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Determinants of Agricultural Technology Adoption in Urban Vegetable Production: A Case Study of Chelencko and Kullubi Towns

Yusuf Umer ^a, Fresenbet Zeleke ^b, Beyan Ahmed ^b, Petros Chavula ^{a,*},
Eliyas Abdi ^a, Selahdin Ahmed ^c

^a Africa Center of Excellency for Climate-Smart Agriculture and Biodiversity Conservation, College of Agriculture and Environmental Sciences, Haramaya University, Haramaya, P. O. Box 138, Dire Dawa, Ethiopia.

^b School Agricultural Economics and Agribusiness, Haramaya University, Haramaya, P. O. B0x 138, Dire Dawa, Ethiopia.

^c School of Environmental Health Science and Technology, Jima University, Jima, Ethiopia.

* Corresponding author Email: chavulapetros@outlook.com

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Abstract: This study focuses on identifying the factors influencing farmers' decisions to adopt agricultural input technology for urban vegetable production among households in Chelencko and Kullubi town within the Meta District, East Hararghe Zone, Oromia, Ethiopia. The study used cross sectional data and collected information from a sample of 232 respondents from the two towns in the Meta District, located in the East Hararghe Zone. Both qualitative and quantitative data obtained from primary and secondary data sources. The multinomial logit model was utilized to achieve its research objective and to identify the determinants of agricultural input technology adoption. The study result indicates that education level, livestock holding, extension contact, farming experience, access to training, off/non-farm activities, and access to credit positively and significantly influenced the agricultural input technology in urban vegetable production, while family size and dependent ratio had a negative and significant influence on technology adoption in urban vegetable production. Agricultural input technology has the potential to enhance vegetable production, which in turn improves the household's residence food security. Moreover, the study calls for Municipal Administrations and District Agricultural Office should prioritize attention on the most significant variables that influence the adoption of agricultural input technology for urban vegetable production practices.

Keywords: Urban Vegetable, Agricultural Technology, Adoption, MNL Mode, Oromia, Ethiopia

1. Introduction

The rapid growths of the global urban population and increased urbanization have intensified pressure on food systems, leading to a mount in food insecurity among the urban communities. This concern most affected areas in the world and is particularly pressing in developing countries, notably in Sub-Saharan Africa (SSA) (FAO & WFP, 2020). Food insecurity is one of top issues in the low developing nation that threatens individuals, at families, as well as at nations in numerous ways (FAO, 2023). For example, when many people have not obtaining enough food at right time or nutritious items of food to adequate, healthy diet, it can have impact consequence such as reduced productivity, malnutrition, and healthy problem (Johnson & Post-doctoral, 2018; Tseng *et al.*, 2017). This situation frequently displays among low income people, which can overall impact of health, well-being, and life satisfaction. As a result, addressing food shortages requires the integration of governments, development organizations, and people are increasingly pursuing sustainable approaches to fortify food systems, boost household resilience and enhance food security (FAO, 2021).

In sub-Saharan Africa, both urban and rural communities face this problem directly, and it's connected to the United Nations Sustainable Development Goals (SDGs). SDG 2 aims to eliminate hunger and poverty, while SDG 11 focuses on creating sustainable cities. Efforts to improve food security in developing countries depend on thoughtful urban planning and the right policies to support those in need (Padgham *et al.*, 2015; Rafael, 2017).



One key approach being considered as a solution to reduce food insecurity in rapidly growing cities and towns among the SSA areas is encouraging and promoting urban and peri-urban agriculture practices in this regard (Jeneral & Kibret, 2022; Ochieng *et al.*, 2022). Urban and peri-urban agriculture are terms that particularly refer to food production activities such as the growing and distribution of agricultural products using the existing resources and services in or near the towns and cities area (Steenkamp *et al.*, 2021). UA serves as a direct and indirect response to urban food insecurity, particularly among vulnerable and low-income households (Nigus *et al.*, 2024a; Nkrumah, 2018). It delivers diverse benefit involving job creation, diversifies income sources, and supports the solution to some of the social and environmental issues in towns and cities (Gonfa, 2019). It is also essential to guarantee consistent access and supply to fresh, nutritious, healthy, affordable, and diverse food options for a large number of urban dwellers. Urban agriculture (UA) enables people practice growing crops, vegetables, and fruits and rearing small livestock or milk cows at the household level for consumption or sale in urban markets (Nigus *et al.*, 2024a; Siegner, 2018).

More people living in cities are struggling to get enough food due to rising costs of production and distribution. Many urban residents, especially those in nearby areas, are facing difficulties in accessing the food they need because of limited agricultural output and financial constraints (Badami & Ramankutty, 2014; Girma *et al.*, 2018). Focusing on urban agriculture could be a key way to tackle the increasing food insecurity in our towns and cities. Correspondingly with this, Ethiopia has been paying special attention to the encouraging developments recently in urban agriculture (Ashagrie *et al.*, 2023; Dessie *et al.*, 2022). In Ethiopia, the adoption of urban agriculture has long been cultivating food in and around the city areas including growing crops, vegetable, and fruit, and small livestock and animal product like milk and eggs (Amsalu *et al.*, 2020; Jeneral & Kibret, 2022). These are popular practices at the household level for consumption or sale to enhance their families' food security (Girma *et al.*, 2018; Joshi *et al.*, 2019). In urban areas, households are cultivating crops and vegetables on plot adjacent to their living houses and other small farm land, which is using rain-fed, shallow well water for irrigation and cycled household water (Nure *et al.*, 2020; Serbessa *et al.*, 2023).

Urban resident widely participate in cultivating vegetable crops because vegetable production has short growing cycles, the ability to grow in small spaces, and can be produced with minimal inputs, these practices are well suited to urban agriculture (Gebru *et al.*, 2019; Ochieng *et al.*, 2022; Sithole *et al.*, 2023). This mechanism helps to reduce the effects of these growing threats to food security. According to (Gashaye, 2020; Serbessa *et al.*, 2023) urban vegetable activities are increasingly being recognized as a significant source of food, nutrition, and income generation for the urban poor, as they enable family members to supplement their diets and thereby improve health while also providing reduction of food expenditures and an increase in come opportunities that enhance food security. The predominant focus of UA activities in the country is on the production of high-value vegetable crops, which are anticipated to be a significant mechanism for poverty reduction in Ethiopia towns and cities (Gashaye, 2020). Despite its recognized potential, the sector continues to suffer from inadequate institutional and policy support (Amsalu *et al.*, 2020); urban vegetable production still faces numerous challenges that limit its productivity and sustainability (Hunde, 2017; Milkias & Degefu, 2024).

Many city municipality authorities have given little attention to support for increasing productivity in urban vegetable production through the agricultural input technologies (Amsalu Ayana, 2015; Nigus *et al.*, 2024b); they focus on prioritizing mere participation in cultivation over the adoption of modern and efficient practices (Adimassu *et al.*, 2024; Masha *et al.*, 2024). This approach has resulted to unsustainable agricultural practices, including the use of fertilizers, pesticides, improved seed varieties and implementation of affordable water saving technologies. Nonetheless, UA particularly urban vegetable has the potential to become a strong ally in urban food and nutrition security strategies, provided adequate production and crop protection technologies are applied that are efficient in water and labour and, as well as environmentally friendly and cost-effective (Ashagrie *et al.*, 2023; Eigenbrod & Gruda, 2015).

Despite its benefits, urban agriculture has several barriers that affect the adoption agriculture input technologies among vegetable growers. Moreover, there is lack enough document data about urban agriculture in the Eastern zone of Ethiopia, and the practices is not supported by policy. Therefore, there is a pressing need for information on the factors that affect the adoption of agricultural technologies in urban vegetable production in Ethiopian town, which is essential for the design strategy or policy and while stimulating further academic inquiry.



Addressing UA, particularly vegetable production, requires multifaceted approaches and a deep comprehension of the factors that either enhance or impede the sub-sector. Accordingly, this study focuses on examining urban household vegetable production practices, with a specific focus on the use of agricultural input technologies in the study area. Several empirical studies have been conducted in Ethiopia and a few in the East Hararghe zone regarding urban agriculture, particularly on vegetable production practices, which focused on narrating the contribution and constraints in different urban areas. These studies have explored a range of topics; include determinants of the adoption of urban agriculture practices (Nigus *et al.*, 2024a). the role of vegetable business and small-scale farmers in ensuring household food security (Gebru *et al.*, 2019). Impact of urban agriculture on poverty reduction (Nure *et al.*, 2020). Additionally, (Serbessa, 2023) examined the contribution urban agriculture to household food security among urban vegetable producers, which did not address the analysis of factors that influence households' decisions to adopt urban vegetable production practices, particularly in relation to the use of agricultural input technologies. Moreover, there is very limit information available concerning the use of agricultural input technologies in urban vegetable production practices by previous studies.

There is a lack of comprehensive studies examining the socioeconomic, demographic and institutional factors influencing the adoption of agriculture input technology among the vegetable producers in Chelencko and Kullubi towns in the Meat District, East Hararghe, Oromia, Ethiopia. This lack of existing literature made it challenging to compare the existing findings. Therefore, this paper will address the existing need by providing up-to-date information on urban vegetable production practices. It identifies the determinants adoption of agricultural input technology for urban vegetable production in the area using a multinomial logit model due to the mutually exclusive adoption choices among urban vegetable producers, while considering the interdependence of each urban vegetable production practices that was not addressed in the past study.

2. Methodology

2.1 Description of the Study Area

The study was conducted in the meta-district of East Hararghe zone in Oromia National Regional State, Ethiopia. Meta District is located 435 km east of Addis Ababa and 82 km west of the city of Harar. In Meta District there are 42 kebeles, of which 3 are urban kebeles (two in Chelencko and one in Kulubbi) and 39 are rural kebeles. The total population of Meta districts is estimated at 321,213 people, of which 162,134 are men and 159,079 are women. The district's agricultural systems are characterized by small-scale subsistence mixed farming with an integral part of animal husbandry. The total area of cultivated area in Meta district is 46397.12 hectares. Land use or land cover of Meta district, intensive and moderately cultivated agricultural areas (AOEHZ, 2022).

The two principal towns in the Meta district were Kullubi and Chelencko. The population of Kullubi town is 6,464, with 3458 males and 3006 females, whereas the population of Chelencko town is 10,756, with 5,450 males and 5306 females. These towns served as administrative hubs for the neighbouring rural and urban areas and were significant hubs within the district, offering necessary services. Geographically, the towns of Chelencko and Kullubi are located between 09°23'30"N to 09°24'00"N latitude and 41°33'00"E to 41°33'30"E longitude, and 09°26'00"N latitude and 41°41'0"E to 41°42'0"E longitude, respectively (Figure 1). In both towns, the annual precipitation varies from 600 to 900 mm, the temperature ranges from 18 to 28 °C, and the elevation varies from 1,400 to 2,800 m above sea level. The town is primarily distinguished by the highland Weynadega climate.

In order of importance, the cereal crops that were most frequently grown were sorghum, maize, wheat, barley, and pulses. The two known cash crops are vegetables and cash crop khat. Among the livestock species raised by the locals in both towns are goats, sheep, and cattle. The production of food crops, cash crops (khat), horticulture (fruit and vegetables), and livestock were the primary economic activities. The most significant crops sold were lettuce, salad, khat, potatoes, and onions. The primary sources of income for smallholder farmers engaged in vegetable production practices in urban areas are potatoes and cabbage, followed by onions and other vegetables. The majority of respondents grow one or more types of vegetables, such as potatoes, onions, carrots, cabbage, lettuce, tomatoes, and peppers in the study area. Urban vegetable production techniques, including the use of agrochemicals and fertilizers (organic or inorganic), along with various agronomic techniques, are being adopted in this town.



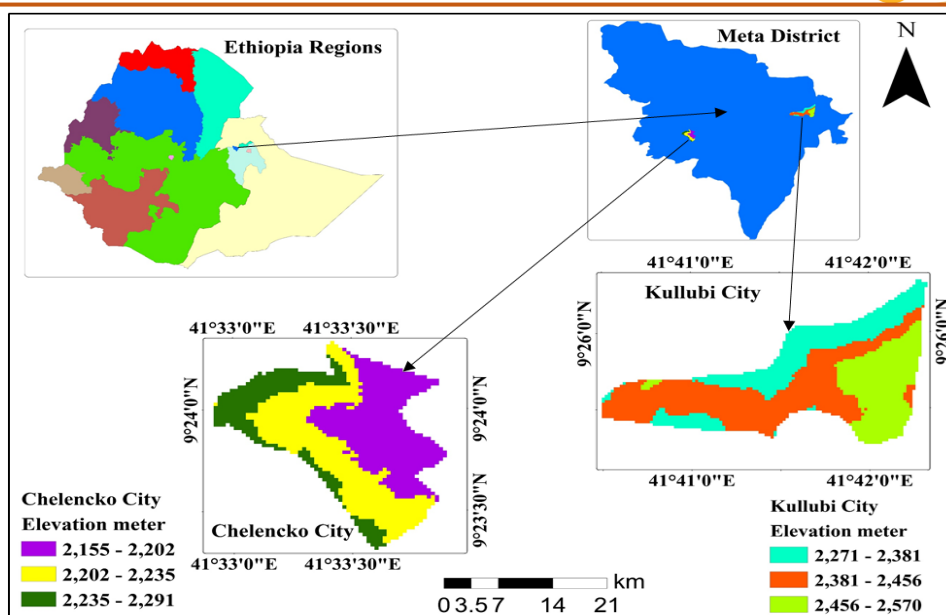


Figure 1. Map of the study area

2.2 Data types, Sources, and Methods of Data Collection

Both primary and secondary data were gathered for this study. Data was collected through a combination of quantitative and qualitative approaches. In this study, the data were collected by using trained enumerators, development agent (DA) and agricultural expert in district. In order to collect the quantitative data, direct interviews were conducted with sample households using a semi-structure was prepared. The present study employed interdependent data collection methods. One key informant interview (KII) was conducted in each town, and focus group discussions (FGDs) were held with vegetable producers in each of the selected towns. Besides this, information was collected on the factors influencing the adoption of agricultural technology for vegetable production practices and constraints related to it. Secondary data were obtained from an array of institutional reports Agricultural Office of the District, municipality, Non-Governmental Organization (NGOs), and supplemented by academic articles and documents in the public domain.

2.3 Sampling Procedures and Sample Size Determination

Household heads were viewed as primary decision-makers and served as respondents for implementing agricultural technology in urban vegetable production practices. The sampling was employed to select the target sample households, in the first two towns of Chelenko and Kullubi were specifically chosen for their relevance to the study’s aims. The study areas were purposively chosen with the help of the Agricultural Office of East Hararghe Zone because the two towns have share similar agro-ecology condition that are favorable for UA and possess extensive experience in using UA practices, especially vegetable production. Additionally, there are evident challenges they face in the availability of agricultural input technology for urban vegetable production. Next they selected two kebeles from each town, which were randomly selected for the study. List of household heads were collected from District Agriculture Office (development agents) who had it for each selected kebeles. The systematic sampling approach typically includes the introduction of a random element. When the sample frame is supplied as a list, this sampling method is helpful. In such a design, the selection procedure begins with the random selection element from the list and continues until the target number is obtained from the sampling frame of 1423 of vegetable producers households across the two kebeles. Final from these kebeles, households head were stratified into two groups of adopters and non-adopters, and then simple random sampling was used to select 232 sample households based on probability proportional to size. The total sample households were 104 adopters and 128 non-adopters of agricultural technology in urban vegetables production (Table 1). Due to considering time and financial limitation, the sample was calculated using a 94% confidence interval with 6% level of precision.

$$n = \frac{N}{1+N(e^2)} \quad n = \frac{1423}{1+1423(0.06^2)} \approx 232.4 = 232 \quad (1)$$



Sample from the all kebeles within the two towns were proportional to number of participant and non-participant households and were determined using the following formula:

$$n_i = \frac{(N_i)(n)}{\sum N_i} \quad (2)$$

Where, n_i is the sample to be selected from the i^{th} kebele; N_i —The total population living in i^{th} kebele; $\sum N_i$ — the summation of the population in the three selected kebeles; n — Total sample size for the kebeles.

Table 1. Population and sample distributions over the selected kebeles

Towns	kebeles	Total HH	Sample selected	Participants	Non-participants	Proportion (%)
Chelenko	02	844	138	61	77	59.5
Kullubi	01	579	94	43	52	40.5
		1423	232	104	128	100

Source: computed based on the data from Meta district, 2024

2.4 Methods of Data Analysis

Descriptive statistics like the means, standard deviations, percentages, and frequency distributions were applied to effectively summarize and interpret the results of data related to demographic, socioeconomic and institutional variables. Inferential statistics such as the chi-square test for categorical variables and the t-test for continuous variables were used to check the statistical significance. For the analyses, STATA software version 15.1 was utilized.

2.4.1 Multinomial-logit model

In this study, the households choose to participate in a specific category of agricultural technology when they engage in urban vegetable production. The multinomial logistic regression model the mutually exclusive choice independent and it does not allow for correlation among the error terms of the adoption equation (Goshu, 2013). The multinomial logit model was selected for this study instead of Multivariate Probit model because the dependent variables is categorical and represents mutually exclusive adoption choices among urban vegetable producers. The multinomial logistic regression model a simple extension of the dependent variable was defined based on farmer technology that selects for adoption practices. Since the household heads that produce the vegetables in the town area use the input for farm; that requires the budget and are applied at different stage of vegetable production. Consequently, each household head chooses single technology practices from the available option: non-adopted, fertilizers only, pesticides only, or joint use of fertilizers and pesticides. In contrast, the multivariate Probit (MVP) approach simulates the influence of the explanatory factors on each of the several adaptation alternatives simultaneously (e.g, soil and water conservation, livestock production, irrigation and crop diversification) and when estimation of many correlated binary outcomes decisions needs to be modeled (William & Solís, 2012). Since the focus of this study is to examine determinants of choice among alternative mutually exclusive technology adoption options choices, where dependent variables is categorical rather than reflecting simultaneous adoption, the multinomial logit (MLogit) model was deemed the most appropriate. There will be $m-1$ dummy variables if there are m categories (Negera *et al.*, 2022; Twongyirwe *et al.*, 2019) and one set of $m-1$ binary is the result. In this study, the dependent variable represents the type of agricultural input technology adopted by the household for urban vegetable production practices, categorized into distinct, mutually exclusive options include the use of fertilizers (inorganic or organic/ both) (Y0), agro-chemical (pesticides) (Y1), fertilizers + pesticides (Y2) and non-participants (Y3). These four categories of practices were considered as dependent variables for the study. Household adoption decisions are based on utility maximization, with economic agents like urban vegetable production choose to adopt specific production technologies when perceived the benefits of adoption greater than other strategies. The farmer chooses one or a joint of urban vegetable production practices from a range of n accessible agricultural technology options. According to (William & Solís, 2012) the suggests that household i choose to use the m^{th} adaptation alternative if the perceived advantage of option m is higher than the utility gained from other option (such as k) described as:



$$U_{im}(\beta_m X_i + \varepsilon_m) > U_{ik}(\beta_k X_i + \varepsilon_k), k \neq m \quad (3)$$

Based on the U_{im} and U_{ik} relationship, the likelihood of a household choosing option m from a set of adaptation practices for vegetable growing can be determined under the following condition:

$$p\left(y_i = \frac{1}{x}\right) = \left(U_{im} > \frac{U_{ik}}{x}\right) \quad (4)$$

The MNL model is used to indicate how keeping other factors remain constant in the variable of X affected the response probability, $p\left(y = \frac{m}{x}\right)$, $m=1, 2, \dots, n$. probability for $p(y=m/X)$ were obtained after the probability for $m=2, \dots, n$ were known, due to the requirement of probability must to one.

Let X be a $1 \times K$ vector with first-element unity. Thus, the probability that household i with characteristic X chooses adaptation option m is specified as follows:

$$\Pr\left(y = \frac{m}{x}\right) = \frac{\exp(\chi_i \beta_m)}{1 + \sum_{m=1}^J \exp(\chi_i \beta_m)} \quad (5)$$

Where $m = 1, 2, 3, 4$

Where P stands for probability, y is adaptation measures taken by households, m represents the urban vegetable agricultural technology practices, β is the estimated parameter and X_i is the household characteristics or variables.

The parameter estimates obtained from the Multinomial Logit (MNL) model only provide insights into the direction of influence that the independent variables exert on the dependent variable, but the estimates do not represent the actual magnitude of the change nor the probabilities (Rilstone, 2002; Zakaria *et al.*, 2020). The result is marginal effects or marginal probabilities are derived as functions dependent on the probability itself and measure the indicators of the expected change in the probability of a particular choice in response to a one-unit change in an independent variable from its mean. The calculation of this measure is as follows:

$$\frac{\partial P_m}{\partial \chi_k} = P_m(\beta_{mk} - \sum_{m=1}^{m-1} P_m \beta_{mk}) \quad (6)$$

The reason for this is that the total probabilities of all options should add up to unity. Therefore, only (4-1) unique combinations of parameters can be determined and calculated for four choices. Marginal effects are used to interpret the effects of explanatory variables on probabilities, allowing for the interpretation of an independent variable's effect on the dependent variable in terms of probabilities.

The validity of the IIA assumption was examined using the multinomial logistic regression adaptation model. The degree of association between the proposed continuous explanatory variables was confirmed using the Hausman specification test for the multicollinearity problem. To investigate the presence of multicollinearity between continuous and dummy/categorical variables, the VIF and contingency coefficients will be employed. The inverse is true if the VIF is greater than 10, which denotes significant multicollinearity among the independent variables.

2.5 Ethical Consideration

The study on *Determinants of Agricultural Technology Adoption in Urban Vegetable Production: A Case Study of Chelenko and Kullubi Cities* adheres to strict ethical principles to ensure participant protection and data integrity. Participants will provide informed consent, with all details about the study's purpose, procedures, and voluntary nature explained in local languages. Confidentiality and anonymity will be maintained, with data securely stored and used solely for academic purposes. The study does not harm participants, and cultural sensitivity will be observed during data collection. Prior approval for data collection will be obtained from local administrative offices and agricultural bureaus, aligning with Ethiopia's national research ethics guidelines. The researcher declares no conflict of interest, ensuring the study is conducted for academic purposes without commercial or political influence. The Ethiopia Social Sciences Study Ethical Review Board has reviewed and approved the research, which confirms compliance with all ethical standards.

2.6 Definition of variables

Dependent variable: A categorical variables representing agricultural input technology use for urban vegetable production, fertilizers, pesticides, joint fertilizers and pesticides, and non-adopted (Table 2).



Table 2. Definition of independent variable

Variable description	Variable types and measurement	Expected sign
Family size	Continuous (person)	-/+
Sex respondent household head	Dummy (1 if male, 0 female)	+
Access to Training	Dummy (1 if yes, 0 if no)	+
Off/non farming activate	Dummy (1 if yes, 0 if no)	+
Access to Credit	Dummy (1 if yes, 0 if no)	+
Cooperative Member	Dummy (1 if yes, 0 if no)	+
Soil fertility status index	Dummy (low, medium and high)	+
Age of household head	Continuous; years	-/+
Cultivated land size	Continuous; (m ²)	+
Dependency ratio	Continuous; (mean %)	-
Educational level household head	Continuous; years of schooling	+
Livestock owned	TLU (Tropical Livestock Unit)	+
Extension contacts	Continuous (Number of days/year)	+
Farming experience	Continuous (Number of years)	+
Distance from market	Continuous (mint)	-

2.7 Summary Model Diagnosis Test

This study conducted most model diagnosis tests before running the model, including pre-estimation and post estimation tests. Pre-estimation tests, the results showed that there was not multicollinearity problem since the mean variance inflation factors (VIF) was 1.09, while no independent variables were removed from the estimated model. Moreover, the Pagan/Cook-Weisberg test for heteroskedastitown (hetttest) Prob> chi-square = 0.2944), this indicated that the test is no evidence of Heteroskedastitown in the data.

Table 3. model diagnosis tests

Variables	VIF	1/VIF	Variables	VIF	1/VIF
Livestock owned	1.15	0.868	Soil fertility status	1.08	0.923
Family size	1.15	0.87	Education level household head	1.08	0.924
Extension contacts	1.15	0.872	Access to training	1.08	0.926
Off/non-farm activate	1.12	0.893	Distance from market	1.08	0.927
Dependent ratio	1.1	0.905	Sex of household head	1.07	0.936
Cultivated land size	1.09	0.917	Cooperative Member	1.05	0.956
Access to Credit	1.09	0.921	Age household head	1.04	0.958
			Farmers Experience	1.04	0.959
Model test			Test name	factors of adoption	
VIF			Multicollinearity	1.09	
hetttest			heteroskedastitown	Prob > chi2 = 0.2494	
ovtest			omitted variable	Prob > F = 0.4156	
Hausman test			IIA	Prob > chi2 = 1.00	

Source: Estimation from our own survey data, 2024



The Ramsey RESET test (ovtest) (Prob > F = 0.4156) suggests no evidence of omitted variable bias. The diagnostic tests, like vif, hettest and ovtest commands, were applied to run after running the regression. The post estimation tests, the Wald test result is chi-squared (45) =116.40, Prob > chi-square =0.0000 and Pseudo R²= 0.2922. The Likelihood ratio (LR) and Wald test were done and the result was almost the same, both indicating that the null hypothesis can be rejected and that the independent variables have a statistically significant joint effect on the model (Rilstone, 2002). Moreover, the model was run and test for the validity of the independence of irrelevant alternatives (IIA) by Hausman test. The result showed that the test statistics were p-values for all comparisons were greater than 0.05 (Prob > chi-square = 1.00) for pesticides, fertilizers and joint fertilizers and pesticide, and Prob > chi-square = 0.342 for non-adopter), indicating that the null hypothesis of no omitted variable. Therefore, the IIA assumption was satisfied, and the use of the MNL model was appropriate for this analysis. The results of the model fit test using (fitstat) suggest that the MNL model indicates that the model is statistically sound and provides an adequate fit to the data. Therefore, based on the hypothesis all variables listed in Table 3 were included to examine the factors affecting agricultural technology adoption in urban vegetable production in the study areas.

3. Results and Discussion

3.1 Descriptive Statistical Results

3.1.1 Characteristics of households (dummy variables)

Off/non-agricultural activities: The result based on the survey of the study indicated that 57.33% of the total sample households were found to be engaged in off/non-farm activities and the remaining 42.67% didn't it.

Table 4. Descriptive statistic of results for sample households' dummy variables

		Non-adopt		Pesticide		Fertilizer		Joint fertilizer and pesticide		Total		Chi2
		Nu m	%	Nu m	%	Nu m	%	Nu m	%	Num	%	
sex of respondent	female	25	10.78	2	0.86	4	1.72	3	1.29	34	14.66	4.89
	Male	109	46.98	9	3.88	42	18.10	38	16.38	198	85.34	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	
Off/non-farm participant	No	72	31.03	7	3.02	11	4.74	9	3.88	99	42.67	22.86***
	Yes	62	26.73	4	1.72	35	15.09	32	13.79	133	57.33	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	
Training	No	75	32.33	3	1.29	16	6.90	13	5.60	107	46.12	12.61***
	Yes	59	25.43	8	3.45	30	12.93	28	12.07	125	53.88	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	
Access credit	No	71	30.60	4	1.72	35	15.09	25	10.78	135	58.19	9.83**
	Yes	63	27.15	7	3.02	11	4.74	16	6.90	97	41.81	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	
Member. coop	No	59	25.43	3	1.29	20	8.62	18	7.76	100	43.1	1.18
	Yes	75	32.33	8	3.45	26	11.21	23	9.91	132	56.9	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	
Soil fertility index	Low	47	20.26	4	1.72	26	11.21	21	9.05	98	42.24	17.01***
	Medium	34	14.66	4	1.72	15	6.47	12	5.17	65	28.02	
	High	53	22.84	3	1.29	5	2.16	8	3.45	69	29.74	
	Total	134	57.76	11	4.74	46	19.83	41	17.67	232	100	

***, ** and * means at 1%, 5% and 10% probability level, respectively

The comparison of agricultural input technologies practices among different groups indicated that with the engaged in off/non-farm activities, 26.73% non-adopted, 1.72% used only pesticide, 15.09% used only fertilizer, and 13.79% adopted joint fertilizer and pesticide. On the other hand, among household heads with non-engaged in



off/non-farm activities, non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices were 31.03%, 3.02%, 4.74%, and 3.88%, respectively. The chi-square test revealed that there is statistically significant mean difference among the four groups in terms of non/non-agricultural activities at 1 percent probability level (Table 4).

Access to training: Of the total sampled households that had access to training of 53.88%, while 46.12% didn't it. The comparison of agricultural input technologies practices among different groups based on the access to training of respondent households indicated this: among households with access to training, 25.43%, 3.45%, 12.93%, and 12.07% were non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices, respectively. In contrast, among those without training, 32.33% were non-adopters, 1.29% used only pesticide, 6.9% used only fertilizer and 5.6% adopted joint fertilizer and pesticide practices. The chi-square test findings showed that were significant differences in training participation among four groups in terms of choice of urban vegetable production practices.

Household access credit: The results showed that credit access has a significant difference among the groups at less than a 5% probability level. The study indicated that 41.81% and 58.19% were found to be participant and non-participant from the sum of sample households, respectively. The comparison of agricultural input technologies practices among different groups indicated that those with access to credit 27.15% non-adopter, 3.02% used only pesticide, 4.74% used only fertilizer, and 6.9% adopted joint fertilizer and pesticide. Conversely, among those who did not access, 30.6% do not adopted, 1.7% used only pesticides, 15.09% used only fertilizers, and 10.78% adopted joint fertilizer and pesticide practices.

Soil fertility index: The estimation of the soil fertility status of households used Principal Component Analysis (PCA) to construct a soil fertility status index based on these components (yield trend, soil erosion, manure use, fertilizer application, and extension contact) from the data survey that was collected from the households. The index continues with a value that changes into categories: if the value is less than 0.33, it is low soil fertility; if the value is between 0.33 and 0.66, it is medium soil fertility; and if it is above 0.66, it is high soil fertility. The findings of the survey data from the total sample respondents regarding soil fertility status index showed that 29.74% reported high, 28.02% reported it as medium and 42.24% reported it as low. Among household heads with high soil fertility status, 22.84% were non-adopted, 1.29% were pesticides used, 2.16% were fertilizer used, and 3.45% were joint fertilizer and pesticide used. On the other hand, among household heads with high soil fertility, non-adopted, adopted pesticides, adopted fertilizers, and those that used joint fertilizers and pesticides practices were 20.26%, 1.72%, 11.21% and 9.05%, respectively (Table 4). The chi-square test showed a statistically significant difference among the groups in terms of soil fertility status at the 1% probability level, revealing that soil fertility status has a major influence on the adoption of agricultural input technologies practices.

3.1.2 Characteristics of households (continuous variables)

Table 5. Descriptive statistic of results for sample households' continuous variables

Variables	Non- adopt	Pesticide	Fertilizer	Joint fertilizer and pesticide	Total	F-Value
Household size	6.87	6.55	6.11	5.8	6.47	6.11***
Age of respondent	37.32	37.27	39.59	37.39	37.78	0.79
Cultivated land size	2302.31	2221.82	2714.57	3119.71	2524.69	3.61**
Dependency ratio (%)	58.12	41.84	42.17	31.38	49.46	3.54**
Educational level	7.53	9.45	8.72	8.93	8.1	3.23**
Total livestock	2.31	1.45	3.13	4.68	2.85	11.54***
Extension contacts	1.68	2.27	1.89	3.27	2.03	13.08***
Farming experience	7.89	8.41	9.13	9.81	8.5	3.18**
Distance from market (minute)	28.71	32.27	28.35	27.66	28.62	0.93

***, ** and * means at 1%, 5% and 10% probability level, respectively



Household size: The mean equivalent family size for the sample households was found to be 6.47. The average household size for who did not adopt, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices were found to be 6.87, 6.55, 6.11 and 5.80, respectively. Adoption of urban vegetable production practices technology is higher in small households' families than in large families' size, as the serve result evidenced, according to, the F-test results of group mean difference comparison, there is a statistically difference between the groups at the 1% probability level (Table 5).

Educational level: The results showed that the average number of years of formal education of the total sample was found to be 8.10 years of grade completed. The average education level for non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices was found to be 7.53, 9.45, 8.72 and 8.93, respectively (Table 5). The F-test results of group mean difference comparison stated that, there is a statistically difference between the groups at the 5% probability level. This indicated that there are significant mean differences in the household head's education level among different agricultural input technologies with in sample households.

Dependency ratio: The result of study revealed that the mean total sample households' dependency ratio in family was found 49.46%. The mean dependency ratio of family households is 58.12 for non-adopted, 41.84 for used only pesticide, 42.17 for used only fertilizer, and 31.38% for adopted joint fertilizer and pesticide practices. The F-test results of group mean difference comparison, there is a statistically difference between the groups at the 5% probability level (Table 5).

Agricultural Experience: The study showed that the mean total sample households farming experience was found to be 8.50. The average farming experience is 8.41 for non-adopted, 7.89 for used only pesticide, 9.13 for used only fertilizer and 9.81for adopted joint fertilizer and pesticide practices. This indicated that the F-test for comparing group mean differences showed a significant difference between groups at the 5% probability level.

Extension contacts: The data indicates that extension agents have averaged 2.03 days of contact with urban farmers in years across the total sample households. The average extension agent contact for non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices was found to be 1.68, 2.27, 1.89 and 3.27, respectively (Table 5). The results of the F-test for comparing group mean differences showed a significant difference between groups at the 1 percent probability level.

Livestock holding: The mean livestock holding in Tropical Livestock Unit for the sample households was found to be 2.85. The average livestock holding for non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices was found to be 2.31, 1.45, 3.13 and 4.68, respectively (Table 5). The F-test findings of group mean difference comparison indicated that there is a significant difference between the groups at the 1% significance level.

Size of cultivated area: The study showed that the mean total sample households cultivated land size was found 2524.69 m². The average cultivated land size for non-adopted, used only pesticide, used only fertilizer, and adopted joint fertilizer and pesticide practices was found to be 2302.31 m², 2221.82 m², 2714.57 m² and 3119.71 m², respectively. The F-test results of group mean difference comparison indicted that, at a 5% probability level, statistically significant mean difference among the agricultural input application in terms of cultivated land size.

3.1.3 Determinant of urban vegetable production practice of the households

The multinomial logit model output indicated that Family size, training, off/non farming activate, access credit, soil fertility status index, dependency ratio, educational level, total livestock, extension contents, farming experience are the significant factors that affect the probability of agricultural input technology adoption in urban vegetable production in the study area. In contrast, the variables age of respondent, cultivated land size, sex respondent, distance from market and member cooperative were statistically significant in Table 6.

Household size: Family size is considered in the study as the number of people living in the respondent's household. The results showed that this variable has a 10% probability of having a negative and significant association with the likelihood of adopting only fertilizer and adopted joint fertilizer and pesticide practices. The value of the marginal effect shows that with one person's increase in household members, the probability of fertilizer uses and joint fertilizer and pesticide use practices adoption tended to decrease by 3.33% and 2.1% compared to non-



adopters, respectively, as the other determinants were constant (Table 6). The previous study result shows that the adoption agricultural technology practices has positive and significant relation with the accessibility of labour, indicating that high numbers of member in households are more likely to adopt more than their low family size. However, in this study shows that in the study area face a circumstance in which the most of household might be responsible for a large part of dependents, and much of the available time is dedicated to childcare. This may threaten the labor demands of urban vegetable farming strategies that employ agricultural technology. As a result, these households are more likely to seek alternative income sources. In addition, the results of the focus group discussions showed that larger families often prioritize securing additional income and meeting their immediate food needs particularly among urban farmers. High food consumption demands in larger families divert time and resources toward immediate needs rather than investing in additional productive activities (Gebru *et al.*, 2019). This result is in contrast with the study of (Etsay *et al.*, 2019), who reported that the family size had a positively correlated and significant impact on the sustainable land management practices.

Table 6. Determinants of urban vegetable production practices technologies

Variables	Fertilizer			Pesticide			Joint Fertilizer and Pesticide		
	Coef.	S.E	ME	Coef.	S.E	ME	Coef.	S.E	ME
Family size	-0.2595*	0.149	-0.0333	-0.1682	0.25	-0.0024	-0.3265*	0.181	-0.0207
Sex	0.9716	0.647	0.1342	0.2024	0.936	-0.0012	0.74	0.811	0.0413
Age	0.0155	0.023	0.0028	-0.0233	0.042	-0.0007	-0.0193	0.028	-0.002
Land size	0.0001	0.0001	.00004	-0.0002	0	0.0001	0.0002	0.001	0.0001
Dependent ratio	-0.0057	0.004	-0.0006	-0.0064	0.009	-0.0001	-0.0144**	0.007	-0.001
Education	0.0864	0.064	0.0095	0.2281*	0.129	0.0053	0.1561**	0.073	0.0101
Livestock	0.0574	0.089	0.0064	-0.3706*	0.208	-0.0107	0.265***	0.095	0.0203
Extension	-0.0531	0.148	-0.02	0.3864	0.246	0.0091	0.6404***	0.173	0.0492
Experience	0.1041**	0.055	0.0133	0.0078	0.1	-0.0007	0.1516**	0.063	0.01
Training	0.7716**	0.425	0.0895	1.4895*	0.798	0.0328	1.2524**	0.54	0.0809
Off/not farm	1.284***	0.45	0.1783	-0.3183	0.748	-0.0175	1.107**	0.541	0.0659
Credit	1.0548**	0.445	0.1586	-0.4882	0.733	-0.0188	0.2073	0.495	0.0006
Member coo	-0.1327	0.41	-0.0234	0.7998	0.791	0.022	-0.0467	0.491	-0.003
Distance market	0.0074	0.025	0.0008	0.0308	0.04	0.0008	0.0091	0.028	0.0005
Soil fertility ind	-0.727***	0.264	-0.1029	-0.2376	0.424	-0.0018	-0.3637	0.3	-0.016
_cons	-4.0386	1.906		-3.7118	2.91		-5.6432	2.314	
Number of obs	232								
Chi ² (45)	147.61								
Prob > chi ² =	0.000								
Pseudo R ² =	0.2922								
Log likelihood	-178.77								
Cox and Snell	0.471								
Nagelkerke	0.531								
McFadden's R ²	0.292								

***, ** and * means at 1%, 5% and 10% respectively

Dependency ratio: The dependency ratio measures the social burden of urban household agriculture activity, with each working-age individual responsible for supporting family dependents. It is used to assess the pressure on the productive parts of household member. This variable has a significant and negative association to



the probability of adoption joint fertilizer and pesticide practices at a 5% probability level. The marginal effects value of -0.001 dependency ratio shows that keeping other factors constant, the increase in dependents by one person reduces the probability of adopting joint fertilizer and pesticide practices for vegetable production by 1%. This could be because families with a higher dependency ratio rely more on the working members to provide food for those who are not productive (Table 6). The result is in line with (*Milkias & Abdulahi, 2018*).

Educational Level HH: The educational status of the household head is a crucial factor in promoting the adoption of urban vegetable-growing practices. The results showed that this variable has a positive and significant association with the likelihood of adopting pesticide and joint fertilizer and pesticide practices at the 10% and 5% probability levels, respectively. The marginal effect value of educational attainment shows that when the educational attainment of the household head increases by one year, the probability of adopting pesticides and joint fertilizers and pesticide practices, holding other factors constant, increases by 0.5% and 1%, respectively (Table 6). The positive sign indicates that the variable is an important determinant of pesticides and joint fertilizer and pesticide adoption practices. This may be because better-educated urban farmers are more likely to participate in urban vegetable farming practices (*Dalango & Tadesse, 2019; Shallo et al., 2020*).

Total livestock: The livestock own in TLU was found to have a positive influence on joint fertilizer and pesticide at a 1% significance level on the adoption of agricultural technology in urban vegetable production practices. Other things remain constant, the marginal effect shows, with a one-unit increase in TLU in the livestock holding the household's, the probability of adopting joint fertilizer and pesticide practices increases by 2%. The positive relationship of livestock owned with agricultural input technology indicates that households with large livestock size better chance to participate in vegetable production practices. Income from livestock ownership contributed to the purchase of agricultural inputs for vegetable production (*Negera et al., 2022; Nure et al., 2020*).

Extension Contacts: Extension services play essential role in provides farmers with useful information, promote the adoption of agricultural practices, and guide to technological choice, shifting opinions from subjective to objective over time (*Kebede, 2020*). This study found that the frequency of contacts affecting the likelihood of adopting joint fertilizer and pesticide practices has a positive and significant association at the 1% probability level. The marginal effect value of 0.0492 extension contact showed that when extension contact frequency increased by one, the probability of adopting joint fertilizer and pesticide practices, holding other factors constant, increased by 5%. Interacting with extension agents increases the chances of obtaining up-to-date information on necessary agricultural technology to improve urban vegetable production practices. The extension service aims to improve urban vegetable production practices with technology through modern agricultural technologies such as chemical fertilizers, pesticides and irrigation and has been instrumental in intensification activities. This finding supports the findings of (*Bekuma, 2018; Negera et al., 2022*), who reported that farmers are more inclined to adopt urban farming practices.

Agricultural Experience: This variable was showed a significant at less than 1% and 5% levels and positively affects to adopt joint fertilizer and pesticide, and fertilizer used, respectively. Experience in farming is an important point for adopting urban agricultural practices, as households with years of experience have high responses towards using agriculture technology (*Hegena & Teshome, 2022*). The value marginal effect indicates, other variables constant, the likelihood of adopting joint fertilizer and pesticide use, and fertilizer use increases by 1% and 1.3%, respectively, as farmer's experience increases by one year. This means that farmers with greater experience in urban vegetable production are more likely to adopt agricultural technologies than farmers who have low experience. Because urban household farmers with longer agricultural experience are expected to be more knowledgeable and knowledgeable about the benefits of agricultural technologies for urban vegetable production. The results agree with the findings of (*Hegena & Teshome, 2022; Mohammed Kassaw et al., 2019; Regassa et al., 2023*).

Access to training: The study indicated that access to training positively influenced farmers' decisions to engage in agricultural input technologies, emphasizing its essentiality as a key tool for encouraging household technology adoption. The model results showed a significant and positively effect of access to training on farmers' adoption of joint fertilizer and pesticide, fertilizer, and pesticide practices at a less than 5% and 1% significance levels, respectively. The marginal effect shows that participants in urban agriculture-related technology training are more likely to adopt practices involving joint use of fertilizer and pesticide as well as individual fertilizer and pesticide applications increases by 8.1%, 8.9% and 3.3%, respectively. This indicated that households who have received



training in any urban agriculture-associated practices are more likely to adopt agricultural technology in urban vegetable production, and they have a greater understanding of the merits of the technology input than not-trainers.. The findings are in line with the results of (Eyitayo Raji *et al.*, 2024; Nure *et al.*, 2020), who reported that urban agriculture training enhances the adoption of agriculture technology like politer management.

Off/non-farm activities: Participating of farmers in off-farm or non-farm activities has an impact on households' decision to adopt agricultural input technologies. This could be because farmers who earn more money from different sources, which may overcome the budget barriers, required to agricultural input technologies practices (Jebesa, 2019). Accordingly, the respondents' off-farm variable had a significant and positive association with 1% and 5% probability of adopting fertilizer and joint fertilizer and pesticide practices, respectively. The marginal effect values of 0.1783 and 0.0659 off/non-farm show that the probability of adopting fertilizers and joint fertilizer and pesticide practices increases by 17.8% and 6.59%, respectively, when off/non-farm income increases by 1% increases if other factors remain constant, respectively (Table 6). This showed that the households that had participated in additional engagement adopted more urban vegetable-growing practices than the households that had not participated. Due to their additional source of income, there is the possibility of adopting or purchasing both technologies used for this purpose (fertilizers and pesticides). This result is consistent with the finding of (Jebesa, 2019; Neway & Zegeye, 2022; Semreab, 2018).

Access to credit: Access to credit is critical for individuals as it supports technology adoption and reduces family financial constraints. Based on the results of (Table 6), this variable was found to be significantly and positively related at a probability level of 5%. The marginal effect value of 0.1586 credit access shows that holding other factors constant, the probability of using fertilizers for urban vegetable growing practices increases by 15.9% when the household uses credit. Studies conducted in Ethiopia have shown that access to credit can significantly increase the use of chemical fertilizers in both rural and urban areas and ultimately improve agricultural productivity (Ayenew *et al.*, 2020; Dessie *et al.*, 2022; Hiko *et al.*, 2020). This condition can be attributed to the fact that access to credit solves budget problems of poor farmers. The findings based on the survey data from KIIs and FGDs showed that access to credit is not enough to the urban agriculture; this affects urban dwellers' participation in agricultural technology practices widely.

Soil fertility status index: The fertility index of the soil in the plot holds importance value when determining on non-user fertilizers, but does not influence the choice of practices in soil conservation agriculture to use for the user group. This study as the resulted of from the Principal Component Analysis (PCA) to construct a soil fertility status index for of 232 respondents across the study area. The result of this variable showed the soil fertility status index of the plot was significantly and negatively affected by the adoption of fertilizers at a probability level of 1%. The marginal effect of the soil fertility status of the plot indicated that fertilizer user decreases by 10.29% when soil fertility increases and other variable factors no change. This may indicate that urban household with fertile soil are less likely to use these inputs. The result is a line with the findings of (Milkias & Abdulahi, 2018; Ochieng *et al.*, 2022; Serbessa *et al.*, 2023). On the contrary, fertilizer uptake rate was neither significant nor negative about soil fertility. This condition revealed that farmers with better soil fertility could use fewer chemical fertilizers and opt for more sustainable methods.

3.1.4 Comparison of Mean Income of Sampled Households

The study from the survey data analysis through pairwise comparison shows that the outcome of Bartlett's test is $X^2(3) = 11.840$, $P\text{-value} = 0.008$, meaning the null hypothesis of equal variances is rejected. This indicates that there are significant differences in household income variances across agricultural technology adoption categories. This suggests heterogeneity, meaning income is not uniformly distributed among urban vegetable growers in different categories. As indicated in table, the outcome income difference between pesticides-only adopters and fertilizers-only adopters was negative ($p = 0.762$), implying that both groups generated almost similar levels of income from vegetable sales. However, households that adopted a joint fertilizer and pesticide user had a much greater average income those who adopter fertilizer-only, with an additional gain of around 5164 ETB. Similarly, the joint adopters of fertilizer and pesticide experience a significant income difference from vegetable sales, estimated at 8,334 ETB, which is higher than that of pesticide-only adopters (Table7). The reason for having better income difference is farmers using the technologies get more vegetable sales income difference.



General, overall estimation of this study presented that by the adoption, the treated joint use of fertilizer and pesticide, fertilizer-only, pesticide-only are better position than the non-adopters practices. This result suggests that promoting integrated use of key agricultural technological input not only enhances productivity but also creates economic resilience for urban farming households, thereby contributing to food and livelihood security in the study area.

Table 7. Comparison of mean income from technology practices

Income Practices	Difference between	Std. Err.	P-value
Pesticides vs fertilizers	-3169.34 ^{ns}	2068.89	0.762
Join fertilizers joint pesticides vs fertilizers	5164.476 ^{***}	1323.927	0.002
Not adopts vs Fertilizers	-10914.97 ^{***}	1053.368	0.001
join fertilizer joint pesticides vs pesticides	8333.816 ^{***}	2093.093	0.0001
Not adopts vs Pesticides	-7745.629 ^{***}	1933.35	0.002
Not adopts vs join fertilizer joint pesticides	-16079.45 ^{***}	1100.145	0.0001

*** (means at 1% probability level) ns (non-significant) Source: Computed based on the data from Meta district, 2024

3.1.5 Constraints of Urban Agriculture Practices

While urban farming offers numerous benefits, there are still challenges and limitations to consider. The importance of fertilizer and pesticide technologies in increasing yields and producing healthy products is undeniable. As part of the survey, significant problems were identified by the respondents surveyed. The majority of survey participants (21.12%) cited the lack of available arable land and its limited size as a major problem (Table 8). Currently, limited land represents a significant constraint for households in both urban and rural areas of Ethiopia (Djibo & Maman, 2019; Teshome & Tegegne, 2020). During the FGDs, participants highlighted that marginalized groups and minorities who would benefit most from urban agriculture are disproportionately affected by the limited availability of land for large-scale vegetable production, which impacts market supply.

The lack of agricultural technology use in Chelenko and Kullubi reported by 17.67% of surveyed households such as: fertilizers, pesticides and others, is a problem in urban agriculture. This problem is particularly problematic in the important period for vegetable sowing. Furthermore, 14.22% of households surveyed said that the lack of improved vegetable seeds was an important factor in achieving high vegetable production in cities. These results highlight the limitations of agricultural inputs in urban areas that hinder the improvement of vegetable crop production. Addressing these challenges through greater access to agricultural technologies is key to improving urban vegetable production and ensuring food security in these households.

Participants noted that the presence of pests and diseases affected vegetable production in urban agriculture. The problems were cited by 14.66% of respondents surveyed. To address these issues, urban farms employ a mix of organic, cultural pest control approaches and pesticides. These integrated pest management tactics are crucial for crop health and long-term urban agricultural sustainability. According to focus group discussions and interviews with key informants, the costs of inputs, notably fertilizers, seeds, and pesticides, rise with time. However, it is difficult to obtain these in a timely manner and in sufficient quantities from the nearest agricultural cooperative. Difficulty accessing necessary inputs exacerbates the challenges faced by urban farmers and affects their ability to maintain productivity and implement sustainable agricultural practices. During the FGDs, respondents highlighted that the low-frequency interaction with extension agents this indicted limited their access to current agricultural technologies essential for improving urban vegetable production. The problems were mentioned by 12.93% of the sampled respondents.



Table 8. Constraints of urban vegetable production practices

Constraints	Freq.	Percent	Cum.
Cost input	17	7.33	7.33
Lack of input agriculture	41	17.67	25
lack irrigation water	28	12.07	37.07
Shortage cultivate land	49	21.12	58.19
Lack improved seed	33	14.22	72.41
Pest and diseases stress	34	14.66	87.07
lack access agriculture Extension agent	30	12.93	100

Source: Computed based on the data from Meta district, 2024

4. Conclusion and Recommendations

This study was carried out to examine the factors affecting the adoption of agricultural technologies among vegetable producers in the towns of Chelencso and Kullubi. Cross-sectional data was gathered from 232 sample households were employed to assess urban farmer's decision to adopt agricultural technologies in vegetable production practices. Both primary and secondary data were collected as source of the quantitative and qualitative data. To determine the adoption of agricultural technologies in urban vegetable production practices, analysis was used the MNL model due to the data representing mutually exclusive adoption choices among urban vegetable producers. The results further indicate that educational level, farming experience, livestock holding, access to training, extension contacts, off/non-farm activities, and access to credit had statistically significant and positive associated with households' decisions to adopt agricultural technologies practices. Conversely, family size and dependence ratio had significant and negative associated. Based on the results of respondents in the study area, the major challenges influencing the urban vegetable production practices are shortages of cultivated land, lack of input agricultural technologies, and pest and disease pressure. To enhance urban vegetable production practices policymakers and development might take into account the following recommendations, which are derived from the study results. The above results have important policy implication. Foremost, it is important to account the joint of different agricultural technologies in vegetable production promotion of their adoption. Thus, the very important encouragement for adoption of the joint fertilizer and pesticide technology practices, it is crucial to ensure that the agricultural input technologies are accessible and affordable to the farmers. This suggests that adoption of agricultural technologies practices could increase yield vegetable production and net farm income for the farming community in the study areas. It is imperative for local authorities, along with municipal and agricultural offices, should celebrate to enhancing targeted training programs, expanding access to extension services to promote the adoption of agricultural technology input for urban vegetable production. It can contribute a significant amount to the proportion of food eaten in the town. The policies that enhance access to credit facilities with low interest rates and farmer cooperatives (obtain technology input such fertilizer, pesticides and insecticides at right time).

The limitations of this study involve the dependent on a cross-sectional analysis design, which may limit the ability to establish impact of agricultural technology on food security outcomes among vegetable production. It focused on farmer decision to adopt agricultural technology in urban vegetable production practices. Additionally, the study was conducted in a specific geographic area that may not fully encompass regional towns or market-level dynamics. It is essential to conduct similar studies that cover a wider, more representative geographic area and a larger sample size. Future studies should enhance this research by utilizing a more robust econometric model, considering spillover effects and other factors influencing agricultural technologies.

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Author contributions

Yusuf Umer: Conceptualization, Validation, Investigation Resources, Data Curation. Fresenbet Zeleke: Software, Supervision, Validation. Beyan Ahmed: Supervision, Validation, Methodology. Petros Chavula: Writing-Original Draft, Writing-Review and Editing. Eliyas Abdi: Validation, Methodology. Selahdin Ahmed: Data Curation. All the authors have read and agreed to the published version of the manuscript.

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Ethics Approval Statement

A questionnaire-based survey of urban vegetable producer households was used in this study with the participants consent. Ethics approval was obtained from the ethics committee of Haramaya University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Declaration of AI Assistance

The authors acknowledge that generative artificial intelligence (AI) tools (ChatGPT, OpenAI) were used to support the refinement of language, editing for clarity, and structural suggestions during the preparation of this manuscript. All content, ideas, interpretations, and conclusions are the authors' own, and the final text was thoroughly reviewed and validated by the authors. No AI tools were used to generate research data, perform analysis, or draw scientific conclusions.

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Yes

Conflict of Interest

The authors have no conflicts of interest to declare. There is also no financial interest to report. The author certifies that the submission is original work and is not under review at any other publication.

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