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Determinants of the Adoption of Chemical Fertilizer in Kaffa, Bench Sheko, and Sheka Zones of Southwest Ethiopia

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Abstract

Agriculture is the backbone of the Ethiopian economy, but the production system was backward, and the adoption of agricultural technology was low. This study aims to identify and determine factors affecting smallholder farmers' adoption of chemical fertilizer. Bita, Chena, Andiracha, and Sheyi Bench district of the southwest Ethiopia region was selected for this study. Household individual survey interview, key informant interview, and focus group discussion were the primary data collection methods used and published and unpublished sources were used for secondary data. A total of 261 households were interviewed by a structured questionnaire, and descriptive statistics like mean, standard deviation, percent, frequency, and a binary logistic regression model were the analysis methods used to indicate the results. The utilization of chemical fertilizers for crop production was lower than half of the sample households. The adoption of chemical fertilizer was lower in all districts except in households in the Sheyi Bench district. Out of the chemical fertilizer adopters, 39.42% used only NPS, and 60.58% used both NPS and urea in the 2023–2024 production year. Chemical fertilizer adoption of households is positively and significantly affected by the education level of the household head, logarithm of total annual income of the household, and frequency of extension agent contact, and negatively affected by age of the household head, distance from market, and livestock ownership of households. Inflated price of chemical fertilizer, problem of supply, and farmers' negative perception are challenges for its adoption. To improve the adoption of chemical fertilizer, it needs to work on its price, changing farmers' negative perception of it, and giving much attention to promotion and strengthening work on organic fertilizer.

Keywords: Adoption, binary logistic, chemical fertilizer, Southwest Ethiopia, factors

INTRODUCTION

Agriculture contributes a major share of the Ethiopian economy and has recently achieved significant development. However, the Ethiopian agricultural system relies mainly on rain-fed crop production, the growth of which depends on a favorable climate, while its dependence on technology is lower [1]. The adoption of agricultural technology in Ethiopia was lower, and many smallholder farmers were producing using the traditional method of production, which lowers productivity. The government of Ethiopia has made many policies and investments that boost the production and productivity of agriculture by accessing agricultural inputs such as improved varieties, chemical fertilizers, small-scale irrigation, and extension service provision to farmers (World Bank, 2015) [2].

Agriculture requires technological support to increase production per unit area by supporting it with irrigation water, plant protection, plant genetic

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improvement, new variety introduction, and taking measures to improve soil fertility. The adoption of improved technologies in the agricultural sector, beyond boosting productivity, is important for food self-sufficiency and alleviating poverty. Agricultural technologies are important to improve smallholder farmers' income and food production and have a positive spillover effect on other sectors and the entire economy of the country. In a developing country like Ethiopia, with many unexploited resources for agriculture, supporting agriculture with recent technology is crucial to overcoming poverty, enhancing food security, and the overall development of the country's economy [3].

The governments of Ethiopia and non-governmental bodies in the country have made many efforts to improve the adoption of technology in agriculture to increase productivity, but there is a problem with it. From the total crop area, on average, only nearly 50% of the land is covered by fertilizers, and only 17.85% are adopters of chemical fertilizers; the majority of farmers produce without using inorganic fertilizers [4].

The study area has many new technologies, including chemical fertilizers, which have been introduced and disseminated. However, the majority of farmers use traditional farming practices that retard progress in smallholder agriculture. Farmers cannot easily adopt improved agricultural technology because of various factors; however, some studies have reported multiple barriers to adoption, including technology awareness, risk aversion, institutional restrictions, and lack of human and financial capital and infrastructure. Many socio-economic, demographic, institutional, and other factors affect the adoption of chemical fertilizers [5].

Only a few farmers use the recommended improved technologies, which results in lower productivity of crops compared to the potential of the area. In addition, during the period of improved seed demand assessment, we recognized that the utilization of chemical fertilizers in these three zones was low compared to other areas of the region. In line with this, some farmers threw away the chemical fertilizer around their gardens or within the Enset rather than applying it to the crop. Why are farmers in these zones reluctant to use chemical fertilizers to improve crop productivity? The utilization of chemical fertilizer by smallholder farmers in the southwest Ethiopia region might be affected by socio-economic, institutional, demographic, and other factors. This study was conducted with the main focus of identifying and analyzing factors determining smallholder farmers' adoption of chemical fertilizers in southwest Ethiopia.

RESEARCH METHODOLOGY

Description of the Study Area

This study was conducted in three zones of the southwest Ethiopia region: the Kaffa, Bench Sheko, and Sheka zones. Four sample districts were taken: two districts, Bita and Chena, from the Kaffa zone, Sheyi Bench district from the Bench Sheko zone, and Andiracha district from the Sheka zone. Bita district is one of the districts in the Kaffa zone, located 523 km southwest of Addis Ababa, the Capital of Ethiopia. It between 7°12′33″ and 7°35′00″ North latitudes and 30°29′15″–35°51′00″ East longitudes. The total area is approximately 109,247 ha, which covers 9.45% of the total area of the Kaffa Zone. The Sheka zone borders Bita district from the west, Gesha district from the north, Gawata district from the northeast, and Chena district from the west. The elevation ranges from 950 to 2570 masl. The main rainy season ranges from June to September, which is locally called 'Yooyo' (summer), while the dry season ranges from December to April and is named 'Qaawo' (winter). It receives a mean annual rainfall of 1571–1862 mm and reaches its maximum between June and September. The monthly temperature of the district ranges from 13.5°C to 32.9°C, with an average of 22.6°C. Households in the district depend on agriculture as their primary source of income. Pretty trade and charcoal production are additional sources of income that support these households. Permanent crops such as coffee, perennial and seasonal crops, cereals, pulses, vegetables, root and tuber crops grow in the district.

Chena district is located at 07º18'48"N Latitude and 036º16'25"E Longitude and in 2020 meters above sea level. It is bordered by the Bench Sheko zone to the south, the Gimbo district to the northeast, the Bita district to the west, the Gewata district to the north, and the Decha district to the east. It has agroecological variation within the district: highland covers 15%, midland covers 80%, and lowland covers 5%. The district has a temperature range of 16–28°C with an annual average rainfall of 1800 mm. The district covers 90, 1.92 km^2 total area and a crop-livestock mixed farming system, with the two dominant perennial crops, Enset and coffee, being practiced in association with livestock rearing. The majority of the population in the district depends on agriculture, and coffee, barley, Enset, maize, sorghum, teff, faba bean, wheat, common bean, and potato are the major crops cultivated in the area.

The district selected from the Bench Sheko zone was the Sheyi Bench district, with coverage of 70%, midland, and 30% were lowland. The Sheyi Bench district was bordered by the Meinit-Golidiya district to the east and south, the Debub Bench district to the west, the Semen Bench district to the northwest, and the Kaffa zone to the north. It is part of the former Bench Woreda, with its capital being Siz town. The district receives an average annual rainfall of 803.35 mm, and the mean annual temperature ranges from 15°C to 25°C. The district has a total area of 46,315.04 ha, out of which crop land covers 23,341.54 hectare, forest land covers 2,325.44 ha, grazing land covers 370.25 ha, and degraded land 1547.80 ha. The total population of the district was 147,560, of which 72,405 were male, and 75,155 were female. A mixed farming system with agroforestry was practiced in the study area.

The Andiracha district is one of the three districts in the Sheka zone, with two lowland kebeles, ten midland kebeles, and five highland kebeles. Geographically, it is located 7°25′N to 7°45′N and 35°5′ to 35°35′E. Andiracha is bordered to the south by Yeki, to the southwest by the Gambela Region, to the northwest by the Oromia Region, to the north by Masha, and to the east by the Keffa. Anderacha has a capital in Gecha town, and the highland agro-ecology covers 15%, the midland 80%, and the lowland 5%. The annual rainfall in the district ranges from 1800 to 2200 mm, and the annual temperature ranges from 17°C to 29°C. The district has a total area of 200,869.5 ha which 36.94% was covered by forest. A mixed farming system was practiced in the area, with an agroforestry system dominated by rain-fed agriculture. Coffee, Enset, potato, maize, and korerima were cultivated mainly in association with livestock raising.

Procedures of Sampling and Sample Size Determination

Multistage sampling procedures were applied to select representative households for this study. Two districts from Kaffa and one district from the Sheka and Bench Sheko zones were selected randomly from FSRP-supported districts in each zone, proportional to the total number of districts in each zone. Second, two sample kebeles were selected from each district using simple random sampling (Table 1). Third, households were randomly selected from a list of households in each kebele (Table 1).

The size of the sample households for this study was determined using the formula developed by Yamane (1967):

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where, n is the number of households selected for the interview, N is the total population of sample kebeles (4321), and e is the level of error. Based on this formula, assuming a level of error of 6% and a 94% precision level, the total sample size of this study was 261 households.

Data Type, Source, and Collection Technique

Quantitative and qualitative data were collected through key informant interviews and focus group discussions using semi-structured questionnaires and household survey interviews using structured questionnaires from primary sources. Key informant interviews conducted at the Woreda and Kebele levels provided better information about the utilization of chemical fertilizer in the area. Focus group discussions were conducted in all kebeles of the four districts by including different community members, which provided better information on the trend and adoption of chemical fertilizer. A household survey was conducted in all eight kebeles, with a total of 261 sample households of different sizes, proportional to households in each kebele. Primary data were about the socio-economic characteristics of households, the type and amount of chemical fertilizer utilized in the 2022/23 production year, challenges of chemical fertilizer utilization, and others. Secondary data were collected from reports of the respective district agricultural office and Kebele agricultural extension agent, published material and unpublished material, the internet, and website reports.

Method of Data Analysis

Two types of analysis methods were used to indicate the results of this study that met its objectives: descriptive statistics and an econometric model.

Descriptive Statistics

Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to indicate the sample respondents' demographic, institutional factors, socio-economic conditions, type, and amount of chemical fertilizer utilized using the SPSS version 23 package. The results of the analysis are presented in tables, graphs, and descriptions. The mean differences in both discrete and continuous variables among adopters and non-adopters were tested using $\chi 2$ and t-tests, respectively:

Econometric Analysis

The econometric models employed in this study were binary logistic regressions to estimate the factors determining the adoption of chemical fertilizers by farming households. The dependent variable was whether the household adopted chemical fertilizers in the 2022/2023 cropping season. The dependent variable is binary, equal to 1 when the household is an adopter and 0 when it is not an adopter.

The model is specified mathematically by:

Pi = E(Y =1/xi) =1/1+e-z=ez/1+ez (2)

Where, Pi represents the probability of adoption of major improved crop seed or chemical fertilizer, Yi = 1, and exp (Zi) is the odds ratio "e to the power Zi." In the case of explanation, Equation (2) is written as for Z.

Pi = 1/1+e-Z (3)

Where, Zi = β0 + βiXi.

The probability that a respondent chooses to perform these activities successfully is given by Equation (3), and the probability that a respondent does not perform the activity is given by Equation (4).

Pi = 1-pi/xi=1/1+eZi (4)

If Pi is the probability of an adopter, the non-adopter is (1 − Pi). So, 1 − Pi =1/1+eZi and

Pi/1-pi= = eZi= (5)

Pi/1-Pi is the odds ratio that favors adopters. That is, the probability that a particular farmer participates in the adoption of chemical fertilizers but does not participate in the adoption.

Then, taking the log to both sides.

Y= ln (Pi/1-Pi) = Zi = β0 + β1X1 + β2X2 + β3X3... + βiXi +Ui (6)

Equation (6) was the binary logistic model, which was regressed.

The explanatory variables that are expected to affect the adoption of chemical fertilizers are indicated with their expected effects in Table 2.

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Table 1. Sample households were taken from each kebele.

District	Kebele	Sample households
Bita	Sheda	37
	Dacha-Difa	35
Chena	Boba-Gota	30
	Boba-Bela	34
Andiracha	Shebena	27
	Chegecha	32
Sheyi Bench	Mazi	34
	Shapa-Guyidi	32

Table 2. Definition of variables, their measurement, and expected effects.

Variable	Type	Measurement	Expected effect
Dependent variable			
Adoption CMFRT	Dummy	1 if adopter of chemical fertilizer, 0 otherwise	
Independent variable			
Sex	Dummy	1 if male and 0 if female	+
Age	Continuous	household head age in years	+/-
FMLSIZ	Continuous	Number of family members	+
LNDSIZ	Continuous	Area of land holding in hectares	+
EDUSTAT	Continuous	household head's educational status in years	+
DSTMRKT	Continuous	Distance of the market from households home	+
LOGTTINC	Continuous	Logarithm of annual income from different sources	+
TLU	Continuous	Total livestock owning	+/-
CRDACSS	Dummy	1 if households have credit access from formal and informal sources; 0 otherwise	+
FRQEXTCNT	Continuous	Frequency of extension agent contact	+

CMFRT: Chemical Fertilizer Adoption: Dependent variable; 1 if household adopts chemical fertilizer, 0 otherwise
Sex: Sex of household head: Independent variable; 1 = male, 0 = female
Age: Age of household head: Measured in years; continuous
FMLSIZ: Family Size: Number of family members in the household
LNDSIZ: Land Size: Area of landholding in hectares
EDUSTAT: Educational Status: Years of schooling of the household head
DSTMRKT: Distance to Market: Distance from household to the nearest market
LOGTTINC: Log of Total Income: Logarithm of annual income from different sources
TLU: Tropical Livestock Unit: Standardized measure of livestock holding
CRDACSS: Credit Access: 1 if household has access to formal/informal credit, 0 otherwise
FRQEXTCNT: Frequency of Extension Contact: Number of times household contacted agricultural extension services

RESULT AND DISCUSSION

Socio-Economic Characteristics of the Sample Households

Out of the sample households, 87.74% were male-headed, and 12.26% were female-headed households. The Pearson chi-square test indicated that there was a significant variation in the adoption of chemical fertilizer with the sex of the household head at the 1% significance level (Table 3). This finding indicates that male-headed households were more adopters of chemical fertilizers than female-headed households, which is consistent with the findings of Birhanu et al. (2023). This might be due to their access to information, decision-making power on resources, and the fact that females are mainly engaged in caring for family and working within the home. Most (97.70%) of the sample households were married, 0.4% were single, 1.5% were divorced, and 0.4% were widowed.

About 36.40 did not attend formal education, 39.08% attended primary education, 20.68% attended secondary school, and 3.83% attended college and above (Table 3). There was a variation in educational level between adopters and non-adopters, with a chi-square value of 7.279. The findings indicate that more educated household heads are more adopters of chemical fertilizers than less educated household heads, which is consistent with the findings of Birhanu et al. (2023).

Of the sample households, 42.53% had credit access from formal and informal sources, including farmers' cooperatives, Omo micro-finance, relatives, and friends, while 57.47% had no credit access. The Pearson chi-square test indicates that there is significant variation in credit access to adopters and non-adopters of widely improved varieties, with a chi-square value of 40.36. Households with credit access are more adopters than those with no credit access.

In the cropping season of 2022–2023, both winter and summer, 36.40% of the sample households received training on crop production, and 63.6% did not receive any training on crop production (Table 3). Access to training is related to the adoption of chemical fertilizers, as indicated by the chi-square test value of 112.07. Household heads with access to training are more adopters of chemical fertilizers than households with no training access at the 1% significant level. Training in farmers' capacity building is crucial for the adoption of chemical fertilizers. Household participation in and receiving training promoted the adoption of improved technologies.

Farmers contact extension agents for different support and advice. Out of the sample households, 54.02% are contacted extension agents in the 2022–2023 cropping season (Table 3). There was significant variation in extension contact between adopters and non-adopters, with a chi-square test at the 1% significance level. The majority of farmers who contacted extension agents were adopters of chemical fertilizers rather than those with no contact with extension agents, which indicates that extension agent contact promotes the adoption of chemical fertilizers. Of the sample households, 36.40% had information on chemical fertilizers from agricultural offices, extension agents, neighbor farmers, and media. The Pearson chi-square test indicates that there is a significant variation in access to information about chemical fertilizers between adopters and non-adopters at the 1% significance level. The majority of farmers who have information access are adopters of chemical fertilizers compared to those with no information. Of the sample households, 10.34% were members of an agricultural cooperative and 89.66% were not members. The Pearson chi-square test indicates that there is a significant variation in agricultural cooperative membership between adopters and non-adopters of chemical fertilizer at 1%, with a chi-square value of 11.057. The findings indicate that agricultural cooperative members are more adopters of chemical fertilizers than non-members.

The sample households had a mean age of 43.38 years, with a minimum of 22 years and a maximum of 75 years. Adopters of major improved seed had a mean age of 36.29 years, and non-adopters had 48.23 years, and the mean difference was significant at 1% significance level (Table 4). This implies that adopters have a lower mean age or are younger, and non-adopters have a higher mean age or are older. This finding was similar with [6] the mean family size of the total sample was seven people, while adopters had six family members and non-adopters had seven, but the mean difference between adopters and non-adopters was not statistically significant.

The mean land size of the sample households was 2.04 hectares, with 2.11 hectares of adopters and 1.99 hectares of non-adopters using chemical fertilizer (Table 4). The mean distance of the sample households from the market to home was 5 km, while adopters were located 4.67 km away from the market, and non-adopters were located 5.22 km away from the market, and t-tests indicated that it was significant at the 5% significance level. This finding indicates that households close to the market are more likely to adopt chemical fertilizers than those far from the market.

This might be due to infrastructure problems, especially road and transportation access, and the cost, hindering households' adoption of chemical fertilizers. The findings were in line with those who stated that households close to the market are more adopters of improved technologies [5]. The sample households were 1.55 km away from the farmers' training center, while adopters of chemical fertilizer were 1.04 km and non-adopters 1.91 km away from the Farmer Training Center (Table 4). Farmer

Training Center is a center of agricultural technology, and farmers close to the Farmer Training Center are more adopters of chemical fertilizers than farmers far from the FTC.

The mean livestock holding of the sample households' interns of TLU was 2.55, while adopters of chemical fertilizer had 2.41 holdings, and non-adopters had 2.65 holdings, and the mean difference was statistically significant at the 10% level. This finding indicates that households with larger livestock holdings are less likely to adopt chemical fertilizers.

Table 3. Discrete socio-economic and institutional characteristics of sample households.

Variable	Variable	Total sample (N=261)	Adopter (N=106)	Non-adopter (N=155)	Chi-square (χ^2)
Sex	Male	229	103	126	14.756*** → χ^2 is very highly significant ($p < 0.001$)
	Female	32	3	29	
Marital status	Single	1	1	0	no asterisk → not significant
	Married	255	105	150	
	Divorced	4	0	4	
	Widowed	1	0	1	
Educational status	Not-joined formal education	95	39	56	χ^2 is significant at 5% level ($p < 0.05$)
	Primary school	102	33	69	
	Secondary school	54	28	26	
	College and above	10	6	4	
Credit access	Yes	111	70	41	40.36***
	No	150	36	114	
Access training	Yes	95	79	16	112.097***
	No	166	27	139	
Extension agent contact	Yes	141	100	41	116.806***
	No	120	6	114	
Access to information	Yes	95	75	120	91.007***
	No	166	31	135	
Agricultural cooperative membership	Yes	27	19	8	11.057***
	No	134	87	147	

****, very highly significant (p < 0.001); *, significant at 5% level (p < 0.05)*

Table 4. Socio-economic and demographic characteristics of sample households of the continuous variable.

Variable	Total sample (N=261)		Adopter (N=107)		Non-adopter (N=154)		Significance
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Age of the household head	43.38	10.58	36.29	6.69	48.23	10.02	0.000***
Family size	6.49	2.07	6.40	2.24	6.56	1.96	0.529
Land size	2.04	1.54	2.11	1.52	1.99	1.57	0.545
Distance from market	5	1.99	4.67	2.33	5.22	1.69	0.028**
Distance from farmer training center	1.55	0.68	1.04	0.58	1.91	0.49	0.000***
Livestock owning	2.55	1.11	2.41	1.02	2.65	1.16	0.090*
Total income	83881.22	55869.89	114603.77	54266.65	62870.96	46563.17	0.000***

The mean annual income of the sample household was 83,881.22 Ethiopian Birr, while adopters of chemical fertilizer generated a mean total annual income of 114,603.77 ETB, and non-adopters generated 62870.96 ETB from different sources, and the mean difference was statistically significant at the 1% significance level. The results indicate that adopters of chemical fertilizers generate higher total income than non-adopters. Total household income had a significant impact on the adoption of chemical fertilizers. As household income increases, households tend to adopt technology, which means that adoption of technology is affected by households' total income and purchasing power.

Chemical Fertilizer Adoption

The use of chemical fertilizers for crop productivity improvement is a common measure used by farmers. Of the sample households, 40.60% used chemical fertilizer for crop production in the 2022/2023 summer and winter production seasons and the finding were more than finding of [6] that only 17.85% were adopters of chemical fertilizer, while it is less than the finding of [4] who reported that 57.04% of the sample households were adopters of chemical fertilizers. The mean annual income of the sample household was 83,881.22 Ethiopian Birr, while adopters of chemical fertilizer generated a mean total annual income of 114,603.77 ETB, and non-adopters generated 62870.96 ETB from different sources, and the mean difference was statistically significant at the 1% significance level. The results indicate that adopters of chemical fertilizers generate higher total income than non-adopters. Total household income had a significant impact on the adoption of chemical fertilizers. As household income increases, households tend to adopt technology, which means that adoption of technology is affected by households' total income and purchasing power.

This finding indicates that the adoption of chemical fertilizer in the area was lower, but the majority of farmers are still producing their crops without chemical fertilizer. There is significant variation in chemical fertilizer utilization between sample districts in the 2022/2023 production year, with a chi-square value of 29.42. Of the sample households from Bita district, 29.16%; Chena district, 37.5%; Andiracha district, 27.11%; and Sheyi Bench district, 68.18% used chemical fertilizer in the 2022/2023 production year. The utilization of households from Andiracha and Bita was very low, and Chena had lower and better adoption of chemical fertilizer in the Sheyi Bench district. The utilization of chemical fertilizers decreased in the study area. The findings indicate that 73.56% of the sample households had experience with chemical fertilizer utilization, and 26.44% had no experience with chemical fertilizer utilization. When we compare the current adopter with the past, the utilization of chemical fertilizer has been decreasing over time, which may be due to its price, delivery problems, and negative perception. The types of chemical fertilizers utilized by farmers in the 2022–2023 production year were NPS and urea. Of the chemical fertilizer adopters, 39.42% used only NPS, and 60.58% used both NPS and urea for crop production in the 2022–2023 production year [7].

Determinant of the Adoption of Chemical Fertilizer

A binary logistic regression model was employed to estimate the factors determining households' decisions to adopt chemical fertilizers. Many independent variables were regressed to determine their effects on the adoption decisions of chemical fertilizer farmers. The results of the binary logistic model indicate that the data fit the logistic regression model well; the chi-square test and log likelihood ratio were significant at 1%, indicating that the coefficients of the model are jointly significant. The results of binary logistic regression indicate that the age of the household head, educational status, logarithm of total annual income, distance from the market, livestock ownership by TLU, and frequency of extension agent contact significantly affect household decisions on chemical fertilizer adoption.

Age of Household Head (AGE)

The age of the household head has a negative and significant relationship with the adoption of chemical fertilizers at the 5% significance level. Keeping other variables constant, an increase in household age by one year decreases the likelihood of chemical fertilizer adoption by a factor of odds ratio of 0.916 (Table 5). This finding indicates that younger household heads are more adopters than older household heads; as younger farmers have access to information, knowledge, and better awareness, they adopt chemical fertilizers better. Studies in eastern Ethiopia and Kalutara and Sri Lanka found that older farmers are fewer adopters of chemical fertilizer than younger farmers. Contradicts of findings in Gimbo and the northeastern highlands said that chemical fertilizer adoption requires knowledge and skill, and above all, lifelong vicarious learning [8].

Educational Status (EDUSTAT)

The educational status of the household head has a positive and significant effect on the adoption of chemical fertilizers at the 1% significance level. The odds ratio corresponding to educational status favors the likelihood of adoption of chemical fertilizer, increasing by a factor of 1.513 as the schooling of the household head increases by one year, holding all variables constant (Table 5). This finding is consistent with education status, which increases the decision-making ability of farmers by improving their knowledge to adopt technology [6]. On the other hand, farmers' literacy levels had a positive effect on the adoption of chemical fertilizer technology.

Distance from Market (DSTMRKT)

The distance of households' residence from the market has a negative and significant relationship with the adoption of chemical fertilizers at the 10% significance level. As the distance of the household home from the market increased by 1 km, the odds ratio disfavored the likelihood of adoption of chemical fertilizer and decreased by a factor of 0.752, holding all factors constant (Table 5). This implies that households close to the market are more adopters of chemical fertilizers than those far from the market, which might be due to transportation costs and access to inputs and to the market. This agrees with studies in the northeastern highlands of Ethiopia and Kalutara and Sri Lanka, which found that the probability of organic fertilizer adoption decreases as the distance between farms and markets increases [9].

Livestock Owning (TLU)

Household livestock ownership has a negative and significant relationship with the adoption of chemical fertilizer at a 10% significance level. As households' livestock ownership increased by 1 TLU, the odds ratio disfavored the likelihood of adoption of chemical fertilizer and decreased by a factor of 0.677, holding all factors constant. This implies that households with a large number of livestock have a lower tendency to adopt chemical fertilizers. This may be due to the utilization of animal manure as an organic fertilizer for crop production. The finding were similar to findings of [10], said that livestock ownership decreases the adoption of chemical fertilizers. This finding contradicts the findings in Hadiya and the northeastern highlands, which state that an increase in livestock ownership increases the likelihood of chemical fertilizer adoption by exchanging cash for input purchasing.

Logarithm of Total Annual Income (LOG TOTINC)

The logarithm of total annual income has a significant positive relationship with the likelihood of adoption of chemical fertilizer at the 1% significance level. The odds ratio in favor of the likelihood of chemical fertilizer adoption by a factor of 16.535 as the logarithm of total annual household income increases by 1%, holding all factors constant (Table 5). Household income has a significant impact on the adoption of chemical fertilizers because the current price is high and depends on households' purchasing capacity. This is consistent with the findings of Ishara et al. (2023) [11], who reported that, as farm income increases, the intensity of inorganic fertilizer usage increases. Households with access to better income opportunities are likely to use more fertilizer than households that have little or no access [12].

Frequency of Extension Agent Contact (FRQEXTCNT)

The frequency of extension agent contact has a positive and significant effect on the adoption of chemical fertilizers by households at the 1% significance level. The odds ratio in favor of the adoption of chemical fertilizers increases by a factor of 1.989 when households have one additional contact with an extension agent, holding all factors constant. This result indicates that households that have more contact with extension agents for advice, learning, and other support are more likely to adopt chemical fertilizers than those with less contact with extension agents. To reinforce farmers' applicability and accurately implement technology packages, extension agent contact is a crucial tool [13].

Challenges to Fertilizer Adoption

Challenges of Chemical fertilizer adoption raised and ranked by the index ranking method were the inflated price of chemical fertilizer, lack of accessibility at the required time and required amount, and the negative perception of farmers on chemical fertilizer, as indicated in Table 6.

Unaffordable Price

The primary challenge raised by the majority and ranked first was the expense of chemical fertilizers (Table 6). The majority of farmers responded that the price of chemical fertilizer was beyond their capacity to afford it, and they perceived that their profitability was in question. This might be due to the lower purchasing capacity of some farmers, the cash payment system, and the lack of loan access.

Supply Problem

Supply problems with chemical fertilizer were its timely delivery problem, and unavailability of the required amount was ranked as the secondary challenge in the adoption of chemical fertilizer (Table 6).

Delays in delivery time and unavailability at the required time are also major problems. According to the sample respondents, they were unable to receive chemical fertilizer at the required time because of their unavailability at the district level. Farmers in the study area intensively used chemical fertilizers for ginger, turmeric, potato, and head cabbage production. They even buy from the black market for the production of these crops when they do not have as much as they want.

Table 5. Result of binary logistic regression of chemical fertilizer adoption.

Independent variables	Odds ratio	Coefficient	SE	p>|z|
Sex	0.331	-1.103	0.890	0.215
Age	0.916	-0.087	0.033	0.010**
EDUSTAT	1.513	0.414	0.104	0.000***
FMLSIZ	0.911	-0.093	0.121	0.443
LNDSIZ	0.852	-0.159	0.198	0.421
DSTMRKT	0.752	-0.285	0.152	0.062*
TLU	0.677	-0.389	0.220	0.077*
LOGTTINC	16.535	2.805	0.927	0.002***
CRDACSS	0.845	-0.168	0.515	0.743
FRQEXTCNT	1.989	0.688	0.132	0.000***
Constant	9.87e-5	-9.223	4.738	0.052*

Sample (N) =261, LR chi2 (10) = 231.13, Pseudo R2 = 0.6556, Probability > chi2= 0.000; Log likelihood = -60.719
*Significant levels are indicated by ***, **, and *, which are P<0.01, P<0.05, and P<0.1, respectively.*
EDUSTAT, Educational Status; DSTMRKT, Distance from Market; TLU, Livestock Owning; FRQEXTCNT, Frequency of Extension Agent Contact
Family Size (number of household members); log of total annual income (from all sources); credit access (1 = access to formal/informal credit, 0 = no access)

Table 6. Challenges of chemical fertilizer adoption.

Factors	Ranks			Sum	Index	Rank
	1	*2*	*3*			
Unaffordable price	121	79	85	606	0.387	1
Supply problem	71	105	84	507	0.324	2
Negative perception of farmers	69	77	92	453	0.289	3

Negative Perception of Farmers

The other challenging issue regarding chemical fertilizer utilization was the negative perception of farmers, who are a challenging development agent of the agricultural office, regarding the supply of chemical fertilizer. Farmers are afraid of cultivating crops with chemical fertilizers because they think that their land will not produce any crops in the future without the application of chemical fertilizers, and they are afraid that they will spoil or dry their land [2].

CONCLUSION

Households' socio-economic, demographic, and institutional factors affect the household adoption of chemical fertilizers. Sex of household, age of household head, educational status of household head, total annual income, distance from the market, credit access, extension agent contact, training access, and information about improved varieties and chemical fertilizer are significantly related to household adoption of chemical fertilizer.

The adoption of chemical fertilizers for crop production was less than half of that of the sample households. The percentage of households using chemical fertilizer from Andiracha Chena and Bita district was very low, and chemical fertilizer was better adopted in Sheyi Bench district. The utilization of chemical fertilizers decreased in the study area. Of the chemical fertilizer adopters, 39.42% used only NPS and 60.58% used both NPS and urea for crop production in 2022/2023. Chemical fertilizer adoption by households is positively and significantly affected by the education level of the household head, the logarithm of total annual income of the household, and frequency of extension agent contact; however, it is negatively affected by the age of the household head, distance from the market, and livestock ownership of households.

The main challenge to the adoption of chemical fertilizer was expensiveness of price, the problem of supplying the required amount of chemical fertilizer at the right time, and farmers' negative perceptions.

Recommendation

To promote the adoption of improved crop technologies, the government should work on improving farmers' knowledge and awareness of technology by improving their educational status and access to opportunities. The government and NGOs work to improve farmers' income and access market opportunities that empower their input purchasing capacity and promote market-oriented production. The availability of sufficient agricultural extension experts is crucial to frequent contact with many farmers for advice and support, since the support and supervision of agricultural experts is an important factor in technological adoption.

As a current challenge with chemical fertilizers, the government should work to find alternative soil fertility improvement practices for organic fertilizer adoption and utilization. There is a variation in chemical fertilizer adoption between districts, and regional and zonal governments should pay special attention to the Andiracha, Bita, and Chena districts by creating awareness, training, demonstration, and accessing inputs of farmers' interest to achieve better technology adoption levels on those lower adoption rates.

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