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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,

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.).

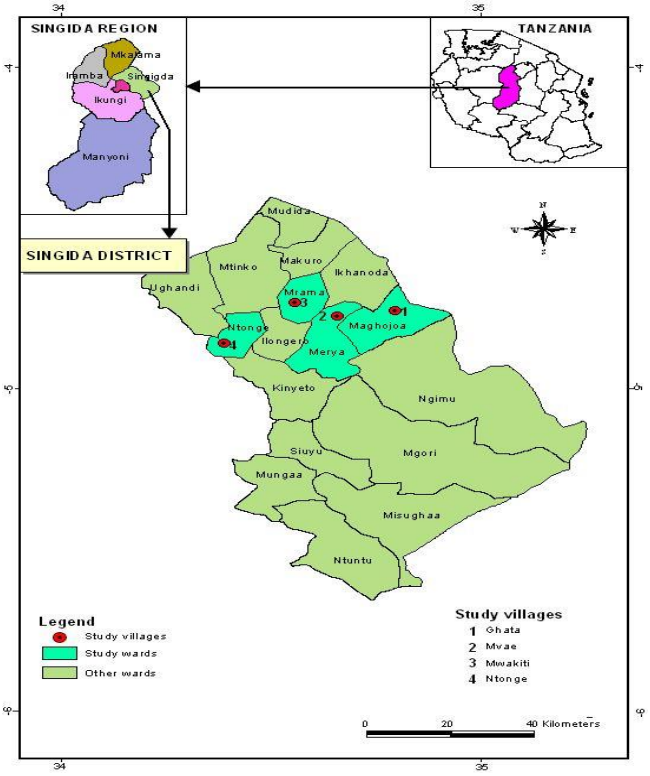

Fig. 1. Map showing the location of the study area Source: GIS (2021).

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:

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

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.

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

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

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,

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

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.

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.

References

[1] Wezel A, Casagrande M, Celette F, Vian JF, Ferrer A, Peigné J. Agroecological practices for sustainable agriculture. *A review. Agronomy for Sustainable Development*. 2014; 4(1):1–20.

[2] Schoonhoven Y, Runhaar H. Conditions for the adoption of agro-ecological farming practices: a holistic framework illustrated with the case of almond farming in Andalusia. *International Journal of Agricultural Sustainability*. 2018;16(6):442–454.

[3] Deaconu A, Berti PR, Cole DC, Mercille G, Batal M. Agroecology and nutritional health: A comparison of agroecological farmers and their neighbors in the Ecuadorian highlands. *Food Policy*. 2021;101:1–10.

[4] Tittonell P, Piñeiro G, Garibaldi LA, Dogliotti S, Olff H, Jobbagy EG. Agroecology in large scale farming-A research agenda. *Frontiers in Sustainable Food Systems*. 2020 Dec 18;4:584605.

[5] Paracchini ML, Justes E, Wezel A, Zingari PC, Kahane R, Madsen S, *et al*. Agroecological practices supporting food production and reducing food insecurity in developing countries. A study on scientific literature in 17 countries. EUR 30329 EN, *Publications Office of the European Union, Luxembourg*. 2020, ISBN 978-92-76-21077-1, doi:10.2760/82475, JRC121570.

[6] Teixeira HM, Van den Berg L, Cardoso IM, Vermue AJ, Bianchi FJ, Peña-Claros M, *et al*. *Understanding farm diversity to promote agroecological transitions. Sustainability*.2018;10(12):1–43.

[7] HLPE *Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition*. High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.2019; [https://www.bayer.com/agriculture/innovations] site visited on 12/08/2020.

[8] Gallardo-López F, Hernández-Chontal MA, Cisneros-Saguilán P, Linares-Gabriel A. Development of the concept of agroecology in Europe: A review. *Sustainability*. 2018;10(4):1–12.

[9] Oteros-Rozas E, Ravera F, García-Llorente M. How does agroecology contribute to the transitions towards social-ecological sustainability? *Sustainability*. 2019;11(16):43–72.

[10] Runhaar H, Wilk B, Persson Å, Uittenbroek C, Wamsler C. Mainstreaming climate adaptation: taking stock about "what works" from empirical research worldwide. *Regional environmental change*. 2017 Apr;18(4):1201–10.

[11] Abera W, Lulseged Tamene L, Tibebe D, Adimassu Z, Kassa H, Hailu H, *et al*. *Characterizing and evaluating the impacts of national land restoration initiatives on ecosystem services in Ethiopia*. 2020;31(1):37–52.

[12] Oyetunde-Usman, Z., Olagunju, K. O., and Ogunpaimo, O. R. Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria. *International Soil and Water Conservation Research*. 2021;9(2):241–248.

[13] De Snoo GR, Herzon I, Staats H, Burton, Rob JF, Schindler S, *et al*. Conservation Letters 6 (2013) 66–72. Wiley Periodicals, Inc Chen WK. *Linear Networks and Systems*, Belmont, CA: Wadsworth. 1993;123–135.

[14] Benitez-Altuna F, Trienekens J, Materia VC, Bijman J. Factors affecting the adoption of ecological intensification practices: A case study in vegetable production in Chile. *Agricultural Systems Journal*. 2021. https://doi.org/10.1016/j.agsy.2021.103283.

[15] Pretty, J. Agricultural Sustainability: Concepts, Principles, and Evidence. Philosophical Transactions of the Royal Society of London

B: *Biological Sciences*,2008; 363,447–465.https://doi.org/10.1098/rstb.2007.2163.

[16] Duru M, Therond O, Fares M. Designing agroecological transitions; A review. *Agronomy for Sustainable Development*. 2015; 13(2):1–22. DOI 10.1007/s13593-015-0318-x.

[17] Ojo S, Ogunyemi I. Analysis of Factors Influencing the Adoption of Improved Cassava Production Technology in Ekiti State, Nigeria. *International Journal of Agricultural Sciences and Natural Resources*. 2014; 1,40–44.

[18] URT. Singida Socio-Economic Profile, 2015: National Bureau of Statistics, Ministry of Finance and Singida Regional Secretariat. *Singida*. 2017; 227.

[19] Isinika AC, Jeckoniah J, Mdoe, Mwajombe K. Sunflower Commercialisation in Singida Region: Pathways for Livelihood Improvement. *APRA Working Paper 67: FAC ICE Team-Publications,Working Papers.*

[20] Clark VLP, Ivankova T. Mixed Methods Research: A Guide to the Field. Thousand Oaks, CA. *Sage Publications*. 2016; 368.

[21] . Creswell JW, Plano, Clark VL. Designing and Conducting Mixed Methods Research. *2nd ed. Thousand Oaks: CA: Sage*. 2011; 457.

[22] National Bureau of Statistics (NBS) [Tanzania]. *Tanzania National Panel Survey Report (NPS)-Wave 3, 2012-2013*. Dar es Salaam, Tanzania. 2014; 120.

[23] Kothari CR. Research methodology: Methods and techniques. 2nd ed. New Age International; 2004.

[24] FAO (Food and Agriculture Organization of the United Nations*). Food Security Impact of Agricultural Technology Adoption under Climate Change: Micro-Evidence from Niger*. Rome. 2015; 139.

[25] Kingu HA. Role of Institutions in Household Food Security in Tanzania: A Case of Singida Region.Tengeru Community *Development Journal*. 2020;7(1):1-18.

[26] Fasha GS, Minde A. Livelihood Assessments among Small-holder Farmers in the Southern Agricultural Growth Corridor in Tanzania: Lessons from Households in Ihemi Cluster. Tanzania *Journal of Agricultural Sciences*. 2020; 19(2):116–130.

[27] Constantine J, Sibuga KP, Shitindi MJ, Hilberk A. Awareness and Application of Existing Agroecological Practices by Small Holder Farmers in Mvomero and Masasi Districts-Tanzania. *Journal of Agricultural Science*. 2021;13(1):1-13.

[28] Wezel A, Herren BG, Kerr RB, Barrios E, Gonçalves ALR, Sinclair F. Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development*. 2020; 40(6):1–13.

[29] Udimal TB, Jincai Z, Mensah OS, Caesar AE. Factors Influencing the Agricultural Technology Adoption: The Case of Improved Rice Varieties (Nerica) in the Northern Region, Ghana. *Journal of Economics and Sustainable Development*. 2017; 8:137–148.

[30] Nigussie Z, Tsunekawa A, Haregeweyn N, Adgo E, Nohmi M, Tsubo M, *et al*. Factors influencing small-scale farmers' adoption of sustainable land management technologies in north-western Ethiopia. *Land Use Policy*. 2017;67:57–64.

[31] Amare A. Simane B. Determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub-basin of the Upper Blue Nile basin of Ethiopia. *Agriculture and Food Security*. 2017;6(1):1–20.

[32] Bongole AJ, Kitundu KMK, Hella J. Usage of Climate Smart Agriculture Practices: An Analysis of Farm Households' Decisions in Southern Highlands of Tanzania. *Tanzania Journal of Agricultural Sciences*. 2020;19(2):238–255.

[33] Ullah A, Khan D, Zheng S, Ali U. Factors influencing the adoption of improved cultivars: a case of peach farmers in Pakistan. *Ciência Rural*. 2018;48:1–11.

[34] Mugure A, Oino PG, Sorre BM. Land ownership and its impact on the adoption of agroforestry practices among rural households in Kenya: a case of Busia county. International *Journal of Innovation and Applied Studies*. 2013 Nov; 4(3):552–9.

[35] Foguesatto CR, Borges JAR, Machado JAD. A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide, *Science of the Total Environment*. (2018), https://doi.org/10.1016/j.scitotenv.2020.138831.

[36] Kangmennaang, J., Kerr, RB., Lupafya, E., Dakishoni, L., Katundu, M. and Luginaah, I. Impact of a participatory agroecological development project on household wealth and food security in Malawi. *Food Security*. 2017; 9(3):561–576.