic fertilizers hence low cost					
Biological control of pest and disease is difficult to apply in large farms such as fifty acres					
Integration of different crops in rotations require high knowledge skills					
Organic fertilizer is bulky hence difficult to transport if the farm is very far from home.					
Planting cover crops and applying mulching it is an easy way to suppress weeds in the farm.					

Section 04: Factors Influencing Farmers in Implementing Agroecological Practices

52. Explain most three important factors that motivated you to implement agro-ecological practices? How was it motivated you?

Factor	**Description of how motivated you to implement agroecological practices**

53. Explain most three important factors that prevented you to implement agroecological practices? How was it prevented you?

Factor	**Description how it was prevented to implement agro-**

	ecological.

Thank you for your cooperation

Appendix 2: Interview guide for Key Informants (Project leaders, Agricultural Extension of officers at District, Ward and Village level and village government leaders)

Name:	Designation
Work place:	Phone number

1. Do farmers in this area implement any agroecological practices?
2. What are common agroecological practices that farmers are implementing?
3. What could be the possible reasons for practising? Please rank based on the priority
4. Who trained farmers to practice agroecological practices?
5. What is the proportional of farmers who are practicing AE practices in the village? (women / Men) (youth/elders, poor/ medium / rich class)
6. Is there any benefit obtained from farmers practicing agroecology? (Increase yield, soil fertility etc.)
7. Is there any difference in yield between farmers who practice agro-ecological practices and those who not practice?
8. How do farmers perceive about agro-ecological practices?
9. What factors hinder or facilitate farmers to implement agro-ecological practices? (Please rank based on the priority)
10. What are the possible action do farmers take to address the hindering factors?

Thank you for your cooperation

Appendix 3: Checklist for focus group discussion (FGD)

1. How do you understand about agroecological practices?
2. Are there any farmers who practice agroecology practices in the village?
3. What are proportional? (Estimate by percentage). (Women /men, youth vs elders; poor vs rich?
4. Which agroecological practices implemented most by farmers in your villages? Give reasons why these?
5. List benefits accrued from agroecology practices? (Rank according)
6. Is there any difference in yield and food security between farmers practising agroecology and those who do not practice
7. How do farmers perceive agroecological practices? Is it useful and easy to practice?
8. Is agroecological useful to support food availability in your household?
9. What factors influence, hinder or facilitate farmers practice agroecology?

Thank you for your cooperation