Adoption of organic fertilizer and its impact on income generation among smallholder farmers in Tanzania: A pathway to sustainable Agriculture

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Abstract

This study examines the determinants of organic fertilizer adoption and its effects on the welfare of smallholder farmers in Tanzania, utilizing secondary data from the National Agriculture Sample Census Survey 2019/20. Employing a non-experimental research design, the study applies a probit model to estimate the factors influencing organic fertilizer adoption and uses Ordinary Least Squares (OLS) to analyze the impact of adoption on farmers' income. The results revealed that female-headed households, larger household sizes, separated marital status, self-employment, and membership in farmers' cooperatives significantly increase the likelihood of organic fertilizer adoption. Conversely, urban residence, land ownership, primary education, receipt of extension services, and lack of market access reduce the probability of adoption. The study further indicates that while organic fertilizer adoption is not directly associated with income gains, factors like access to credit, proximity to farms, and education positively impact farmers' welfare. The study suggests policy measures to strengthen cooperative unions, enhance gender-responsive support for female farmers, improve extension services to promote organic practices, develop market access, and provide tailored financial services to encourage sustainable agricultural practices. These insights aim to improve the livelihoods of smallholder farmers and advance sustainable agriculture in Tanzania.

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1. Introduction

Agriculture remains a fundamental driver of economic development and growth, supporting livelihoods and ensuring environmental sustainability (Belete, 2022; Dawson et al., 2016). Despite its critical role, farmers worldwide face decreasing crop yields due to declining soil fertility, a key biophysical factor affecting agricultural productivity (Wasil et al., 2023). This reduction in soil fertility has both immediate and far-reaching consequences on agricultural output and the well-being of rural households (Amare et al., 2017). A contributing factor to this problem is the continued use of chemical fertilizers, which has led to nutrient depletion, increased soil acidity, and reduced organic matter, thus negatively impacting crop yields and smallholder farmers' livelihoods (Oyetunde-Usman et al., 2021; Mustapha et al., 2021; Salami, 2013).

Organic fertilizers have emerged as a viable solution to the problem of soil fertility depletion, offering a sustainable alternative to conventional chemical fertilizers. Derived from plant and animal materials, organic fertilizers are rich in carbon and nutrients that improve soil health and contribute to sustainable agricultural practices (Rioux et al., 2017; Singh, 2012). This is particularly relevant in sub-Saharan Africa (SSA), where smallholder farmers face challenges such as food insecurity and economic instability (Amede et al., 2023). In SSA, around 65% of agricultural land suffers from soil degradation, leading to significant productivity losses (Zingore et al., 2015). Research indicates that organic fertilizers improve soil properties, such as bulk density and organic matter content, and enhance vital nutrients like calcium, magnesium, phosphorus, and nitrogen, which positively impact crop yields and soil fertility (Amede et al., 2023).

In Tanzania, organic agriculture dates back to 1898 with the establishment of the first organic garden in Peramiho (Taylor, 2006). Smallholder farmers increasingly view organic fertilizers as a pathway to sustainable agriculture and enhanced income generation (Sanga et al., 2024). The government has recognized the importance of organic farming in its broader agricultural policies, leading to the establishment of the Tanzania Organic Agriculture Movement (TOAM) and the inclusion of organic agriculture in national policy frameworks (Mwageni et al., 2015; Taylor, 2006). Additionally, non-governmental organizations (NGOs) like Kilimo Hai and the Foundation for Organic Agriculture Tanzania actively promote organic practices, aiming to address soil degradation and low productivity while facilitating the transition from conventional to organic farming.

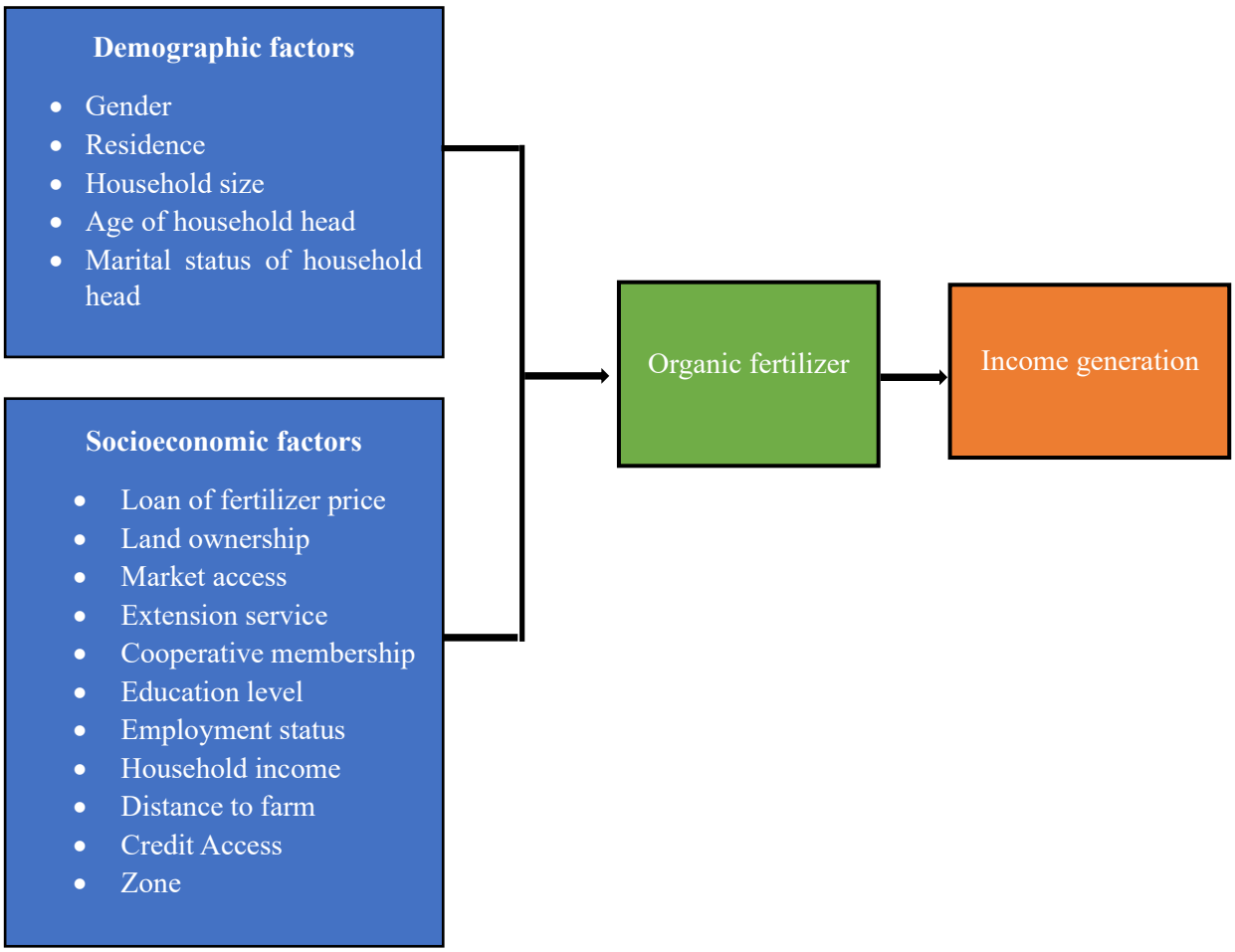
Despite these efforts, the adoption of organic fertilizers in Tanzania remains limited (Mwageni et al., 2015). Barriers such as a lack of knowledge regarding the long-term benefits of organic fertilizers, low market demand for organic products, slow nutrient release from organic sources, and cultural perceptions hinder widespread adoption (Basasola et al., 2018; Sanga et al., 2024). Therefore, understanding the factors influencing the adoption of organic fertilizers and their impact on smallholder farmers' welfare is crucial. This study seeks to provide insights into these factors and assess how organic fertilizer use affects income generation, thereby informing policymakers on strategies to promote sustainable agricultural practices and improve rural livelihoods.

Existing studies have explored factors influencing the adoption of organic fertilizers in various contexts. For example, research in Ethiopia and Afghanistan found that factors such as household size, land ownership, market access, and extension services significantly influence farmers' adoption of organic fertilizers (Terefe & Ahmed, 2016; Wasil et al., 2023; Belete, 2022). These studies highlight the positive role of education and market proximity in enhancing organic fertilizer

use while indicating that off-farm income negatively affects adoption. Additionally, in Ghana, the use of organic fertilizers was found to significantly enhance crop yield, income, and gross margins by over 50%, suggesting that increased awareness, accessibility, and affordability of organic fertilizers could improve smallholder farmers' profitability (Bidzakin et al., 2023). Similarly, studies in Zimbabwe demonstrated that agro-ecological regions, education levels, and market distance play a crucial role in the adoption of both organic and inorganic fertilizers (Gumindoga et al., 2024). These findings collectively underscore the importance of extension services, technical training, and market accessibility in promoting sustainable agricultural practices through organic fertilizer use.

Despite these findings, there is a research gap in understanding how these determinants specifically influence the adoption of organic fertilizers among smallholder farmers in Tanzania and what impact such adoption has on their welfare. Therefore, this study aims to assess the factors influencing organic fertilizer adoption and evaluate its effects on the welfare of smallholder farmers in Tanzania. By identifying these determinants and impacts, the study seeks to provide crucial insights that can guide policymakers in promoting organic fertilizer use, ultimately contributing to sustainable agricultural practices and improved livelihoods for rural farmers.

Figure 1: Conceptual framework



2.Methods and Data

Non-experimental research design is important in this study because it allows for the exploration of data sets for agriculture sample census survey 2019-20 by the National Bureau of Statistics (NBS). In this study non-experimental research design helps to provide a realistic depiction of the factors enhancing adoption of organic fertilizer in Tanzania. Non-experimental research design is observational in nature which means the researcher can observe the variables as they naturally occur in the environment. By using a non-experimental design, this study provides insights into the complex dynamics of organic fertilizer in Tanzania without directly manipulating variables or controlling the research environment. This approach allows for a more naturalistic understanding of the factors at play and their impact on organic fertilizer adoption. The non-experimental research design provides Analysis of the existing conditions and variables to gain a deeper understanding of the factors contributing to adoption of organic fertilizer usage in the country.

3. Data analysis

Analytical modelling

In explaining factors influencing the adoption of organic fertilizer among smallholder farmers in Tanzania a study uses a probit regression model on explaining various household factors toward organic fertilizer analyze (Sesabo, 2024). This model often estimates using the maximum likelihood procedure, which involves various factors such as demographic and economic on describing organic fertilizer usage among smallholder farmers in Tanzania. Therefore, this study took into account an equation that defines smallholder farmers organic fertilizer usage status with the following connection for the probit model.

$$y_i^* = \beta w' + \mu_i \text{ where } \mu_i \sim (0, \sigma^2) \quad \ldots\ldots 1$$

y* is the dependent variable, which assumes and observed status, β represents the independent variables, w' represent the coefficient of independent variable and μ_i is the error term which stands for normal distribution (Komba, 2020; and Sesabo, 2024). As for this function probit model will be derived to analyze factors influencing adoption of organic fertilizers. Since y_i^* is unobserved what we observe is y^*, which makes only two values as explained that one may or may not use organic fertilize as described below

when $y_i^* > 0, y_i = 1$ *if smallholder farmers are using organic fertilizer.*

when $y_i^* \leq 0, y_i = 1$ *if smallholder farmers are not using organic fertilizer.*

Because the probability that the smallholder farmers is using organic fertilizer is greater than zero ($y^* > 0$)

$$\text{Prob}(y = 1) = \text{prob}(y_i^* > 0) \quad \ldots\ldots 2$$

Or less than or equal to zero ($y^* \leq 0$)

$$\text{Prob}(y = 0) = \text{prob}(y_i^* \leq 0) \quad \ldots\ldots 3$$

The likelihood of smallholder farmers of using organic fertilizer is therefore presented by unobserved factors through the dependent variables as follows

$$organic\ fertilizer = \begin{matrix} 1\ if\ smallholder\ farmers\ is\ using\ organic\ fertilizer > 0 \\ 0\ if\ smallholder\ farmers\ are\ not\ using\ organic\ fertilizer < 0 \end{matrix} \quad \ldots\ldots 4$$

If $y_i^* = 0$ then y = 1 implying the smallholder farmer is using organic fertilizer. Therefore, the probability that the smallholder farmer is using organic fertilizer assumes that the probability density function of e_i assumed $f(\mu_i)$ which result in the creation of a new parameter.

Prob (y_i =1 $|x|$) = $\int_{-\infty}^{x\beta} f(\mu_i)$ du = F $x_i'\beta$……5

Prob (y_i =1 $|x|$) =$2\pi^{1/2}$ exp $\left((-\beta x_i)\frac{2}{2}\right)$……6

Hence, based on the variables used in this study the probit model is therefore presented as follows

$y_i = \beta_0 + \beta_1 x_1 + \beta_2 D_i + \mu_i$……7

Where the β_0 is the constant term while β_1 and β_2 are the parameters that will be estimated in the probit equation. On the other side $x_1$are the covariates while D_i represents the group of dummy variables used in this study

Moreover, multiple linear regression model was used to assess the outcome of adaptation of organic fertilizer by smallholder farmers on income generation in Tanzania, because it allows us to explicitly control for many other factors that simultaneously affect the dependent variable(Wooldridge, 2001)

$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots\ldots \beta_k x_k + \mu$

Where y is the dependent variable, β_0 is the intercept, β_1, $\beta_2$and β_3 and β_k are the coefficient and x_1, x_2, x_3 and x_k are the independent variables and μ is the error term. Additionally, variables used in this study are explained in Table 1.

Table 1: Description and measurement of variables

Variable name	Operational definition
Income generation	Amount of income generated
Organic fertilizer usage	Use organic fertilizer=1, do not use organic fertilizer=0)
Sex	Categorical variable=female, male (reference category)
Household size	Number of people within a household
Residence	Categorical variable = urban, rural (reference category)
Age of household head	Number of years old
Marital status of household head	Categorical variable= widowed, separated, polygamous married, never married, divorced, living together, monogamous married (reference category)
Loan of fertilizer price	Total price of fertilizer taken as loan
Land ownership	Categorical variable=own land, don't own land (reference category)
Market access	Categorical variable=with access to market, No access to market (reference category)

Extension service	Categorical variable=received extension services, Not received extension service (reference category)
Cooperative membership	Categorical= member in farmer's cooperative union, not member in farmers' cooperative union (reference category)
Education level	Categorical variable =some secondary, some primary, more than secondary, completed secondary, completed primary, no schooling (reference category)
Employment status	Categorical=unpaid household worker, unemployed, self-employed, retired, paid household worker, never worked, employee (reference category)
Distance to farm	Categorical variable=less than 5 Km, more than 5 Km (reference category)
Credit access	Categorical variable= with access to credit, with no access to market (reference category)
zone	Categorical variable=western zone, southern zone, southern highlands zone, northern highlands zone, central zone, east coast zone, lake zone (reference category)

4.Findings and Discussions

Findings

Results in Table 2 show that majority of population are males who forms 76.66% of the entire population while females are just 23.34%. on the other hand, results show that 4,011 households equivalent to 85.87% are residing in rural areas while 660(14.13%) are residing in urban areas. Moreover, findings show that large population (29.07%) resides in lake zone, while those residing in Southern highlands zone were just 19.37%, Northern highlands zone (15.86%). Moreover, those residing in Southern zone, Western zone, East coast zone, Central zone was just 9.7%,9.38%,8.56% and 5.05% respectively.

Results based on education level in Table 2 show that large population (55.38%) are with no school, while those completed primary were just (30.21%), some prime (10.53%), completed secondary (2.48%), more than secondary (1.03%) and with some secondary (0.36%). Results also show that 12.42% of households are widowed, 3.28 are separated, 13.92% are polygamous married, 2.27% are never married, 60.74% are monogamous married, 4.3% are living together and 3.06% are divorced. As per results in table 2, a large number of population (60.4%) are self-employed while 6.43% are unpaid household workers, 4.13% are unemployed, 1.91% are retired, 0.24% are paid household workers, 17.05% never worked and 9.85% are employees.

The results in Table 2 also show that majority of households (76.71%) did not own land and only few (23.29%) owned land. 1,912 households (40.93%) travelled less than 5 kilometers to farms while 2,759 households (59.07%) travelled more than 5 kilometers to farms. A large number of households (78.91%) reported to have not received extension services while only 21.09% reported to have received extension services. The results also show that 84.93% of households were members in farmers' cooperative union and the rest 15.07% of households were not members.

Moreover, results in Table 2 show that 57.33% of households had no access to credit while 42.67% had access to credit. Only 426 households had access to market accounting to 9.12%, the remaining 4,244 households had no access to market accounting to 90.88%. The results also shows that 47.55 of households do not use organic fertilizer and the rest 56.43% use organic fertilizer. 1,892, 2,636 and 143 households use organic fertilizer, inorganic fertilizer and biological fertilizer respectively.

Table 2: Household characteristics

Variables	Attributes	Frequency	Percent	Cum.
sex	Male	3,581	76.66	76.66
	Female	1,090	23.34	100.00
Total		**4,671**	**100.00**	
Residence	Rural	4,011	85.87	85.87
	Urban	660	14.13	100.00
Total		**4,671**	**100.00**	
Zone	Western Zone	438	9.38	9.38
	Southern Zone	453	9.70	19.08
	Southern Highlands Zone	905	19.37	38.45
	Northern Highlands Zone	741	15.86	54.31
	Lake Zone	1,358	29.07	83.39
	East Coast Zone	400	8.56	91.95
	Central Zone	376	8.05	100.00
Total		**4,671**	**100.00**	
Education	Some Secondary	17	0.36	0.36
	Some Primary	492	10.53	10.90
	No Schooling	2,587	55.38	66.28
	More than Secondary	48	1.03	67.31
	Completed Secondary	116	2.48	69.79
	Completed Primary	1,411	30.21	100.00
Total		**4,671**	**100.00**	
Marital status	Widowed	580	12.42	12.42
	Separated	153	3.28	15.70
	Polygamous Married	650	13.92	29.62
	Never Married	106	2.27	31.89
	Monogamous Married	2,836	60.74	92.63

	Living Together	201	4.30	96.94
	Divorced	143	3.06	100.00
Total		**4,669**	**100.00**	
Employment status	Unpaid Household Worker	300	6.43	6.43
	Unemployed	193	4.13	10.56
	Self Employed	2,820	60.40	70.96
	Retired	89	1.91	72.86
	Paid Household Worker	11	0.24	73.10
	Never Worked	796	17.05	90.15
	Employee	460	9.85	100.00
Total		**4,669**	**100.00**	
Land ownership	No land owned	1,051	23.29	23.29
	Own land	3,461	76.71	100.00
Total		**4,512**	**100.00**	
Distance to the farm	Less than 5 Km	1,912	40.93	40.93
	More than 5 Km	2,759	59.07	100.00
Total		4,671	100.00	
Extension services	No extension services	3,686	78.91	78.91
	Received extension services	985	21.09	100.00
Total		**4,671**	**100.00**	
Membership in farmers' cooperative union	Not member	704	15.07	15.07
	Member	3,967	84.93	100.00
Total		**4,671**	**100.00**	
Access to credit	No access	2,678	57.33	57.33
	Has access	1,993	42.67	100.00
Total		**4,671**	**100.00**	
Access to market	With access	426	9.12	9.12
	No access	4,244	90.88	100.00
Total		**4,670**	**100.00**	
Organic fertilizer usage	Don't use	2,221	47.55	47.55
	Use	2,450	52.45	100.00
Total		**4,671**	**100.00**	
Type of fertilizer used	Organic Fertilizer	1,892	40.51	40.51

	Inorganic Fertilizer	2,636	56.43	96.94
	Biological Fertilizer	143	3.06	100.00
Total		**4,671**	**100.00**	
Age		Mean	48.70349	
		Std.dev.	15.50949	
Household size		Mean	5.603511	
		Std.dev.	3.199227	
Adult equivalent household size		Mean	4.514331	
		Std.dev.	2.520742	
Household income		Mean	329872.5	
		Std.dev.	401226.9	
Household consumption		Mean	302637.2	
		Std.dev.	287442.8	

Source: Census survey 2019-20 by the National Bureau of Statistics (NBS)

Additionally, results in Table 2 show that the average age of households is 49 years old with the standard deviations of 15.51, moreover, average household size is 6 indicating that each household at least has six members with the standard deviation of 3.2. On the other hands average adult equivalent household size is 5 with the standard deviation of 2.52. Results in table 2 show that the average household income is approximately Tanzanian shillings 329,900 with the standard deviation of 401226.9. Furthermore, results show that on average household consumption per month is 302637.2 with the standard deviation of 287442.8.

Adoption of organic fertilizer among households

Results in table 3 show that females are more likely to use organic fertilizer than males significantly ($p<0.05$). Moreover, large household size are more likely to use organic fertilizer compared to households with lower number of family members($p<0.01$). Additionally, other variables that were found to influence adoption of organic fertilizer positively includes separated marital status ($p<0.05$), employment status whereas household whose head of households are self-employed, never worked and unpaid household workers were found to increase chances for their households to adopt the use of organic fertilizer as compared to employee counterpart significantly ($P<0.01$), also being member in famers' cooperative union increases the chance for adopting the use of organic manure than not being a member significantly ($p<0.01$)

Table 3: Adoption of organic fertilizer

Variable	Coefficient	Standard error	P-value
Residence (Urban)	-.6838894	.0661267	0.000***

Sex (Female)	.1650318	.0718682	0.022**
Loan Fertilizer price	-.0000361	.0348269	0.999
Household size	.1263798	.0334057	0.000***
Polygamous Married	-.1187997	.0635489	0.062*
Living together	-.0412247	.101511	0.685
Separated	.2750294	.1317382	0.037**
Divorced	.1424326	.1426125	0.318
Never married	-.010994	.1480106	0.941
Widowed	-.0082159	.0934717	0.930
Own land	-.1464311	.0509901	0.004***
Received extension service	-.3707523	.0514116	0.000***
Some primary	-.2531488	.0691615	0.000***
Completed primary	-.2817997	.0505819	0.000***
Some secondary	-.4196076	.3723183	0.260
Competed secondary	-.6542794	.1473647	0.000***
More than secondary	-.6094342	.2299321	0.008***
Self employed	.2579668	.0752298	0.001***
Paid household worker	-.1716326	.4243506	0.686
Unpaid household worker	.452269	.1077717	0.000***
Unemployed	.1364265	.1209828	0.259
Retired	.087791	.1687795	0.603
Never Worked	.3797547	.0874031	0.000***
Distance to farm(less than 5 Km)	.2328773	.1609652	0.148
Western Zone	-.0245943	.0789027	0.755
Central Zone	.0107258	.0831908	0.897
East Coast Zone	-.2465799	.085254	0.004***
Southern Highlands Zone	-.1531974	.0628858	0.015**
Northern Highlands Zone	-.4268616	.0657087	0.000***
Southern Zone	-.0344844	.0791663	0.663

Adult equivalent household size	-.4074396	.0426488	0.000***
Household head's age	-.0016116	.0347773	0.963
No market access	-.2681825	.0739088	0.000***
Member in farmers' cooperative union	.264081	.0604078	0.000***
With access to credit	.2211194	.1596185	0.166
Household income	-.0110804	.0276637	0.689
Constant	1.426568	.4009257	0.000***
Number of observations	4,507		
Pseudo R squared	0.1887		
Chi squared	0.0000		

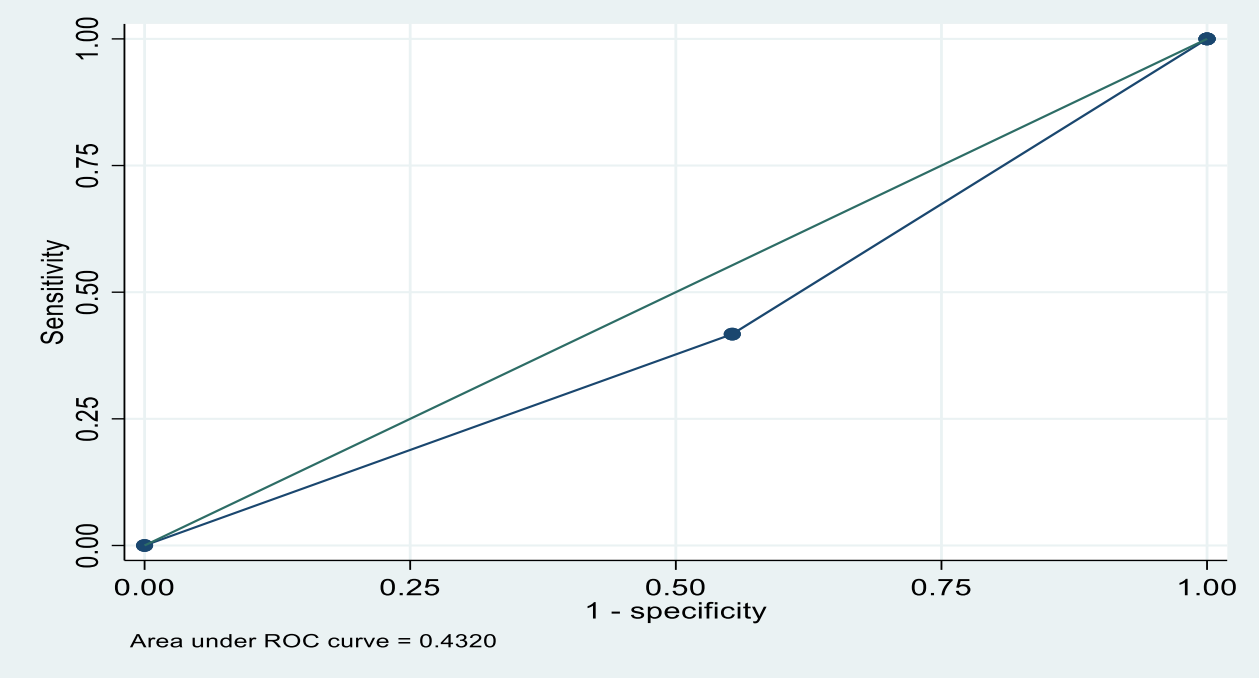
P-values; *, ** and *** imply significance level at 10%, 5% and 1%
Source: Census survey 2019-20 by the National Bureau of Statistics (NBS)

On the other hand, several variables in table 3 were found to influence decline in the household likelihood of adopting the use of organic fertilizer, for instance household being in urban areas decreases the likelihood of using organic fertilizer compared to the rural counterpart significantly ($p<0.01$). This implies that urban household have less chances of adopting to the use of organic fertilizer compared to those in rural areas. Also, similar variables with negative influence on adoption of organic fertilizer were Own land, received extension services, some primary, completed primary, East coast zone, Northern highlands zone, no market access ($p<0.01$) and Southern highlands ($p<0.05$). Whereas households owning land and received extension services were less likely to adopt the use of organic fertilizer as compared to the ones with no land and not received fertilizer, households with some primary and competed primary were found less likely to adopt to the use of fertilizer than with no schooling. Also, households residing in East coast zone, Northern highlands zone and Southern highlands zone were found less likely to adopt the use of organic fertilizer as compared to the one residing in lake zone. In addition to that, households with no access to market have lower chance to adopt the use of organic fertilizer as compared to households with access to market counterpart.

Prediction of extension service on adoption of organic fertilizer among small holder farmers.

As per results in Figure 1, it was found that extension service poorly predicts the adoption of organic fertilizer (area under curve 0.432). The model is more likely to rank negative instances higher than positive ones. This complies to findings in table 3 as farmers that had received extension services were less likely to adopt the use of organic fertilizer.

Figure 1 prediction of extension service on adoption of organic fertilizer

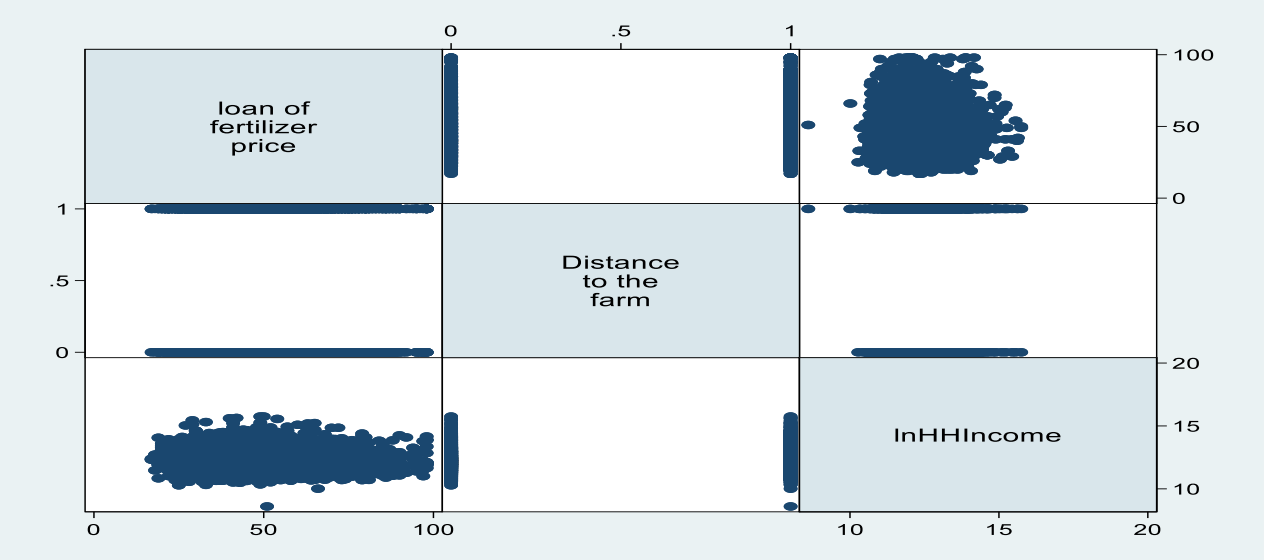


Source: Census survey 2019-20 by the National Bureau of Statistics (NBS)

Correlation of loan of fertilizer price, distance to farm and household income among farmers

The results in Figure 2 show that there is a very weak negative correlation between loan of fertilizer price and household income. This implies that an increase in loan of fertilizer price is associated with a very small decrease in household's monthly income. Only meaningful results were interpreted.

Figure 2 Correlation matrix for loan of fertilizer price, distance to farm and household income



Source: Census survey 2019-20 by the National Bureau of Statistics (NBS)

Impact of adoption of organic fertilizer on income generation among smallholder farmers

Results in table 4 show that households residing in urban area have more income generation as compared to households residing in rural counterpart ($p<0.05$). Also, the results show that farmers with some primary education have more income generation than the ones with no schooling significantly ($p<0.1$). Moreover, farmers who travel less than 5 kilometers to farm have more income generation than farmers travelling more than 5 kilometers significantly ($p<0.01$). In addition to that, farmers with credit access have more income generation than the ones with no access to credit ($p<0.01$).

Table 4: Effects of adoption of organic fertilizer on income generation

Variables	Coefficient	Standard error	t-value	P-value	[95% Confidence Interval]	
Use organic fertilizer	-.0081003	.0250982	-0.32	0.747	-.0573052	.0411046
Residence(urban)	.0832901	.0356367	2.34	0.019**	.0134246	.1531557
Sex (Female)	.0218928	.0387323	0.57	0.572	-.0540417	.0978273
Loan Fertilizer price	.0165712	.0197826	0.84	0.402	-.0222125	.0553549
Household size	-.0132143	.0172886	-0.76	0.445	-.0471086	.0206799
Polygamous Married	-.0889921	.0343269	-2.59	0.010***	-.1562897	-.0216944
Living Together	.0821426	.0557029	1.47	0.140	-.0270627	.1913478

Separated	.0088999	.0676886	0.13	0.895	-.1238033	.1416032
Divorced	-.1117708	.0734678	-1.52	0.128	-.2558041	.0322625
Never Married	-.1000816	.0810508	-1.23	0.217	-.2589812	.0588181
Widowed	-.0892129	.0499732	-1.79	0.074*	-.1871852	.0087593
Own land	-.0238507	.0274191	-0.87	0.384	-.0776057	.0299043
Received extension services	.0255476	.0281182	0.91	0.364	-.0295779	.0806732
Some Primary	.0653212	.0378622	1.73	0.085*	-.0089075	.1395499
Completed Primary	-.0049388	.0276445	-0.18	0.858	-.0591357	.049258
Some Secondary	.2262832	.18883	1.20	0.231	-.1439171	.5964835
Completed Secondary	.0127886	.0763974	0.17	0.867	-.1369881	.1625654
More than Secondary	.0365996	.1185749	0.31	0.758	-.1958658	.269065
Self Employed	-.0125154	.0406273	-0.31	0.758	-.0921651	.0671343
Paid Household Worker	-.1058397	.2275845	-0.47	0.642	-.5520178	.3403385
Unpaid Household Worker	-.1236874	.0579896	-2.13	0.033**	-.2373757	-.0099991
Unemployed	-.0068882	.0668423	-0.10	0.918	-.1379321	.1241558
Retired	-.0075404	.0892529	-0.08	0.933	-.1825202	.1674394
Never Worked	-.0567424	.0473009	-1.20	0.230	-.1494755	.0359907
Distance to farm(less than 5 Km)	.6074136	.0851105	7.14	0.000***	.440555	.7742722
Western Zone	-.0391355	.042175	-0.93	0.353	-.1218194	.0435484
Central Zone	-.0660042	.0447671	-1.47	0.140	-.1537699	.0217616
East Coast Zone	-.0604285	.0458753	-1.32	0.188	-.1503667	.0295097
Southern Highlands Zone	-.0117623	.0338569	-0.35	0.728	-.0781385	.054614
Northern Highlands Zone	-.0099901	.0357984	-0.28	0.780	-.0801727	.0601926
Southern Zone	.0143362	.0431009	0.33	0.739	-.0701629	.0988353

Adult equivalent household size	.0178598	.022107	0.81	0.419	-.0254809	.0612004
Household head's age	-.0173009	.0197578	-0.88	0.381	-.0560359	.0214341
No market access	.0912132	.0394951	2.31	0.021	.0137833	.1686432
Member in farmers' cooperative union	-.0190528	.0324252	-0.59	0.557	-.0826223	.0445167
With access to credit	.443	.0845903	5.24	0.000***	.2773704	.609048
Constant	11.861	.1230584	96.38	0.000***	11.61928	12.10179

Mean dependent var	12.385	SD dependent var	0.752
R-squared	0.032	Number of observation	4507
F-test	4.121	Prob > F	0.000
Akaike crit. (AIC)	10144.020	Bayesian crit. (BIC)	10381.315

P-values; *, ** and *** imply significance level at 10%, 5% and 1%
Source: Census survey 2019-20 by the National Bureau of Statistics (NBS)

On the other hand, some variable in table 4 were found to have a negative influence on income generation, for instance polygamous and widowed households had less income generation as compared to monogamous households significantly ($p<0.1$). In addition to that, unpaid household workers were found to have less income generation as compared to employee's counterpart ($p<0.05$).

5.Discussions

As per findings, households with large number of family members had high chance of adopting the use of organic fertilizer than households with lower number of family members. This finding comply to the one found by Wasil et al., (2023) and Belete, (2022), who also found family size to have a positive impact on adoption of organic fertilizer. This can be triggered by the motive to increase food availability in the household as organic fertilizer increases agricultural yields. This then ensures that the household has enough food to meet the demands of its lager size.

It was found that employment status had a positive significant influence on adoption of organic fertilizer. Thus, household with self-employed, unpaid household worker and with never worked head of household had more chance of adopting the use of organic fertilizer as compared to households whose head of household are employees.

This study also revealed that households that were members in farmers' cooperative union had more chance of adopting the use of organic fertilizer than households that were not members. This shows how people within the same group are more likely to share common interest and thus easily influencing each other among the group.

It was also found that households that were located in urban areas were less likely to adopt the use of organic fertilizer as compared to the ones located in rural areas and households located in East coast zone and Northern highlands zone had low chance to adopt the use of organic fertilizer than households located in lake zone. Similar finding were found by (Terefe & Ahmed, 2016) and Gumindoga et al., (2024). In their studies found that organic fertilizer adoption was significantly influence by agro-ecological regions and slope of the plot.

As per findings, households that own land were less likely to adopt the use of organic fertilizer than households don't own land. This finding contradicts to the one found by (Belete, 2022). The study found that the ones that owned land were more likely to adopt the use of organic fertilizer than the ones that rent land. It is due to fact that the farmers that own land are assured with the same land use in the future and thus deciding to use organic manure.

Households that received extension services were less likely to adopt the use of organic fertilizer than the households that never received extension services. This finding contracts that found by Belete, (2022) and Terefe & Ahmed, (2016) who found that extension services increases the likelihood for usage of organic fertilizer among farmers. Among important roles of extension services is increasing farmers' understanding of the productivity in agriculture through giving them information on agricultural technology adoption.

As per findings households with household heads that had some primary and completed primary were less likely to adopt the use of organic fertilizer as compared to the households with household heads that had no school. This finding contradicts to that by Wasil et al., (2023) who found positive impact of education on adoption of fertilizer. Education does not only make farmers use organic fertilizers; it also increases the effectiveness of the use of organic fertilizer.

Households with no market access were found less likely to adopt the use of organic fertilizer than households with access to market. This finding is similar to that found by Wasil et al., (2023) and Terefe & Ahmed, (2016). Their studies found that farmers that had access to market were more likely to adopt the use of organic fertilizer. Having access to market would even reduce high transaction cost that farmer normally face (Wasil et al., 2023; and Terefe & Ahmed, (2016).

The study revealed that farmers with some primary education have more income generation than the ones with no schooling. This study is similar to the one found by Wasil et al., (2023) and Terefe & Ahmed, (2016) who revealed that farmers with education are more likely to use organic fertilizer effectively as required and thus getting more yield and increasing their income. Farmers with education have more multiple income source Wasil et al., (2023), they use their education to have other various means to generate income apart from agriculture.

Farmers who travel less than 5 kilometers to farm have more income generation than farmers traveling more than 5 kilometers. This is due to the fact that the near the farm is the less the time that one uses to get to farm, this would also allow a farmer to increase working time and still ensure the farmer with more time to engage in other income generating activities and thus earning more.

Conclusion

The main findings of this study reveal that factors such as gender, household size, employment status, marital status, and cooperative membership positively influence the adoption of organic fertilizers among smallholder farmers. Conversely, households located in urban areas, those owning land, those receiving extension services, and those with limited market access are less

likely to adopt organic fertilizers. The adoption of organic fertilizers does not directly translate to income generation, although variables like credit access, education, and farm proximity positively influence household income.

The study's findings have significant policy implications for enhancing the adoption of organic fertilizers and improving the welfare of smallholder farmers in Tanzania. First, policies should aim to strengthen farmers' cooperatives and social networks, as membership in such groups has a positive impact on the adoption of organic practices. Cooperative unions can be empowered through capacity-building programs, access to financial resources, and market linkages that encourage collective decision-making and information sharing among farmers about the benefits of organic fertilizers.

The findings also highlight a need to reform extension services to better support organic fertilizer adoption. Extension officers should be trained on sustainable farming practices and the benefits of organic fertilizers, ensuring that they can effectively communicate these benefits to farmers. This may require the introduction of specialized training programs and the inclusion of organic farming modules in agricultural education curricula to ensure that extension workers are well-equipped to advise farmers on organic practices.

Furthermore, improving market access is crucial for facilitating the adoption of organic fertilizers. Policies aimed at developing market infrastructure, such as roads, storage facilities, and marketplaces, can help connect farmers to buyers and reduce transaction costs. Encouraging local and regional markets for organic produce can also create higher demand for organically grown crops, making organic farming more economically viable for smallholder farmers.

Finally, access to financial services, such as credit facilities tailored for smallholder farmers, can play a pivotal role in enhancing income generation and supporting the adoption of organic fertilizers. Microfinance institutions and agricultural banks should design financial products that support farmers in transitioning to organic practices, including loans with low-interest rates and flexible repayment options based on the agricultural calendar. These financial services should be accompanied by educational programs that help farmers understand the economic benefits of organic fertilizers and how to effectively manage their financial resources.

By implementing these policies, the Tanzanian government and development partners can promote the adoption of organic fertilizers, enhance sustainable agricultural practices, and improve the welfare of smallholder farmers, thereby contributing to economic development and environmental sustainability.

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