Knowledge, Attitude, and Practice of Farmers on Pesticide Use and Their Impacts on the Environment and Human Health From Small Scale Vegetable Farming Along the Littoral of Lake Ziway, Ethiopia

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Abstract

Background: The insecure utilization and misapplication of pesticides in Ethiopia are major fears to farmers' wellbeing and the ecosystem. This study aimed to assess the level of knowledge, attitude, and practices of the [small](#)-scale vegetable farmers towards the use of pesticides in Ethiopia along the littoral of Lake Ziway.

Methods: It was a cross-sectional study involving a total of 210 farmers randomly selected during pesticide application from a purposively selected irrigation-using village located in the immediate vicinity of Lake Ziway. Data were generated through structured in-depth interviews and observations on-farms. A chi-square test was applied to evaluate whether the collected data and their probable association were significant.

Results: The results show that WHO class II pesticides (moderately toxic) are the most frequently used pesticides in the study area. The use of WHO classes 1a and 1b and banned or restricted pesticides such as DDT and Endosulfan were not reported. A great portion (92%) of farmers indiscriminately disposed of empty containers in the field while 86.7% apply the leftover pesticides to other crops. More than 90% of small-scale farmers did not use any personal protective equipment (PPE) when handling pesticides. About 95% of farmers had poor knowledge regarding pesticides. A significant association ($p < 0.001$) was observed between the knowledge of the farmers and their practices related to the pesticide.

Conclusion: Generally, the Knowledge of small-scale farmers on pesticides was poor. Moreover inappropriate disposal of pesticides and its container will damage the environment. The finding of the study underlines the need to train farmers concerning the safe and proper use of pesticides to prevent health and environmental hazards.

1. Introduction

Pesticides are essential chemicals that are used to protect against crop damage and advance agricultural output. However negative effects of pesticide use in vegetable cultivations have been reported throughout the universe [1]. A great majority of pesticides are utilized for pest and vector control in farming areas, but many farming societies around Lake Ziway Ethiopia are not adequately abreast of concerning the hazards related to the pesticide [2]. Consequently, farmers use pesticides without knowledge of their impact on human well-being and the environment. Even though many vegetable farms along the Lake Ziway shore depend on irrigation [3], their closeness to water bodies could make the use of pesticides problematic. Pesticide use in vegetable growth negatively affects both the surrounding environment and human health and farmers' productivity[2]. Numerous studies in Africa have shown that misuse and improper handling of pesticides and poor knowledge of pesticides among farmers in genera [4, 5, 6, 7]. This innocent of pesticide management could be severe damage to the well-being of society and may produce ecological issues.

Fortifying environmental protection and sustainability of pesticide supply and use is commonly seen as a fundamental challenge for pesticide administration[8]. Likewise, the recent use of pesticides and their poor management in Ethiopia increasing due to the fast growth of large-scale farm companies[9, 10]. Currently, Ethiopia is the 2nd largest flower exporting country in Africa showing that the sector is rapidly growing. Regardless of the huge economic advantages, the state of flower production has made the sector susceptible to criticism about its working conditions and environmental impact [9, 10, 11]. Besides because of the rapid growth of agricultural activities in the watershed of Lake Ziway it is currently exposed to various anthropogenic burdens [3, 12]. The expansion of these agricultural activities around the Lake caused a growth in the intensive and unplanned uses of pesticides and fertilizers and therefore added to the increasing degradation of the lake's water quality [9]. This misuse of pesticides also has undesirable effects on human wellbeing. They can be severely shown as headache, rashes, disorientation, shock, nausea, vomiting, respiratory failure, and even death. Since there are no formerly available studies on the investigation of the level of knowledge, the practice of pesticide use, and their association, among small-scale farmers near Lake Ziway in Ethiopia, this study was carried out. Therefore to assess some of these problems this study investigates how pesticides are utilized in practice in small-scale vegetable farm fields along the littoral zone of Lake Ziway and how these uses impact the well-being of vegetable farmers and the environment. In specific, this study focused on the Lake adjacent to the vegetable growing areas that are used intensively for food production, showing the possibility that biological effects due to pesticide use may exist.

2. Material And Methods

2.1 Study area.

The study was designed purposely along the littoral of Lake Ziway located in the Rift Valley Region in Ethiopia. It is the region of a major vegetable growing area. Tomato, cabbage, and onion production is the major business utilizing the dominant cultivated land of the area. The farm activities have considerably transformed the area operationally and economically. Water from Lake Ziway has been of countless importance in farming vegetables (Tomato onion, cabbage, etc.) in the region. Due to the current growing production of different kinds of vegetable crops, small-scale farmer's expected the intensive use of fertilizers and pesticides. Vegetables produced in this cultivated framework are for export purposes and neighborhood utilization basically within Addis Ababa (the capital city of Ethiopia) [8].

Site selection was based on the representation the most small-scale farmers use their land for vegetable cultivation by irrigation whereas the farms are located in the vicinity of Lake Ziway. Village leaders and agricultural expertise were consulted when the study group was selected on the ground that they cultivate vegetables that require the use of pesticides. Before the start of the interview oral informed consent was pursued from the respondents. Respondents knew their right to decline involvement and to resign participation from the study at any time. The privacy of the sampled data was also guaranteed. The instrument used was a structured and semi-structured questionnaire that was established according to

the WHO field survey of exposure to pesticides code of behavior (WHO, 1982) and from similar published studies [2].

2.2 Sampling procedures.

A total of 210 randomly selected small-scale farmers were interviewed from purposively selected vegetable growing villages located along the littoral of Lake Ziway. Respondents were household members who grow vegetable crops. The sample size was according to Leslie [13]. formula and uniformly designated from irrigation using villages. Primary sample gathering was done by fieldwork for all three observed studies. Farmers' interviews, key informant interviews, and field observations were performed. This mixed-method approach aids triangulation and increases the rationality and dependability of the results [14]. Face-to-face interviews were piloted to collect samples from farmers. The questionnaire was prepared in English and directed in Amharic and local languages (Oromifa) by the researcher and field assistants (under the command of the researcher). The sample size was obtained using the formula:-

$$n = \frac{\frac{Z^2 * P(100 - p)}{e^2}}{1 + (\frac{Z^2 * P(1 - P)}{e^2 N})}$$

Where: n = required sample size

z = 1.96 for 95% confidence level

p = percentage selecting a choice

e = the percentage maximum error required (margin of error)

N = population size (930)

The questionnaire was aimed to collect data under the following categories

1. General information: this was adapted to take data on farmers' biography such as sex, age, and land hold magnitude, level of education, Vegetable grew experience, trend pesticide use past 5 years, and land tenure situation.
2. The 2nd part consisted of eight questions to evaluate the knowledge of small-scale farmers about pesticides. The answers were documented as 'yes', 'no' or 'don't know'. For every 'correct' answer, a mark of '+1' was given. For the 'wrong' answer, a mark of '-1' and for 'don't know', a mark of '0' was agreed. A tally of four or more was reflected pretty much as good knowledge and fewer than four as poor knowledge [15].
3. Pesticide use and practices: this part was wont to get information on the kinds of pesticides used, source of pesticides used, ability to read the information available on the pesticide label, pesticide

use practices such as the method of mixing, rates, and amounts of pesticides sprayed, personal protective equipment, disposal of pesticide cans and application methods [2].

4. Social and ecological effect: This part was used to get data about the negative effect of pesticides exposure, for example, the symptoms of illness frequently faced pre or post pesticide spraying procedures and altering trends in biodiversity, e.g. changes in pests, birds, and insects (whether increasing, decreasing or constant). For the social health problems, we deliberated intense side effects (symptoms) that showed up inside forty-eight hours of pesticide sprays. Long-term and chronic well-being disabilities were not taken due to methodological problems.

Data regarding training and support to farmers were obtained by interviewed either retailers or agriculture extension workers. 10 retailers, 5 government extension workers, and 4 plant protection workers were interviewed to collect additional information. We conducted extra interviews with environmental expertise. Photographs of crucial observations were incorporated as supportive data. Checklists were used as an aid during field observation. Photos were frequently taken of how farmers store, mix, and spray pesticides.

2.3 Statistical analysis

The data were prearranged and entered in the MS-Excel spreadsheet and then analyzed by using a statistical package SPSS version 20. A chi-square test was applied to evaluate whether the collected data and their probable association were significant or whether variables were related to each other. The results were showed in frequencies, and percentages for specific variables, and as mean $\pm$ SD for continuous variables. The significant levels were set at $P \leq 0.01$ and $P \leq 0.05$.

3. Results

3.1 Demographic characteristics and profile of the farmers

The demographic characteristics of small-scale farmers are shown in Table 1S. More than 98% of small-scale farmers interviewed in the study were men, as farm accomplishments mainly those related to pesticide spray are done by men in the study area. The age of half of the small-scale vegetable farmers (50.5%) was ranged between 31 and 54 years old, with a mean of 35.2 years. Nearly 8% of the farmers were 55 years and beyond. A substantial number of the farmers (41.4%) were illiterate, while 51.4% had joined the elementary school (grade1-8), and few (5.7%) farmers had completed secondary school, while the remaining (1%) had completed college/university education. 45.7% of farmers had five to ten years of farming experience, while 41.9% had greater than ten years of farming experience. The respondents were typically smallholders with farm sizes ranged from less than one hectare to over ten hectares with an average of 1 ha. Nearly 60% of the farmers had land possessions less than 1.1 ha and 40% of the frames had above 1.0 ha. The land used by 61.9% of the small-scale farmers was rented from local farmers for 3 to 5-year contracts. 81.9% of the farmers stated an increasing trend in pesticide use during the past five years, while 18% reflected the situation as constant and no one stated that pesticide use is decreasing.

3.2 Types of pesticides used by small scale vegetable farmers

Results indicate that a wide range of pesticides is used by small-scale farmers along the littoral Lake Ziway. In the study area, a total of 28 pesticides (active ingredients) were reported. These pesticides are shown based on the WHO classification, and chemical class in Table 1. The great majority of the pesticides (90%) used belonged to the WHO toxicity class II (moderately hazardous), followed by Class-U (unlikely to present acute hazard in normal use and class III (slightly hazardous). Extremely hazardous (Ia) or highly hazardous (Ib) was not reported by any of the farmers. WHO Class II pesticides mainly metalaxyl (98%), profenofos (98%), dimethoate (95%), cypermethrin (93%), lambda-cyhalothrin (72%), and imidacloprid (52%) were reported by small-scale farmers. Among Class-U pesticides, Mancozeb (100%) was the most reported pesticide. Herbicides like propanil and 2, 4-D are in utilize but not exceptionally common. The Majority of the farmers along the littoral of Lake Ziway used insecticides and fungicides on vegetables (Table 1). Insecticides and fungicides were utilized by 98% and 90% of the farmers respectively while herbicides were used by only 3.8% of the farmers. In general, limited herbicide use was reported by small-scale farmers.

Table 1

Types of pesticides (fungicides) used by small-scale vegetable farmers near lake Ziway, Ethiopia

Trade Name	Active ingredient(s) and concentration	Chemical Class	Reported use(N)	Reported use (%)	WHO toxicity class
Fungicides					
Agrolaxyl M2-63.5 wp	Metalaxyl – Mancozeb	Dithiocarbamate	206	98.1	Unk
Bayleton 25 WP	Triadimegon 250 g/kg		82	39.0	II
Cerozeb 80WP	Mancozeb 800 g/kg	Dithiocarbamate	210	100.0	II
Cropaxyl Gold72 WP	Metalaxyl 80 g/kg + Mancozeb 640 g/kg	Phenyl amide + Dithiocarbamate	206	98.1	Unk
Cropzeb 80 WP	Mancozeb wp 800 g/kg	Dithiocarbamate	210	100.0	II
Cruzate R	Cymoxanil + Copper oxychloride		96	45.7	Unk
Ethiozeb	Mancozeb 80% wp	Dithiocarbamate	210	100.0	U
Fungozeb	Mancozeb 80% wp	Dithiocarbamate	96	45.7	U
Indofil M-45	Mancozeb 80% wp	Dithiocarbamate	210	100.0	U
Indom	Mancozeb 80% wp	Dithiocarbamate	196	93.3	U
Kocide 101	Copper hydroxide	oxime + inorganic	79	37.6	II
Mancolaxyl 72 WP	Mancozeb 80% + metalaxyl 64%	Dithiocarbamate+	201	95.7	Unk
Mancolxyl 72%WP	Metalaxyl 85 + Mancozeb 64%	Dithiocarbamate	210	100.0	II
Masco_ 8–64	Mancozeb 64%WP	Dithiocarbamate	96	45.7	II
Matco 8–64	Metalaxyl 8% + Mancozeb 64%WP	Dithiocarbamate	205	97.6	II
Natura 250 EW	Tebuconazole		56	26.7	II
Nimrod 25 EC	Buprimate		72	34.3	II
Perfecto175 SC	Imidacloprid 12.5% + Lambada Cyhalothrin 5%	Neonicotinoid + Pyrethroid	69	32.9	Unk

Trade Name	Active ingredient(s) and concentration	Chemical Class	Reported use(N)	Reported use (%)	WHO toxicity class
Revus 250SC	Mandipropamid	Triazole Fungicide	76	36.2	II
Ridomil 68WG	Metalaxyl-M 68%WG	Phenyl amide	207	98.6	II
Sabozeb 80%WP	Mancozeb 800 g/kg	Dithiocarbamate	201	95.7	II
Tilt@250	Propiconazole	Triazole fungicides	96	45.7	II
Unizeb	Mancozeb 80% wp	Dithiocarbamate	206	98.1	II
Victory 72 WP	Metalaxyl + Mancozeb 64%	Phenyl amide + Dithiocarbamate	203	96.7	unk

Toxicity class as classified by the World Health Organization (2004) where Ia, extremely hazardous; Ib, Highly hazardous; II, moderately hazardous; III, slightly hazardous; U, unlikely to present acute hazard in normal use; unk, unknown

Table 1
continued: Types of pesticides (insecticides) used by small-scale vegetable farmers near lake Ziway, Ethiopia

Trade Name	Active ingredient(s) and concentration	Chemical Class	Reported use(N)	Reported use (%)	WHO toxicity class
Agro-Thoate40%EC	Dimethoate 40%EC	Organophosphate	203	96.7	II
Aim 10%EC	Alpha-cypermethrin100g/l	Pyrethroid	196	93.3	II
Con-Findence	Imidacloprid 35%W/V	Neonicotinoid	109	51.9	II
Coragen 200 SC	Chlorantraniliprole	Anthranilic diamide	96	45.7	III
Decis 2.5%EC	Deltamethrin	Pyrethroid	153	72.9	II
Dimeto40%EC	Dimethoate	Organophosphate	156	74.3	II
Dursban 48%EC	Chlorpyrifos-ethyl	Organophosphate	96	45.7	II
Ethiodemethrin2.5EC	Deltamethrin 25 g/l	Pyrethroid	125	59.5	II
Ethiolathion 50EC	Malathion	Organophosphate	93	44.3	II
Ethiothoate 40%EC	Dimethoate	Organophosphate	165	78.6	II
Ethiozinon 60EC	Diazinon	Organophosphate	97	46.2	II
Farrate	Lambda-cyhalothrin 5%	Pyrethroid	203	96.7	II
Globe 72% EC	Profenofos 720 ml/l	Organophosphate	201	95.7	II
Hanclopa 48% EC	Chlorpyrifos	Organophosphate	56	26.7	II
Helerat 50EC	Lambda-cyhalothrin	Pyrethroid	197	93.8	II
Karate 2.5% EC	Lambda-cyhalothrin 25 ml/L	Pyrethroid	197	93.8	II
Karate 5% EC	Lambda-cyhalothrin 50 ml/l	Pyrethroid	197	93.8	II
Lamdex 5% EC	Lambda-cyhalothrin	Pyrethroid	96	45.7	II
Perfecto@175SC	Imidacloprid 12.5% + Lambda Cychalothrin5%	Neonicotinoid + Pyrethroid	186	88.6	Unk
Polytrin_KA315EC	Profenofos 300 g/l + Lambda-cyhalothrin 15 g/l	Organophosphate	138	65.7	Unk

Trade Name	Active ingredient(s) and concentration	Chemical Class	Reported use(N)	Reported use (%)	WHO toxicity class
Profit 72 EC	Profenofos 72% EC	Organophosphate	205	97.6	II
Pyrinex 48%EC	Chlorpyrifos-ethyl	Organophosphate	82	39.0	II
Radiant 120SC	Spinetoram	Spinosyn	54	25.7	II
Roger	Dimethoate 40% EC	Organophosphate	167	79.5	II
Selecron 720%EC	Profenofos "Q" 720 g/l	Organophosphate	203	96.7	II
Tracer 480SC	Spinosad	Spinosyn	67	31.9	II
Tutan 36%SC	Chlorfenapyr 360 g/l	Organophosphate	68	32.4	II
Hanclopa 48% EC	Chlorpyrifos	Organophosphate	53	25.2	II
Herbicides					
Herbax	Propanil 360 g/L	Acetanilide	3	1.4	III
Aura 72 SL	2,4-D 720 g/l	Chlorophenoxy	5	2.4	II

Toxicity class as classified by the World Health Organization (2004) where Ia, extremely hazardous; Ib, Highly hazardous; II, moderately hazardous; III, slightly hazardous; U, unlikely to present acute hazard in normal use; unk, unknown

3.3 Knowledge and attitudes towards pesticides among small scale farmers

The small- scale farmers' level of knowledge of pesticides, comprising routes of exposure, impact on the ecology, and human wellbeing, and their consciousness of pesticide policy and code of practice was summarized (Table 2S). Only 4.2% of small scale farmers did get training on the proper use and safe handling of pesticides. However, 94% of the farmers had not got any training. Likewise, 69% of the farmers did not read and obey directions on pesticide labels. The vast majority of the farms (95%) did not aware of the toxicity color codes present on the pesticide containers.

In the present study, the most frequent routes of exposure to pesticides reported by farmers were dermal (17%), inhalation (50%), and oral (46%). About 17% of the farmers reported a lack of knowledge of any route of exposure to pesticides. The vast majority of the small-scale farmers (92.4%) are not aware that some pesticides have been banned or are restricted for use. Merely 7.6% of the respondents knew the names of some of the pesticides that are prohibited or limited for use. Of the farmers who are conscious that some pesticides have been prohibited or limited for use reported that 56% of framers stated the high toxicity of the pesticides, 19% farmers described as not effective, 13% stated because they are expensive, and other 13% mentioned don't know as main reasons for the prohibition or limit use. Overall, solely 10

farmers have good knowledge, and the rest 200 had poor knowledge. Significant association ($\chi^2 = 77.82$, $p < 0.01$) was observed between good knowledge and level of education (Table 2).

3.4 Sources of pesticides and pesticide information

Table 2 shows the association between knowledge and farmers' sources of information concerning pest control and pesticide spray technique. 46% of small-scale farmers get relevant information source regarding pest control and how to apply pesticides is oral communication with other farmers followed by previous long years experience (34%). About 4.3% of the farmers stated that they had learned the information on pest control and pesticide application from government extension services. There was a significant association between the source of information for the proper use of pesticides and the knowledge of the farmers (χ^2 , 23.48, $P < 0.001$).

Table 2

Association between knowledge of pesticide and educational level, age, farm experience, and source of pesticide, information sources for pesticide application, dose, and place where pesticide bought.

Variables	Good Knowledge(n = 10)	Poor Knowledge(200)	Total (n = 210)	χ ² value & p value	
Educational level					
Illiterate	0	86(43%)	86(40.9%)	77.82 < 0.001	
1–8	3(30%)	106(53%)	109(51.9)		
9–12	5(50%)	8(4%)	13(6.2%)		
University/ Collage	2(20%)	0	2(1%)		
Age group(years)					2.01
18–30	3(30%)	83(41.5)	86(40.9%)	0.368	
31–54	7(70%)	99(49.5)	106(50.5%)		
>55	0	18(9%)	18(8.6%)		
Farm experience (years)					0.79
1–3	2(20%)	25(12.5%)	27(12.9%)	> 0.05	
5–10	5(50%)	91(45.5%)	96(45.7%)		
>10	3(30%)	84(42%)	87(41.4%)		
Farmers who received information about the choice of a pesticide to buy or apply					
Agrochemical retailers	28(14%)	7(70%)	35(17%)	23.484 < 0.001	
Other farmers	95(47.5%)	2(20%)	97(46%)		
Previous experience	68(34%)	0(0%)	68(34%)		
Agriculture extension officers	8(4.5%)	1(10%)	9(4.3%)		
Farmers who received information about pesticide doses					
Agrochemical retailers	85(42.5%)	1(10%)	86(41%)	26.21 < 0.001	
Other farmers	64(32%)	0	64(30.5%)		
Previous experience/can read from the container	40(20%)	9(90%)	49(23.3%)		

Variables	Good Knowledge(n = 10)	Poor Knowledge(200)	Total (n = 210)	χ^2 value & p value
Agriculture extension officers	6(3%)	0	6(3%)	
Agriculture extension officers + retailers	5(2.5%)	0	5(2.5%)	
Place where pesticides were bought				
Agrochemical retailers	94(47%)	9(90%)	103(49%)	7.89
General household shops	20(10%)	1(10%)	21(10%)	0.019
Other farmers	86(43%)	0	86(41%)	

Regarding the doses of pesticides to use, irrespective of category small-scale farmers relied mostly on agrochemical retailers (41%), followed by other farmers (30.5%). The majority of the farmers with good knowledge (90%) reported that read the instruction from the containers and used their previous experience. There was a significant association between the source of information for the dose of pesticide to apply and knowledge of the small scale farmers ($\chi^2 = 26.21$, $P < 0.001$). When inquired where they purchased pesticides, nearly half of respondents (49%) said they bought pesticides from agrochemical retailers' stores which is the principal source of pesticides in the study area, followed by other farmers (41%). Few farmers (10%) were purchased pesticides from general household shops. The majority of farmers with good knowledge (90%) bought pesticides from agricultural chemical retailers. There was a significant association between the source of pesticide from which the pesticides were bought and the knowledge of the farmers (χ^2 , 7.89, $P = 0.019$) (Table 2). The general household's shops did regularly repackaged products, without labeling the container. According to the key informant (agricultural extension workers) reported that informal traders decanted pesticides into empty plastic bottles (highland water bottles) or scraps of plastic, without labeling.

3.5 Pesticide use practices among small-scale farmers

All of the interviewed small-scale farmers (210, 100%) used pesticides on their farms. Whereas none of the vegetable farmers reported using biological methods or other such integrated pest management (IPM). Small-scale farmers in the study area did not use biological methods and safe pesticides as the case in some low-income countries. Besides they depend on the experience of other farmers to identify how active a pesticide is. Nearly 86.6% of respondents reported not eating and 57.7% reported not drinking when blending or spraying pesticides (Table 3). Besides, 93.8% of farmers stated did not take a shower after mixing or spraying pesticides. Only 6.2% reported taking a shower sometimes after mixing or applying pesticides. Likewise, 64.7% of respondents stated that they did not take into account wind direction while spraying pesticides. A lever-operated knapsack sprayer was the only type of sprayer by small scale farmers. There was a significant association between farmers considering wind direction and

knowledge of pesticide($X^2 = 107.8$, $p < 0.001$). Many small scale farmers (40.5%) mixed directly in the sprayer (knapsack), but most farmers (59.5%) stated mix in a separate blue drum container before transferring it to knapsack sprayer. According to the key informant (agriculture extension workers) the mixing containers are reused by the farmers for other activities, such as holding fruit and vegetables from the farm and storing drinking water.

Table 3
Association between farmer's knowledge and pesticide use practices

Variable	Poor Knowledge	Good knowledge	Total (n=210)	χ^2 & P-value
Do You use a pesticide?				
Yes	200(100%)	10(100%)	210(100%)	
No	0	0		
Do You use biological pesticides or other such as IPM?				
Yes	0	0		
No	200(100%)	10(100%)	210(100%)	
Eating while mixing or spraying				
Always	0	0		1.615
Sometimes	28(14%)	0	28(13.3%)	0.204
Never	172(86%)	10(100%)	182(86.6%)	
Drinking while mixing or spraying				4.508
Always	0	0		0.034
Sometimes	88(44%)	1(10%)	89(42.3%)	
Never	112(56%)	9(90%)	121(57.7%)	
Use of inappropriate materials to quantify pesticide				
Yes	71(35.5%)	0	71(35.5%)	16.72
No	129(64%)	2(20%)	131(62.4%)	< 0.001
Sprayed with the wind direction				
Always	4(2%)	8(80%)	12(5.7%)	107.8
Sometimes	36(18%)	1(10%)	37(17.6%)	< 0.001
Never	160(80%)	1(10%)	161(76.7%)	
Showering immediately after mixing or spraying				
Always	0	0.0		20.668
Sometimes	9(4.5%)	4(40%)	13(6.2%))	< 0.001

Never	191(95%)	6(60%)	197(93.8%)	
Peptides formulation trends of farmers		0.0		
In the farm	116(58%)	5(5%)	121(57.6%)	0.324
Near water /community water sources	63(31.5%)	4(40%)	67(31.9%)	0.851
At home	21(10.5%)	1(10%)	22(10.5%)	
Devices used for mixing pesticides				
Knapsacks	84(42%)	1(10%)	85(40.5%)	4.048
Blue containers (drum)	116(58%)	9(90%)	125(59.5%)	0.044
How farmers mix pesticides?				
With a stick, but bare hands	182(91%)	7(70%)	189(90%)	34.907
With bare hands	16(8%)	0	16(7.6%)	< 0.001
With hands and wearing gloves	2(1%)	3(30%)	5(2.4%)	
Frequency of pesticide application				
3–5 times per season	17(8.5%)	8(80%)	25(11.9%)	47.060
7–10 times per season	64(32%)	0	64(30.5%)	< 0.001
12–15 times per season	95(47.5%)	1(10%)	96(45.7%)	
More than 15 times	24(12%)		26(12.4%)	

More than half of the interviewed farmers mixed their pesticides in their farm (57.6%) and 31.9% of the farmers mix near water as it was adjacent to their water source (Lake Ziway). The remaining 10.5% formulate at their home. No significant association was observed between pesticide formulation trends and knowledge of farmers ($P > 0.05$). Farmers frequently using an elongated stick and naked hands without a glove (90%) and with bare hands only (7.6%) to mix pesticides (Fig. 1S). Only 2.4% of farmers wear gloves when mixing. Farmers with good knowledge wear gloves while mixing pesticides compared to farmers with poor knowledge ($\chi^2 = 34.4$, $P < 0.001$). While farmers have no records of the amount of pesticides sprayed, they mentioned that their application rate wide-ranging, depending on weather conditions and crop types. 45.7% of vegetable farmers mix pesticides and spray 12 to 15 times per season 30.5% 5 to 10 times per season, 11.9% 3 to 5 times per season, and 12.4% of farmers reported that they spray more than 15 times pre-season (Table 3). About 12.4% of farmers sprayed fungicides up to 20 times and insecticides up to 16 times per harvesting season. There was a significant association between spraying frequency and knowledge of pesticide ($\chi^2 = 47.06$, $p < 0.001$).

3.6 Farmers' reports of pesticide poisoning symptoms

The most commonly stated symptoms were headaches (74.3%), skin burning sensation (67.6%), itchy skin (58.6%), itchy eyes (89.5%), runny nose (41%), fatigue (37%), and coughing (31.4%). Further farmers reported symptoms such as fatigue (37.1%), nausea (26.7%) poor vision (26.2%), stomach ache (21.4%), excessive sweating (12.4%), skin redness (10%) Vomiting (10%), and sore throat (12.4%). Regarding the action they took following a happening of poisoning, 75% of farmers stated did not take any action as the case was insignificant or required only self-treatment (Fig. 1).

3.7 Use of personal protective equipment as reported by farmers

Almost all of the small-scale farmers in the study area did not use personal protective equipment (PPE) when mixing or spraying pesticides. There was a significant association between the use of protective equipment and the knowledge of the farmers ($P < 0.001$) (Table 4). Almost 45% of farmers reported that the explanations for not using PPE were lack of accessibility when wanted, and 64.3% of respondents stated that PPE is not comfortable because of the local hot and humid climate. About 39.5% of farmers reported that the price is expensive and the other 43.8% mentioned slowing you down. The majority of farmers stated not wearing a face mask (94.3%), eye goggles (94.3%), gloves (93.3%), or boots (68.6%) at all. Farmers with high education levels were more probable to use PPE compared with farmers with low levels of education ($p < 0.05$). 92.4% of farmers wore their regular clothes during pesticide application, whereas few (7.1%) wore poor long-sleeved shirts and trousers that did not cover most parts of the body. At the time of our field visit, all of the farmers did not use PPE (gloves, glasses, masks, or goggles) (Fig. 1S and Fig. 3S).

Table 4
Use of protective clothing during pesticide application small scale vegetable farmers

Variables	Poor Knowledge	Good knowledge	Total (n = 210)	X ² & P-value
Glove				
Yes	8(4%)	6(60%)	14(6.7%)	48.00
No	192(96%)	4(40%)	196(93.3%)	< 0.001
Boot				
Yes	57(28.5%)	9(90%)	66(31.4%)	16.714
No	143(71.5%)	1(10%)	144(68.6%)	< 0.001
Face and nose mask				
Yes	5(2.5%)	7(70%)	12(5.7%)	80.54
No	195(97.5)	3(30%)	198(94.3%)	< 0.001
Long-sleeved shirt and trousers				
Yes	8(4%)	7(70%)	15(7.1%)	62.55
No	192(96%)	3(30%)	195(92.3%)	< 0.001
Eyeglasses/Goggle				
Yes	5(2.5%)	7(70%)	12(5.7%)	80.54
No	195(97.5)	3(30%)	198(94.3%)	< 0.001
Wearing normal clothes				
Yes	192(96%)	2(20%)	194(92.4%)	78.15
No	8(4%)	8(80%)	16(7.6%)	< 0.001
Reason for not using PPE(multiple answers possible)				
lack of availability when needed	96(45.7%)			
Too expensive	83(39.5%)			

Variables	Poor Knowledge	Good knowledge	Total (n = 210)	X2 & P-value
PPE being uncomfortable in the local hot and humid climate	135(64.3%)			
Slowing you down	92(43.8%)			

3.8 Pesticide storage, container disposal, and sprayer washing

Table 5 shows farmers' practice on the storage and disposal of pesticides. The study revealed that small-scale farmers store pesticide containers in the open shed just for pesticides, in animal houses, under the bed, on roofs, in the kitchen, and in toilets. Few farmers (5.7%) reported that they did not store pesticides. 80% of farmers with good knowledge directly used the pesticide after buying it (do not store it). However only 2.1% of farmers with poor knowledge of farmers directly using without storing. Farmers with good knowledge said that they buy their pesticide the same day they anticipate to utilize it. A significant number of the respondents (29.5%) kept their pesticides under the bed, on the roof (23.3%), in the kitchen (8.6%), toilet (9.5%)(Fig. 2S). Only 6.2% of farmers store open shed just for pesticides as suggested by the Ministry of Agriculture. In addition to storing pesticides, the stores were utilized for storing food, firewood, farming materials, and kitchen utensils which seem to lead to unintentional poisoning. Farmers with good pesticide knowledge significantly less probable to store pesticides in their homes ($X^2 = 109.6$, $p < 0.001$).

The majority of farmers spray the leftover solutions to another crop listed on the product label (86%) and 7% of small-scale farmers dispose of them in the field. Few farmers (3%) reported that they mix only requires the number of pesticides. A very few farmers stated that they release the leftover pesticides close to irrigation canals and drains (1%). The vast majority (92%) of the small-scale framers conveyed that they left the empty containers on the farm and 3% of farmers throw them near and into irrigation canals and the lake. No significant association was observed between dumping empty containers by farmers and knowledge of pesticides ($X^2 = 0.92$, $P > 0.05$ of). only 1.9% of farmers stated that they collect empty containers and bury them on the farm and about 1.5% of farmers collect empty containers for selling while 1.9% of respondents keep the empty containers for domestic uses. The majority of the farmers indicated that they endure using leftover pesticides for spraying (92%), whereas only 1% said that they burn leftover pesticides in their original containers. A small number of respondents claimed that they buy only the amount of pesticides they need (3.5%). Significant association ($X^2 = 67.69$, $p < 0.001$) was observed between knowledge of pesticide and leftover pesticide handling of small scale farmers (Table 5).

Table 5
Farmers' practices on storage and disposal of pesticides (n = 210).

Variable	Poor Knowledge	Good knowledge	Total (n = 210)	χ ² & P-value
Where do you store pesticides?				
Open shed just for pesticides	9(4.5%)	1(10%)	10(4.8%)	109.66 ≤ 0.001
Toilet	20(10%)	0	20(9.5%)	
In the open field	13(6.5%)	0	13(6.2%)	
Roof	49(24.5%)	0	49(23.3%)	
Under the bade	61(30.5%)	1(10%)	62(29.5%)	
Kitchen	18(9%)	0	18(8.6%)	67.76 ≤ 0.001
Animal house	26(13%)	0	26(12.4%)	
Did not store pesticide	4(2%)	8(80%)	12(5.7%)	
What do you do with the unused leftover pesticides?				
Dispose of in the field	14(7%)	0	14(6.7%)	
Mix only needed pesticides	6(3%)	6(60)	12(5.7%)	67.69 ≤ 0.001
Apply on other crops	179(89.5)	3(30%)	182(86.7%)	
Dispose of in the sewer	1(0.5%)	1(10%)	2(1%)	
What do you do with leftover pesticide stocks?				
Continue to use pesticide for spray	191(95.5)	3(30%)	194(92.4%)	
Buy the only amount needed	7(3.5%)	7(70%)	14(6.7%)	0.925
Burn old pesticides in their original containers	2(1%)	0	2(1%)	
What do you do with empty pesticide containers?				
Dump them by the field (throw away on the farm)	183(91.5%)	10(100%)	193(91.9%)	
Throw into irrigation canals or rivers	6(3%)	0	6(2.9%)	
Bury on-farm	4(2%)	0	4(1.9%)	

Variable	Poor Knowledge	Good knowledge	Total (n = 210)	0.921 X ² & P-value
Keep for domestic uses	4(2%)	0	4(1.9%)	
Collect and sell them	3(1.5%)	0	3(1.4%)	
Rinsing or cleaning empty containers before disposal				
Yes	6(3%)	0	6(2.9%)	0.309
No	194(97)	10(10%)	204(97.1%)	0.578

3.9 Pesticides and biodiversity in the study area

About 57% of the farmers interviewed mixed pesticides in the farm which can be carried away into the water body (e.g. Lake Ziway) by flood and 31% of farmers mix and sprayed pesticides near water bodies. Likewise, they continuously utilize water from the lake to blend pesticides in the field and wash spraying tanks after spraying procedures. These poor activities may intensify the exposure of the farmers to pesticide harming (since the farmers on occasion rely on these waters for their drinking water source), as well as affecting the health of the water and having harmful impacts on water life such as snails, insects, fish, and frogs. The greatest of the respondents stated changes in the aquatic life around Lake Ziway following pesticide application. However, the majority of the small-scale farmers depending on their long years of experience instead of paying attention to the concentration rate on pesticide labels, unlimited utilization of pesticides in the study area in a risky routine is likely to pose countless threats to these organisms. The investigation further showed that useful insects, fish, birds, and other animals may be decreasing in the region. When farmers are asked whether they had observed any instantaneous changes in the number of fish, frogs, insects, and birds and animals in the area over the last two years after pesticide application, 79%, 49%, 81.9%, and 29.3% of the farmers described that they had noticed a decrease in the numbers of fish, frogs, insects, and birds and animals, respectively (Fig. 2). Likewise, the farmers stated rare visits to their farms by honeybees and a shortage of honeycombs, which accustomed to be abundant in the study area.

4. Discussion

In the present study, males do major farming activities (98%). Correspondingly, Waichman *et al.* [16] and Adjrah *et al.* [17] conveyed farming was controlled by males in Brazil (97.4%) and Togo (92%) respectively. An investigation by Nguetti *et al.* [17] also showed 90% of male farmers in Kenya. A large number of the small scale-farmers in the present study were illiterate, had no formal education and similarly, the large numbers of the small-scale farmers did not get training about the proper use of

pesticides. Many of the farmers had got informal training from untrained farmers. Besides, another study by Negatu *et al.* [8] in Rift Valley Region in Ethiopia reported that no consideration by the local government extension workers and farmers cooperatives is given to training small scale farmers on the proper utilization of pesticide and no attention at all by local health extension services or other institutions such as the local labor and social affair or environmental office. Accordingly, these farmers could not read and understand pesticide labels about the proper and safe use of pesticides [16]. Accordingly, the application procedures are disorganized and largely by guess. This has significant inferences for the ecological and the well-being of the farmers. Farmers with high-level education are well-informed about pesticide safety, can read, recognize, and obey hazard signs on container labels, and intellectualized the effect of poor pesticide usage practices [18].

Pesticide use, source information in the study area seems to be affected by agrochemical retailers encouraged by pesticide sales, who were working their economical benefit in the farming societies and fascinated by attaining large sales of their pesticides. The influence of sellers on small-scale farmers' pesticide applications was previously reported in Ethiopia around the Rift valley region [8] and other low-income countries [4, 7]. This result was also in agreement with the study by Mohanty *et al.* [15]. Other sources of information on pesticides such as colleagues or small informal shops, other farmers reported in the present study agreed to a study by Nalwanga and Ssempebwa [19] in Uganda. A great number of small-scale farmers buy pesticides from agrochemical retailers. However few retailers had a formal education about pesticides [20]. As a result, those pesticide retailers are unable to recommend farmers on appropriate use, supervision, and disposal of pesticide which may lead to improper use and handling of pesticides resulting in increased occupational and ecological hazards.

Our result demonstrates that class II pesticides mostly metalaxyl, cypermethrin, lambda-cyhalothrin, profenofos, and Mancozeb (unlikely to present acute hazard in normal use), are the most commonly used pesticides for small-scale farmers in the study area. Fortunately, none of the pesticides reported in the study are in WHO Class I. Unlike the previous studies in Ethiopia by Mengstie *et al.* [2], it was revealed that farms that used pesticides such as Aldicarb (imported only for the flower industry) which is classified as extremely hazardous class1a are found on vegetable farms. In several other developing countries, extremely toxic pesticides are used widely. Contrasting the present study, other studies have revealed extended use of class I pesticides in developing countries. In a survey study by Matthews *et al.* [21], in Cameroon, and Jørs *et al.* [22], in Bolivia for small-scale farmers, it was presented that one of the regularly used organophosphorus insecticides is called Methamidophos, which is categorized as highly hazardous class Ib [23]. Correspondingly in Vietnam, the use of class I pesticides, and many banned pesticides were reported [24]. Conversely, a survey study conducted by Ngowi *et.al.* [4] in Tanzania, has described a low magnitude of class I pesticides; while a study conducted in Ghana shows that small-scale farmers mostly used class II pesticides[25]. Similarly, a study by Anna *et al.* [26] in Uganda appeared that entirely the small-scale farmers used class II and III pesticides. In any case, class II pesticides are still classified as moderately hazardous and known to have an extremely negative impact on human wellbeing and the environment, and thus other less dangerous options should still be encouraged [7]. According to key informants(chemical retailer and agricultural expertise), interviews and

field observation conducted concurrently in Ziway and Meki pesticide traders and their store of pesticides support the finding that the pesticides used are predominantly class II (moderate toxicity class) and no class I pesticides were identified in the retailers' shops.

Providentially in the present study, small-scale farmers did not report the use of banned or have restricted use globally under the Stockholm Convention such as DDT and Endosulfan. However previous studies by Negatu *et al.* [8]. in Ethiopia around the Rift Valley Region, DDT and Endosulfan were reported to be used by, 25% and 94% of the small scale irrigation farmers within the one year before the interview and by 87% and 98% of the small-scale irrigated farmers since their connection in pesticide application work, respectively. Similarly, Mengstie *et al.* [2]. reported the use of banned pesticides (DDT) by the vegetable farmer in Ethiopia around Meki and Ziway. Recent decrease and no use of these banned and restricted pesticides in the present study could be attributed to the effectiveness of the National Implementation Plan (NIP) for the Stockholm Convention in Ethiopia. According to Gubena, [27]. the main aim of the NIP is to get ready comprehensive and practical activities for the effective controlling of POPs chemicals in the Ethiopian situation and to decrease, and eventually avoid, the use and release of POPs after fulfilling the requirements of the Stockholm Convention and national sustainable development objectives and strategies such as the Environmental Policy and the Plan for Accelerated and Sustainable Development [28].

About 45% of the farmers sprayed chemical pesticides up to 12 to 15 times. Roughly 12% of the farmers stated applying pesticides more than 15 times per season. Consequently, the rate of pesticide use by small scale vegetable farmers was very high. This intensive use of pesticides may cause everyday contact with pesticides, which can lead to substantial human health problems and possible environmental contamination. Sun *et al.* [29] revealed that insufficient governmental agricultural extension services are the most central factor in the overdoing and misuse of chemical pesticides. Some countries in Africa reporting substantial use of pesticides, for instance, in Ghana vegetable farmers sprayed more than 12 times per crop cultivation. Moreover in Tanzania, farmers sprayed more than 21 times per crop season [25].

In this study, we assessed the practice of storage and disposal of pesticides by farmers and their association with their level of knowledge. The level of education affects knowledge. This was apparent from the present study in addition to the study in South India by Mohanty *et al.* [15] where a significant association was reported between a good level of knowledge about pesticide disposal and education level. Our study presented that farmers with good knowledge had safe pesticide practices than farmers with poor knowledge. Our study showed some upsetting activities about the storage of pesticides, with 94.5% of the farmers storing pesticides in residential rooms under the bed, on the roof, in the kitchen, in the toilet, and an animal house with other items. While only 5.7% did not store pesticides, buy the required amount, and use it immediately (Table 5). This proves the farmers' shortage of knowledge of pesticides and a suitable methodology for storing pesticides. The study conducted in the West Bank by Sa'ed *et al.* [30] showed that few farmers (7.3%) buy and use it directly (did not store). Our study revealed that farmers

with good knowledge take protective care compared to farmers with poor knowledge. Our results were consistent with the study conducted in Puducherry, South India by Mohanty *et al.* [15].

Appropriate pesticide waste disposal is also an imperative part of accountable pesticide use. However unplanned release of uncontrolled discharge of pesticide into the environment can impaired society and pollute the ecosystem [31]. A great number of farmers throw away an empty container on the farm (Table 5). Empty pesticide containers may regularly hold an undesirable amount of pesticide solution or powder if not rinsed well. This improper disposal could damage the community and the ecosystem. Even if only 8.1% of farmers reuse empty containers for domestic purposes, the practice is widespread in many low-income countries. Studies by Benjamin *et al.* [7] in Rwanda, Nadja *et al.* [32] in Tanzania, and Jallow *et al.*, [33] in Kuwait reported that farmers used empty pesticide containers for domestic use, such as for holding drinking water and storing food ingredients.

In our study, nearly half of the farmers did not dispose of leftover pesticide safe way i.e. disposed of the leftover pesticide by discarding it into the field and apply on other crops. Very few farmers reported mixing only needed pesticides. Sa'ed *et al.* [30] reported that 60.9% of framers apply the leftover pesticide solution on the same day they bought it without store it. However, 29.4% of farmers reserved the leftover pesticide in an unlabeled plastic container which usually many poor farmers use the container as a drinking utensil. The culture of discarding the excess solution of pesticide into the farmland in our study can be correlated with the knowledge, where the majority of the farmers were unfamiliar with the excess of pesticides affecting soil and gradually carry away into the surrounding water body (e.g. Lake Ziway). In the present study, the majority of the small scale farmers (97%) did not rinse or clean empty containers before disposal. This risky activity, disposing of leftover pesticides, and empty pesticide containers seen in our study is a worry because it has an impact on the environment by polluting soil, surface, and groundwater besides cause hazard to non-target creatures. These poor activities were reflected to be one of the major difficulties associated with pesticide use and its management and control in low-income countries [34].

In the present study, very few small scale farmers took bath after pesticide mix and spray. Mekonnen and Agonafir [35] and Negatu *et al.* [8] conveyed comparable results in which many of the farmers did not take a shower habitually after the application of pesticides. Only 35% of the small-scale farmers considered the wind direction during spraying. However, 64.8% of the farmers were not considering the direction of the wind while spraying. This is in agreement with the study done in Nepal [36]). According to Khanal and Singh [37] not considering the wind direction cause uncertainties such as bad odor, unable to spray-on targeted crop, trouble in spraying as well as difficulty in inhalation by the person spraying the pesticides. The inadequate knowledge of the pesticide use and methods of the application procedure for this study is in agreement with other studies done in low-income countries [17, 36, 38, 39].

When asked small-scale farmers, whether they used biological pesticides or others such as IPM, none of the farmers reported the use of IPM. Integrated Pest Management (IPM) has been shown to reduce the use and improper practices during utilizing pesticides. IPM focuses on the significance of the production

of healthy crops and inspires natural pest control systems [25, 40]. Even though most small-scale vegetable farmers had some knowledge of the health effect related to pesticide use, they did not protect themselves effectively from acute pesticide toxicity. In this study, almost all farmers wore poor personal protective equipment leading to unsafe protection when mixing and spraying pesticides. From field observations, it was noted that none of the farmers used any protective equipment. Likewise, a study by Negatu *et al.* [8] in the rift valley region in Ethiopia reported that less than 5% of farmers used the mask, or gloves during pesticide application. Three fourth of small-scale vegetable farmers in this study reported that they did not wear the boot and 94% did not wear eye goggles while 94.2% of farmers wearing normal clothes while they are spraying and mixing pesticide. While a study by Mekonnen and Agonafir [35] has stated that 18% of small-scale farmers had flaccid goggles and the other 29% dressed in worn-out gloves. In our study, nearly 97.5% of farmers with poor pesticide knowledge did not use face masks and gloves while spraying. This is consistent with the results of the study conducted by Williamson *et al.* [41]. Farmers did not use PPE because of the inadequate knowledge about the safety measures, inaccessibility of protective devices at the local market, PPE being uncomfortable in the local hot and humid climate, and their high cost at the private shops. Warm climate was one of the causes of low use of PPE as mentioned by studies done in the USA [42].

Small-scale farmers tended to use a high amount of pesticides to protect their vegetables from pest alteration for more economic benefits [5]. Our result indicates that the rate of applications of pesticides is higher. In this study, any farmer did not report the correct knowledge regarding pesticide application interval. Similarly, an extensive amount of pesticide application was reported in other countries: in Benin, many farmers spray pesticides every 3–5 days, [41], in Brazil, the pesticide spraying rate ranged from 3–15 days [16]. Our results have shown that insecticides and fungicides dominated chemical pest management in all vegetable farms, reflecting the serious problems of insect and fungi attacks in the survey zone. However, very limited farmers reported the use of herbicides because most of the time vegetable farmers in the study area use inexpensive human labor to remove the weeds manually. While somewhere else in America and Europe, herbicides, as far as possible, are the most commonly used pesticides followed by insecticides, fungicides, and others. This is probably because it is inexpensive to use this product than renting additional labor during weeding [16].

The most common health problems related to exposure to agrochemicals, reported cases by the small-scale farmers include skin problems, headache, teary and eye irritation, seizure, sore throat, and respiratory disorder, fatigue, nausea, and stomach ache. Burning sensation in the eyes is the most regularly reported symptom. According to USEPA [43], all of the reported cases can be symptoms of pesticide exposure. Most of these signs are deliberated as indicators of acetylcholinesterase inhibition [44]. Many of the reported pesticides in the present study have acute toxicity to humans. For example, Cypermethrin is moderately toxic through skin contact or ingestion. It may also irritate the skin and eyes. Symptoms of dermal exposure comprise unresponsiveness, stinging, itching, burning sensation, unskillfulness, and possible death. According to Khan *et al.*, [45], exposure to Lambda Cyhalothrin caused up to 20% and 57.1% inhibition in the activity of brain cholinesterase enzyme. Lake Ziway is used as a key water supply for irrigation and domestic purposes such as drinking, food preparation, and cleaning

clothes in addition to its ecosystem service. The misuse of pesticide cause possible health risks to the communities around the Lake Ziway as well as the biodiversity of the lake, which may be exposed to water polluted by pesticide carried by flood. Moreover, human exposure to pesticides is probably occurring through work-related exposure [46], (but can also occur through exposure to polluted water sources [47].

Pesticides have been found to contaminate Lake Ziway [12, 48, 49]. These pesticide residues are highly lethal to fish and amphibians [50]. The present study revealed the insufficient knowledge of small-scale farmers about the fate of pesticide accumulation in surface water and groundwater. Anju *et al.* [51] examined pesticides that had damaged aquatic organisms including fish. In our study above 86% of the farmers interviewed sprayed pesticides close to Lake Ziways. Similarly, they continuously used water from the lake to blend pesticides in the farm, cleaning, and rinsing the spraying container after spraying tasks. This misuse of pesticides may intensify the susceptibility of the farmers to pesticide poisoning as well as affecting the quality of the water. Likewise, 46% of the respondents get information or advice from other farmers and their long term personal experience instead of paying attention to the concentration rate on pesticide labels, increasing misuse of these pesticides in the study area is apparent to cause a deterioration of aquatic organisms.

The study further revealed that useful insects, birds, and fish get declining in the study area. The farmers reported instantaneous changes in the number of insects and animals in the area over the last two years succeeding pesticide application, 89, 79 and 80 percent of the farmers conveyed that they had noticed a decrease in the numbers of beneficial insects, frogs, and birds and mammals, respectively (Fig. 2). These declines may be due to fortuitous exposure by the organisms with pesticides misused by the farmers [52, 53]. Similarly, the farmers reported recently no honeybees have been seen on their farm, which used to be plentiful in the area. The possible explanation could be the use of pesticides such as organochlorine, carbamate, organophosphorus, and parathyroid pesticide exposure [54].

Conclusions

Contrasting the practice in previous studies small-scale vegetable farmers around the littoral zone of Lake Ziway in Ethiopia, do not use the most hazardous pesticides of WHO class 1a and 1b and banded organochlorine pesticides including notorious DDT and Endosulfan. The WHO class II pesticides were the most commonly used agrochemicals in the study area. However, our study reveals farmers lack sufficient knowledge of pesticides and practices among the farmers so they regularly adopt risky behaviors when using pesticides. Lack of knowledge included no use of personal protective equipment and the inappropriate storage and disposal of pesticides were common practices. These may result in a danger of acute intoxications, chronic health problems, and environmental degradation. Therefore increase farmers' knowledge about pesticides and creating awareness by giving them training on health-related effects from exposure of pesticides, the impact of pesticides on the ecosystem, proper disposal and storage of pesticides, and teaching of farmers in IPM methods. Training pesticide vendors to improve

their awareness of pesticides is also important as they are farmers' key source of information about pesticides.

Declarations

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Ethical considerations

The study was granted an exemption from requiring ethics approval from the Hawassa University College of Natural and Computational Science, Research and Review Committee. The purpose and importance of the study were explained to the participants. Data were collected after full informed verbal consent was obtained and confidentiality of the information was maintained by using a unique code

Conflict interest

The authors declare that there is no conflict of interest associated with the subject of the article

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Availability of data and materials

All data generated or analyzed during this study are included in the manuscript and supplementary information

Consent of publication

Not applicable

Authors contribution

Weldemariam, Eklo, and Yimer designed and supervised all stages of the study. Mergia and Weldemariam participated in data collection and data collection monitoring. Mergia prepared the datasets, wrote the first draft of the manuscript, and performed the preliminary statistical analyses. All authors have read and approved the final manuscript

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Figures

Figure 1

Effects of pesticide exposure reported by farmers during and after pesticide application (multiple answers possible)

Figure 2

Small scale framers response on change of biodiversity status along the littoral zone of Lake Ziway over the last two years following pesticide application

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