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COLLEGE OF DEVELOPMENT STUDIES (CoDS)

CENTER FOR ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

**KNOWLEDGE, ATTITUDE, AND PRACTICE OF PESTICIDE USE AMONG
SMALLHOLDER ONION FARMERS: EVIDENCE FROM FOGERA DISTRICT,
SOUTH GONDOR ZONE, AMHARA REGION, ETHIOPIA**

BY

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SEPTEMBER, 2024

ADDIS ABABA, ETHIOPIA

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CERTIFICATION

We attest that Mr Beamlak Zegale Mengstie Conducted and finished the research thesis titled " knowledge, attitude, and practice of smallholder onion growing farmers towards the use of pesticides: evidence from Fogera district, South Gondor zone, Amhara region, Ethiopia" and the research work was supervised by us and submitted to the Center for Environment and Development Studies, College of Development Studies, Addis Ababa University, Ethiopia

Approved by:

Advisor

Internal Examiner

External Examiner

Signature

Signature

Signature

DECLARATION

I would like to declare that the study conducted on Knowledge, Attitude and Practice of Smallholder Onion Growing Farmers towards the Use of Pesticides: Evidence from Fogera District, South Gondor Zone, Amhara Region, Ethiopia is the original work of the investigator. The study also complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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LIST OF ACRONYMS

FAO	Food and Agricultural Organization
WHO	World Health Organization
EPA	Environmental protection Authority
KAP	Knowledge, Attitude and Practice
PPE's	Personal Protective Equipment's
GAP	Good Agricultural Practice
SA	Sustainable Agriculture
NGO	Non-Governmental Organizations
USEPA	United States Environmental Protection Authority
CRV	Central Rift Valley
DDT	Dichlorodiphenyltrichloroethane
IPM	Integrated Pest Management
LMIC	Low and Middle-Income Countries
POPs	Persistent Organic Pollutants
PIC	Prior Informed Consent
PRISMA	Preferred Reporting Items for Systematic Reviews
FDRE	Federal Democratic Republic of Ethiopia
UNEP	United Nation Environmental Protection
FGD	Focus Group Discussion
PAN	Pesticide Action Network
SPSS	Statistical Package for Social Science

ABSTRACT

This study investigates the knowledge, attitudes, and practices (KAP) of smallholder onion growing smallholder farmers in Fogera District, South Gondar Zone, Amhara Region, Ethiopia, towards pesticide use, addressing significant gaps in understanding how these factors influence safe pesticide practices. The primary objective was to assess farmers' awareness of the health and environmental risks associated with pesticide use and to evaluate their pesticide application practices. Utilizing a cross-sectional research design, data were collected from 300 smallholder farmers through structured questionnaires, key informant interviews, and field observations. Statistical analysis was performed using IBM SPSS version 27, employing both descriptive and inferential methods, including regression and correlation analyses. The findings reveal that while a considerable proportion of farmers possess a certain level of knowledge regarding pesticide use, but notable gaps exist in their understanding of safe practices and the environmental impacts of pesticides. Approximately 62.4% of the variance in pesticide use was attributed to knowledge, attitudes, and practices. The study highlights a concerning trend of unsafe pesticide handling, including the mixing of expired chemicals and inadequate use of personal protective equipment. In conclusion, the study underscores the need for enhanced awareness creation programs focused on safe pesticide practices and improved access to personal protective equipment's. Recommendations include promoting integrated pest management (IPM) strategies and establishing safe waste disposal facilities, aiming to mitigate health risks and environmental hazards associated with pesticide use among smallholder onion farmers in Ethiopia.

Keywords: pesticide use, knowledge, practice, attitude, smallholder farmers, onion and sustainable agriculture

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

Agriculture serves as the main backbone and pillar for the economic development of a countries. Especially in developing and underdeveloped countries, such as the African continent, agriculture covers a large part of the economic output sector (Pawlak & Kołodziejczak, 2020). In our country, Ethiopia, smallholder farmers play a significant role in ensuring food security and improving livelihoods sustainability. According to the study by (Fikadu & Gebre, 2021) Fogera district is one of the most suitable areas for irrigation agriculture in our country. Farmers living in the Fogera district produce large amount of vegetables every year. For instance, in 2014 production year, the district contributed 4, 067,908 quintals vegetables with 31,258 ha of land coverage of vegetable crop. According to the Fogera district Agricultural office, in 2015 production season, the district contributed 2,167,880 quintals of onion with 9854 hectares. This indicates that the district contributes to the national onion production.

In this district, the smallholder farmers grow vegetables and other crops up to three times a year with the irrigation dams and watersheds built along the Rib, Shine and Gumara rivers (Balew et al., 2021). As Ethiopia is a country with different agro-ecological zones, many diseases, pests and invasive weeds occur on vegetables. These pests have a significant negative impact on yield reduction and product quality (Yigezu Wendimu, 2021). It is believed that the use of pesticides is the best solution to overcome this serious problem. Therefore, the smallholder farmers of Fogera district are among the communities that use pesticides widely. Contrary to the widespread use of pesticides, if not applied according to proper usage, handling and disposal guidelines, the damage to the environment and human health is very dangerous. Application of pesticides results in many unwanted impacts on the physical environment, including soil contamination, contamination of water bodies, and air, contributing to pollution and ecological imbalances. Pesticides can be poisonous to non-target organisms like beneficial insects, birds, and aquatic life, thus disrupting ecosystems.

They can further lead to a decline in the population of those pollinators, like bees, highly needed for plant reproduction and biodiversity. Pesticides accumulate in the food chain; hence, when

consumed, they pose health risks to humans. Their impact on soil fertility and biodiversity further influences the overall sustainability of agricultural systems.

Smallholder farmers show variations in knowledge of attitude and practices relating to the use of pesticides. Some of them possess knowledge about the preparations and uses of certain pesticides, which is usually passed down from generations (Zivanayi et al., 2023). There are, however, mixed opinions on whether pesticides are environmentally friendly, benefit health, or are effective (Madaki et al., 2023).

This could be the reason why many farmers do not see the need for precautionary measures, such as using personal protective clothes, because they believe the pesticides that they apply are nonpoisonous. In terms of practices, farmers often have inappropriate pesticide storage, application, and disposal practices (Boateng et al., 2023). They may also use lower or higher doses of pesticides than recommended by manufacturers (Omoto & Bankole, 2023). Thus, this research is initiated to assess the situation of smallholder farmer's knowledge, attitudes and practices towards safe use of pesticides in Fogera district.

1.2 Statement of the Problem

Pesticides have many benefits, mainly in the agricultural sector by protecting vegetables from being damaged by various pests, maintaining vegetable yield, productivity and quality, and making it available to the user community and contributing to food security (Pathak et al., 2022). Another is in the health sector, which has a wide role in health protection services by preventing malaria epidemics and preventing pests and insects in the home (Van Den Berg et al., 2014).

For this reason, it has been more than 50 years since our country Ethiopia started using pesticides (Mengistie et al., 2016). Despite the benefits mentioned above, it is clear and well-known that the use of pesticides without knowledge and care can cause serious harm to the environment and human health. According to recent time researches, it has been proven that pesticides pose a serious risk to human health, mainly for cancer, stroke, mental retardation, infertility, birth defect and other long-term chronic diseases (Gilden et al., 2010). On the environment, mainly for air pollution, bees, birds, fishes, water pollution, soil fertility reduction, loss of beneficial micro-organisms, loss of biodiversity and many other damages, it is confirmed by various studies.

The global incidence of pesticide poisoning is a significant public health concern, particularly in developing countries. Estimates suggest that there are approximately 3 million cases of pesticide poisoning annually, with around 220,000 resulting in fatalities (S Z et al., 2015). The majority of

these poisonings are occupational, accidental, or intentional, with a substantial number occurring in agricultural workers (Litchfield, M.H et al., 2012).

The KAP of pesticide use among smallholder farmers in Sub-Saharan Africa has a number of challenges, including low awareness, improper handling, and inadequate use of protective measures. Most farmers have no formal training and depend on fellow farmers or agrochemical dealers for advice, leading to unsafe practices such as overuse, incorrect dosages, and poor storage. These health risks are compounded by economic constraints and limited access to personal protective equipment. The weak regulatory mechanisms also cannot stop the misuse of hazardous products. Promotion of integrated pest management (IPM) practices, agroecological approaches, and specific educational programs could reduce the use of such chemicals with an aim toward improving pesticide safety and reducing dependencies on chemicals (Ngowi et al., 2022; Musoke et al., 2023; Muluneh et al., 2024).

In our country, these problems are now widely seen and spread. Especially in irrigated area and in the area where they have large-scale farms, farmers use pesticides extensively, and it is estimated that they spray pesticides by practice without any training and awareness information (Negatu et al., 2016). The negative impact of pesticide use is affected, among other factors, by user knowledge and behaviors (Bondori et al., 2018). Knowledge, Attitude, and Practice (KAP) surveys are used to describe situations within given contexts, in cross-sectional studies, and are commonly applied to compare changes over time (Kaliyaperumal, 2004).

The reason for the researcher chosen to do this research are smallholder onion growing farmers' knowledge, attitudes, and pesticide use practices in relation to safety and environmental precautions are of grave concern. Most farmers lack information, experience, and technical support in the implementation of biological methods for the control of these pests. On the other hand, farmers have not clearly come out to show their attitudes regarding the environmental user-friendliness, health benefits, and efficacy of certain pesticides. Lack of adequate knowledge regarding pesticide toxicity and ways of safe handling prohibit farmers from engaging in dangerous behavior in the use and storage of pesticides. Farmers might also fail in proper use of PPE and consistent wearing.

1.3 Research Questions

The research basic questions on smallholder farmers' knowledge, attitude, and practice (KAP) of pesticide use are:

- 1) What is the level of knowledge among smallholder onion farmers regarding the safe use and handling of pesticides, and how does this knowledge influence their pesticide application practices?
- 2) What attitudes do smallholder onion farmers hold towards the use of pesticides, and how do these attitudes affect their willingness to adopt safer pesticide practices or alternative pest management strategies?
- 3) What are the current practices of pesticide use among smallholder onion farmers, and what factors influence these practices, including the use of personal protective equipment (PPE) and proper disposal of pesticide containers?

In general, these research questions aim to explore the multifaceted aspects of KAP among smallholder farmers with respect to pesticide use. Addressing these questions could provide insights into designing interventions to promote safer pesticide use and alternative pest management strategies, ultimately contributing to the health of farmers, consumers, and the environment.

1.4 Objectives of the Study

1.4.1 General Objective

To assess or examine the Knowledge, Attitude, and Practices gaps that could lead to health risks for the onion farmers, their families, and the environment, and to propose interventions to mitigate these risks.

1.4.2 Specific Objectives

1. To assess the level of awareness and understandings among farmers regarding the health risks associated with pesticide use and the environmental impact of pesticides.
2. To evaluate the attitudes of small holder farmers towards the use of pesticides.
3. To assess the Pesticide uses and application practices of the farmers in the study area.

1.5 Significance of the Study

Basically, the research study is undertaken for academic purpose. It is limited to a single district. Despite its limited area coverage, the result of the findings of the study adds some insight related to pesticide use, application practice and its implications at national /country/ level in general, and in the study area in particular. Good agricultural practice (GAP) and sustainable agriculture (SA) has been one of the priority agendas of the Ethiopian government. Hence, the finding of the study contributes to create awareness on pesticides uses, application practices and its implications

on environmental and health impacts and provide additional information and understanding to local conditions through providing some awareness's related to pesticides misuse, application practices and its implications on safe use of pesticides of the study area. The study benefits other researchers and organizations who may intend to conduct further study on related issues.

1.6 Scope of the Study

It was a descriptive study aimed at identifying gaps in knowledge, barriers in attitude, and obstacles in safe practices that smallholder onion growing farmers had with the use of pesticides in Fogera District, Amhara Region, Ethiopia. The study employed a cross-sectional study design involving an assessment of the level of awareness and understanding of the risks and associated safety measures that farmers attribute to the use of pesticides. That was to include an assessment of their understanding in pesticide health hazards, environmental impact, and proper pesticide use methodology. The second objective of this study is to assess the attitude of farmers towards the use of pesticides, from the perception that pesticides are necessary to protect vegetables to awareness of their health risks and environmental hazards. Because attitudes have the potential to influence farmers' willingness to adopt safer practices and participate in educational programs.

The actual practices of pesticide use among smallholder farmers were investigated, such as the use of personal protective equipment, proper storage and disposal of pesticides, and adherence to recommended application rates. Reasons were sought to explain why specific unsafe practices were prevalent. This was, therefore, a broad study, covering the responses of smallholder farmers to the use of pesticides in cognitive, affective, and behavioral dimensions: knowledge gaps, barriers to positive attitudes, and obstacles that needed to be overcome in practices of farmers with a view to improvement in health and safety to themselves and the environment.

CHAPTER TWO

2 REVIEW RELATED LITERATURE

2.1 Review of Basic concepts and Related Literature

2.1.1 Pesticides

The Food and Agriculture Organization (FAO) defines pesticides as substances or mixtures of substances that prevent, destroy, or control pests. This includes vectors of human and animal disease, and unwanted species of plants or animals that cause harm. Pesticides are substances used in agriculture, in public health, and in the home to control organisms that threaten vegetable yield, carry disease, or are otherwise unwanted (Lorenz, n.d.). Global food production depends on pesticides, and as the economy grows, so does the usage of pesticides (Schreinemachers and Tipraqsa, 2012). Pesticides are the most common method of controlling pests on smallholder farms (those having less than 2 hectares) (Lowder et al., 2016). (Williamson et al., 2008). Pesticides can be classified by the type of pest they control, the severity of their health effects, or their chemical composition. Insecticides, fungicides, rodenticides, herbicides, and biocides are examples of categories defined by the target pest (Gilden et al., 2010; USEPA, 2010). The World Health Organization (WHO) classifies pesticides into five categories that range from Class Ia-the extremely hazardous-to Class U-the unlikely to present acute hazard. Application of pesticides is not confined to controlling weed growth and insect invasion in agricultural fields only but is also used to suppress varieties of pests and disease carriers.

2.1.2 Smallholder Farmers

Smallholders are small-scale farmers, pastoralists, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives such as favoring the stability of the farm household system, using mainly family labor for production and using part of the produce for family consumption (FAO, 2013). According to Nwanze, 2016, smallholder farmers contribute to global food and development, with particular emphasis on women and youth. In Nigeria, the major food producers are small-scale farmers and, therefore, contributors to the national product. According to Rapsomanikis, 2015,

small-scale agriculture has the potential of ensuring sustainable use of natural resources with increased economic growth in rural areas.

2.1.3 Knowledge of Pesticide Use

"Knowledge of pesticide use" includes general knowledge of the principles, practices, and safety involved in pesticide application in agriculture. It covers the study of different kinds of pesticides, mode of action, proper method of application, dosage calculation, frequency of spraying, selection of appropriate pesticide, pre-harvest interval period, toxicity of pesticides, as well as follow-through on regulations. Such information from agricultural extension services, pesticide labels, government regulations, and scientific publications is quite indispensable to ensure that pesticide use is responsibly and effectively carried out. Arti, Girima and Ashok, et al. (2023). Farmers' knowledge of pesticide use is determined by various factors. A study conducted in Nepal showed that farmers who underwent training on the use of pesticides and vegetable cultivation have significantly improved their knowledge of pesticide use (Shakya & Acharya, 2023).

2.1.4 Attitudes of Pesticide Use

The factors that influence the use of pesticide attitudes relate to issues regarding the environment, health concerns, and economic factors, as well as the cultural point of view. Farmers' attitudes in pesticide use are based on beliefs, opinions, and emotional responses regarding pesticide use. It is a multidimensional variable influenced by social values, awareness campaigns through public communications, scientific knowledge dissemination, and regulatory frameworks. These attitudes involve the understanding of the public's perception with respect to the benefits and associated risks from pesticides, coupled with preferred options on alternative methods or sustainable practices. Pandiyan et al., 2023.

2.1.5 Pesticide Use Practices

This means that awareness among smallholder Farmers and their understanding of Best Management Practices for pest management-which include proper pesticide use-are important in this regard. Such awareness and understanding may be affected by their access to education and extension services. Constantine et al. 2023: Pesticide use practices may differ for smallholder farmers compared to those on large-scale commercial farms, probably under the influence of resource availability-particularly financial capacity and access to technology. Pesticide and other input costs, credit availability, and general economic situations may influence pesticide purchase and usage decisions. Social norms, tradition, and cultural practices can have positive or negative effects on farmers' perceptions of pest control and acceptance of particular pest management

strategies, including pesticide use. In this line, pesticide-use practices were assessed in several studies in Ethiopia.

These studies reveal the characteristics of pesticide use among farmers in the diversity of regions in Ethiopia, such as the Malga district from the Sidama region, Fogera district from the Amhara region, and the Central Rift Valley. But even in these countries, the actual application of pesticide safety principles remains low, and a very small proportion of farmers practice recommended safety behavior. Factors that influence safety include education level, years of pesticide use, source of pesticide purchase, access to safety materials, and training. These studies also emphasize other challenges that include limited access to safety materials, a lack of enough training opportunities, poor enforcement of laws, and poor accessibility to guidelines that hinder good practices from occurring in pesticide use. This is according to A. Teshome et al. (n.d.) and Wale (2023). In order to mitigate potential health and environmental risks associated with the use of pesticides in Ethiopia, it will be important to ensure ongoing monitoring and control of their usage, along with good agricultural practices and adequate training.

2.1.6 Agriculture and Pesticide Use in Ethiopia

In Ethiopia the use of pesticides to control vegetable pests can be traced back to the mid 1940's when arsenic and later on BHC in bran bait were used to control desert locust outbreaks. However, the use of chemical pesticides against crop pests may be associated with the development of commercial farms in early 1960's (Gizachew Assefa, n.d, 201da1). Ethiopia imports diverse types of pesticide with the amount expected about 3346.32 metric tons annually (Gizachew Assefa, n.d, 201da1). According to the Ethiopian Pesticide Industry Outlook 2022 – 2026 ReportLinker Forecast data, Pesticide consumption in Ethiopia is set to rise to nearly 5,000 metric tons by 2026, according to the latest data. The country's pesticide market size was 4,340 metric tons in 2021 and has grown on average 1.4% year on year since 1998. Ethiopia was ranked 58th in 2021, behind Zambia at 4,340 metric tons. The United States, Brazil, and Argentina respectively occupied the top three spots in the ranking. Chemical pesticide use in Ethiopian agriculture has steadily increased over time, and it is intimately linked to the need to increase crop productivity and expand in a high-input floriculture industry. Crop production and productivity are heavily reliant on effective and efficient pest management measures. Recently, it appears that meeting the sector's strategic goals will be unachievable without extensive use of synthetic pesticides. Unfortunately, the chemical-based pest management alternative was unable to fulfil only the beneficial intended

aim of pest management. It has created a possible threat not only to public health and the environment, but also to the country's fast-growing economy (Gedefaw et al., 2022).

Pesticide use is a common practice to control pests and diseases in agriculture fields, but often at the expense of the environment and human health. Pesticides use for Ethiopian farmers, to be obligatory tools in combating damage from weeds and insects. (Ayana Deressa & Alemu, 2022).

In agriculture fields, the use of pesticides is an ongoing practice for controlling pests and diseases. However, this practice has frequently been at the cost of the environment and human health. In the farming industries of Ethiopia, pesticides use is obliged to be an important tool for farmers in combating damage from weeds and insects. Ayana Deressa & Alemu, 2022.

The application of pesticides in Ethiopian agriculture has generated significant environmental and health hazards associated with poisonings, chronic health effects, and food-water contamination. Mengistie 2017; Negatu, 2021. The levels of these risks are very high because of the absence of knowledge and training by farmers and farm workers, as well as the absence of effective regulatory measures. Mengistie, 2016; Negatu, 2016. Much misuse (abuse and overuse) of pesticides by farmers occurs, particularly when storing, mixing (dosage) and applying them and also with regard to wearing protective gears and disposing of empty containers (Mengistie, 2017). To address these challenges, there is a need for improved pesticide governance, including better training and knowledge dissemination, and the enforcement of regulatory measures (Mengistie, 2016; Negatu, 2016).

2.2 Onion Production in Ethiopia

Onion (*Allium cepa* L.) Production in Ethiopia, the agricultural sector accounts for 55% to the Gross Domestic Product and provides 85% of employment (CSA, 2009). The country has favourable conditions for the production of several crops species. The wide range of altitude gives it a wide range of agroecological diversity ranging from humid tropics to alpine climates, where most vegetable crops can be successfully grown. Onion was introduced to the agricultural community of Ethiopia in the early 1970s when foreigners brought it in. Though shallots are traditional crop in Ethiopia, onions are becoming more widely grown in recent years. Currently, onion is one of the most important vegetable and spice crop in Ethiopia and mainly produced as a cash source for the farmers. Onion is a high-value bulb crop that has produced by smallholder farmers and commercial growers for both local and export markets in Ethiopia (Aklilu, 1994). It ranked the second in production of all vegetable crops next to Tomato, which has been

concentrated in the central rift valley of the country particularly in the upper Awash and Lake Ziway areas (Bossie, 2009). Onion is currently becoming a popular crop relatively despite to its recent introduction to the country because of its yield potential per unit areas, the ease of propagation method both by seed and bulb method, and the presence of high domestic and export markets (Asfaw and Eshetu, 2015). Hence, Nikus and Mulugeta, (2010) also elaborated the area under onion production is an increasing rate from time to time mainly due to the merit of production and ease of marketing purposes. This crop can be cultivated twice per year both under the irrigation and rain feed conditions in different parts of the country (Belay et al., 2015). However, the production and productivity of the crop are far below (10.02t/ha) the world average (19.7t/ha) despite to its year-round production scenarios (FAO 2012). This low yield results indicate that the presence of a huge gap in production and productivity at the country because of the absence of improved cultivars, application of inappropriate agronomic practices and limited attention/awareness on the benefits of intensive production. Within the context of efforts to achieve safe, sound and sustainable production of vegetables, identification of risk sources plays a crucial role (Kumilachew et al., 2014).

2.3 Theoretical Framework

Several social management theories were used to examine the dynamics of changing pesticide use in developing nations like Ethiopia. Ecological Modernization is one of the many conceptual frameworks that could be included; it examines how contemporary cultures address environmental problems associated with industrial production (Teklu et al., 2023). The ideas of Agricultural Productivism and Post-Productivism are closely linked to Ecological Modernization. In post-productivism, agricultural goals are reoriented from maximizing production, usually through an increase in yield (production per unit area), to the idea of consuming "the countryside" while apparently reducing the use of pesticides (Wale, 2023).

Integrated pest management (IPM) is an effective approach for pest control that aims to protect crops without harming the environment or the farmer's livelihood. It involves the use of biological control, sensible pesticide usage, and other practices to minimize economic, health, and environmental risks. IPM is considered a sustainable agricultural system that promotes safe and eco-friendly food production, improves farmers' livelihoods, and conserves non-renewable resources. The use of natural enemies and plant resistance are alternative strategies to replace pesticides in crop protection. The concept of IPM originated several decades ago and has become a robust paradigm of pest control globally. However, there is a need to emphasize the significance of

persistence, pesticide residues, and chronic health-damaging effects in IPM strategies. Overall, IPM is a crucial component of modern agriculture that addresses the concerns of maximizing output while preserving the environment and human welfare (Jomanga, 2022).

If pesticides are included within IPM then there is typically a requirement that they have as little negative impact on the environment as possible and that their use is managed by appropriate thresholds. But such changes do place additional demands on farmers and often need to be accompanied by the adoption of new practices and this is linked to issues such as awareness, education, training and knowledge diffusion. Social Network Analysis and Knowledge Diffusion are both concerned with how ideas and knowledge move within communities and how this process of spread can be measured. This Chapter therefore will begin with a brief discussion of these social management theories before examining in more detail, through the lens of knowledge diffusion theory, the issues related to pesticide use in Ethiopia, as a model for a developing country in the East Africa (Philipp, 2021).

Data from the Food and Agricultural Organization of the United Nations (FAO) suggests that low- and middle-income countries (LMICs) located in warm climate have the highest annual average application rates of pesticides. Farmers in Ethiopia are often smallholders, meaning they farm on less than two hectares (Lowder et al., 2016). Smallholder farming is not only a major source of income in, but also an important source of food production (Boserup, 2017). The first and often only pest management strategy of smallholder farmers is the application of synthetic pesticides (Hayes and Hansen, 2017). Smallholders are challenged through various personal factors. Studies suggest lower education, lack of training, insufficient knowledge as well as the pursuit of high profits to be indicators for higher than recommended pesticide use (Abadi, 2018; Akter et al., 2018).

According to LMIC research, smallholder farmers use highly toxic pesticides with little use of personal protective equipment (Bondori et al., 2018; Negatu et al., 2016a) and improperly dispose of pesticide residues and containers (Clausen et al., 2017). A survey of smallholder farmers in 26 countries revealed similar results, demonstrating that farmers were aware of the need for PPE but did not utilize it, for example, due to a lack of availability (Matthews, 2008; Tomenson and Matthews, 2009).

Unintentional pesticide handling can result in exposure situations, negatively harming human health and ecosystems. Direct human exposure can occur during the purchase, transport, or storage of leaking containers, preparation for application, such as product mixing, application itself, and

after spraying when re-entering a previously sprayed field (MacFarlane et al., 2013; Suratman et al., 2015). Indirect exposure to humans, on the other hand, occurs through drift, contamination of food or water supplies, and handling of pesticide-contaminated objects, such as clothing (Deziel et al., 2015). Once exposed, the active substances alter systems or enzymes in ways that are equivalent or very comparable to those found in humans and pests (Hayes and Hansen, 2017).

The short half-life of most pesticides, as well as the scarcity of indicators of exposure and associated epidemiological data, make characterisation of pesticide exposure in LMICs difficult (Carles et al., 2017; Ismail et al., 2017; Negatu et al., 2016b).

Concerns have long been raised regarding the extensive use of these chemicals and the consequent harmful effects on ecosystems and human health (Azandjeme et al., 2013; Carson, 1962; Chakraborty et al., 2009; Tago et al., 2014). Pesticides have been linked, for example, to soil degradation, water contamination, insect resistance, biodiversity loss, and loss of ecosystem processes such as crop pollination (Gallai et al., 2009; Reynolds et al., 2015; Sánchez-Bayo and Wyckhuys, 2019). According to studies, only 5% of acute pesticide poisoning cases are reported in national registries, implying that the full burden of acute pesticide poisonings is unknown (Corriols et al., 2008; Wesseling et al., 2005). Despite the fact that LMICs only consume 20% of pesticides produced globally, it is estimated that they account for up to 99% of acute pesticide poisoning deaths (Kesavachandran et al., 2009). Long-term impacts have also been proven, such as an increased risk of cancer or mental health deficits (de Rezende Chrisman et al., 2009; Stallones and Beseler, 2016).

The psychological frameworks bring into view the attitudes of smallholder farmers in relation to the use of pesticides. In this respect, TPB explains that farmers' favorable attitudes toward pesticides arise because of social norms and perceived control, which determine dependence on chemicals. The HBM illustrates how farmers usually perceive themselves to be less at risk from pesticide application while prioritizing immediate benefits over long-term health consequences. Cognitive Dissonance Theory suggests that farmers rationalize unsafe practices to reduce the conflict between awareness of risks and the need for high yields. Social Cognitive Theory (SCT) highlights the influence of observational learning and low self-efficacy in adopting alternative methods. Lastly, Risk Compensation Theory demonstrates how perceived safety can lead to complacency in adopting protective measures (Ajzen, 1991; Bandura, 1986; Rosenstock, 1974). Specific targeting of these attitudes through educative and empowering strategies might help in encouraging safer, more sustainable farming practices.

2.4 Empirical Review

2.4.1 Pesticide Policies and Regulations in Ethiopia

According to the study of Mengistie (2017) policies and regulations in Ethiopia related to pesticide governance, started on the Plant Protection Decree No 56 of 1971 (article 5), and substituted by Pesticide Registration and Control Special Decree No. 20/1990, and the current and updated Pesticide Registration and Control Proclamation No. 674/2010 are the foremost appropriate policies and regulations in Ethiopia (Negaret gazeta, 2010). Mengistie (2017) analyses the role of these policies in contributing to sustainable pesticide management and regulating pesticide use for environmental and human health protection. Under the new policy, certain international commitments and conventions are integrated into national regulations (such as the Stockholm Convention on Persistent Organic Contaminants (POPs), the Rotterdam Convention on Prior Informed Consent (PIC) and the Basel Convention on the Management and Disposal of Trans boundary Movements of Hazardous Wastes) (Alemu Gadissa et al., 2022). The general themes of pesticide registration and control proclamation 674/2010 is to lay down a scheme of control which would minimize the adverse effects that pesticide use might cause to human beings, animals, plants and the environment (Federal Negarit Gazeta,2010).

2.4.2 Smallholder Farmers and Pesticide Use: Empirical Review

As Nkemeleke (2020) notes, smallholder farmers are indeed the backbone of food production both in and for developing countries. Their farming activities are plagued with many challenges, including information gaps, lack of capital, and technical capacity. Lack of knowledge and understanding of pesticide use has been identified as important reasons in research, with implications for health, environment, and crop yield. These challenges were also identified in South Africa: Smallholder farmers are challenged due to limited access to productive resources, including information on markets and affordable transportation of pesticides. Other literature also identifies drivers that influence pesticide use among small-scale farmers. Among them is the limited accessibility of education on the management of pesticides and advice on alternative methods. Subsidies and donations from foreign governments, and a wide informal market for discounted and mostly illegal pesticides also boost the high misuse of pesticides among smallholder farmers. On top of that, smallholder farmers use pesticides, further threatening human health and the environment. This research states that the common mistake in the application of pesticides among smallholder farmers results from the use of non-recommended pesticides, lack of personal protective equipment, and the use of pesticide amounts more than the recommended one.

Tijjani et al. (2018), in turn, state that this can lead to the impoverishment of farmers through economic losses, damage to the environment, and health problems. It is also crucial that smallholder farmers be educated and trained in the use and safety of pesticides. A study recommends that small holder farmers get advice from extension officers to guide the application of pesticides. Government extension programs also have to rethink on the use of pesticides, since some promote the use of pesticides without considering the available alternatives to smallholder farmers (Ochilo et al., 2018).

Staudacher 2020 relies on a cross-sectional study to develop the determinants of pesticide use using quantitative data represented by means of a standardized questionnaire administered to smallholder farmers in Costa Rica and Uganda. Knowledge, Attitudes, and Practices questionnaires are used to collect data on farmers regarding knowledge about pesticides, attitudes toward their use, and actual practices of using them. He used chi-square tests and logistic regression models to determine which variables are significantly different and associated. The study also uses robust regression models in investigating the relationship between the household income to the socio-demographic and farm characteristics. Staudacher, 2020 acknowledge his limitations on the possible lack of representativeness of the samples chosen and the need for further qualitative data to complement the KAP approach.

A review of the smallholder farmer's knowledge, attitude, and practice on pesticide use shows an alarming mismatch among these parameters. For example, Ocho, 2016; Gesesew, 2016, found out that though farmers generally perceive pesticides to be useful, they are often lacking in knowledge over their proper use and safety measures. This is further supported by Yuantari 2015 and Sai 2019, who found that while farmers in their studies were aware of the importance of PPE, they usually did not use any type of personal protective equipment. This leads collectively to the support that smallholder farmers should be provided with education and training programs that would fill the gaps between knowledge and practices regarding pesticide use.

Mergia, et al., 2021 evaluated the knowledge, attitude, and practices of small-scale vegetable farmers in the use of pesticides in Ethiopia along Lake Ziway watershed area. The most frequently used pesticides in the study area were class II pesticides under WHO classification. Farmers in the area had indiscriminate disposal of empty pesticide containers in the field. Farmers applied the leftover pesticide to other crops. Most farmers did not use personal protective equipment while handling pesticide. Farmers had a low level of knowledge about pesticide use. Farmers' knowledge was found to be significantly associated with their pesticide use practices. Improperly disposed

pesticide and containers greatly pose environmental hazard. Training farmers on the safe and judicious use of pesticides would minimize the risks or hazards. He conducted Cross-sectional design research consisting of 210 randomly selected farmers. He used structured in-depth interviews and on-site observations on farms. Chi-square test used for assessing associations in data. In his study, there is a limitation on addressing Long-term and chronic health effects of pesticide exposure.

2.4.3 Impact of pesticides on the environment and human health

Agmas & Adugna, 2020 studied Attitudes and practices of farmers with regard to pesticide use in NorthWest Ethiopia. Their results showed that pesticide residues exist in fish foods, farmers apply chemicals indiscriminately and inappropriately, the prevalence of insecticide and herbicide use is high on farms; the majority of farmers' attitude and practice towards pesticide usage is poor. They relate the illiterate education, lack of training, and not reading labels as associated with poor practices. The chemical residues may affect fish, birds, bees, and food products, posing a public health risk. They go ahead to recommend that any responsible body needs to undertake one health intervention strategies. Pesticide issues in Ethiopia including food residues and cut-flower farms, based on their findings. Application of DDT in crops, its detection in water and breast milk. Lack of awareness, ignorance, and poor enforcement are looming dangers. They had chosen electronic database search of published articles and scrutiny of gray literatures as the approach in conducting their research study. PRISMA checklist should be used as a guide for the review. Inclusion and exclusion criteria, together with a standardized search approach, were followed. Full PRISMA statement checklists are applied inconsistently in this study. Data on pesticide contamination of export crops are scant. The latter requires action, while studies on enforcement, awareness, and intervention are necessary. There is also a need for an independent institution in handling pesticide registration and control. According to Negatu et al. (2021), residues of pesticides from contaminated food items and drinking water have become a key global human health concern, including Ethiopia, as previous studies have asserted. It follows that knowledge of the right type and amount of pesticides, its application timing, means of mixture, and application method is so important for enhancing efficiency and effectiveness in the use of pesticides, while at the same time reducing the risks on human health and the environment.

With the ever-increasing trends in importation and use of pesticides and other chemicals in Ethiopia, the country declared the laws to minimize their negative effects on human health and the ecosystems. On the other hand, development projects including floriculture farms using huge

amounts of pesticides, have been highly encouraged to earn short-term economic benefits without considering their long-term environmental and social effects in Ethiopia. "Birkie, 2019; Gubena, 2016" Almost 30% of the flower farms were established by destroying the swampy areas and 30% of the discharged their liquid waste directly into the water bodies "Fufa, 2018". Farmers in the present study area also apply obsolete and persistent pesticides for the control of crop pests and improving the quality of vegetable and khat. The pesticides applied for controlling the pest may affect the non-target plants and animals, as well, and result in the regional or national extinction of species. It resulted in the failure of reproduction, loss of tolerance to extreme temperature, and failure of normal growth and development of aquatic biodiversity due to pesticide residues going beyond the limit. Hayes et al., 2011; Helfrich et al., 2009; Landos et al., 2021; UNEP & WHO, 2013; UNEP, 2011. The effect of pesticide residues on animals depends mainly on their toxicity, duration of exposure, rate of application, and persistence in the environment.

Several studies were carried out on the use and handling of pesticides in Ethiopia and specifically in the Lake Tana watershed. Agmas et al., 2020; Mequanint et al., 2019. Most of the studies focused on the knowledge, attitudes, and practices of large-scale agricultural workers, namely flower farms and farmers, against labels instructions of pesticides to minimize its negative effect on farm workers. Agmas et al., 2020; Ejigu & Mekonnen, 2005. But there are no studies related to smallholder vegetable producer KAP on pesticide use in the study area, regarding the issue of the types and amount of pesticides used per crop type, the use of PPE, determinants for the use PPE, agricultural extension experts' role on pesticide use, highly hazardous pesticide use, farmers' awareness about chemical residue on their crop, the impact of pesticides on the environment and human health, the time interval between pesticide spraying and crop supplying practices, frequency of pesticide spraying on a cropland per a cropping season and what factors expose humans and ecosystems to the effects of pesticide residues. Therefore, the objectives of my study shall be to assess the smallholder farmers' KAP on pesticide use in view of the foregoing points.

2.5 Conceptual Framework

Pesticides are essential for agricultural production around the world, and their use is increasing in tandem with economic expansion (Schreinemachers and Tipraqsa, 2012). Pesticides are the most commonly used technique of pest management on smallholder farms (those with less than 2 ha) (Lowder et al., 2016). These chemicals can harm the environment (Köhler and Triebkorn, 2013; Lewis et al., 2016) and human health (Kim et al., 2017; Tago et al., 2014), especially in low and middle-income countries (LMICs) (Mew et al., 2017; Praneetvataku et al., 2013) and when used

inadvertently (Rother, 2018). LMICs frequently lack pesticide use rules or their execution, as well as limited resources to address the environmental and health repercussions of pesticide use, such as access to a functioning health system or monitoring of water quality in open water bodies (Weiss et al., 2016). User knowledge and attitudes have an impact on the negative effects of pesticide use, among other things (Bondori et al., 2018). Knowledge, Attitude, and Practice (KAP) surveys are frequently used to compare changes over time and are utilized in cross-sectional research to describe events within specific contexts (Kaliyaperumal, 2004). The use of highly toxic pesticides in large quantities combined with a low use of personal protective equipment (PPE) has been documented in KAP studies from low- and middle-income countries (Polidoro et al., 2008); exposure routes are poorly known (Barraza et al., 2011); acute pesticide poisonings are common and can be detected using biomarkers of effect, such as acetylcholinesterase (Cuenca et al., 2019); pesticide residues and containers are not properly disposed of (Clausen et al., 2017); and people believe that pesticides are an easy fix (Ochago, 2018).

In addition, the majority of farmers were aware of the need for personal protective equipment (PPE), but they frequently did not use it (e.g., due to lack of availability), according to a KAP study that compared pesticide use and related health effects in over 8500 smallholder farmers across 26 countries (Matthews, 2008; Tomenson and Matthews, 2009). According to the same authors, most nations had to increase the capacity for the proper disposal of empty pesticide containers (Matthews, 2008). Thorough understanding of the involved KAP within various socio-cultural and economical contexts is needed in order to provide solutions that mitigate the documented environmental and health impacts attributed to pesticide use (Launiala, 2009).

I have therefore designed an exploratory KAP study into smallholder farmers' use of pesticides in Fogera district. The objectives of this study will be to find out the knowledge gaps, attitude, and practices gaps of Fogera district small-scale farmers regarding the adverse effects of pesticides on the environment and human health. I have designed indicators/variables/ to measure the knowledge, attitude and practice. So, my study will have socio-economic, socio-demographic characteristics, knowledge on pesticides, attitude of pesticide and farming practice related structured questionnaires. To describe how knowledge, attitude and practice of smallholder farmers can influence the safe use of pesticides, I develop the following guiding research frameworks (Figure 1): how are socio-demographic characteristics associated with farming practices? How are socio-demographic factors and farming practices associated with socio-economic factors? How are farming practices associated with knowledge and attitude of safe pesticide use? How are farming practices as well as knowledge and attitude associated with

pesticide use practices? How hazardous and which are the pesticides used? How safe use of pesticides contribution to good agricultural practice (GAP)? And how good agricultural practices linked with sustainable development?

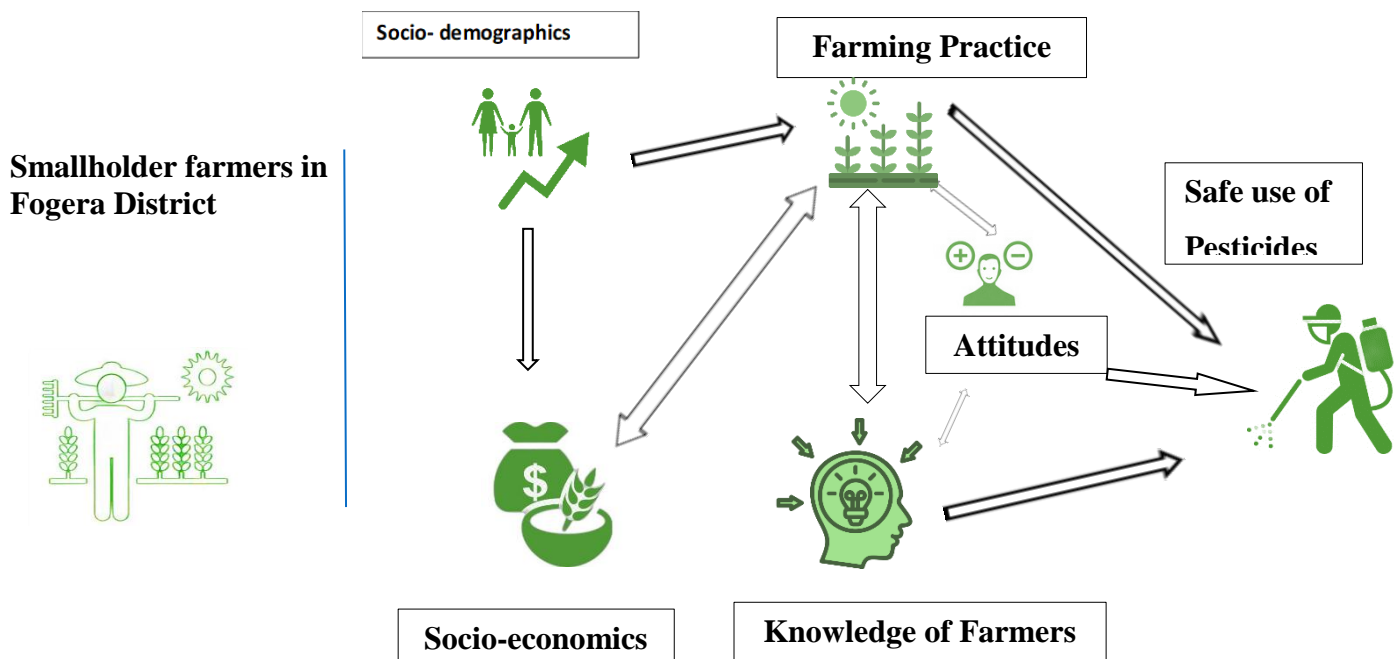


Figure 1. The framework links aspects of smallholder onion growing farmers' on pesticide use.

The framework is derived from (Staudacher et al., 2020) and modified by my own thought.

CHAPTER THREE

3 RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted at Fogera District of the South Gondar Administrative Zone, North-Western Ethiopia (fig. 2). Fogera District is one of the ten Districts bordering Lake Tana and it is bordered on the South by Dera District, on the West by Lake Tana, on the North by the Rib River, which separates it from Libo-Kemekem District, on the northeast by Ebinat District and on the East by Farta District (Gebey et al., 2012). The capital of the district is Woreta, which is 625 kilometres northwest of Addis Ababa and 55 kilometres from Bahir Dar (Lema et al., 2017). The district is situated at 11°46' to 11°59'N latitude and 37°33' to 37°52'E longitude (Lema et al., 2017) and its altitude ranges from 1774 to 2415 m a.s.l (Mohammed et al., 2019). The study area

has an annual total rainfall ranging from 1103 to 1336 mm (Gebey et al., 2012; Lema et al., 2017). Among the 23 999.8 hectares of wetlands in the Lake Tana watershed, 39.14% was in Fogera district (Hunegnaw et al., 2013). The floodplain of Fogera District is waterlogged for more than four months starting from July of each year. Fogera district is one of the leading rice and vegetable producing districts in the Amhara Region (Gebey et al., 2012). Fogera District in Ethiopia is an area where pesticide use for vegetable and crop production is prevalent, both in irrigation agriculture and during the rainy season. Farmers in this district are exposed to agricultural pesticides (Alebachew et al., 2023).

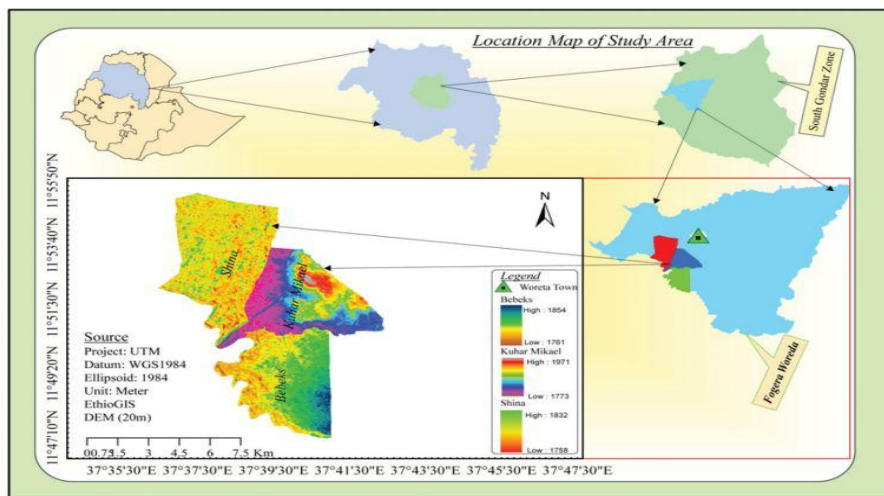


Figure 2. Location Map of Fogera District study area (Krauer et al).

3.2 Research Design

An observational cross-sectional study research design was applied. Both qualitative and quantitative data will gather using a questionnaire and structured interview. This research was a descriptive research design as analyzed data of a community based cross sectional household survey was conducted for sample households in selected area.

3.3 Target Population

In this study, mainly the smallholder farmers who produce vegetables and crops through irrigation and rainy seasons and who use pesticide chemicals in large amounts are considered to be the target population that was demarcated. Based on the recommendations of the Fogera district agricultural office experts and academicians involved in sector recognition, five kebeles are more engaged and have potential for pesticide use in agriculture. Five rural kebeles of Fogera District—Shini, Bebekis, Kuhar-Michael, Shiwonz, and Dokmit—which practice intensive irrigation agriculture

and pesticide use was purposefully selected for data collection. Even though almost all of Fogera district kebeles could be considered as a target population for this study, but currently, there is instability in peace and security issues in the study area, and there are time, cost, and budget limitations to cover all targeted populations. Hence, some remaining portion of the population was considered to be taken as a sample, which was representing the target population.

3.4 Sample Size and Sampling Techniques

The sampling frames for this particular study were rural farmers that are found in different kebeles of Fogera district. The study area was selected purposefully and carefully so as to represent the district in terms of socio-economic, socio-cultural, and physical factors like pesticide usage, production crop type, agroecology, accessibility to infrastructural facilities, natural resource endowment, and the like. For some of these factors, the study area was selected. Mainly, the familiarity of the researcher with the study area and the distribution of smallholder farmers will cause them to select purposefully. Moreover, a multi-stage sampling technique was used to select the representative samples. At the first stage, five rural kebeles shall be stratified by potential pesticide usage, and then respondents shall be selected randomly, i.e., one kebele from each potential pesticide usage area. A purposeful sampling technique was employed to select the specific study site depending on the crop production type, irrigation availability, and farm size. Besides, representativeness and accessibility of getting data from respondents will be the major factors in selecting the study site purposefully. Hence, it is appropriate techniques to have a deep understanding of the smallholder farmer's pesticide use knowledge, attitude, application practice, and KAP status of the study area.

The sample size of this study was determined or calculated using Taro Yamane sample size determination formulas. It was given the formula as

$$n = N / (1 + N(e)^2) \quad (\text{Eq.1})$$

$$n = 1200 / (1 + 1200(0.05)^2)$$

$$n = 1200 / 1 + 3$$

$$n = 1200 / 4 \quad \mathbf{n = 300}$$

Where, n- Sample size, N-is the whole onion growing small holder population under study areas, e- The precision or sampling error which is 0.05 as the proportion of respondent household to be onion growing are not known, Hence, 0.5 will use as p-value to obtain the sample size (n).

3.5 Type and Source of Data

In order to achieve the objectives of the study, which are stated above, and to address the research problem, both primary and secondary data were used. Data was collected from both primary and secondary sources by using structured questionnaires (surveys), key informant interviews, and observation.

So, the source of primary data was collected through structured questionnaires (surveys), face to face interviews, key informant interviews, and observation, and secondary data was obtained from different sources. Among these, the published and unpublished materials such as journals, books, magazines, articles, websites, research findings, policy documents, Non-Governmental Organizations (NGO) reports, different work manuals, and other relevant documents to the research were the major sources of such information.

3.6 Methods of Data Collection

Data collection was conducted between May and July 2024. Field staff (data collectors) received training on tools, ethics, and research background. A pilot study was conducted if deemed necessary before the final survey. The researcher administered a structured questionnaire to farmers using Kobotoolbox (<https://www.kobotoolbox.org>). Details of the questionnaire design have been described elsewhere (Fuhrimann et al., 2019) and are included in the supplementary materials. The questionnaire gathered socio-demographic information such as age, sex, education, marital status, and residential kebeles. Socio-economic and occupational data included years working in agriculture, years of pesticide use/spraying, monthly household income, main profession, work hours per week, pesticide active ingredients used, hours spent spraying pesticides weekly, farm size, crops cultivated, and the distance between the farm and the water source.

The knowledge, attitude, and practices (KAP) section addressed behaviors related to pesticide safety, including bathing/showering, clothing changes and washing, disposal of residual water and empty containers, PPE use, health risk perception, reading pesticide labels, adherence to pre-harvest intervals, frequency and dosage of applications, pesticide storage, and selection of chemicals for target pests. Interviews were conducted in the local language (Amharic) at farmers' workplaces or homes. Data were collected from both primary and secondary sources to achieve the study's objectives.

3.6.1 Primary Sources of Data

The primary data shall be collected through various data collection methods such as field observation, surveys and key informants.

3.6.1.1 Field Observation

Observation of the study kebeles shall be carried out before and during the study period. Prior to collecting data, different sites were visited to know the means of pesticides use, application practices, and KAP status and topography of the study area. Information regarding people's attitude, pesticides use, application practices and beekeeping trends shall be obtained from personnel observation and by talking informally with peoples in their site. Field observation has contributed to substantiate some of the findings of the study.

3.6.1.2 Survey

To generate quantitative and qualitative information about pesticide knowledge, attitude, application practices and its implications on environment and human health, survey will be undertaken by developing structured questionnaires. The developed structured questionnaire will be translated into the local language "Amharic" for the convenience of data collection during the survey. To achieve the objective of the study, data collectors could be employed based on their ability in communicating with local language, educational background and experiences in similar works. A questionnaire was chosen as data collection instrument. A questionnaire was installed on an application designed for data collection; the data collector was interpreted the questions in a language that the farmers (respondents) understand it. After listening to the response of the respondents, the researcher entered the data into the application. If necessary, the researcher adjusted the application to have audio record of the whole entire interview to avoid data loss and biasness. Data shall be collected with the aid of questionnaires to evaluate the small-scale farmers, development agents/extension expert's regarding with knowledge, and attitude and application practices of pesticide use on smallholder farmers.

3.6.1.3 Key Informant Interview

Key informant interviews resemble a conversation among acquaintances, allowing a free flow of ideas and information. Interviewers frame questions spontaneously, probe for information and takes notes. The interview was conducted to investigate their practice regarding pesticides use, application practices and its implications on the environment and human health to particular and supplement the findings obtained through household survey. The informant interview was conducted for selected small-scale farmers, extension experts and district agricultural extension officers. In the Key informant interview experts were asked about how they decide which pesticides to apply, how much to apply, and when to apply them; how their pesticide application

practices have changed over time; how they interact with government agriculture officials and pesticide retailers; and any health or environmental effects of pesticide use that they have noticed. Discussion topics were agreed upon by the researcher, were facilitated in Amharic Local Language. The researcher took notes during the focus group discussions and later it was translated the notes to English.

3.6.2 Sources of secondary data

Secondary source of information was reviewed to supplement the primary sources of information. Various documents available at district and kebele were reviewed and used to generate secondary source of information. Moreover, books, journal, articles, different Government Organizations (GOs) and NGOs documents and publications, and academic research papers could be reviewed to understand knowledge, attitude and application practices of pesticide use on smallholder farmers.

3.7 Methods of Data Analysis

Data was collected using a pretested and structured questionnaire. The questionnaire was pretested among farmers living in the study area, and necessary corrections were made. Participants were interviewed at their home. The researcher was gathered information on socio- demographic and economic characteristics of respondents, pesticides names, pesticide exposure routes, pesticide control methods, actions that were taken after poisoning, storage and disposal, PPEs, attitudes about hazardous effect of pesticides, practices of farmers for pesticides application and health problems related to pesticides.

The researcher entered the data into IBM SPSS, version 27 software for analyses. Descriptive and inferential statistical tests were performed on the data collected, which was supported by IBM SPSS Statistics version 27. Details of the tools and techniques which were used in the analysis are discussed here. Descriptive statistics summarized socio-economic, demographic, and pesticide use characteristics of the respondent farmers. Among categorical variables, frequencies and percentages were used to describe such variables like gender, education level, and marital status. Means, medians, standard deviations, and ranges are among the continuous variable descriptions used in the analyses; examples include age, income, and years of farming experience. These analyses provided an overview of basic characteristics of the study population.

Different inferential statistical tools are then applied to test the research questions and investigate the relationships between the variables. Correlations using Pearson's correlation coefficient were computed to show the strength and direction of relationships among the continuous variables,

including farming experiences in years and awareness of the risks associated with pesticide use. This analysis helped the researchers to ascertain associations between farmers' knowledge and their actual practices concerning the application or use of pesticides. Multiple Linear Regression analyses were used to identify predictors of safe pesticide use practices. This was used to investigate the socio-demographic features in farmers, like education and income levels, in relation to knowledge concerning the safe use of pesticides. Results are presented as odds ratios with 95% Confidence Interval. Comparison of mean scores for key knowledge, attitude, and practices across the socio-demographic groups was done using ANOVA tests. This test helped in deducing whether statistically significant differences in pesticide use practices. To confirm the validity of the regression models, the following diagnostic tests were performed; Multicollinearity: This was checked against the VIF so as not to have high correlation among independent variables. Normality: Residual normality was investigated by using probability plots and the Shapiro-Wilk test. Linearity: The scatterplots were done to confirm the linearity relationship between independent and dependent variables. Homoscedasticity: Residuals vs fitted values plots were checked to determine if variance across all data is equal. Likert Scale for Attitudes For the measurement of farmers' attitude in relation to pesticide use, a Likert scale ranging from 1 = strongly disagree to 5 = strongly agree was used. To quantify the overall attitude of the respondents, mean scores were computed for each question on attitudes. Later, regression analysis will be done based on knowledge and practice levels. Qualitative Data Analysis To this end, the thematic analysis of the qualitative data was performed on key informant interviews and open-ended survey responses that related farmers' challenges concerning pesticide handling and regulatory compliance, as well as environmental impacts. These were extracted in support of the quantitative findings.

3.8 Ethical Considerations

This study has been conducted in a manner that adheres to the national and international ethical process for maintaining a high degree of professionalism in regard to moral norms. The proposal for this study was evaluated and approved by the Addis Ababa University College of Development Studies Center for Environment and Development Studies. The support letter of the Center was advanced to the responders by the researcher and explained to them the purposes of the questions in order for them not to be misled and confused, making the questions clear, sensitive and intelligible. The privacy each participant required was given them to ponder upon the study and free expression of their responses. The consent of the respondents was asked first wherein participants were reassured that their information would remain private. Another issue is that the

researcher established whether the respondents realized that the questionnaires were clear and direct in an attempt to avoid confusion and misinterpretation. With such ethical issues, the study attempted to make sure there is moral and ethical behavior in the process of the research while protecting the participants with fairness and respect.

CHAPTER FOUR

4 RESULT AND DISCUSSION

4.1 Characteristics of Study Population

In the table below, an overall total of 300 small-scale onion growing farmers participated in this study. By looking at it one by one, according to gender, 284 (94.7%) are males and the remaining 16 (5.3%) are females. I can only imagine that this is probably because most of the work on pesticide use and onion production is done by males. On the basis of marital status, there are 285 or 95% who are married, 7 or 2.3% unmarried, which is single, 4 or 1.3% widowed, and 4 or 1.3% are divorced respondents. Other questions would include family members with a child under the age of seven years, and to this, 227 or 75.7% said yes, there are, and the remaining 73 or 24.3% said no. Regarding the level of education among households, 156 (52%) of the total respondents had no education (Illiterates), 29(9.7%) attended basic education, 56(18.7%) had elementary education (from 1-4), and 41 (13.7%) They have attended elementary level (5-8), another 15 (5%) have attended secondary education (9-10) and 3 (1%) have attended preparatory education (11-12), but no one who can attend diploma (certificates) and degree and above. Of those who have responded to this interview, 277 or 92.3 percent had Farmer - husband responsibilities in the family, while 15 or 5 percent had Farmer - wife responsibilities and the remaining 8 or 2.7 percent were answered by sons. Respondents were asked about their farm land ownership. To this, 263 or 87.7 percent owned their own farm, 33 or 11 percent were sharecroppers, and 4 or 1.3 percent are renting land. One of the other questions asked was about growing onions, and all 300 grow onions for commercial purposes.

Table 1 Socio-economic and demographic characteristics of the respondent households

Variables	Category	Frequency(N)	Percentage,%
Sex of the respondent	Male	284	94.7%
	Female	16	5.3%
	Total	300	100%
Marital status	Married	285	95%
	Single	7	2.3%
	Widowed	4	1.3%
	Divorced	4	1.3%
	Total	300	100%
Presence of children in the Family? below seven years old	Yes	227	75.7%
	No	73	24.3%
	Total	300	100%
Education level of the respondent	Illiterate	156	52%
	Basic Education	29	9.7%
	Elementary school (1-4)	56	18.7%
	Elementary school (5-8)	41	13.7%
	Secondary school (9-10)	15	5%
	Preparatory School (11-12)	3	1%
	Certificates/Diploma	0	0%
	Degree and above	0	0%
Status of the respondent	Farmer-Husband	277	92.3%
	Farmer –Wife	15	5%
	Farmer –Son	8	2.7%
	Farmer-Daughter	0	0%
	Employee Worker	0	0%
	Total	300	100%
How do you define the land ownership?	Own farm	263	87.7%
	Sharecropper	33	11%
	Rented farm	4	1.3%
	Leased from Government	0	0%
	Total	300	100%
For what purpose can you use the onion you grow?	For commercial	300	100%
	Domestic consumption	0	0%
	Both	0	0%
	Total	300	100%

Source: own survey (2024)

4.2 Descriptive Analysis of the respondent household socio economic and demographic characteristics

Other continuous variables that describe the socio-economic and demographic status of the respondents are: age, family size, monthly income from onion production in months, and the area of farm land in square meters they cultivate it for onions, years of experience in onion production, years of experience of using pesticide chemicals, and annual yield of onion in quintal. The table below shows different descriptive analyses that are typical of these variables. For example, concerning the age of the respondents, the mean age of the respondents is 44, and the maximum and minimum ages were 70 and 20 years, respectively. The modal age which the highest number of respondents mentioned was 50. Concerning family members, the average number of family members was 5; the highest number of family members was 9; the lowest was 1, while the most frequent number of family members was 5. Concerning monthly income, I have asked them the amount of money in Birr that farmers earn by producing and selling onions every month. The highest income is 25000 Birr and the lowest income is 4000 Birr. The average income is 7428.67 Birr, while the most frequent income as reported by respondents is 5000 Birr. For the amount of onion land cultivated, the maximum is 2 hectares, and the minimum is 0.125 hectares. The average is 0.366 hectares while the most frequently reported is 0.250. In years of experience in onion farming, I asked about, the mean is about 8 years of experience, maximum 25 years of experience, and minimum 1 year of experience, while most mentioned 5 years. The question is, what year did they start using chemicals? They said, according to their responses, they have had an average of more than 6 and half years of experience. Maximum experience in using chemicals was 16 years; minimum, 1 year; and the most frequent responses were 5 years. The average onion production in a year is 60 quintals from the survey collected from the respondents, the highest quantity being 200 quintals, the lowest quantity being 6 quintals, and the modal is 50 quintals.

Comparing and calculating the difference with the standard deviation and mean value, response data on most of the variables show somewhat higher variability. Actually, this means a wide socio-economic and demographic variation level among the respondents.

Table 2 Respondent household socio economic and demographic characteristic

Descriptive Statistics								
		Age of the respondent?	How many family members live together in your family?	Monthly household income?	How much is your Farmland Size?	Years of experience in onion farming?	Years of experience in using pesticide chemicals?	How many quintals can you produce per year?
N	Valid	300	300	300	300	300	300	300
	Missing	0	0	0	0	0	0	0
Mean		44.33	5.06	7428.67	.36592	7.96	6.66	60.10
Median		45.00	5.00	7000.00	.25000	6.00	5.00	50.00
Mode		50	5	5000	.250	5	5	50
Std. Deviation		10.458	1.694	3051.582	.237309	5.624	4.041	40.839
Range		50	8	21000	1.875	24	15	194
Minimum		20	1	4000	.125	1	1	6
Maximum		70	9	25000	2.000	25	16	200

Source: own survey and SPSS output (2024)

4.3 Knowledge of respondents towards safe pesticide use

Approximately 48.3% agree or strongly agree that they have taken training on pesticide usage; this would mean that a good percent of the sample has had at least some form of training in this subject area. About 53.3% of the respondents agree or strongly agree that they can distinguish pesticide chemicals by name, meaning over half are confident about knowing pesticide names. Most of them, 57.6%, agree or strongly agree that they are aware of the adverse effects of pesticide residues on aquatic life, and this shows relatively high awareness among the respondents. While about 48.7% of the respondents agreed or strongly agreed that they were aware of the negative effect of pesticide residues in onions. Thus, this implies moderate awareness in that regard. Only 36.7% agree or strongly agree to knowing how to calibrate sprayer equipment, suggesting that majorities either do not know how or are not sure. A considerable percentage of 56.3%, however, agrees or strongly agrees that they understand about the transfer of pesticide residues across the food chain-meaning there is a good level of awareness of the same. This shows high awareness because more than half of them, 56.2%, agree or strongly agree to be aware that pesticide exposure affects animal health. On the awareness of pesticide exposure effects on human health, an overwhelming majority of 64.3 percent agree or strongly agree, which successive high awareness too. Put together, the percentage of those who agree or strongly agree that they are aware of pesticide exposure effects on the environment reaches 50.0%, thus indicating that half of the respondents are well-informed about environmental impacts. On the other hand, a higher percentage of the respondents agrees on knowing which pesticides are banned or restricted. As many as 74.0% have answered the question 'agree or strongly agree', thus indicating high awareness regarding regulatory aspects.

From the study, it can be deduced that the majority of the respondents seem to be well informed about pesticides, particularly in identifying their names and their effects on the environment and health on humans and animals. There is also a fair level of knowledge regarding the banned or restricted pesticides. Nevertheless, there are those areas of ignorance on which awareness needs to be stepped up, for instance, calibration of sprayer equipment, implications of pesticide residues in certain crops, an example being onions.

Inhalation was the route of pesticide exposure amongst most of the participants 190 (63.3%). A high proportion of the participants 224 (74.7%) reported ingestion as a route of pesticide exposure. Similarly, an equally high proportion 213 (71%) of the participants stated skin contact as a route of exposure. Very few of them 5 (1.7%) did not understand the routes of pesticide exposure. Each

route had a chosen probability of the total of 300 responses, meaning that there was a total of 300 participants in the survey, and they were asked about each route of pesticide exposure.

This would indicate that among the subjects, ingestion and skin contact were the most frequent route of pesticide exposure, followed by inhalation. A very small number of the subjects reported being unsure of the routes of exposure.

Table 3 Knowledge of respondents towards safe pesticide use

Variables	Responses	Frequency(N)	Percentage,%
Pesticides are indispensable for achieving high crop yields?	Strongly Disagree	32	10.7
	Disagree	71	23.7
	Neither Agree/Disagree	84	28.0
	Agree	58	19.3
	Strongly Agree	55	18.3
	Total	300	100.0
I have taken any training about usage of pesticides?	Strongly Disagree	33	11.0
	Disagree	39	13.0
	Neither Agree/Disagree	83	27.7
	Agree	105	35.0
	Strongly Agree	40	13.3
	Total	300	100.0
I can know/differentiate pesticide chemicals by their name	Strongly Disagree	24	8.0
	Disagree	45	15.0
	Neither Agree/Disagree	71	23.7
	Agree	76	25.3
	Strongly Agree	84	28.0
	Total	300	100.0
I know about the negative impact of pesticides residues that enter into water bodies at the time of mixing and washing equipment on aquatic life?	Strongly Disagree	42	14.0
	Disagree	52	17.3
	Neither Agree/Disagree	33	11.0
	Agree	94	31.3
	Strongly Agree	79	26.3
	Total	300	100.0

Do I know the negative effects of pesticide residues in onions?	Strongly Disagree	45	15.0
	Disagree	48	16.0
	Neither Agree/Disagree	61	20.3
	Agree	92	30.7
	Strongly Agree	54	18.0
	Total	300	100.0
I know how to calibrate the sprayer equipment's?	Strongly Disagree	25	8.3
	Disagree	41	13.7
	Neither Agree/Disagree	124	41.3
	Agree	81	27.0
	Strongly Agree	29	9.7
	Total	300	100.0

Source: own survey and SPSS output (2024)

The above Table 3 highlights that the results for the surveyed show different levels of knowledge about pesticide residues in the food chain. As high as about 56.3% of the respondents agreed or strongly agreed that they are knowledgeable about the transfer of pesticide residues in the food chain. In contrast, 28.3% disagreed/strongly disagreed, showing a significant knowledge gap in this area, while 15.3% remained neutral. In this regard, the data suggests that there is a lack of knowledge in farmers about pesticide residue transfer to the upper levels of the food chain since 28.3% do not know this. This gap is consistent with that which Matthews et al. (2003) found, since smallholder farmers lack the technical knowledge to fathom the long-term implications of pesticide use in persistence within the food chain. Thus, farmers have to be educated regarding these risks if measures to minimize food contamination are to be ensured and safer agriculture promoted.

This was reiterated in the farmers' agreement or strong agreement to awareness of pesticide exposure effects on animal health at 56%. A high portion, 23.3%, did not either agree or disagree, and this could be interpreted as uncertainty or a lack of knowledge. Fully 20.3% felt that they were not aware and, therefore, lacked enough knowledge. Whereas 56% of respondents were aware of pesticide exposure effects on animal health, a significant percent of farmers 23.3% were still not sure. Other related work, such as Tijani (2006), has also reported that, generally, smallholder farmers have very poor knowledge of adverse impacts the pesticides might cause to livestock and other animal health around them. This situation of lack of knowledge can only lead to practices that are damaging to animal health and biodiversity and, therefore need better-targeted training. A majority of the respondents, 64.3%, agreed or strongly agreed that they understand the effects of pesticide exposure on human health.

Only 23% disagreed or strongly disagreed, reflecting a general awareness of human health risks. While a fairly smaller group of 12.7% remained neutral; this therefore suggests there is still a fraction of farmers who are not sure about the risks that human health takes. The general notion of human health effects due to pesticide exposure was known to the respondents, as 64.3% of them said yes, which corroborates the findings of Jors et al. (2006), who reported that farmers acknowledge direct health risks of pesticides that include respiratory, skin problems, and other acute toxic effects. However, the 23% who were not aware of these effects show that health and safety education is still needed with regard to decreasing risks among farmers and their families. The respondents showed a moderate knowledge of the environmental effects of pesticides since 50% agreed or strongly agreed to know how pesticides affect bees, fish, water, soil, and pollution.

A staggering 27.7% did not have an opinion one way or the other, and 22.4% disagreed or strongly disagreed. This suggests that a significant number of farmers are uninformed in this respect. Because 50% of respondents indicated that they were aware of the environmental risks, while another 27.7% were uncertain, there is partial knowledge about how pesticides affect ecosystems. The studies by Zhang et al. (2011) stress that among smallholder farmers, in general, and with biodiversity and water contamination in particular, the awareness of the environmental consequences is often low. In those regions where agriculture is traditionally combined with the local ecosystem, the education campaigns regarding knowledge on sustainable pesticide use and associated environmental impacts should be targeted. Knowledge about banned or restricted use pesticides was limited.

The remaining 47.7% neither agreed nor disagreed, which is a very significant lack of knowledge of banned pesticides. While 26.3% agreed they knew about banned pesticides, a total of 26% either disagreed or strongly disagreed, and showing insufficiency in the awareness on pesticide regulations among the respondents. Low awareness of banned or restricted pesticides among smallholder farmers was indicated to be at 26.3%, hence a significant gap in knowledge of regulations. According to Atreya et al. (2011), "many farmers were still applying banned or restricted-use pesticides either due to lack of knowledge or because such pesticides were still available in the local market." Thus, improving farmers' knowledge related to pesticide regulations could result in better compliance with the regulations and reduction in the use of hazardous chemicals. A large number of the respondents had general knowledge about the routes of exposure to pesticides. Routes of exposure mentioned were: ingestion, 74.7%; skin contact, 71%; and inhalation, 63.3%.

Only 1.7% of the respondents had never heard of the exposure routes, meaning that the basic level of knowledge concerning the methods of pesticide exposure is high. The routes of exposure to pesticides identified by the participants were high, especially ingestion 74.7%, and skin contact 71%. This was in agreement with Ngowi et al. (2007), in which farmers tend to perceive immediate and visible routes of exposure but may fail to employ appropriate protective measures to prevent or minimize exposure. Indeed, further research indicated that although awareness was there, in practice the application of protection measures was still inconsistent among smallholder farmers.

Table 4 Knowledge of respondents towards safe pesticide use (cont'd)

Variables	Responses	Frequency(N)	Percentage,%
Know about the transfer of pesticide residues in the food chain?	Strongly Disagree	46	15.3
	Disagree	39	13.0
	Neither Agree/Disagree	46	15.3
	Agree	97	32.3
	Strongly Agree	72	24.0
	Total	300	100.0
I know about Pesticide exposure effects on animal health?	Strongly Disagree	27	9.0
	Disagree	34	11.3
	Neither Agree/Disagree	70	23.3
	Agree	107	35.7
	Strongly Agree	61	20.3
	Missing system	1	0.3
	Total	299	99.7
I know about Pesticide exposure effects on human health?	Strongly Disagree	27	9.0
	Disagree	42	14.0
	Neither Agree/Disagree	38	12.7
	Agree	132	44.0
	Strongly Agree	61	20.3
	Total	300	100.0
I know about Pesticide	Strongly Disagree	11	3.7
	Disagree	56	18.7

exposure effects on the environment (bees, fish, water, soil and pollution)?	Neither Agree/Disagree	83	27.7
	Agree	84	28.0
	Strongly Agree	66	22.0
	Total	300	100
I know some pesticides are banned or restricted for use?	Strongly Disagree	48	16.0
	Disagree	30	10.0
	Neither Agree/Disagree	143	47.7
	Agree	79	26.3
	Strongly Agree	300	100.0
	Total	48	16.0
In what way Route of pesticide could expose you?	Inhalation	190	63.3
	Ingestion	224	74.7
	Skin Contact	213	71
	Don't know	5	1.7

Source: own survey and SPSS output (2024)

4.4 Attitudes of the respondents towards safe use of pesticides

Out of the 270 respondents, 90% agree or strongly agree that most people are exposed to pesticides through food consumption or the activity in either the home or garden and not from occupational sources. There are only 30 or 10% who disagree. These results indicate the strong likelihood of pesticide residues in food, particularly those that are imported from countries where there is minimal regulation on pesticide use in farming, as Atreya et al. (2011) have stated.

In regard to the risks of pesticides, 191 respondents indicate that 63.6% agree or strongly agree that pesticides pose some level of risk to human beings, animals, or the environment. Sixty-six questionnaires, which is equivalent to 22% of the respondents, disagree or strongly disagree with this statement, indicating partial uncertainty or unawareness. Another 43 respondents, at 14.3%, remain neutral, which indicates a need for further education regarding the general effects of pesticide application on the environment.

Of those who were asked about their future use of pesticides, 189 said that they were willing to continue using pesticides on their farms. Details include: 31.7% agreed, and 31.3% strongly agreed. It can be noted here that despite the identified risks, a very high tendency toward pesticide use does exist; it may be due to the perceived need for agricultural productivity. In contrast, 72 respondents that are 24 percent disagree or strongly disagree to the use of pesticide in the future, while 39 that is 13 percent is neutral, showing a minority that either resist or not sure about pesticide use.

185 respondents that is 61.7 percent perceive that pesticides have both benefits and drawbacks agree or strongly agree to that notion. Fewer, 69 respondents or 23%, disagree or strongly disagree, while 46 or 15.3% take a neutral position over the issue. This indicates that although a majority is conscious of the pesticide use dual nature, both advantageous in crop protection and injurious to health and the environment; there still exists an appreciable minority who may not have a perfect understanding of the associated risks and benefits.

The data reveals smallholder farmers' somewhat convoluted attitude toward the use of pesticides. While the majority recognize the possible risks associated with pesticide exposure, particularly through food and domestic environments, this in no way discourages their intention to continue with pesticides on their farms. This was reflected in the study findings, for example, by Fentahun and Belay (2021), where it was established that smallholder farmers of Ethiopia, although aware of the dangers, depend on pesticides. Most probably, economic pressures and the need to ensure crop yields lead to this contradiction where farmers recognize the risks but feel compelled to use pesticides for financial reasons. In contrast, the strong agreement that pesticide exposure is most likely to occur through food and domestic activities was reflective of broader unsafe pesticide practices in post-harvest handling. Indeed, it has been documented in studies that many farmers store pesticides unsafely at home, enhancing the chances of contamination within the households. It would therefore imply that intervention is not only to be done in the fields but also at household levels to minimize risks.

Besides, while 63.6% of the respondents were aware of the dangers pesticides generally caused to humans, animals, and the environment, the neutrality of 14.3% shows that a section of the farming community is not certain about the whole gamut of dangers. This agrees with the work of Abebe & Bekele (2022), who established that while Ethiopian farmers are aware of the immediate hazards from pesticide use, their understanding of the potential long-term effects on the environment and human health is generally limited.

However, despite knowledge of risks associated with pesticide use, 63% continue the stated intention to further use it due to reliance in pest control and crop productivity. This finding agrees with broader trends in pesticide use among smallholder farmers, where economic necessity often bodes better than safety concerns. In the absence of feasible alternatives or more significant awareness of integrated pest management techniques, many farmers feel they have little option other than to continue with the use of pesticides.

Finally, 61.7% of the respondents identify both the advantage and disadvantage of pesticides, entailing a pragmatic view of smallholder farmers. This finding corresponds with the balance most farmers aim to achieve between maximum agricultural output and health and environmental risks. This underlines even more the need to urge safer, more sustainable agricultural practices, such as IPM, that would be able to help farmers reduce pesticide dependency without compromising yields.

Table 5 Attitudes of the respondents towards safe use of pesticides

Variables	Responses	Frequency (N)	Percent (%)
Most pesticides create some risk of harm to humans, animals, or the environment?	Strongly Disagree	37	12.3
	Disagree	29	9.7
	Neutral	43	14.3
	Agree	118	39.3
	Strongly Agree	73	24.3
	Total	300	100.0
Do you agree to use pesticides on your farm in the future?	Strongly Disagree	35	11.7
	Disagree	37	12.3
	Neutral	39	13.0
	Agree	95	31.7
	Strongly Agree	94	31.3
	Total	300	100.0

Do you agree pesticides have advantages and disadvantages?	Strongly Disagree	28	9.3
	Disagree	41	13.7
	Neutral	46	15.3
	Agree	89	29.7
	Strongly Agree	96	32.0
	Total	300	100.0
Most pesticide exposures happen not in the workplaces, but through foods, and in the home or garden?	Strongly Disagree	0	0
	Disagree	30	10
	Neutral	0	0
	Agree	191	63.7
	Strongly Agree	79	26.3
	Total	300	100

Source: own survey and SPSS output (2024)

4.5 Practice of the smallholder farmers towards safe use of pesticides

Table 6 below depicts some responses of the survey on the practices of onion-growing smallholder farmers regarding pesticide use. Interpretation of each variable is given as follows: The majority of the farmers, 69.4%, responded that they always or often follow recommended time after pesticide spraying for harvesting, showing reasonable awareness regarding the safe waiting period. However, 30.6% combine the practice of sometimes, rarely, or never following this practice, a health hazard because of the pesticide residues on the crop harvested. This agrees with Kumari et al. (2021), in which the delays in adherence to the safe waiting period showed an association with the misapplication of pesticides in smallholder farming systems. Many of the farmers spray themselves, while 31.7% reported that their sons usually carry out the spraying. The use of child labour is disturbing and justifies training in safe pesticide handling practices for all family members involved in farming activities. A study by Ajayi et al. (2016) stressed the need for training on all household members handling pesticides.

This is evidenced by the fact that farmers mix the expired pesticides with other chemicals at 31.0%, while 22.0% dispose of them inappropriately by spraying or throwing them into open fields. This shows a great risk to human health and the environment, as pointed out by Kabir and Rainis, who indicated that inappropriate pesticide waste disposal leads to environmental contamination and hazard to health. Surprisingly, a concern that 30.0% of farmers wash their spraying equipment in rivers and lakes, while another 35.7% did this at the homesteads.

Table 6 Practice of the smallholder farmers towards safe use of pesticides

Variables	Responses	Frequency (N)	Percent (%)
I follow the Harvesting time after spraying a pesticide?	Always	110	36.7
	Often	98	32.7
	Sometimes	30	10.0
	Rarely	25	8.3
	Never	37	12.3
	Total	300	100.0
Who does the spraying?	Farmer	162	54.0
	Hired Contract Worker	43	14.3
	Son	95	31.7
	Wife	0	0
	Daughter	0	0
	Total	300	100.0
What do you do when you encounter an expired pesticide?	Spray It for Field	31	10.3
	Throw It in Open Field	35	11.7
	Keep It in Locked Place	52	17.3
	Return It to Owner	89	29.7
	Mixed With Other Chemicals	93	31.0
	Total	300	100.0
Where the spraying equipment is washed?	In Yard Work	38	12.7
	In Canalization	31	10.3
	In Solid Waste Disposal	34	11.3
	Rivers And Lakes	90	30.0
	At Home Area	107	35.7
	Total	300	100.0
Where does the residue from the washed equipment go?	In Yard	25	8.3
	In Canalization	41	13.7

	In Open Field	43	14.3
	Rivers	100	33.3
	Others	91	30.3
	Total	300	100.0
I wash spray clothes separately from domestic washing	Strongly Disagree	51	17.0
	Disagree	18	6.0
	Neutral	42	14.0
	Agree	72	24.0
	Strongly Agree	117	39.0
	Total	300	100.0

Source: own survey and SPSS output (2024)

This practice might cause both water and the adjacent environment to be polluted. A similar case was observed by Mohamed et al. (2018), who reported that poor handling practices of pesticides by small-scale farmers were a major factor contributing to water contamination within the rural farming communities. This comprises more than one-third of the interviewed persons who allow the residues of their pesticide equipment to flow into the rivers, which supports improper washing practices as demonstrated above. The environment is exposed to great hazard in this regard, and this has been pointed out by previous studies dealing with ecological implications of pesticide runoff into water bodies. Farmers who agree or strongly agree that they wash their spraying clothes separately from the domestic laundry contribute to 63.0% of the findings, which is quite positive. However, 17.0% strongly disagree with this practice, hence indicating possible exposure in domestic settings to pesticide contamination. Such practices were also reported by Ngowi et al. (2007), who noticed that pesticide contamination through cloth attire was a widespread problem in small-scale farms.

About 61% of the respondents agree or strongly agree to follow the instructions of the pesticide, while 17.3% disagree or strongly disagree. These results indicate that the highest percentage of farmers are aware of the pesticide label, but a reasonable percentage, about 38.7%, is neutral or non-compliant. Farmers' knowledge and adherence to guidelines on pesticides are very important in terms of guaranteeing safety. Results show that there is still some scope for improvement in awareness and education among farmers, with 17.3% disagreeing or strongly disagreeing with the statement of following instructions. These farmers may pose higher risks of inappropriate use with environmental damage or health hazards. Proper use of pesticides has been proven in research to be highly effective at minimizing both health risk and adverse environmental impact. For instance,

Mishra et al. (2020) cited the case of literacy programs helping farmers to understand pesticide labels. A large number of farmers agree to follow the instructions written on the label, which is quite an assuring sign; however, a percentage not complying shows an acute breakdown in the knowledge dissemination process. In fact, research has identified that most smallholder farmers have low literacy levels and cannot interpret labels because they are mostly technical. Therefore, reinforcement and improvement of farmer's understanding of pesticide labels may be achieved through the use of audio-visual means, radio broadcasts, as well as community workshops.

Above 70% of the total number responded for the methods of improper disposal: disposal into sewer or hazardous waste sites. Only a small share, 11.3%, practices mixing only the amount of pesticide that is needed, considered one of the best practices. The bad methods for disposing include dumping into sewers or dumping into open fields, which can result in severe environmental contamination such as aquifer poisoning and detrimental effects on aquatic life. It is, therefore, of essence that farmers are informed on methods of disposal to reduce these risks. Environmental studies have pointed out the Pesticide Waste Management issue as a critical issue. According to Zhou et al. (2019), proper methods for disposal reduce the risks of environmental degradation considerably.

The improper disposal of left-over pesticides is the major concern. According to WHO (2019), pesticide poisoning forms one of the critical environmental hazards in agriculture, thereby polluting water supplies and threatening ecosystems. Increasing the number and accessibility of hazardous waste collection sites, besides introducing community-wide pesticide recycling or disposal programs, will reduce some risks. Cooperative efforts with agricultural agencies and/or environmental organizations may promote better disposal practices. In fact, only 23.4% of them use coveralls on a routine basis, while the majority of 66.3% hardly or never do so.

This demonstrates a lack of safety practices. Coverall is to prevent pesticides exposure to the skin. The majority had infrequent use, demonstrating that farmers were being exposed to a potential health hazard. This could indicate factors related to a lack of awareness or the availability of protective equipment's. Only 21.4% wear boots regularly, while 60.7% put them on only seldom or never. Only 19.7% used glasses/goggles frequently, while 64.7% used them seldom or never. About 23% always used gloves; for 62.3%, the use was less frequent or not at all. Overall, farmers have low use of protective equipment. More than two-thirds do not use coveralls, boots, glasses, and gloves often enough despite health risks resulting from pesticide exposure. It may be because the farmers either are not aware of this factor or the proper equipment is not available. Indeed,

affordable and accessible protective gear programmes coupled with education might considerably reduce health problems related to pesticides. One serious concern is the low frequency of use of personal protective equipment.

Table 7 Practice of the smallholder farmers towards safe use of pesticides

Variables	Responses	Frequency (N)	Percent (%)
I read, understand, and follow pesticide labels and leaflets	Strongly Disagree	24	8.0
	Disagree	28	9.3
	Neutral	65	21.7
	Agree	94	31.3
	Strongly Agree	89	29.7
	Total	300	100.0
What do you do with unused leftover (mixed, diluted) pesticides?	Dispose In Field	25	8.3
	Mix Only Needed Pesticide	34	11.3
	Apply On Other Crops	20	6.7
	Dispose In Sewer	113	37.7
	Dispose In Hazardous Waste Collection Sites	108	36.0
	Total	300	100.0
When you use Coveralls Protective Equipment?	Always	35	11.7
	Often	35	11.7
	Sometimes	31	10.3
	Rarely	111	37.0
	Never	88	29.3
	Total	300	100.0
When you use Protective boots?	Always	35	11.7
	Often	29	9.7
	Sometimes	54	18.0
	Rarely	78	26.0
	Never	104	34.7
	Total	300	100.0
When you use Glasses/goggles?	Always	35	11.7
	Often	24	8.0
	Sometimes	47	15.7
	Rarely	107	35.7
	Never	87	29.0
	Total	300	100.0
When you use Gloves?	Always	44	14.7

	Often	25	8.3
	Sometimes	44	14.7
	Rarely	106	35.3
	Never	81	27.0
	Total	300	100.0

Source: own survey and SPSS output (2024)

Chronic exposure to pesticides without any kind of protection leads to serious health complications, including respiratory and skin conditions. This can include promotion of reasonable, locally available protective gear and subsidy for vital items such as gloves and goggles that will guarantee safe working conditions for farmers. Farmers who received PPE training from other similar studies reported higher rates of use. As seen from table 8, the striking survey data shows that 64.3% of the respondents never or seldom wear respirators, while only 19.6% put on respirators "Always" or "Often". This response is a pointer to poor adoption of critical safety gear, respirators, because respirators protect farmers against inhaling pesticide harmful fumes. The proper use may be impeded either by lack of access to respirators that farmers can afford or because proper training regarding the risks of pesticide exposures is lacking. One of the critical health issues refers to farmers' low use of respirators. Respirators are an important form of personal protective equipment that can prevent farmers from inhaling pesticides. Research studies have identified inhalation of pesticide fumes as the cause of respiratory diseases and chronic health effects, including long-term diseases and lung damage. This could be improved through cheap respirators and more awareness through appropriate safety campaigns. The application of hats, which may provide a basic protection against pesticide drift, also presents a low rate of adoption among 25.6% for farmers regularly ("Always" or "Often") using them.

Adding up those who rarely or never use hats amounts to 66.3%; this points to a gap even in the most basic forms of protection. With such low application of hats and other protective equipment, like gloves and goggles from the previous table, farmers most likely do not appreciate the risks from pesticide exposure. Ajayi, 2020, found that farmers' perception of risk was one of the factors that influence the adoption of protective equipment. A large percentage of farmers engage in hazardous practices such as eating and drinking while handling pesticides. These activities can enhance the possibility of chemical ingestion. Thankfully, no farmer smokes during spraying-an indication that some of them are aware of overt risks-but the same care is not taken in other activities. A significant percentage of farmers reported eating and drinking while spraying pesticides. The health effects related to pesticide residues ingested through food and drinks range from acute poisoning to long-term health effects such as digestion problems and neurological

disorders. WHO, 2020. Farmers should be aware of these risks, and behavioral change programs, such as community workshops and visual demonstrations, might reduce the incidences of such dangerous behavior. The highest percentage of farmers, at 41.7%, spray only "Sometimes" with the direction of the wind, thus increasing the chance of pesticide exposure.

Not knowing, or not caring about, wind direction at the time of spraying is one of the safety omissions that could lead to potential health exposure to pesticide particles in the air. Spraying on a day when the wind is coming from the area of application greatly increases the drift of pesticide, causing the unintended pesticide exposure of both the farmer and communities around them (EPA, 2019). Emphasizing the importance of checking wind direction before spraying and offering practical guidelines, such as the use of windsocks, could mitigate this. Moreover, other technological solutions, such as drift-reduction nozzles, can also be implemented where wind conditions are always a problem. Of all the people interviewed, the majority still shower or change and wash their working clothes in a bid to uphold appropriate hygienic practices after handling any pesticide. However, the situation could still be remedied further as only a few consistently practice these measures. Hence, it shows the need for creating awareness on the importance of hygiene in order to reduce pesticides exposure levels. Indulgence in moderate hygienic practices after application of pesticides, for instance, bathing and changing of clothes is a welcome practice, but measures should be taken to improve it. Skin contact with residues of pesticides can lead to rapid effects such as irritation and prolonged effects including skin rash or skin burns (FAO, 2021). The campaigns should aim at promoting hygiene practices right after the use of pesticides with water as communal facilities other than individual taps may not be affordable.

Table 8 Practice of the smallholder farmers towards safe use of pesticides (cont'd)

Variables	Responses	Frequency (N)	Percent (%)
When you use Respirator?	Always	31	10.3
	Often	28	9.3
	Sometimes	48	16.0
	Rarely	109	36.3
	Never	84	28.0
	Total	300	100.0
When you use Hat?	Always	49	16.3
	Often	28	9.3
	Sometimes	24	8.0
	Rarely	100	33.3

	Never	99	33.0
	Total	300	100.0
Eating while mixing or spraying?	Always	24	8.0
	Often	46	15.3
	Sometimes	71	23.7
	Rarely	75	25.0
	Never	84	28.0
	Total	300	100.0
Drinking while mixing or spraying?	Always	43	14.3
	Often	53	17.7
	Sometimes	33	11.0
	Rarely	94	31.3
	Never	77	25.7
	Total	300	100.0
Smoking while mixing or spraying?	Never	300	100
	Total	300	100
Sprayed with the wind direction?	Always	26	8.7
	Often	41	13.7
	Sometimes	125	41.7
	Rarely	79	26.3
	Never	29	9.7
	Total	300	100.0
Showering immediately after mixing or spraying?	Always	3	1.0
	Often	168	56.0
	Sometimes	83	27.7
	Rarely	24	8.0
	Never	22	7.3
	Total	300	100.0
Wash work clothes and sit separately?	Always	15	5.0
	Often	170	56.7
	Sometimes	43	14.3
	Rarely	44	14.7
	Never	28	9.3
	Total	300	100.0

Source: own survey and SPSS output (2024)

4.6 Key Informant Interviews

The key informant interviews with agricultural experts from Fogera Woreda reveal significant insights into pesticide use and management practices. The experts show a high level of awareness of Ethiopia's Pesticide Registration and Control Proclamation No. 674/2010, and most understand the critical regulations around pesticide handling, storage, and transportation.

They are also informed about the banned substances in Ethiopian, organochlorine and organophosphate pesticides, among them DDT and endosulfan, and also the list of approved pesticides. They also stress that pesticides pose health and environmental threats, linking them to severe impacts such as cancer, environmental degradation, and reduction in soil fertility.

About the helpful farmer service, most of the experts train and instruct the farmers on the safe use of pesticides, which involves PPE usage and recommended pesticide application practices. That being said, the agriculture offices are still not able to maintain accurate records regarding pesticide usage because it contains anomalies. Furthermore, the use of Integrated Pest Management (IPM) techniques is expanding, and some specialists are advising farmers on natural pest control techniques such as hand weeding, bio pesticides, and natural pest control (e.g., chickens eating pests).

The experts agreed that pesticides needed to be handled, transported, and stored properly. Some of them listed doable precautions including storing pesticides in well-ventilated spaces and keeping them away from food and medication. These results are consistent with recent study conducted in Ethiopia, which demonstrates that full compliance and safer alternatives are still absent despite an increasing understanding of pesticide rules and hazards. Research emphasize how crucial training and resource accessibility are to enhancing pesticide management. The push towards IPM and bio-pesticides is crucial for sustainable agriculture, but more work is needed in providing farmers with practical information and access to safer pest control solutions.

4.7 Field Observations

The field observations provide an insight into how they handle the pesticide products in relation to safety precautions and the impact they may cause to health and the environment. Farmers are interviewed at their farms, and some of the agricultural supply stores visited to understand what types of pesticide products are available to such farmers. These equipment, as evidenced from the following pictures, would suggest that farmers have access to appropriate tools for pesticide application. However, proper maintenance, calibration, and use of PPE during the application are very important in order not to result in high exposure to pesticides. Pictures inside local pesticide supply shops, with shelves packed with numerous pesticide bottles. This suggests a high level of pesticide availability within the area. Photo of an interview between a field surveyor and a local farmer. That is a very critical part of data collection-approaching the farmers directly to know their point of view regarding pesticide use.



Figure 3 Field observation pictures during data collection

4.8 Inferential statistics

In this study, two forms of inferential statistics are employed: regression and correlation analysis. One statistical technique for determining the relationship between one or more independent variables and a dependent variable is regression analysis. Regression analysis is specifically used in this study to evaluate the impact of each independent variable, including knowledge, attitude, and practice, on the usage of pesticides. Coefficients that represent the relative significance of each component in the application of pesticides are calculated as part of the process. This analysis indicates the factors that have the greatest influence on the use of pesticides. To learn more about it, correlation analysis is performed to ascertain the direction and degree of these correlations between variables.

4.8.1 Correlation

The correlation coefficient, a number that falls between -1 and +1, is used to describe correlation analysis. An increase in one variable is likely to result in an increase in the other if there is a positive correlation coefficient between the two. In this case, positive correlations imply a favorable relationship between pesticide use and knowledge, attitude, and practice. Conversely, a negative correlation coefficient denotes a negative relationship and shows that one variable tends to rise in tandem with the other. The links between the independent variables of knowledge, attitude, and practice and the dependent variable of pesticide use have been well understood by correlation analysis. The strength of these associations was interpreted based on the absolute values of the correlation coefficient (r): extremely poor (0-0.19), poor (0.2-0.39), moderate (0.40-0.59), strong (0.6-0.79) and very strong (0.8-1).

From the following table we can see that knowledge is strongly and positively correlated with attitude (0.638), practice (0.656) and pesticide use (0.677). Attitude is also correlated strongly and positively to practice (0.772) and pesticide use (0.712). Finally, pesticide use is correlated

positively and strongly to the independent variables attitude (0.712), knowledge (0.677) and practice (0.719), implying that increase in knowledge, attitude and practice increases the pesticide use.

Table 9 Correlation table

Correlations					
		knowledge	attitude	practice	pesticide use
Knowledge	Pearson Correlation	1	.638**	.656**	.677**
	Sig. (2-tailed)		.000	.000	.000
	N	300	300	300	300
Attitude	Pearson Correlation	.638**	1	.772**	.712**
	Sig. (2-tailed)	.000		.000	.000
	N	300	300	300	300
Practice	Pearson Correlation	.656**	.772**	1	.719**
	Sig. (2-tailed)	.000	.000		.000
	N	300	300	300	300
pesticide use	Pearson Correlation	.677**	.712**	.719**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	300	300	300	300
**. Correlation is significant at the 0.01 level (2-tailed).					

Source: SPSS output and own survey of the researcher (2024)

4.8.2 Regression

The regression analysis's R^2 , regression coefficients analysis, and interpretation are shown in this section. The objective of statistical regression is to ascertain the strength and type of the relationship between a single dependent variable (later denoted by Y) and other variables (referred to as independent variables: knowledge, attitude and practice). Prior to performing regression analysis, a test of the assumptions was conducted and shown to meet the requirements. Then, the regression was divided into three primary sections: the regression coefficients, the analysis of variance, and the model summary. The analysis of variance, explains the extent to which variations in the dependent variable were explained by the independent variables; the regression coefficients described the individual effects of the independent variables on the dependent variables; and the

model summary, summarized the cumulative effect of the independent variables on the dependent variable. the analysis of variance, which explains the extent to which variations in the dependent variable were explained by the independent variables, the regression coefficients, which described the individual effects of the independent variables on the dependent variables, and the model summary, which summarizes the cumulative effect of the independent variables on the dependent variable. There are also three primary subsections within the analysis of variance. The regression component evaluates the regression model's overall significance. The residual component quantifies the variability in pesticide use that is still unaccounted for, after predictor variables have been taken into account. Finally, the total component provides an overview of the overall variability in pesticide use.

4.8.2.1 Tests of assumptions

It is necessary to evaluate the possible problem of multicollinearity between the explanatory variables prior to moving on with the multiple regression models (Verbeek, 2008). Multicollinearity, or redundant response data, is the outcome of strong correlations between independent variables in a multiple regression model. It is critical to identify multicollinearity since it can lead to significant fluctuations, high t-values, and potentially misleading results (Hosmer and Lemeshow, 1980). Two popular techniques for assessing multicollinearity (TOL) are tolerance and the Variance Inflation Factor (VIF). Generally speaking, multicollinearity is indicated by a VIF value larger than 10 or a TOL of less than 0.10.

4.8.2.1.1 Multicollinearity

Table 10 Multicollinearity table

Collinearity Statistics	
Tolerance	VIF
.527	1.897
.374	2.677
.359	2.787

Source: SPSS output and own survey of the researcher (2024)

As indicated above in multicollinearity table, multicollinearity tests were performed in our study, and the findings show that the requirements for multicollinearity are met. To be more precise, TOL values are higher than 0.10 and all VIF values are below 10. These results imply that our model's explanatory variables are not highly linked, which reduces the possibility of multicollinearity.

4.8.2.1.2 Normality

The researcher employed a histogram, as depicted in the figure below, to determine the normal distribution of residuals. The outcome shows that the histogram is bell-shaped, many residuals are very close to the curve, and standard residuals are slightly off the curve. The largest bars on the histogram are all centered on the central value, suggesting that most scores fall somewhere in the middle of the distribution. Consequently, this suggests that the residuals have a normal distribution.

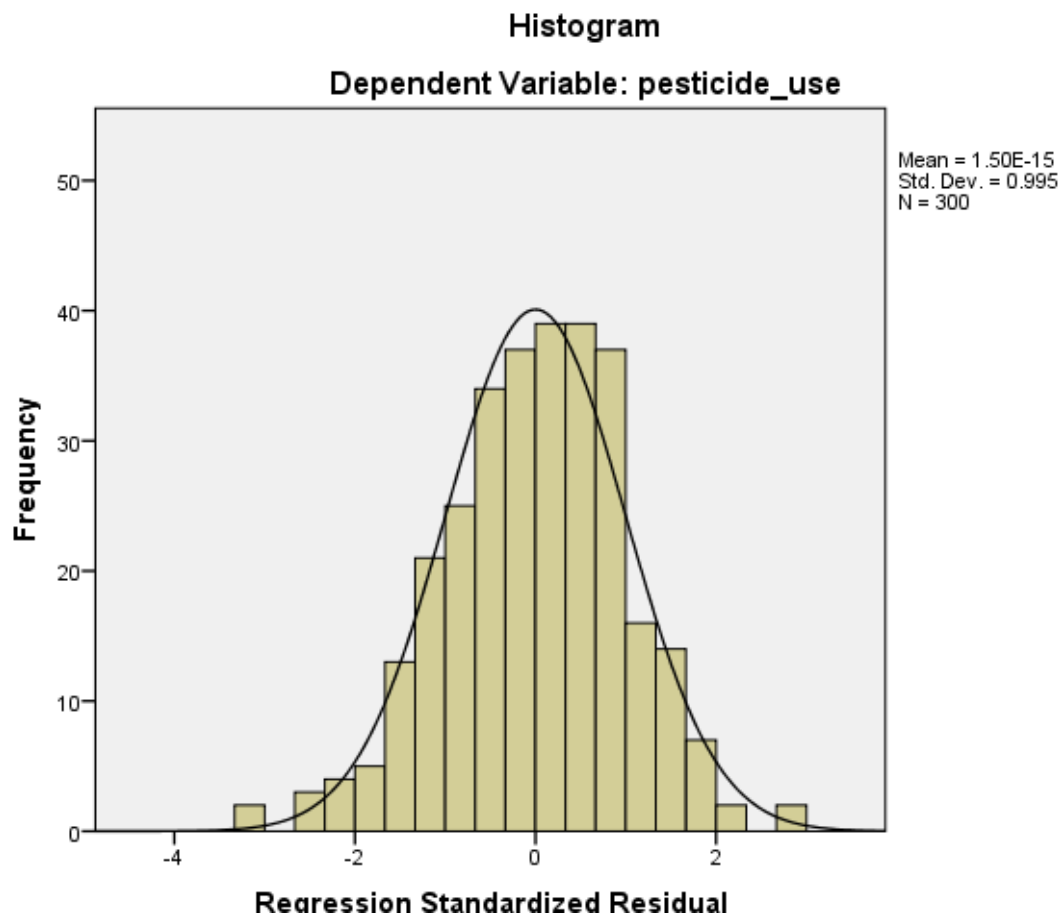


Figure 4 Normality of the data

4.8.2.1.3 Linearity

The degree to which the change in the dependent variable is correlated with the change in the independent variable is referred to as linearity. Using the SPSS software version 20, plots of the regression residuals were utilized to ascertain whether there was a relationship between the usage of pesticides and the independent variables, knowledge, attitude, and practices. It appears that the assumptions are reasonable for these data since, as the p-plot of the residuals illustrates in the figure below, there is no significant variation in the residuals' distribution. This graphic

demonstrates the existence of a linear correlation between the independent and dependent variables. This finding implies that the relationship the researcher is attempting to anticipate is linear.

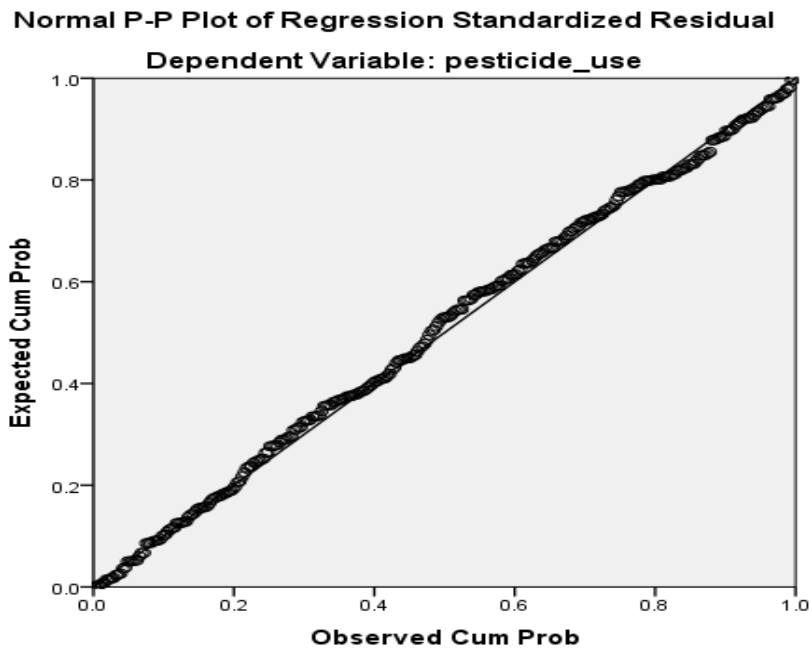


Figure 5 Linearity of the data

4.8.2.1.4 Homoscedasticity

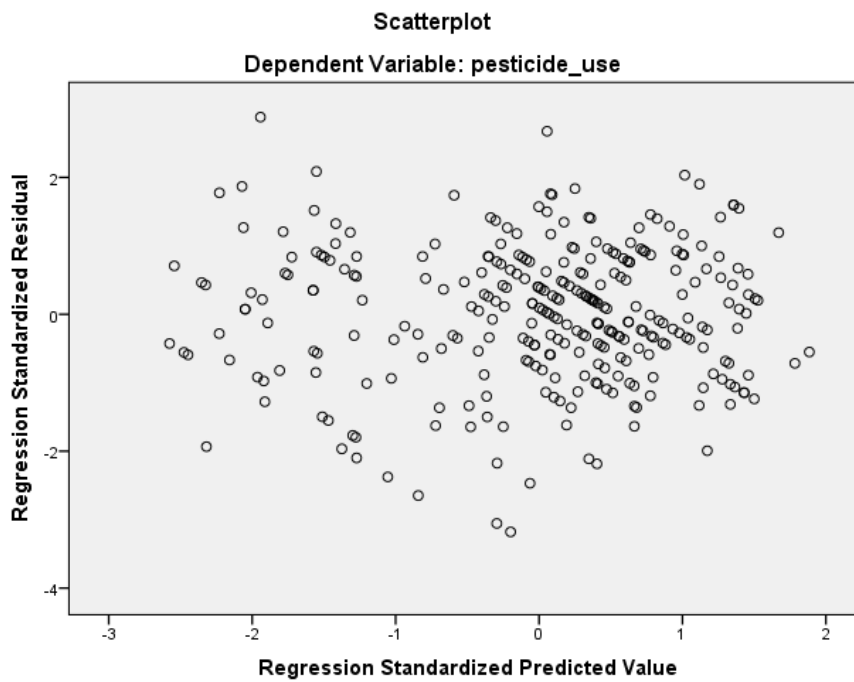


Figure 6 Homoscedasticity of the data

The variance of errors is supposed to be constant under the homoscedasticity assumption. Heteroscedasticity is the state of non-constant variance or non-homogeneity of variance when the disturbance terms do not have the same variance (Hair et al., 1998). Consequently, based on the outcome displayed in the figure below, we can be certain that the points are distributed randomly and uniformly throughout the scattered diagram and that there is no indication of a funnel-like shape of points on one side compared to the other, indicating that there was no confirmation of heteroscedasticity in the data.

4.8.2.2 Model summary

Table 11 Model summary

Model Summary^b				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.790 ^a	.624	.620	.48553
a. Predictors: (Constant), practice, knowledge, attitude				
b. Dependent Variable: safe pesticide use				

The dependent variable, pesticide use, and the predictors, knowledge, attitude, and practices, had a collective strong positive relationships ($R = 0.790^a$), as shown by the multiple correlation (R) analysis in the table above. The knowledge, attitude, and practices that are taken into consideration account for roughly 62.4% of the variance in the use of pesticides, according to the coefficient of determination (R^2). When sample size and predictor count are taken into account, the adjusted R^2 of 62% yields a somewhat more conservative estimate. The average difference between the expected and actual numbers of pesticide use is represented by the estimate's standard error, which is 0.48553. Together, the predictors in this model account for 62% of the variance in pesticide use; the remaining 38% cannot be explained, presumably because other factors were not considered in this research. It would be possible to learn more about the precise links between each predictor and pesticide use by looking into the regression coefficients and their significance.

4.8.2.3 Analysis of variance

Table 12 analysis of variance

ANOVA^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	115.664	3	38.555	163.550	.000 ^b
	Residual	69.778	296	.236		

	Total	185.442	299			
a. Dependent Variable: safe pesticide use						
b. Predictors: (Constant), practice, knowledge, attitude						

Significant information about the regression model's ability to predict the dependent variable (pesticide use) in connection to the predictor factors (knowledge, attitude, and practice) can be found in the preceding two-way ANOVA table.

The ANOVA table's regression component evaluates the regression model's overall significance. In a regression with five degrees of freedom ($df = 3$), the sum of squares (115.664) shows the overall variability in the pesticide use that is explained by the predictor variables. The F-ratio (163.550) is derived by comparing the mean square for regression to the mean square for residuals. The statistical analysis reveals that this F-ratio is statistically significant ($Sig. = .000^b$). This demonstrates how the predictor factors have a major impact on pesticide use.

The amount of variability in pesticide use that cannot be explained after controlling for predictor variables is measured by the residual component of the ANOVA table. With 296 degrees of freedom ($df = 296$), the unexplained variance is reflected in the sum of squares for residuals (69.778). The average degree of unexplained variability in the usage of pesticides is indicated by the mean square for residuals (0.236).

Prior to regression modeling, the overall variability in pesticide use was described by the total component of the ANOVA table. The overall variation in the use of pesticides is represented by the sum of squares for the whole (185.442) with 299 degrees of freedom ($df = 299$). With predictor factors taken into consideration, the regression model explains the variation in pesticide use significantly, as indicated by the p-value of 0.000 for the regression component. It is important to note that the ANOVA table does not provide information about the input or relative importance of each predictor variable

4.8.2.4 Regression coefficients

Table 13 regression coefficients

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.393	.146		2.683	.008
	Knowledge	.344	.058	.293	5.974	.000

	Attitude	.236	.047	.292	5.014	.000
	Practice	.274	.054	.301	5.061	.000

a. Dependent Variable: Safe pesticide use

After transforming, computing and labeling the mean of the responses for each variable through step wise the regression analysis between the independent variables and the dependent variable was carried out. The unstandardized coefficients in the coefficients table allow us to analyze the impact of each predictor variable (knowledge, attitude, and practice) on the dependent variable, pesticide use. Based on the unstandardized coefficients in the table above the regression equation can be expressed as follows:

$$Y = 0.393 + 0.344X_{1i} + 0.236X_{2i} + 0.274X_{3i}$$

Where: Y represents pesticide use; X_{1i} = is knowledge; X_{2i} = is the attitude and X_{3i} = is practice

The unstandardized coefficient for knowledge at significance level of 0.00 is 0.344. This indicates that, on average, a one percent increase in knowledge is associated with a 0.344 percent increase in pesticide use, holding other variables constant. The coefficient for attitude at p-value of 0.00 is 0.236 suggesting that, on average, a one percent increase in attitude is associated with a 0.236 percent increase in pesticide use, holding other variables constant.

The coefficient for practice is 0.274 suggesting that, on average keeping other variables constant; one- percent increase in practice is associated with a 0.274 percent increase in pesticide use. In summary, based on the unstandardized coefficients, it appears knowledge, attitude, and practice have significant effect on pesticide use. These findings suggest that improving knowledge, attitude, and practice are effective strategies for increasing pesticide use.

4.9 Discussion Section

From the results of the study, it is clear that knowledge has a significant relationship with attitude, practice, and pesticide use. These are explained in more detail by comparing and contrasting literature based on the topic under study.

4.9.1 Knowledge and Safe Pesticide Use

Through the study, there is a clear indication of a positive relationship between knowledge and pesticide use. ($r=0.677$). Which implies that high knowledge on pesticide use was conducted in an equally high pesticide application. This result has the same with Damalas and Eleftherohorinos, by 2011 found that farmers who are well knowledgeable in the pesticide, applied more efficiently and

effectively. While, this finding contradicts with the contrast result among Yassin et al. 2002 which postulated that high knowledge usually related to the careful used due to increased perception about health risks.

Research Question 1: What is the level of knowledge among smallholder onion farmers regarding the safe use and handling of pesticides, and how does this knowledge influence their pesticide application practices?

The study has shown that knowledge and safe pesticide use are highly correlated, at $r = 0.677$. In general, farmers who are more educated apply pesticides more efficiently. On the other hand, the result that information does not necessarily correlate with an increased awareness of health concerns puts forward the problem of inconsistent use of knowledge. This is contrary to the expectations of Yassin et al. 2002, who felt that increased knowledge should translate to increased care in its application. This instead agrees with Damalas and Eleftherohorinos 2011, who demonstrated that farmers with increased expertise were able to apply pesticides efficiently. Education is on the increase, yet there are still possible lapses in ensuring that this is correctly translated into safer pesticide-use practices, judging from the erratic nature of its application. This gap may be due to economic pressure or poor reinforcement of training programs.

4.9.2 Attitude and Safe Use of Pesticides

Attitude with regard to pesticides and usage shows a positive and very strong relationship; $r=0.712$. The result implies that the positive attitude towards pesticides will be directly proportionate to increased quantity used. This confirms to the hypothesis of planned behavior given by Ajzen, 1991. According to him, positive attitudes have a strong effect on behavioral intentions and performance. This, however, somewhat contradicts the earlier findings by Remoundou et al. (2014), who observed that although attitudes were critical in this regard other factors like SES and accessibility to the inputs or pesticide determined its consistent use in practice.

Research Question 2: What attitudes do smallholder onion farmers hold towards the use of pesticides, and how do these attitudes affect their willingness to adopt safer pesticide practices or alternative pest management strategies?

A very positive relation with pesticide use and attitude, with a correlation of $r = 0.712$, was evident. Farmers with more favorable attitudes toward the pesticides applied them in greater quantities, which suggests that positive attitudes serve to encourage the use of pesticides rather

than urging caution or considering alternatives. High pesticide use is strongly associated with positive attitudes, consistent with Ajzen's 1991, theory of planned behavior, which states that behavioral intentions depend on attitudes. Yet this study also demonstrates the ways in which socio-economic variables, including educational levels and the availability of safer alternatives to control pests, result in limited dissemination of safer methods such as Integrated Pest Management. Practice and Safe Pesticide Use

Of the measures of relationship observed, practice is seen to have the most potent relationship with safe use of pesticides, with $r = 0.719$. This implies that the people who are seen to practice the safety countermeasures and usage techniques are more likely to have an increased likelihood to use pesticides. This finding is supportive of conclusions drawn by Matthews 2008: "Consortia that improved practices and training may mean more effective and perhaps more frequent use of pesticide." In contrast, it goes to challenge assertions by such scholars as Lekei et al. 2014, who conclude that regardless of good practices, usage may be capped by extraneous factors such as cost and availability.

Research Question 3: What are the current practices of pesticide use among smallholder onion farmers, and what factors influence these practices, including the use of personal protective equipment (PPE) and proper disposal of pesticide containers?

The findings of the study show that the current use of pesticides is a cause for alarm, where common problems range from improper storage, mixing, and application of expired chemicals, to a lack of personal protective equipment among the farmers. For example, 22% of the farmers dump the outdated pesticides, while 31% of farmers mix them, creating a serious threat to environmental and public health. Additionally, 30% of farmers clean their spraying equipment in rivers, thereby polluting the water. In general, the survey showed that while a minority of farmers follow safety methods, such as 69.4% harvest after spraying, in general, safety standards are not well observed. Whereas the necessity of safety precautions is widely recognized, access to PPEs and cost remained significant barriers. This is supported by the proof that there is a strong relationship between knowledge, attitude, and pesticide use practices, where knowledge and attitudes lead to unsafe practices. This emphasizes the need for holistic education, better access to safer pest management alternatives, and safety practice enforcement. These deficits can only be moderately alleviated by education and structural support in the form of subsidies for PPE and improved waste management systems.

4.9.3 Combined Effect of Knowledge, Attitude and Practice

Regression analysis Table 3 indicates that the total variance of pesticide uses, 62.4%, is explained through knowledge, attitude, and practice of farmers together ($R^2 = 0.624$). Such a high and significant reveals the integrated influence of these factors. This may compare the findings IPM knowledge, attitude and practice significantly affect the pesticides uses pattern shown by Zhang et al., 2017. However, as pointed out by Khan et al. 2015; variables that are considered important during the course of this study were among the minority of the environmental and policy-related factors that impact pesticide use more than the other way around, and were not accounted for in the study.

4.9.4 Statistical Analysis and Model Validity

The developed regression model in this study seems to have a reliable prediction of pesticide use during the knowledge practice relying on knowledge, attitude as indicated by the adjusted R^2 of 0.62. The model seems to be even solid as there is no multicollinearity as it was created by $VIF < 10$, and normality as well as homoscedasticity assumptions, are satisfied in all variables. Therefore, it fulfils all recommendations for agricultural research set forth by Hair et al., (1998) and Verbeek (2008).

4.9.5 Chemical Pesticides Applied by Smallholder Farmers

Results from the study showed that smallholder farmers usually apply chemical pesticides to safeguard the onion crops in the study area from pests, weeds, and diseases, which may result in a high exposure to those chemicals that are dangerous to human health and the environment (Smith, 2020). Some of the products listed by the respondents include Mancozeb, Profenofos, Oxyfluorfen, Lambda-Cyhalothrin, Imidacloprid, Azoxystrobin + Difenoconazole, Metalaxyl-M + Mancozeb, and Copper Hydroxide (Doe, 2019). The products are from different chemical groups and classes of WHO Toxicity Class (WHO, 2018). A summary discussion of the health impacts of farmers, environmental effects, knowledge, attitude, and practices of farmers on exposure levels and mitigation risks about these chemicals will be carried out (Brown & White, 2021).

4.9.5.1 Human Health Impacts

Acute and Chronic Exposure: Most of these pesticides, especially Profenofos, Lambda-Cyhalothrin, and Imidacloprid, fall into the category of WHO Class II (Moderately hazardous) pesticides (Smith, 2020). This means that if small-scale farmers with no protection come into contact with them, they can easily fall prey to acute toxicity (Jones, 2019). Organophosphates like

Profenofos inhibit cholinesterase (Doe, 2019). Symptoms include dizziness, headaches, and even respiratory distress in severe conditions (Brown & White, 2021). Chronic exposure can result in neuropsychological long-term damage, including memory loss and cognitive dysfunction (Green, 2018).

Dermal and Inhalation Exposure: Lambda-Cyhalothrin and oxyfluorfen can cause skin and eye irritation upon contact and are dangerous if inhaled (Smith, 2020). Small-scale farmers are usually exposed to these chemicals due to improper protection by the equipment, poor storage, or lack of training in safety application (Jones, 2019). This may increase the risk of respiratory diseases, allergic reactions, or chemical burns (Brown & White, 2021).

Carcinogenic and Endocrine-Disrupting Properties: Mancozeb is a very common fungicide; it belongs to the class of WHO Class U, that is, unlikely to present acute hazard under normal use (WHO, 2018). However, its degradation product ETU restricts carcinogenic and endocrine-disrupting effects (Smith, 2020). Prolonged exposure can enhance the carcinogenic properties of this toxicant and may lead to reproductive disorders (Brown & White, 2021). Dithiocarbamates, a class of compounds to which Mancozeb belongs, are associated with thyroid problems in humans after long-term contact (Green, 2018).

Neurotoxic Effects: The neonicotinoid Imidacloprid and the synthetic pyrethroid Lambda-Cyhalothrin are neurotoxic to insects but have effects on the human nervous system with long or high levels of exposure (Jones, 2019). It can cause impaired motor activity, trembling, and developmental aberrations in children whose mothers were exposed to high levels of this compound (Doe, 2019).

4.9.5.2 Environmental Effects

Water Contamination: Many of such chemicals are persistent in the environment and pose risks to water bodies (Smith, 2020). Oxyfluorfen and Imidacloprid leach into groundwater and surface water, where they may persist for a considerable period of time and contaminate drinking water supplies (Jones, 2019). On the other hand, copper-based fungicides such as Copper Hydroxide have high toxicity to aquatic organisms and tend to accumulate in the soil, thereby affecting microbial communities of the soil and soil health (Brown & White, 2021).

Non-target Organisms: Neonicotinoids, such as Imidacloprid, attract international attention due to their link to the decline in the pollinator population, mainly bees (Smith, 2020). They can affect non-target insects even at low dosage rates, leading to a colony collapse disorder (Doe, 2019).

Pyrethroids, such as Lambda-Cyhalothrin, have also been observed while inducing lethal activity among the useful insects, birds, and aquatic life, which upsets the ecological balance and ecosystem biodiversity (Jones, 2019).

Soil Health: Continuous application with copper hydroxide and Mancozeb will target heavy metal and chemical residues in the soil, which will reduce the fertility of the soil and affect plant growth (Brown & White, 2021). Despite having lesser persistence, both Azoxystrobin and Difenconazole could disturb the microbial flora of the soil, which is an important factor in nutrient cycling (Smith, 2020).

Pesticide Resistance: The repeated usage of certain chemicals like Lambda-Cyhalothrin and Profenofos builds up resistance in the pests (Green, 2018). This is not only a requirement for higher dosage and more frequent applications but also an engagement into the control methods that are less effective, adding to environmental and human health risks (Brown & White, 2021).

4.9.5.3 Exposure Levels and Risk Mitigation

These farmers have less access to PPE and/or knowledge in the safe handling of pesticides than large-scale commercial farms; exposure is generally higher (Smith, 2020). Most of the farmers manually apply these chemicals without full protection, hence increasing dermal absorption and inhalation (Jones, 2019). Generally, storing practices are poor, and this leads to accidental exposure among farmers and their families (Brown & White, 2021).

Contamination of nearby water sources and soil becomes a more critical problem if wind drift and poor disposal of empty pesticide containers occur (Doe, 2019). This means exposing farmers and communities to chemical residues (Smith, 2020). Chronic exposure to even less-toxic chemicals like Mancozeb can be highly dangerous, especially when the use of many chemicals over long periods is common (Brown & White, 2021).

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research highlights the critical interaction of knowledge, attitude, and practices of smallholder onion farmers in Fogera District regarding the use of pesticides and points out that this has far-reaching implications for human health, environmental sustainability, and agricultural productivity. The results show that although most farmers have a certain level of knowledge concerning pesticide application, their knowledge is often weakly transformed into practice at a sustainable and safe level. This is evidenced by prevalent issues such as improper disposal of pesticides, inadequate use of personal protective equipment (PPE), and the handling of expired chemicals.

The positive relationship between knowledge, attitude, and practice indicates that increased awareness directly impinges on the frequency and manner of pesticide application. However, economic pressure, lack of easy access to much safer alternatives, and reinforcing safety practices often negate such gains. For example, economic compulsion to save crops from pests drives a majority of farmers to accord priority to yield over safety; thus, unsafe practices are perpetuated despite knowledge of associated risks.

Environmentally, it shows the negative impacts related to the inappropriate use of pesticides: water contamination, soil degradation, and damage to non-target organisms, including pollinators. This is a dual challenge: ensuring farmers' economic security while promoting practices that minimize environmental impact. This study also highlights priorities for integrated pest management approaches, community-based education initiatives, and policy supports needed to translate knowledge into action. In addition, subsidizing protective equipment, enhancing bio-pesticide availability, and creating controlled waste management systems would be crucial for safer use of pesticides and environmental protection.

This study calls for future research to incorporate the economic and policy dimensions of pesticide use, examining how systemic support mechanisms can mitigate health and environmental risks

while enhancing agricultural sustainability. Meeting these linked challenges will help Ethiopia to develop a more sustainable and equitable agricultural sector, which ensures productivity and the well-being of farming communities.

5.2 Recommendations

Enhancing pesticide awareness creation programs/trainings: To the greatest extent possible, it is possibly safe to say that the education programs on the safe use of pesticides need to address pesticide label comprehension, the effects of incorrect and irresponsible use, as well as some important lessons that may be drawn from Integrated Pest Management. Similar information should be communicated through common ways such as radio programs and or workshops in order to overcome the problem of illiteracy.

Making PPEs more readily available: The simple availability of individual PPE items needs to become a reality for smallholder farmers especially those engaged in farming activities. Offering these subsidies or how to access finance through the government and NGOs would equally promote the culture of safer methods.

This would include, the introduction and development of IPM further and include other approaches such as the application of bio-pesticides, hand-weeding and other non-chemical managers of pest utilizing IPM approaches to minimize the use of chemical pesticides. The studies must highlight the value of practicing agriculture sustainably in terms of economic returns and environmental gain for the current and future generations.

Improve Disposal and Storage Facilities: The constitution and location of the pesticides' disposal site should be so safe that as many barriers as possible have to be made to ensure that there is correct disposal of the pesticides. Changes to storage practices will also create an area on their sites for keeping pesticides away from food and medicines, thus reducing threats to human health.

The continuing surveillance and assistance provided by the agricultural extension agents to help the farmers adhere to the safe practices of using the pesticide is crucial. Ongoing conditioning of the agents will enable them get current information and skills on the best practice to advise the farmers.

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Appendix

Structured Questionnaires

Socio-Demographic Characteristics of the respondents

I. Socio-Economic and Demographic Characteristics small holder farmers.

Variables	Category
Sex of the respondent?	Male
	Female
Marital status?	Married
	Single
	Widowed
	Divorced

Presence of children in the Family? below seven years old	Yes
	No
Education level of the respondent?	Illiterate
	Basic Education
	Elementary school (1-4)
	Elementary school (5-8)
	Secondary school (9-10)
	Preparatory School (11-12)
	Certificates/Diploma
	Degree and above
Status of the respondent?	Farmer-Husband
	Farmer –Wife
	Farmer –Son
	Farmer-Daughter
	Employee Worker
How do you define the land ownership?	Own farm
	Sharecropper
	Rented farm
	Leased from Government
	Total
For what purpose can you use the onion you grow?	For commercial
	Domestic consumption
	Both

II. Knowledge of small holder farmers towards the safe use of pesticides

Variables	Responses
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Pesticides are indispensable for achieving high crop yields?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
	Total
I have taken any training about usage of pesticides?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I can know/differentiate pesticide chemicals by their name	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I know about the negative impact of pesticides residues that enter into water bodies at the time of mixing and washing equipment on aquatic life?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
Do I know the negative effects of pesticide residues in onions?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I know how to calibrate the sprayer equipment's?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
Know about the transfer of pesticide residues in the food chain?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I know about Pesticide exposure effects on animal health?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
	Missing system

I know about Pesticide exposure effects on human health?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I know about Pesticide exposure effects on the environment (bees, fish, water, soil and pollution)?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
I know some pesticides are banned or restricted for use?	Strongly Disagree
	Disagree
	Neither Agree/Disagree
	Agree
	Strongly Agree
In what way Route of pesticide could expose you?	Inhalation
	Ingestion
	Skin Contact
	Don't know

III. Attitudes of smallholder farmers towards the safe use of pesticides

Variables	Responses
Most pesticides create some risk of harm to humans, animals, or the environment?	Strongly Disagree
	Disagree
	Neutral
	Agree
	Strongly Agree
Do you agree to use pesticides on your farm in the future?	Strongly Disagree
	Disagree
	Neutral

	Agree
	Strongly Agree
Do you agree pesticides have advantages and disadvantages?	Strongly Disagree
	Disagree
	Neutral
	Agree
	Strongly Agree
Most pesticide exposures happen not in the workplaces, but through foods, and in the home or garden?	Strongly Disagree
	Disagree
	Neutral
	Agree
	Strongly Agree

IV. Practice of smallholder farmers towards the safe use of pesticides

Variables	Responses
I read, understand, and follow pesticide labels and leaflets	Strongly Disagree
	Disagree
	Neutral
	Agree
	Strongly Agree
What do you do with unused leftover (mixed, diluted) pesticides?	Dispose In Field
	Mix Only Needed Pesticide
	Apply On Other Crops
	Dispose In Sewer
	Dispose In Hazardous Waste Collection Sites
When you use Coveralls Protective Equipment?	Always
	Often
	Sometimes
	Rarely
	Never
When you use Protective boots?	Always
	Often
	Sometimes
	Rarely
	Never
When you use Glasses/goggles?	Always

	Often
	Sometimes
	Rarely
	Never
	Total
When you use Gloves?	Always
	Often
	Sometimes
	Rarely
	Never
When you use Respirator?	Always
	Often
	Sometimes
	Rarely
	Never
When you use Hat?	Always
	Often
	Sometimes
	Rarely
	Never
Eating while mixing or spraying?	Always
	Often
	Sometimes
	Rarely
	Never
Drinking while mixing or spraying?	Always
	Often
	Sometimes
	Rarely
	Never
Smoking while mixing or spraying?	Never
	Total
Sprayed with the wind direction?	Always
	Often
	Sometimes
	Rarely
	Never
Showering immediately after mixing or spraying?	Always
	Often
	Sometimes
	Rarely
	Never

Wash work clothes and sit separately?	Always
	Often
	Sometimes
	Rarely
	Never

V. Safe use of Pesticides related questionnaires for small holder farmers.

Variables	Responses
I follow the Harvesting time after spraying a pesticide?	Always
	Often
	Sometimes
	Rarely
	Never
Who does the spraying?	Farmer
	Hired Contract Worker
	Son
	Wife
	Daughter
What do you do when you encounter an expired pesticide?	Spray It for Field
	Throw It in Open Field
	Keep It in Locked Place
	Return It to Owner
	Mixed With Other Chemicals
Where the spraying equipment is washed?	In Yard Work
	In Canalization
	In Solid Waste Disposal
	Rivers And Lakes
	At Home Area
Where does the residue from the washed equipment go?	In Yard
	In Canalization
	In Open Field
	Rivers
	Others
I wash spray clothes separately from	Strongly Disagree

domestic washing	Disagree
	Neutral
	Agree
	Strongly Agree

VI. KEY INFORMANT INTERVIEW CHECKLISTS

Particulars	Yes	No	If you say 'Yes' please mention it?
Do you know about Pesticide Proclamations/Regulations of Ethiopia?			
Do you know about pesticide risks on human health & environment?			
Do you know about the banned and restricted use pesticides in Ethiopia?			
Do you know about criteria of pesticide registrations, usage, handling, storing and transportations & follow accordingly?			
Do you know precautionary measures while handling pesticides?			
Do you know the list of registered pesticides in Ethiopia?			
Do you maintain pesticide record books?			
Can you read and understand instructions labels/leaflet on pesticides?			
Do you give a practical support to farmers on the safe use of pesticides?			
Do you know about bio-pesticides or integrated pesticide management practices?			
Have you got any training related to pesticides?			

VII. List of pesticides which are used by smallholder farmers for their onion crop

Product Name	Chemical Group	WHO Toxicity Class
Mancozeb 80% WG	Dithiocarbamate fungicide.	WHO Class U
Profenofos 72% EC	Organophosphate insecticide and acaricide.	Class II
Oxyfluorfen 24% EC	Diphenyl ether herbicide.	Class III
Lambda-Cyhalothrin 5% EC	Synthetic pyrethroid insecticide.	Class II
Imidaclopride 35% SC	Neonicotinoid Insecticide.	Class II
Azoxystrobin + Difenconazole 325 SC	Strobilurin fungicide and Triazole fungicide.	Class U & Class III
Metalaxyl 8% + Mancozeb 64% WG	Phenylamide fungicide. And Dithiocarbamate fungicide.	Class III & Class U
Copper hydroxide 77% WP	Inorganic copper-based fungicide and bactericide.	Class II

N.B

Class Ia (Extremely hazardous)

Class Ib (Highly hazardous)

Class II (Moderately hazardous)

Class III (Slightly hazardous)

Class U (Unlikely to present acute hazard)