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Research Article

Assessments of Pesticide Utilization and Safety Practices Among Vegetable Crop Producers in the East Shewa Zone, Oromia, Ethiopia

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Abstract

Pesticide application poses risks to human health and the environment, potentially causing acute and chronic health effects, biodiversity loss, and harm to non-target organisms. Short-term adverse effects can include stinging eyes, rashes, blisters, nausea, and dizziness, and in severe cases, death. Long-term exposure can lead to various health problems, such as cancer, birth defects, reproductive harm, neurological and developmental toxicity, and disruption of the endocrine system. The aim of this study is to identify the factors affecting the adoption and intensity of pesticide safety practices among vegetable producer farmers in the East Shewa zone, Oromia region, Ethiopia. To conduct the study, primary data was collected from 120 randomly selected vegetable producers in the Ada'a and Dugda districts. Descriptive and economic statistics were used to analyze the data. The results indicated that only 36.67% of farmers used at least one piece of personal protective equipment during pesticide application, while 63.33% did not. Among the personal protective equipment (PPE) used, boots were the most common, followed by masks. The average adoption intensity of personal protective equipment was 0.14, which is very low. The results of the Tobit model indicated that the factors affecting the adoption decision and the level of adoption of pesticide safety practices were experience in pesticide application, knowledge of pesticide risks, availability of PPE in the market, distance of residence to a pesticide drug shop, frequency of extension contact, and provision of training related to chemical application. Various pesticide drug shops and concerned bodies should focus on improving communication and information on pesticide use. This could contribute to the improvement of pesticide safety practices in the study area.

Keywords

Pre-Harvest Interval, Farmers Training Center, Personal Protective Equipment, Pesticide Safety Practice, Tobit Model, Central Rift Valley

1. Introduction

Vegetable crops are important high-value commodities grown in many parts of Ethiopia. These crops are important food supplements and serve as regular sources of income for poor rural farmers. Different types of vegetables grow around the Central Rift Valley and, to some extent, in urban and peri-urban areas. The major vegetables cultivated throughout the year by small and large-scale commercial farms include tomato, onion, pepper, cabbage, and snap

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beans. However, the productivity of these vegetable crops is very low due to several biotic and abiotic factors, among which diseases are the major ones. The major vegetable crop diseases are caused by fungi, bacteria, nematodes, and viruses; although some of these pathogens have been identified correctly, the majority have either not been identified or are named only based on the symptoms they cause [13].

Pesticides are a key agricultural input needed to protect seeds and safeguard crops from unwanted plants, insects, bacteria, fungi, and rodents. At the same time, pesticides can have negative health and environmental impacts through the contamination of soil, water, and non-target plants and animals, which can decrease biodiversity and harm living organisms, including humans [11]. Modern agricultural production, in its conventional mode, relies upon large amounts of chemical inputs in the form of fertilizers and pesticides [9]. Although both pesticides and fertilizers have allowed for the rapid expansion of global food production and consumption, these agrochemicals have been associated with several human and environmental hazards. Pesticide use, for example, is linked to thousands of annual accidental fatal poisonings from either direct contact with the chemical or indirectly from contact with contaminated objects [22]. and soil contamination [2], among many other hazards. Chemical pesticides concurrently feature as pillars of high-yielding, intensified agriculture and as major pollutants that drive environmental change [12], compromise human health, and destabilize farm profits [15]. There is a general lack of training and knowledge regarding the safe use of pesticides, especially among small-scale farmers. The misuse of pesticides can pose significant health and environmental risks, including pesticide poisoning and contamination of water sources. To avoid crop losses and ensure high production, farmers worldwide use millions of tons of pesticides ([3]. Considerable increment in chemical pesticide usage intensity, illegitimate usages of DDT and Endosulfan on food crops and direct import of pesticides without the formal Ethiopian registration process were also indicated ([7]. While pesticides are important in modern agriculture, their indiscriminate use has been linked to environmental and human health hazards [17].

Studies conducted on the knowledge and usage of pesticides in several developing countries have shown that farmers' practices are often unsafe and can result in health problems [5, 16, 19] and environmental hazards [8, 23]. Improper use of pesticides is still prevalent in many areas, and this has several negative impacts. It is causing various health issues in humans and animals [18, 21]. Therefore, it is important to identify the adoption decisions and the level of adoption of pesticide utilization safety practices in the study area to inform further intervention and policy recommendations.

Objectives of the Study

Specific Objectives

The specific objectives of the study were:

1) To identify the pesticide utilization and safety practices of vegetable farmers in the study area.
2) To identify the intensity of pesticide utilization by farmers.
3) To identify the adoption status of pesticide utilization safety practices.
4) To identify the factors affecting the adoption decision and intensity of adoption of pesticide safety practices.

2. Materials and Methods

The survey was carried out in selected vegetable-growing districts of the Central Rift Valley of Ethiopia during the crop production season. A total of two FSRP districts from East Shewa were considered. The study districts were Dugda and Ada'a. Two kebeles from Dugda district Bekele girisa and Korke adi from Ada'a Godino and Dekeka known for growing vegetable crops and farmers from each kebele who had cultivated vegetables for one or more years in the previous five years were selected for interviews. Kebeles and farmers were sampled purposively based on a set of criteria and information provided by agricultural experts and development agents (DAs) at the district bureau of agriculture in each district.

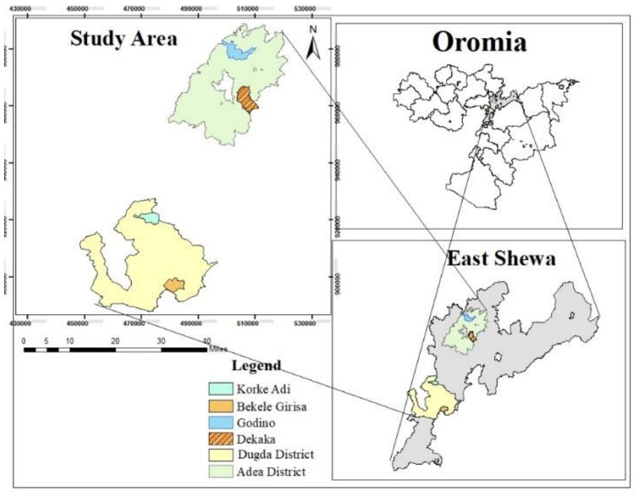

Figure 1. *Study area.*

2.1. Data Types, Sources, and Methods of Data Collection

Both qualitative and quantitative types of data were collected, and both primary and secondary data sources were used. The primary data was collected from sample farmers, and secondary data was collected from published and unpublished sources.

2.2. Sampling Procedure and Sample Size

A two-stage sampling technique was employed to select sample respondents. In the first stage, two kebeles were randomly selected from vegetable-producing kebeles in

Dugda and Ada'a Districts. In the second stage, 120 sample vegetable producer farmers were selected randomly for a formal interview using Yamane's sample size determination (1967).

$$n = N / (1 + N(e)^2)$$

Where: n = is the sample of vegetable producers, N = is the total number of vegetable producers in both districts, and e = 0.09 is the level of precision defined to determine the required sample size at a 9% level of precision because it is possible to use a 5% to 10% level of precision while considering data representativeness.

The total number of vegetable producer households is 4200, so the sample size is calculated as follows:

$$n = 4200 / (1 + 4200(0.09)^2) = 4200 / 35.02 = 120.$$

2.3. Method of Data Analysis

Descriptive statistics and an econometric model were used for analyzing the data. The Tobit model was used to analyze the factors affecting the adoption decision and intensity of adoption of pesticide safety practices. The dependent variable for this study was the use of pesticide safety practices, categorized as whether a farmer decides to use pesticide safety practices or not. Pesticide safety usage takes a value of 1 if the farmer uses pesticide safety practices and 0 otherwise.

2.4. Variable Descriptions and Hypotheses

The dependent variable

The dependent variable for this study was pesticide safety practices, categorized as whether a farmer decides to use pesticide safety practices or not. Pesticide safety usage takes a value of 1 if the farmer uses pesticide safety practices and 0 otherwise.

Independent variables

The independent variables selected for the models are based on a review of the literature and include demographic, resource endowment, and institutional variables that are expected to influence the adoption decision and intensity of pesticide safety practices. The variables considered for this study are: age of respondents, education level, total family size, experience in pesticide application, knowledge about the risk of pesticides, availability of personal protective equipment in the local market, participation in social organizations, distance of the farmer's residence from the pesticide shop, access to credit services, frequency of extension contact, access to market information, and provision of training.

1) *Age of respondents:* It is a continuous variable measured in years. A farmer's age can influence their adoption of pesticide utilization safety practices negatively. Older farmers may have more experience with pesticides, but this does not always translate to better safety practices. They might have relied on older methods that are now known to be unsafe.
2) *Education level:* It is a continuous variable measured in terms of the level of education a farmer has attended in years of formal education. It is expected that the more years an individual is exposed to education, the more open he/she will be to new ideas and to reading pesticide application labels. Educated farmers may also be more aware of the benefits of modern technologies and may have a greater ability to learn new information, hence easily adopting new technologies. Education was expected to have a positive effect on the adoption of pesticide safety practices.
3) *Family size:* It is a continuous variable measured in terms of the adult equivalent of persons living together in the household. Larger families may have less time and resources available for proper pesticide handling and safety practices, potentially leading to shortcuts and increased risks. Hence, it is hypothesized that family size negatively influences the adoption of pesticide safety practices.
4) *Experience in pesticide application:* It is a continuous variable measured in years of pesticide application. It is expected that farmers who have adequate farm experience are more likely to use pesticide safety practices than less experienced farmers. Therefore, it is expected that experience in pesticide application is positively related to the adoption of pesticide safety practices.
5) *Knowledge of pesticide risks:* This is a dummy variable indicating whether the farmers know the risks related to human health and environmental problems. It is hypothesized to have a positive relationship with the adoption decision and intensity of adoption of pesticide application safety practices. This implies that farmers who understand the dangers of pesticide exposure are more likely to adopt protective measures.
6) *Availability of personal protective equipment at the local market:* This is a dummy variable, with 1 if personal protective equipment is available at the local market and 0 otherwise. It is hypothesized to have a positive relationship with the adoption decision and intensity of adoption of pesticide application safety practices, suggesting that when PPE is readily accessible, farmers are more likely to use it, leading to reduced pesticide exposure and improved safety.
7) *Participation in farmer groups:* This is a dummy variable, with 1 if the farmer participated and 0 otherwise. It provides a platform for sharing information that may be helpful in production and pesticide safety application activities by the farmers. It is expected that membership in farmer groups will have a positive effect on the adoption decision and intensity of pesticide application safety practices.
8) *Distance to pesticide store shop:* It is a continuous variable measured in kilometers. It is expected that farmers

living near the shop would more easily access information about the drug than farmers far away from the pesticide drug shop, which is related to the adoption of pesticide application safety. Therefore, it is hypothesized that the distance to the market pesticide drug shop is inversely related to the adoption decision and intensity of pesticide application safety practices.

9) *Access to credit services:* This is a dummy variable, with 1 if the farmer has access to credit and 0 otherwise. It is expected that access to credit has a positive effect on the adoption decision and intensity of pesticide application safety practices, as credit services provide farmers with cash for buying personal protective equipment from the market.
10) *Extension frequency:* It is a continuous variable measured in terms of the frequency of contact between the extension agent and the farmer in a year. It is hypothesized to be a potential force that accelerates the effective dissemination of adequate information to the farmers, thereby enhancing farmers' adoption of pesticide safety practices. It was hypothesized that contact with extension workers increases a farmer's knowledge of pesticide utilization practices.
11) *Access to market information:* This is a dummy variable, with 1 if the farmer has access to market information and 0 otherwise. It is hypothesized to have a positive relationship with the adoption decision and intensity of adoption of pesticide application safety practices, suggesting that farmers who have easy access to market information can more easily buy personal protective equipment than those who do not.
12) *Provision of pesticide training:* This is a dummy variable, with 1 if training was taken by farmers and 0 otherwise. It is expected that training will have a positive effect on the adoption decision and intensity of pesticide application safety practices, suggesting that knowledge and understanding of safe handling practices are crucial for preventing health risks and promoting responsible use.
13) *Participation in non-farm and off-farm activities:* This is a dummy variable, with 1 if the farmer participated and 0 otherwise. It is expected that participation in other activities outside of farming will have a positive effect on the adoption decision and intensity of pesticide application safety practices, suggesting that it increases farmers' additional income, which is related to the ability to buy personal protective equipment.

Table 1. *Explanatory variables and expected signs.*

Dependent Variables	**Unit/ type**	**Variables Description**	
Adoption decision	Dummy	Pesticide safety usage value of 1 and 0 otherwise	
Level adoption of pesticide safety practice	Continuous	Ratio of type of safety used to full protective equipment	
Explanatory Variables	Description of variables		Exp sign
Age of household head	Dummy, 1 for male and 0 for female		-
Education level	Continuous, education level years of schooling		+
Total family size	Continuous, number of family living together		+
Experience pesticide application	Continuous, experience of production in years		+
Knowledge of pesticide risks	Dummy, yes=1, 0=No		+
Availability of PPE at market	Dummy, yes=1, 0=No		+
Participation in farmer groups	Dummy, yes=1, 0=No		+
Distance to FTC	Continuous, in kilometers		-
Distance to pesticide drug store	Continuous, in kilometers		-
Access to credit service	Dummy, yes=1, 0=No		+
Frequency of extension contact	Continuous, number of extensions contact		+
Access to market information	Dummy, yes=1, 0=No		+
Training provision on Pesticide safety practices	Dummy, yes=1, 0=No		+
Participation in non/and off-farm activities	Dummy, yes=1, 0=No		+

3. Results and Discussion

3.1. Demographic and Socio-Economic Characteristics

Sex of the household heads: As indicated table below 98.33% of households were male headed and 1.67% were female-headed households. The proportion of female household heads in the sample is much lower than male household heads which indicated that chemical spray mostly practiced by male.

Table 2. *Sex of sample household heads.*

Variable		Frequency	Percent
Sex of household	Male	118	98.33
	Female	2	1.67
	Total	120	100

Source: Survey result, 2025

Participation in social organizations: As indicated table below, participation in social organization is believed to enhance information exchange and experience sharing among farm households. Sample farmers participated in social organizations was 52.10% while 47.90% participated.

Availability of PPE at local market: - Availability of PPE at local market was an opportunity for producers to buy the equipment and used it. About 17.5% of farmers respond that PPE like boots, masks and gloves were available at local market. The availability in this case was full package of PPE.

Participation in training: Participation in training improves farmers' knowledge and creates awareness about pesticide safety practices. From the total sample respondents interviewed, 14.17% of sample respondents participated in training related to pesticide application safety practices during survey season mostly provided by the Agricultural Research Center and Non-Governmental Organization (NGO) while a majority of about 85.83% did not participate in training.

Access to credit services: Credit is important for farmers especially when cash shortages for buying pesticides and personal protective equipment. Only 19.17% used credit while the majority, about 80.83%, did not use it because of no need, inappropriate payback period and high interest rates.

Access to market information: Access to market information was important for producers to know the price, place and market information for PPE. About 75.42% of producers had access to market information while 24.58% were not accessed.

Participation in non/and off-farm activities: Participation in other activities out of farming increase farmers' additional income which is related to ability to buy personal protective equipment. From total respondents interviewed 23.33% of producers participated in non/and off-farm activities like papaya trading, crop trading, sheep fattening and shopping.

Table 3. *Summary of categorical variables.*

Variables	Response	Frequency	Percent
Participation in social organization	Yes	62	52.10
	No	57	47.90
Availability of PPE at local market	Yes	21	17.50
	No	99	82.50
Participation in pesticide related training	Yes	17	14.17
	No	113	85.83
Credit utilization	Yes	23	19.17
	No	97	80.83
Access to market information	Yes	89	75.42
	No	29	24.58
Participation in non/and off-farm activities	Yes	28	23.33
	No	92	76.67

Source: Own survey result, 2025

Age of household heads: Age was important contribution in pesticide application safety practice as it relates to experience and awareness. The mean age of the sample household was found to be 37.81 years. The result implies that this average age at adult and productive age understands pesticide application related risk.

Family size: Family size also contributes to pesticide application safety practices. The larger family size the lower pesticide application safety practices suggest that the care only for family feed rather than safety practices. The mean family size was 5 people in the study area.

Experience in pesticide applications: The mean experience in pesticide application of the sample household was 7.72 years. This implies that the experience farmers accumulate more knowledge about pesticides and application safety practices which were important for adoption decision and intensity of pesticide application safety practices.

Education level of household head: The mean education level of the sample household was 5.94 years of schooling. This implies that literate farmers can easily understand agricultural instructions and advice provided by the pesticide drug sellers which was important for adoption of pesticide application safety practices.

Table 4. *Descriptive of continue variables sample household heads.*

Variables	Mean	Std.Dev.	Minimum	Maximum
Age of household in years	37.81	9.74	20	58
Family size in number	5.03	2.66	1	12
Experience in pesticide application	7.72	2.79	1	15
Education level in years of schooling	5.94	3.52	0	15

Source: survey result, 2025

Cultivated land: Cultivated farmland land is land used by sample farm households to undertake agricultural production. The average cultivated land of the sample household was 1.27 hectares.

Frequency of extension contact: Agricultural extension services are expected to enhance farmers' skill and knowledge, link farmers with experts to enhance technology adoption. The frequency of extension contact was how many times extension provisions given to farmers in years. Thus, extension services given to sample respondents were mostly focused on input use, production and post-harvest management. The average extension frequency of the sample household was 2.28 times.

Distance to farmers training center (FTC): Distances from farmers training center decrease the chance to participate in technologies demonstrated at FTC and different non-governmental organizations also work around FTC and it is center of information and training to farmers. The average distances from the farmers training center of the sample household were 2.36 kilometers.

Distance to pesticide drug store shop: Distances farmers residence from pesticide drug shop decreases the chance to get more information about pesticides and associated risks. The average distance from farmers residences from pesticide drug shops was 4.02 kilometers.

Table 5. *Descriptive of continue variables.*

Variables	Mean	St.Dev.	Minimum	Maximum
Cultivated own land in ha	1.27	0.86	0.25	3
Frequency of extension contact	2.28	2.41	0	12
Distance farm from FTC in km	2.36	1.05	0.5	4
Distance to pesticide drug shop	4.023	1.11	2	6

Source: survey result, 2025

3.2. Knowledge and Personal Protection Equipment Utilization

Agricultural pesticide handlers around the world are advised to adhere to safety procedures, including reading pesticide labels and wearing personal protective equipment (PPE) like safety glasses, long-sleeved shirts, masks, etc., to minimize the health effects of pesticides.

Table 6. *Knowledge and PPE Utilization.*

Variables	Response	Frequency	Percentage
Do you know Pesticide name	Yes	103	85.83
	No	17	14.17
Do you think that pesticides affect human health?	Yes	112	93.33

Variables	Response	Frequency	Percentage
	No	8	6.67
Do you think that pesticides affect livestock and Harmful to farm animals?	Yes	114	95
	No	6	5
Do you think that pesticides affect environment (water bodies)?	Yes	113	94.17
	No	7	5.83
Do you apply according to the instruction on the labels	Yes	1	0.83
	No	119	99.17
Do you ever read pesticides labels?	Yes	90	75
	No	30	25
Are you know the risk of pesticide usage?	Yes	103	85.83
	No	17	14.17
Keep in a safe place out of reach of children	Yes	118	98.33
	No	2	1.67

Source: survey result, 2025

The majority 62.14% responds that burning and itching was the effect of pesticide that sense after application of pesticides to vegetables and crops followed by skin irritation 19.42% and least 1.94% headage.

Table 7. *Type of pesticide risk respondents respond.*

Type of risk of pesticides	Frequency	Percentage
Skin irritation	20	19.42
Burning and itching	64	62.14
Headage	2	1.94
Breathing problem	17	16.50
Total	103	100

Source: survey result, 2025

3.3. Pesticide Utilization and Dosage on Vegetable Production

The common pesticides used were fungicides, insecticides and herbicides for vegetable production. From fungicides used on vegetables Mancozeb is extensively used for tomato and onion disease control, along with other pesticides like Malathion, Selecron, Redomil, Karate, Thionex, and Profit. The common insecticides used on vegetables include organophosphates (like malathion, diazinon, and profenofos), pyrethroids (like deltamethrin and lambda-cyhalothrin), and carbamates and herbicides like Glyphosate was used. The dosage is based on pesticide drug seller and mixing with water in equipment known as "*Roto*" and apply using manual knapsack sprayer.

3.4. Trends of Pesticide Utilization Last Five Years

The pesticide utilization for vegetable production shows increasing trend in the study area. Most respondents 99.17% responses the pesticide utilization in the study area shows increasing trend this may due to increased pest incidence, climate change, the promotion of pesticides by extension programs, and the susceptibility of high-yielding crop varieties. The result in line with [11], which indicated that pesticide utilization shows increasing trend.

Table 8. *Trends of pesticide utilization last five years.*

Variable	Response	Frequency	Percentage
Trends of pesticide uses in last five years	Increasing	119	99.17
	Decreasing	1	0.83

Source: survey result, 2025

3.5. Adoption Status of Pesticide Utilization Safety Practices

The adoption of safety practices like wearing protective clothing and proper disposal of containers remains low, highlighting a need for improved training and awareness. In this study we take adopters the farmers that at least wear one persona protective equipment during pesticide spray. The majority about 63.33% of respondents do not adopt pesticide safety practices while 36.67% adopt it. This may be due to some reasons like to save additional cost for persona protective equipment, the equipment not comfortable while spraying (very hot) and lack of awareness.

Table 9. *Adoption status of pesticide utilization safety practices.*

Variable	Adopters		Non-Adopters	
	Freq.	Percent	Freq.	Percent
Adoption status of pesticide utilization safety practices	44	36.67	76	63.33

Source: survey result, 2025

Even though the percentage uses of personal protective equipment low, Wear respirators /masks high 35% followed by wearing boots 13.33% and least Wear eye protection (Goggles) 6.67% of respondents. This result indicated that as corona consequences the mask bought by sample respondents. The majority 63.33% sample respondents did not use any type of personal protective equipment when apply pesticides while 5.85% used full package of personal protective equipment.

Table 10. *Type of Personal Protective Equipment (PPE).*

Type of Personal Protective Equipment (PPE)	Response	Frequency	Percentage
Protect your feet/wear boots	Yes	16	13.33
	No	104	86.67
Wear protective clothing	Yes	13	10.83
	No	107	89.17
Wear gloves	Yes	12	10
	No	108	90
Wear eye protection (Goggles)	Yes	8	6.67
	No	112	93.33
Cover face/use a face shield	Yes	9	7.50
	No	111	92.50
Wear respirators /masks	Yes	42	35
	No	78	65
Status of pesticide safety usage by farmers	None	76	63.33
	Partial	37	30.83
	Full Package	7	5.83

Source: survey result, 2025

Pesticide safety practice is wearing appropriate personal protective equipment (PPE), store pesticides separately and securely, and dispose of empty containers properly, while also following label instructions and seeking professional guidance when needed.

The sample respondents not consider some safety practices like eat, drink, or smoke while handling Pesticides, wash hand after use, not allow children to play around sprayers or mixing, storage, and disposal area, follow the pre-harvest interval (PHI) on Pesticide label before harvesting crops, keep pesticides in a dry and locked storage area away from food and feeds, triple rinse or pressure rinse empty containers and dispose or recycle in accord and avoid drift into non-target areas and pesticide runoff into streams, rivers, lakes. Even though more than 50% take safety practices, still some farmers not aware about pesticide safety practices.

Table 11. *Pesticide safety practices during application.*

Items	Response	Frequency	Percentage
Eat, drink, or smoke while handling Pesticides	Yes	31	25.83
	No	89	74.17
Wash hand after use	Yes	107	89.17
	No	13	10.83
Not allow children to play around sprayers or mixing, storage, and disposal area	Yes	106	88.33
	No	14	11.67
Follow the pre-harvest interval (PHI) on Pesticide label before harvesting crops	Yes	68	56.67
	No	52	43.33
Do you keep pesticides in a dry and locked storage area away from food and feeds?	Yes	103	85.83
	No	17	14.17
Triple rinse or pressure rinse empty containers and dispose or recycle in accord	Yes	71	59.17
	No	49	40.83
Avoid drift into non-target areas and pesticide runoff into streams, rivers, lakes	Yes	75	62.50
	No	45	37.50

Source: survey result, 2025

Pesticide was applied by vegetable producer or by daily labour. The majority 60% of respondents spray pesticides by themselves. The tomato producers hired daily labour for guarding, management and pesticide application start from planting until harvesting almost three months.

Table 12. *Pesticide safety practices during application.*

Who apply pesticides	Frequency	Percentage
Owner	72	60
Daily Labour	27	22.50
Owner and daily labour	21	17.50

Source: survey result, 2025

Sources of pesticides very important for pesticide utilization and awareness about the safety utilizations. Most respondents 98.33% bought pesticides from private drug sources. Unions supply in rainy season for crop production but only supply small amount for vegetable production.

Table 13. *Source of pesticides.*

Sources of pesticide	Frequency	Percent
Unions	2	1.67
Private drug shop	118	98.33
Total	120	100

Source: survey result, 2025

To apply pesticides on vegetables effectively and safely, always read and follow the instructions on the pesticide label, spray thoroughly, and consider timing and environmental factors. In the study area pesticides applied to vegetables by mixing with water. The dosage is based on pesticide drug seller guidance. When farmers want to buy pesticides, he/she introduces about disease either orally or give sample of vegetables. The pesticide drug seller advice the instruction to use and dosage. Farmers mixing the pesticides at field with materials like Roto and spray by using manual Knapsacks. Farmers in the study area used different types of pesticides for vegetable production. Most respondents 78.33% were used fungicides and insecticides type of pesticides while herbicides rarely used (Figure 2).

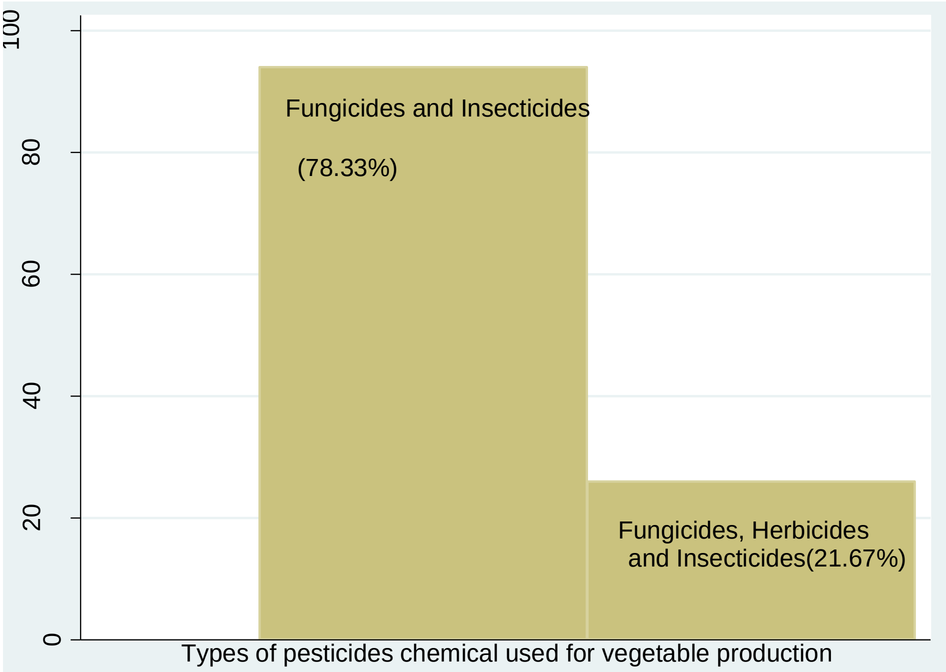

Figure 2. Type of pesticides applied to vegetables by respondents.

Fungicides are chemical substances designed to target and eliminate fungi, which are organisms that can cause diseases in plants. Fungicides can work in different ways, some by preventing fungal spores from germinating, others by inhibiting fungal growth, and some by killing the fungi directly. The majority of respondents 77.5% were used Mancozeb and Redomil types of fungicides for vegetable production while 22.5% were used only Mancozeb type of fungicide.

Table 14. Type of fungicide used for vegetable production.

Common fungicide types	Frequency	Percentage
Mancozeb	27	22.50
Mancozeb and Redomil	93	77.50

Source: survey result, 2025

In agriculture, herbicides are chemicals used to control or eliminate unwanted plants, commonly known as weeds, that compete with crops for resources like nutrients, water, and sunlight. They work by interfering with the plant's metabolic processes, leading to weed growth inhibition or death. Most respondents 84.62% were used Glyphosate type of herbicide followed by 2, 4D and Glyphosate 11.54% vegetable production.

Table 15. Type of herbicides used for vegetable production.

Common Herbicide types	Frequency	Percentage
2, 4-D	1	3.85
Glyphosate	22	84.62
2, 4D and Glyphosate	3	11.54

Source: survey result, 2025

Insecticides are chemical substances or natural compounds used to kill or manage insect populations. They are crucial for protecting crops from insect damage, which can lead to significant yield losses and economic impact. In the study area different insecticides were used for vegetable production. The majority of respondents were used different types of insecticides. Profit, Radiant and Agenta were used by 57.5% of respondents followed by Karate, Profit, Ethiodemethrin and Malathion, Radiant and Agenta 24.17% of respondents. The respondents in the study area ask each other for type of pesticide uses and give sample of plant diseases to pesticide drug sellers.

Table 16. Type of insecticides used for vegetable production.

Common Insecticide types	Frequency	Percentage
Malathion	17	14.17
Karate, Profit, Ethiodemethrin and Malathion, Radiant and Agenta	29	24.17
Profit, Radiant and Agenta	69	57.50
Profit, Radiant, Malathion and Agenta	5	4.17

Source: survey result, 2025

3.6. Adoption of Intensity of Pesticide Safety Practices by Farmers

The adoption intensity of pesticide safety practices is the use of personal protective equipment proportion to full equipment. Only few respondents utilize full package of personal protective equipment. The mean adoption intensity of pesticide safety practices was 0.14 which is very low.

Table 17. Adoption intensity of pesticide safety practices.

Variable	Mean	Std. Dev.
Adoption intensity of pesticide safety practices	0.14	0.25

Source: survey result, 2025

3.7. Pesticide Application Frequency on Vegetables

Tomatoes, onions, snapbean, cabbages and hot peppers are among the most economically important vegetables grown by sample respondents. The introduction of irrigation wheat also influences on vegetable production in the study area. The majority 68.33% of sample farmers produced onion followed by cabbages 13.33%. Snapbean produced by small number of farmers. Hot pepper is the recently popularized and under production in the study area which 10% of sample farmers produced it. Even though application of pesticides not exactly known and based on disease occurrence, the average frequency of application on tomato was higher than other vegetables which was 16.15 times on average range from 10 to 20 times. Pesticide application frequency of onion was next two tomato which on average 7.65 times range from 2 to 15 times. Generally, the application frequency is not appropriate and not based on scientific evidence in the study area.

Table 18. Type of vegetables produced and frequency of pesticide application.

Type of vegetables	Number of producers		Pesticide application frequency			
	Frequency	Percent	Mean	Std.Dev.	Minimum	Maximum
Tomato	13	10.83	16.15	3.39	10	20
Onion	82	68.33	7.65	3.10	2	15
Snapbean	8	6.67	6.25	2.31	3	10
Hot Pepper	12	10	7.08	1.56	4	8
Cabbages	16	13.33	5.38	1.20	4	8

Source: survey result, 2025

Pesticide utilization has increased in Ethiopia particularly in the study area due to factors like the emergence of new invasive pests, the inclusion of pesticides in crop production technology packages, an increase in the agrarian population and cultivated land, and the susceptibility of high-yielding crop varieties. Low efficacy of pesticides and high incidence of diseases/pests was highest which was 27.5% followed by high incidence of diseases/pests 22.5% due to climate change.

There were also other like low efficacy of pesticides and influence from retailers and their guidance increase the pesticide utilization in the study area. This result is similar with the finding of [1].

Table 19. Type of vegetables produced and frequency of pesticide application.

Reasons increase pesticide utilization	Frequency	Percent
Low efficacy of pesticides	21	17.5
Influence from retailers and their guidance	25	20.83
High incidence of diseases/pests	27	22.50
Low efficacy of pesticides and high incidence of diseases/pests	33	27.50
Low efficacy of pesticides and influence from retailers and their guidance	14	11.67
Total	120	100

Source: survey result, 2025

When apply pesticides proper and safety must be considered. Those safety practices were change clothes and wash your hands immediately after applying pesticides. Before applying a pesticide (indoors or outdoors), remove children, toys and pets from the area and keep them away until the pesticide has dried or as recommended by the label. Remove or cover food during indoor applications. The sample farmers in the study area does not care for their safety while apply pesticides to vegetables. The majority 55.83% wearing normal clothes during spray pesticide chemicals. Some farmers even spraying with bare feet, but bath after application.

Table 20. Safety practices during pesticide application.

Safety practices during pesticide application	Frequency	Percent
Wearing normal clothes	67	55.83
spraying with bare feet	5	4.17
Using boots	4	3.33
Bath after application	23	19.17
Wearing normal clothes and spraying with bare feet	11	9.17
Wearing normal clothes and bath after application	1	0.83
using hat and bath after application	3	2.5
Using boots and bath after application	2	1.67
spraying with bare feet and bath after application	4	3.33
Total	120	100

Source: survey result, 2025

After pesticide application, empty containers pose a hazard if not managed correctly, potentially leading to environmental contamination or accidental poisoning if reused for food or water storage. Proper disposal methods, such as rinsing, crushing, and controlled incineration or recycling, are crucial. Even though empty containers such consequences the sample farmers not properly used. The majority 44.17% dump them by the field (throw away on field) followed by keep for domestic uses and collect to sell 20.83%. Only 2.5% collect and burn on farm.

Table 21. Fate of empty pesticide container.

Fate of empty pesticide container	Frequency	Percent
Throw into irrigation canals or rivers	5	4.17
Collect and bury in ground on farm	19	15.83
Collect and burn on farm	3	2.5
Collect and sell them	15	12.5
Dump them by the field (throw away on field)	53	44.17
Keep for domestic uses and collect to sell	25	20.83
Total	120	100

Source: survey result, 2025

3.8. Factors Affecting the Adoption Decision and Intensity of Adoption of Safety Practices

The model chi-square test indicated that the overall goodness-of-fit of the Tobit model was statistically significant at 1%

probability level which indicates the usefulness of the model to explain the relationship between the dependent and at least one independent variable. The result of Tobit model estimation indicated adoption decision and level of adoption pesticide safety practices in the study area is significantly influenced by experience in pesticide application, knowledge of about pesticide risk, availability of PPE at market, distance residence to pesticide drug shop, frequency of extension contacts and training related to chemical application (Table 22).

Table 22. *Factors affecting adoption decision and level of adoption of pesticide safety practices.*

Variables	Coefficient	Robust Std. Err.	t	P>|t|	Marginal effect
Age of household head	-0.012	0.009	-1.30	0.195	-0.012
Education Level	0.010	0.026	0.40	0.689	0.010
Total family size	-0.015	0.028	-0.52	0.601	-0.015
Experience pesticide application	0.066**	0.025	2.63	0.010	0.066
Knowledge of pesticide risk	0.527***	0.174	3.03	0.003	0.527
Availability of PPE at market	0.369**	0.159	2.32	0.022	0.369
Social participation	-0.045	0.150	-0.30	0.765	-0.045
Distance to Pesticide drug shop km	-0.335***	0.081	-4.13	0.000	-0.335
Access to credit services	-0.02	0.16	-0.10	0.921	-0.02
Extension frequency	0.051*	0.03	1.70	0.091	0.051
Access to market information	0.04	0.27	0.14	0.890	0.04
Training provision	0.46***	0.16	2.85	0.005	0.46
Non/and off-farm activities	0. 14	0.140	0.99	0.323	0. 14
Constant	0.55	0.68	0.80	0.425	

***, **, *: implies statistical significance 1%, 5% and 10% levels, Log pseudo likelihood = -54.156442, Pseudo R^2= 0.5213, F (13, 107) = 12.45, Prob >= 0.0000, Limits: lower = 0 upper = +inf, N =120, Source: model result, 2025.

Experience in pesticide application: Experience of the household head in had positive relationship with adoption decision and intensity of adoption pesticide safety application as prior expectation significantly at 5% significance level. Experience of pesticide application increased by one year increase adoption decision and intensity of adoption pesticide safety practices by 6.6% keeping all other factors constant. This implies that farmers who have adequate farm experience are more likely to adopt chemical application safety practices and are aware of pesticides than less experienced farmers. The result is in line with the findings of [10].

Knowledge of pesticide risk: Knowledge about pesticide risk had a positive relationship with adoption decision and intensity of adoption pesticide safety application as prior expectation significantly at 1% significance level. Knowledge about pesticide risk increases adoption decision and intensity of adoption pesticide safety practices by 52.7% keeping all other factors constant. The results suggest that farmers who understand the dangers of pesticide exposure being more likely to adopt protective measures. The result in line with the findings of [14].

Availability of PPE at market: Availability of PPE at local market had positive relationship with adoption decision and intensity of adoption safety application as prior expectation significantly at 5% significance level. Availability of PPE at local market increase adoption decision and intensity of adoption pesticide safety practices by 36.9% keeping all other factors constant. The results suggest that when PPE is readily accessible, farmers are more likely to use it, leading to reduced pesticide exposure and improved safety. The result in line with the findings of [6].

Distance residence to pesticide drug shop: Distance residence from pesticide drug shop had negative relationship with adoption decision and intensity of adoption pesticide safety application as prior expectation significantly at 1% significance level. Distance residence from pesticide drug shops increase in one kilometer decreases adoption decision and intensity of adoption pesticide safety practices by 33.5% keeping all other factors constant. This may be due to increased distance may lead to reduced access to information, resources, and training related to safe pesticide handling and use, potentially leading to less adherence to safety protocols.

The result in line with the findings of [6].

Frequency of extension contact: Frequency of extension contact had positive relationship with adoption decision and intensity of adoption pesticide safety application as prior expectation significantly at 10% significance level. Frequency of extension contact increase by unit increase adoption decision and intensity of adoption pesticide safety practices by 5.1% keeping all other factors constant. This result indicated that the frequency of agricultural extension workers with farmers have potential force, which accelerates the effective dissemination of adequate information to the farmers, thereby enhancing farmers' adoption of pesticide safety practices. The result in line with the findings of [4].

Provision of training related to chemical application: Provision of training had a positive relationship with adoption decision and intensity of adoption safety application as prior expectation significantly at 1% significance level. Provision of training related to pesticide applications increases adoption decision and intensity of adoption pesticide safety practices by 46% keeping all other factors constant. This result suggested that knowledge and understanding of safe handling practices are crucial for preventing health risks and promoting responsible use. The result is in line with the findings of [20].

4. Conclusions and Recommendations

4.1. Conclusions

Pesticides were applied to vegetables in the study area. Most respondents, 78.33%, used fungicides and insecticides, while herbicides were rarely used. Pesticide use shows an increasing trend, with 99.17% of respondents indicating an increasing trend in pesticide utilization in the last five years. The low efficacy of pesticides and the high incidence of diseases/pests were the highest reasons, at 27.5%, followed by a high incidence of diseases/pests (22.5%) due to climate change, for why pesticide utilization showed an increasing trend. The sources of pesticide chemicals during vegetable production were private pesticide drug stores, from which 98.33% of respondents bought them. The majority, about 63.33% of respondents, do not adopt pesticide safety practices, while 36.67% do. The sample farmers in the study area do not care for their safety while applying pesticides to vegetables. The majority, 55.83% of respondents, wear normal clothes while spraying pesticide chemicals. Even though empty containers have such consequences, the sample farmers do not properly dispose of them; only 2.5% collect and burn them on the farm. The majority, 44.17%, dump empty pesticide containers in the field (throw them away in the field), followed by 20.83% who keep them for domestic use and collect them to sell.

Even though the pesticide application frequency is not exactly known and is based on disease occurrence, the application frequency is not appropriate and is not based on scientific evidence. The average frequency of application on tomatoes was higher than on other vegetables, at 16.15 times on average, ranging from 10 to 20 times. The pesticide application frequency for onions was second to tomatoes, at an average of 7.65 times, ranging from 2 to 15 times.

The model results indicated that the adoption decision and level of adoption of pesticide safety practices in the study area are significantly influenced by experience in pesticide application, knowledge of pesticide risk, availability of PPE in the market, distance of residence to the pesticide drug shop, frequency of extension contact, and provision of training related to chemical application.

4.2. Recommendations

Based on the findings of this study, the following recommendations are made:

1) *Experience in pesticide application influences the adoption decision and level of pesticide application safety practices.* Therefore, farmers should exchange experiences on pesticide application safety practices with each other.
2) *Knowledge of pesticide risk influences the adoption decision and the level of pesticide application safety practices.* Agricultural Research centers and Agricultural offices should jointly provide practical training on the long-term effects of pesticides on human health and the environment.
3) *The availability of PPE in the market influences the adoption decision and level of pesticide application safety practices.* Different textile industries should supply personal protective equipment based on climate conditions and at fair prices.
4) *The frequency of extension contacts influences the adoption decision and level of pesticide application safety practices.* Therefore, development agents should create wide awareness about the effects of pesticides when they have contact with farmers, as they already focus on production and input utilization.
5) *Finally, the provision of training related to chemical applications also influences the adoption decision and level of pesticide application safety practices.* Governments and other responsible bodies should focus on the expansion of chemical safety practice training, and the regulations related to pesticide application should also be better applied to improve the adoption decision and level of pesticide application safety practices in the study area.

Abbreviations

TLU	Tropical Livestock Unit
ATARC	Adami Tulu Agricultural Research Center
CSA	Central Statistical Authority
PPE	Personal Protective Equipment
FTC	Farmers Training Center

PHI Pre-Harvest Interval

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Conflicts of Interest

The authors declare no conflicts of interest.

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