



Factors Affecting Compliance with Pesticide Safety Standards Among Smallholder Farmers in Suakoko District in Bong County

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ABSTRACT

Compliance with pesticide safety standards among smallholder farmers in Suakoko District, Bong County, was assessed using data collected from 204 farmers. The findings revealed a generally high level of knowledge and adherence to recommended pesticide safety practices. Most farmers had received pesticide safety training (80.4%), while 82.8% and 83.3% were aware of the health and environmental risks associated with pesticide misuse, respectively. Compliance with key safety measures was relatively high, with 76.5% always wearing protective clothing during pesticide application, 84.8% consistently mixing pesticides according to label instructions, 87.7% keeping pesticides away from children and food items, and 77.0% observing the recommended pre-harvest interval before harvesting. Furthermore, 78.4% reported always washing their hands and body after pesticide application. Despite these positive practices, several factors were identified as barriers to full compliance. The high cost of personal protective equipment (PPE) was a major challenge, with 58.8% of respondents agreeing that PPE was too expensive. Limited access to PPE also affected compliance, as 68.6% agreed that inadequate availability reduced adherence to safety standards. Additionally, 99.0% of farmers indicated that agrochemical dealers provided inadequate information on pesticide safety, while 51.0% believed that low literacy levels hindered understanding of pesticide instructions. Health-related consequences of pesticide use remained significant, with 58.8% of farmers reporting pesticide-related health problems, mainly headaches, dizziness, and skin irritation. Extension services played an important role in promoting compliance, as 68.6% of farmers received monthly visits from extension officers and 85.7% believed that extension services improved adherence to pesticide safety standards. The study concludes that although compliance with pesticide safety standards is generally high, affordability and accessibility of PPE, inadequate information from agrochemical dealers, and literacy challenges remain key factors affecting compliance among smallholder farmers in Suakoko District.

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INTRODUCTION

Globally, plant pests and diseases cause losses of up to 40% of food crops annually, posing substantial risks to food security, nutrition, and agricultural livelihoods (Food and Agriculture Organization of the United Nations [FAO], 2021, 2022). Pesticides are among the tools used to protect crops from insects, weeds, and diseases and can contribute to maintaining crop productivity when used appropriately. However, pesticide use also creates occupational and environmental risks when products are misused or when users are inadequately protected (World Health Organization [WHO], 2022).

Many countries have strengthened pesticide-management policies and regulatory systems to reduce risks to human health and the environment. The FAO/WHO pesticide-management framework emphasizes responsible pesticide management throughout the product life cycle, including production, distribution, use, storage, and disposal (FAO & WHO, 2021). Effective pesticide management is therefore important for sustainable agricultural production, particularly among smallholder farmers who may have limited access to technical information and protective resources.

Unsafe pesticide use can expose farmers to acute and chronic health risks. WHO (2022) notes that agricultural workers who handle or apply pesticides are among the groups at greatest risk of occupational exposure and recommends following product instructions and using appropriate protective measures. Recent evidence from smallholder farmers in Nigeria also shows that the quality and source of pesticide information are associated with pesticide-handling knowledge and PPE use (Madaki et al., 2024). In Uganda, a 2026 cluster-randomized trial further demonstrated that pesticide-safety education can improve self-reported PPE use among smallholder farmers (Ssekkadde et al., 2026).

Several factors can affect farmers' exposure to pesticides, including access to appropriate protective equipment, knowledge of safe handling, quality of information, training, storage practices, and waste-management practices. Recent evidence from Nigeria indicates that pesticide labels and farmer-to-farmer information can influence knowledge of pesticide handling and PPE use, while unsafe disposal of pesticide containers remains common (Madaki et al., 2024). These findings support the need for practical training and accessible, understandable safety information for smallholder farmers.

The safe use, storage, and disposal of pesticides are important for reducing exposure and environmental contamination. WHO (2022) emphasizes that pesticide exposure can have acute and chronic health effects and that people who apply pesticides should be adequately protected. FAO and WHO (2021) similarly provide guidance covering pesticide management from production through disposal. Accordingly, this study focuses on farmers' knowledge, handling practices, access to information and extension services, and factors that may affect compliance with pesticide safety standards.

Self-efficacy is an important determinant of safe pesticide-handling behaviour. Recent evidence indicates that farmers with higher perceived self-efficacy are more likely to adopt recommended pesticide safety practices, including appropriate protective measures and safer handling behaviours (Suphim & Songthap, 2024; Oludoye et al., 2023). Similarly, farmers' perceptions of their susceptibility to pesticide exposure and the severity of its consequences can influence their motivation to adopt protective practices (Oludoye et al., 2023; Suphim & Songthap, 2024). Reported symptoms associated with pesticide exposure, including headaches, dizziness, skin irritation, and other acute health effects, may increase farmers' awareness of pesticide risks and reinforce the importance of preventive practices (Kumar et al., 2022).

Safety knowledge, perceived self-efficacy, social support, access to information, and perceived barriers can therefore interact to influence whether farmers adopt safe or unsafe pesticide-handling practices. Suphim and Songthap (2024) found that perceived self-efficacy, knowledge, social support, pesticide-label reading, and perceived susceptibility were significant factors associated with safe pesticide-use behaviour. Similarly, Oshingbade

et al. (2025) identified knowledge, training, access to protective equipment, and other safety-related factors as important determinants of safe pesticide handling among rural farmers in Nigeria. Providing appropriate personal protective equipment and strengthening pesticide-safety education may therefore enhance farmers' ability and confidence to practice safer pesticide handling (Ahmadipour & Nakhei, 2024; 2026). Accordingly, this study hypothesizes that greater access to cues to action and higher levels of self-efficacy are positively associated with safer pesticide-handling behaviours.

OBJECTIVES OF THE STUDY

The general objective of this study is to assess the factors affecting compliance with pesticide safety standards among smallholder farmers in Suakoko District, Bong County, Liberia. Specifically, the study seeks to evaluate farmers' knowledge and compliance with recommended pesticide safety standards, identify the socio-economic, institutional, and behavioral factors influencing compliance, examine the health effects associated with pesticide exposure, and generate evidence to support policies and interventions that promote safe pesticide use, protect human health, and enhance sustainable agricultural production.

The specific objectives of this study are to determine and assess farmers' knowledge and awareness of pesticide safety standards and recommended pesticide handling practices; evaluate the level of compliance with pesticide safety standards during pesticide application, storage, use of personal protective equipment, and disposal of pesticide containers; identify the key factors influencing compliance with pesticide safety standards, including access to training, extension services, personal protective equipment, literacy, and information provided by agrochemical dealers; examine the health effects experienced by farmers as a result of pesticide exposure and their responses to pesticide-related health incidents; assess the role of agricultural extension and information services in promoting compliance with pesticide safety standards; and provide evidence-based recommendations to improve farmers' compliance with pesticide safety standards, reduce pesticide-related health and environmental risks, and strengthen sustainable agricultural practices in Suakoko District, Bong County.

MATERIALS AND METHODS

Description of the study area

Suakoko District is one of the twelve administrative districts of Bong County, located in the south-central part of the county, approximately 120 km northeast of Monrovia, Liberia's capital city. The district serves as an important educational, health, and agricultural center in Liberia. It hosts major institutions such as the Central Agricultural Research Institute (CARI), Cuttington University, Phebe Hospital, and several agricultural training centers. The district is predominantly inhabited by the Kpelle ethnic group, whose primary livelihood activities include crop farming, particularly rice and cassava production. Suakoko experiences a tropical monsoon climate characterized by high temperatures and humidity throughout the year. Average annual temperatures range from approximately 26°C to 35°C, with the hottest months occurring between January and April and the coolest conditions occurring during July to September.

Study design and period

A cross-sectional study was conducted among 204 farmers in Suakoko district, using a structured questionnaire. The survey was conducted from March to June 2026, with informed consent from household heads or farmers.

Sample size determination

The sample size for the study was determined using Yamane's (1967) formula, where $N = 44,930$ represents the target population and $e = 0.07$ represents the level of precision. Substituting these values into

the formula yielded a sample size of 203.16, which was approximated to 203 respondents. To ensure adequacy of representation and account for possible non-response, the sample size was rounded up to 204 respondents.

Sampling techniques and Data collection

Data collection took place in Suakoko district within 45 towns and villages. The study participants were selected through a three-stage process. In the first stage, 25 towns and villages were purposefully chosen from a total of 45 towns and villages, based on their high levels of participation in farming. In the second stage, 10 towns and villages were randomly selected. In the third stage, 10 towns were selected. The head of the household or farmers served as the respondent, and if the head was unable to participate in farming activities due to old age or illness, an adult individual (age 18 or above) engaged in farming activities was selected as the respondent. The data were collected using face-to-face interviews with a pre-tested, structured questionnaire. The questionnaire was written in English. The questionnaire contained socio-demographic information, pesticide utilization variables, knowledge, and attitudes of the farmers about safe pesticide handling and safe pesticide handling practices. Ten trained agricultural extension workers collected the data, and three environmental health experts participated in supervising the fieldwork.

Data processing and analysis

The data was entered into Excel and exported to SPSS version 26 for analysis. Descriptive analysis was used for age and duration of participation in farming activities. For the categorical variables, sex, educational status, safe pesticide handling practice, knowledge of pesticide safety standards, pesticide handling practices, factors affecting compliance, health effects and incidents, and access to extension and information services, the questionnaire is structured for straightforward analysis using SPSS, Excel, or Stata, employing descriptive statistics, Chi-square tests, correlation analysis, and logistic or multiple regression to identify the factors influencing compliance.

RESULTS AND DISCUSSION

Table 1. Socio-economic Characteristics of Farmers (N = 204)

Attributes	Characteristics	Frequency	Percentage (%)
Gender	Male	194	95.1
	Female	10	4.9
Age (Years)	18–29	40	19.6
	30–39	90	44.1
	40–49	60	29.4
	50–59	14	6.9
Residence	Rural	156	76.5
	Urban	48	23.5

Attributes	Characteristics	Frequency	Percentage (%)
Education Level	Uneducated	10	4.9
	Primary	15	7.4
	Junior High	25	12.3
	Senior High	45	22.1
	Vocational	85	41.7
	University	24	11.8
Main Farming Crop	Rice	94	46.1
	Vegetables	80	39.2
	Mixed Farming	30	14.7
Farming Experience	Less than 5 years	21	10.3
	5–10 years	67	32.8
	11–15 years	71	34.8
	More than 15 years	45	22.1
Pesticide Experience	0–10 years	39	19.1
	11–20 years	102	50.0
	21 years and above	63	30.9

The predominance of male respondents (95.1%) indicates that men are the primary participants in farming and pesticide application in Suakoko District. This finding is consistent with studies by Ahmed et al. (2024) and Awoke Keleb et al. (2024), which reported that agricultural production and pesticide handling in many developing-country settings are largely male-dominated. Most respondents were aged 30–39 years (44.1%), followed by those aged 40–49 years (29.4%), indicating that most farmers are within the economically active age group. This agrees with Ahmed et al. (2024) and Alebachew et al. (2023), who reported that age and farming experience are associated with pesticide safety practices. Most respondents (76.5%) resided in rural areas, which is expected because farming activities are concentrated in rural communities. This finding is consistent with Awoke Keleb et al. (2024), whose study examined pesticide safety practices among farmers in rural irrigation areas. The high proportion of respondents with vocational (41.7%) and senior high school education (22.1%) suggests that many farmers possess the literacy needed to understand pesticide labels and safety instructions. This agrees with Alebachew et al. (2023) and Ahmed et al. (2024), who found that education was associated with better pesticide safety and handling practices. Rice (46.1%) and vegetable (39.2%) farming were the dominant agricultural enterprises, consistent with

Awoke Keleb et al. (2024), who reported substantial pesticide use among farmers producing vegetables and cereal crops. Most respondents had over 11 years of farming experience, while 80.9% had more than 11 years of pesticide-use experience. These findings agree with Alebachew et al. (2023) and Ahmed et al. (2024), who reported associations between farming/pesticide-use experience and pesticide safety or handling practices.

Table 2. Knowledge of Pesticide Safety Standards (N = 204)

Attributes	Characteristics	Frequency	%
Received training on pesticide safety	Yes	164	80.4
	No	40	19.6
Who provided the training?	Ministry of Agriculture	109	53.4
	NGO	47	23.0
	Agrochemical dealer	25	12.3
	Private company	23	11.3
Read and understand pesticide labels	Very good	114	55.9
	Good	45	22.1
	Sometimes	35	17.2
	None	10	4.9
Know the recommended dosage for the pesticides used	Yes	159	77.9
	No	45	22.1
Aware of health risks associated with pesticide misuse	Yes	169	82.8
	No	35	17.2
Aware of environmental risks associated with improper pesticide use	Yes	170	83.3
	No	34	16.7
Which safety practices do you know?	Wearing PPE	48	23.5
	Proper storage	40	19.6
	Correct mixing procedures	30	14.7
	Safe disposal of containers	31	15.2
	Observing pre-harvest intervals	25	12.3
	Washing after spraying	30	14.7

The finding that 80.4% of respondents had received pesticide safety training indicates a high level of exposure to extension and educational programs. This is consistent with Alebachew et al. (2023), who reported that training significantly improves farmers' knowledge and safe pesticide handling practices. Similarly, Awoke Keleb et al. (2024) emphasized that training is essential for promoting the safe use of pesticides and reducing occupational exposure. The Ministry of Agriculture (53.4%) was the leading provider of pesticide safety training, followed by NGOs (23.0%), highlighting the important role of government and development partners in farmer education. This finding agrees with FAO (2023), which reported that public agricultural extension services and development organizations are the primary channels for disseminating pesticide safety information in developing countries. Most respondents demonstrated a very good (55.9%) or good (22.1%) understanding of pesticide labels. This finding is consistent with Ojo et al. (2024), who found that farmers with adequate literacy and training are better able to interpret pesticide labels and follow safety instructions. However, it contrasts with Gebremariam et al. (2025), who reported that many Ghanaian farmers had difficulty understanding pesticide labels because of limited literacy.

The high proportion of respondents who knew the recommended pesticide dosage (77.9%) and were aware of the health (82.8%) and environmental (83.3%) risks of pesticide misuse agrees with Awoke Keleb et al. (2024), who found that trained farmers generally possess better knowledge of pesticide application and associated risks. Similarly, Alebachew et al. (2023) emphasized that awareness of pesticide hazards is fundamental to reducing poisoning and environmental contamination. Knowledge of pesticide safety practices was highest for personal protective equipment (23.5%) and proper pesticide storage (19.6%). This finding is consistent with FAO (2023) & Ojo et al. (2024), which identify the use of PPE and safe pesticide storage as key components of pesticide safety training. However, the relatively low knowledge of safe disposal and correct mixing procedures suggests that additional training is needed to improve farmers' comprehensive understanding of pesticide safety practices.

Table 3. Pesticide Handling Practices (N = 204)

Attributes	Characteristics	Frequency	%
Wearing protective clothing when applying pesticides	Always	156	76.5
	Sometimes	30	14.7
	Never	18	8.8
Which PPE do you normally use?	Face mask	30	14.7
	Goggles	20	9.8
	Boots	20	9.8
	Spray suit with all the above (PPE)	134	65.7
Mix pesticides according to label instructions	Always	173	84.8
	Sometimes	25	12.7
	Never	5	2.5
Where do you store pesticides?	Locked storage room	149	73.0
	House	14	6.9
	Farm shed	31	15.2
	Open area	10	4.9
Keep pesticides away from children and food items	Yes	179	87.7
	No	25	12.3
How do you dispose of empty pesticide containers?	Burn them	102	50.0
	Bury them	33	16.2
	Throw them into the bush	25	12.3
	Reuse them	24	11.8
	Return them to suppliers	20	9.8
Observe the recommended waiting period before harvesting after pesticide application	Always	157	77.0
	Sometimes	40	19.6
	Never	7	3.4
Wash hands and body after pesticide application	Always	160	78.4
	Sometimes	38	18.6
	Never	6	2.9

The findings indicate that most farmers practiced appropriate pesticide handling measures, although some unsafe practices persisted. The high proportion of farmers who always wore protective clothing (76.5%) is consistent with Thapa et al. (2021), who reported that trained farmers are more likely to use personal protective equipment (PPE) during pesticide applications. Similarly, Boateng et al. (2023) found that the use of PPE reduces occupational pesticide exposure. However, the inconsistent use of protective clothing by some farmers contrasts with Boateng et al. (2023), who reported generally low compliance with PPE use among smallholder farmers in Ghana. The finding that 65.7% of respondents used complete PPE and 84.8% always followed pesticide label instructions agrees with WHO (2021), which identifies proper PPE use and adherence to label instructions as essential practices for minimizing pesticide exposure and promoting safe pesticide application.

Most respondents stored pesticides in locked storage rooms (73.0%) and kept them away from children and food items (87.7%). These findings are consistent with FAO (2023), which recommends secure pesticide storage to prevent accidental poisoning and environmental contamination. Likewise, the findings are supported by Boateng et al. (2023), who examined pesticide storage and disposal practices among smallholder cocoa farmers in Ghana. Most farmers (77.0%) observed the recommended pre-harvest interval before harvesting, which agrees with Mitku (2021), who assessed farmers' knowledge and practices concerning pesticide pre-harvest intervals and emphasized the importance of following pesticide instructions. However, the common disposal methods of burning (50.0%) and burying (16.2%) empty pesticide containers contradict FAO (2021), which discourages unsafe disposal practices because they may contribute to environmental contamination and health risks. This finding indicates the need for improved training on environmentally sound pesticide waste management. Finally, the high proportion of farmers who always washed their hands and bodies after spraying (78.4%) agrees with Thapa et al. (2021), who emphasized the importance of safe pesticide handling practices and the adoption of PPE to reduce pesticide exposure and associated health risks.

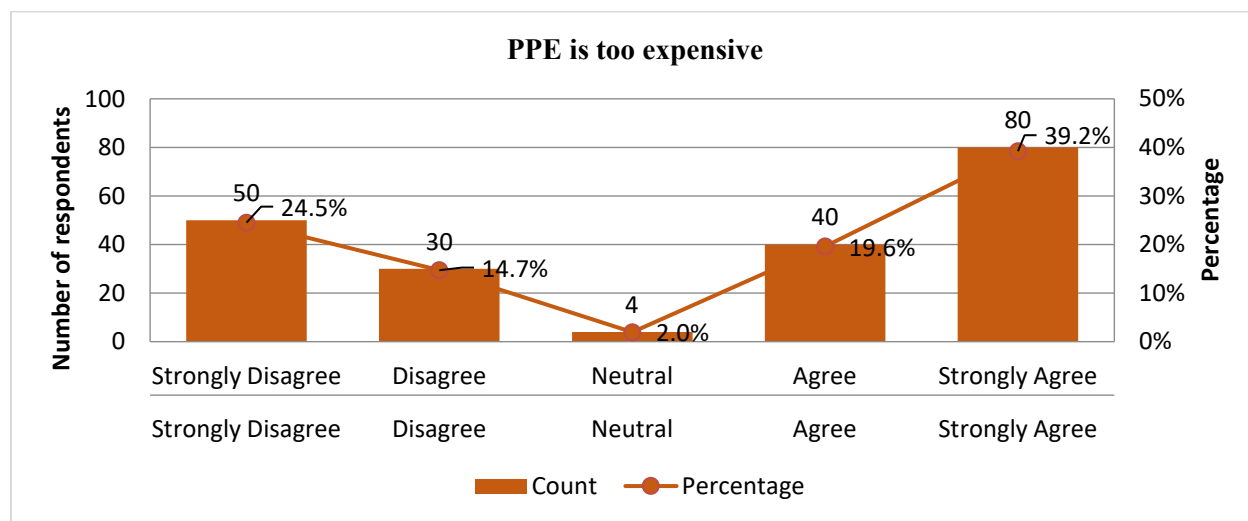


Figure 1. PPE is too expensive

The finding that 39.2% of farmers strongly agreed and 19.6% agreed that personal protective equipment (PPE) is too expensive indicates that PPE cost is a significant barrier to consistent use during pesticide application. This finding is consistent with Migheli (2021), who reported that income is an important factor influencing farmers' use of adequate protective equipment, particularly where farmers face resource constraints. Similarly, FAO & WHO (2021) noted that financial constraints and limited access to affordable protective gear remain major obstacles to safe pesticide handling among smallholder farmers. However, the finding that 24.5% of respondents strongly disagreed that PPE is too expensive suggests that some farmers may have better financial capacity, access to subsidized PPE, or greater awareness of the benefits of investing in protective equipment, a result also reported by

Ansah and Skevas (2024), who found that access to credit and training positively affected farmers' adoption and intensity of PPE use.

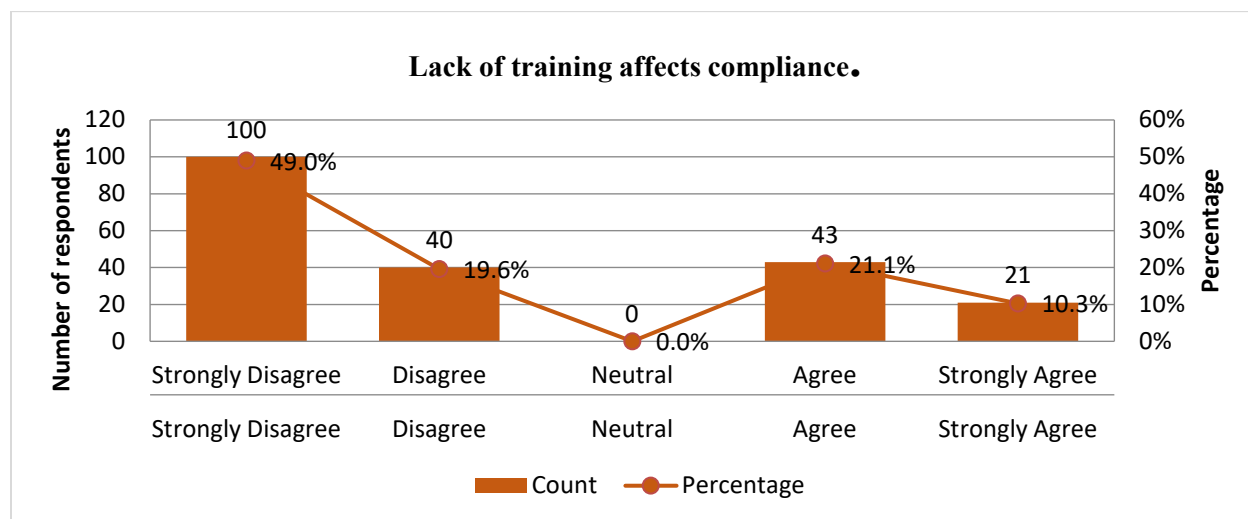


Figure 2. Lack of training affects Compliance

The finding that 49.0% of farmers strongly disagreed and 19.6% disagreed that lack of training affects compliance with pesticide safety standards suggests that most respondents believe they have received adequate knowledge to follow recommended pesticide safety practices. This finding contrasts with studies by FAO & WHO (2021) and Thapa et al. (2021), which reported that inadequate training is a major factor contributing to poor pesticide handling and low compliance with safety standards among farmers. However, the 21.1% who agreed and 10.3% who strongly agreed that lack of training affects compliance are consistent with these previous studies, indicating that a proportion of farmers still require additional training to improve safe pesticide use and reduce health and environmental risks.

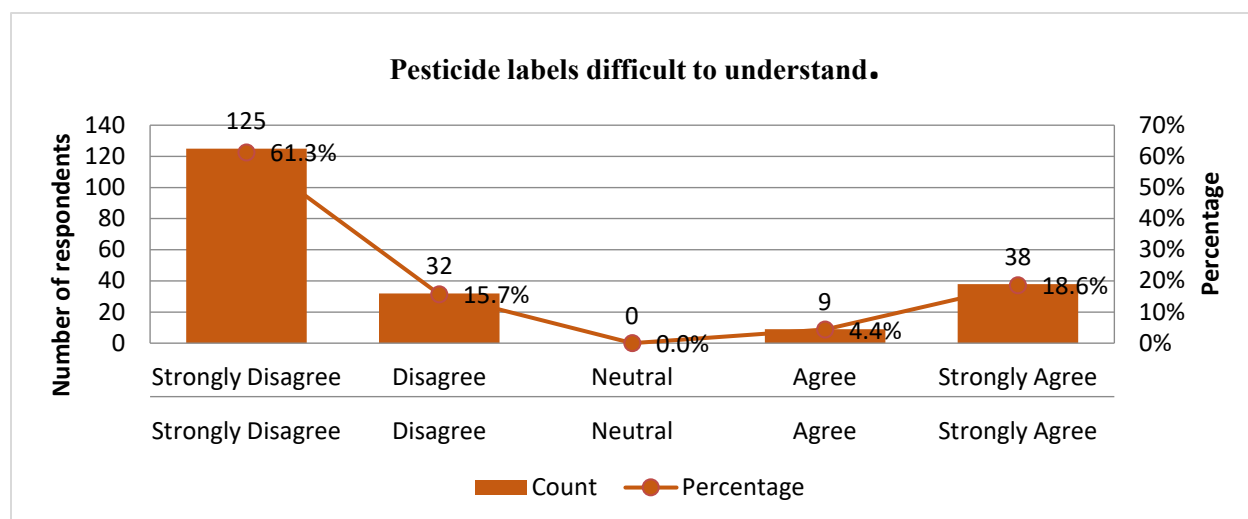


Figure 3. Pesticide labels are difficult to understand

The finding that 61.3% of farmers strongly disagreed and 15.7% disagreed that pesticide labels are difficult to understand suggests that most farmers can interpret label instructions correctly. This is consistent with studies by the Food and Agriculture Organization (2021), which reported that farmers with adequate literacy and extension support are more likely to understand pesticide labels and follow recommended application and safety instructions. Similarly, the World Health Organization (2021) emphasized that clear label comprehension contributes to the safe handling and proper use of pesticides. However, the finding that 18.6% of farmers strongly agreed that pesticide labels are difficult to understand is consistent with studies by Sharma et al. (2022), who found that limited literacy, technical language, and complex label formats can hinder farmers' understanding, leading to improper pesticide use and increased health risks. This suggests that while most farmers in the study can interpret pesticide labels, targeted training and the use of simpler, more user-friendly labels are still needed for farmers who experience difficulties.

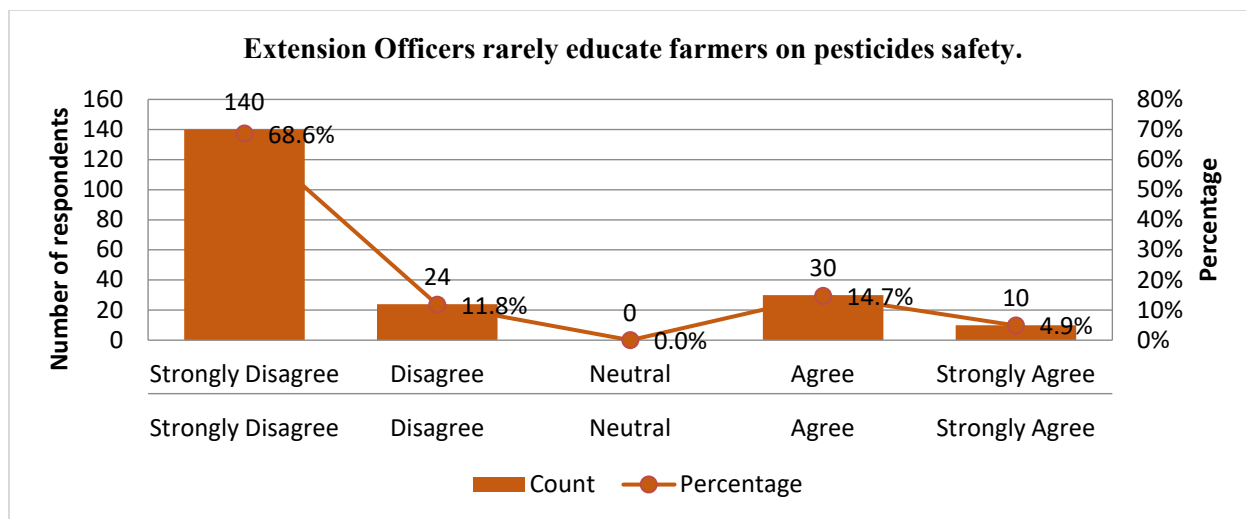


Figure 4. Extension Officers rarely educate farmers on pesticide safety

The finding that 68.6% of farmers strongly disagreed and 11.8% disagreed that extension services rarely educate farmers on pesticide safety indicates that most respondents recognize the important role of extension services in promoting safe pesticide use. This is consistent with studies by the Food and Agriculture Organization (2021), which found that agricultural extension services significantly improve farmers' knowledge of pesticide safety and encourage compliance with recommended practices. Similarly, Thapa et al. (2021) reported that farmers who receive extension training demonstrate better pesticide safety behaviours than those without such support. However, the finding that 14.7% agreed and 4.9% strongly agreed that extension services rarely provide pesticide safety education contradicts the expectation of universal extension coverage and suggests that some farmers still have limited access to training. This agrees with Dlamini et al. (2022), who found that inadequate extension outreach leaves some farmers without sufficient knowledge of safe pesticide handling, increasing the risk of unsafe practices.

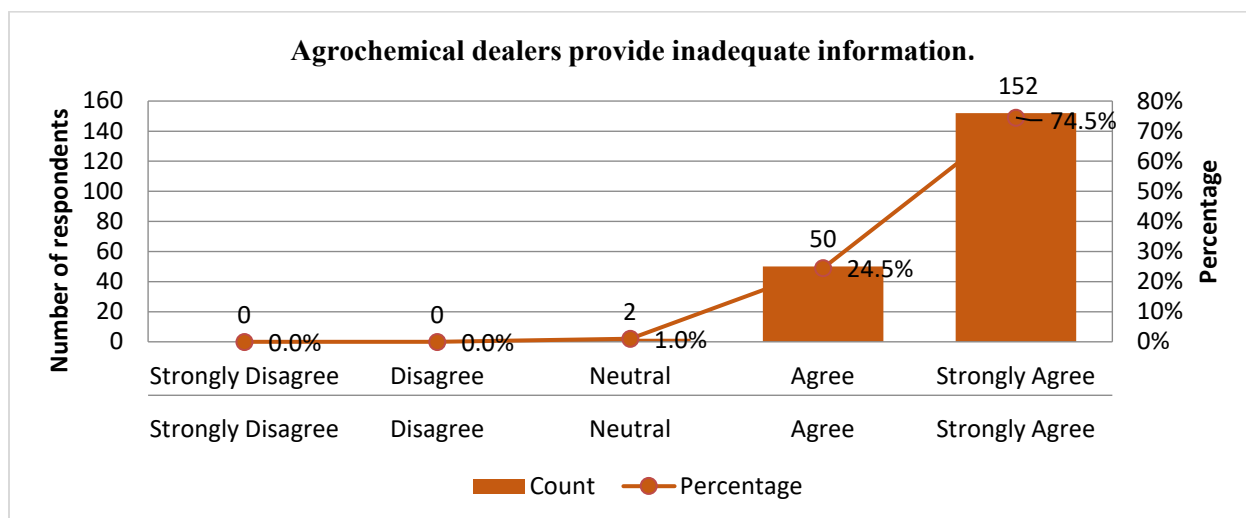


Figure 5. Agrochemical dealers provide inadequate information

The finding that 74.5% of farmers strongly agreed and 24.5% agreed that agrochemical dealers provide inadequate information indicates that most farmers perceive dealers as an insufficient source of pesticide safety guidance. This is consistent with the findings of Tambo et al. (2021), who reported that pesticide retailers and other information sources may provide farmers with insufficient guidance on pesticide use and safety. Similarly, Sharma et al. (2022) found that limited information and inadequate guidance on pesticide use can contribute to incorrect pesticide application and increased health and environmental risks among farmers. These findings, however, contrast with Nguyen et al. (2021), who reported that in areas where agrochemical dealers receive formal training and government supervision, they can provide farmers with accurate information on pesticide selection, dosage, and safe handling, thereby improving pesticide use practices.

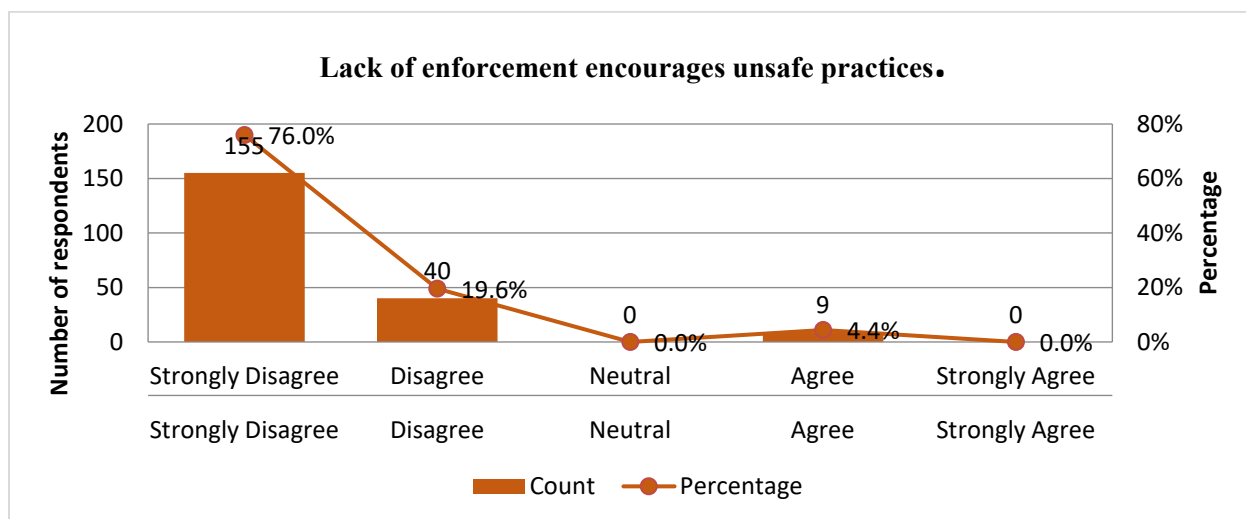


Figure 6. Lack of enforcement encourages unsafe practices

The finding that 76.0% of farmers strongly disagreed and 19.6% disagreed that lack of enforcement encourages unsafe pesticide practices suggests that most farmers do not view weak regulatory enforcement as the primary determinant of safe pesticide use. This contrasts with the findings of Pesticide Action Network International (2021), which reported that inadequate enforcement of pesticide regulations in developing countries

contributes to unsafe pesticide handling and poor compliance with safety standards. Likewise, the European Food Safety Authority (EFSA, 2022) emphasized that effective enforcement and regulatory monitoring are essential for ensuring compliance with pesticide safety requirements and reducing health and environmental risks. The difference may reflect variations in farmers' experiences, where respondents in the present study place greater importance on personal knowledge, awareness, and access to safety resources than on regulatory enforcement.

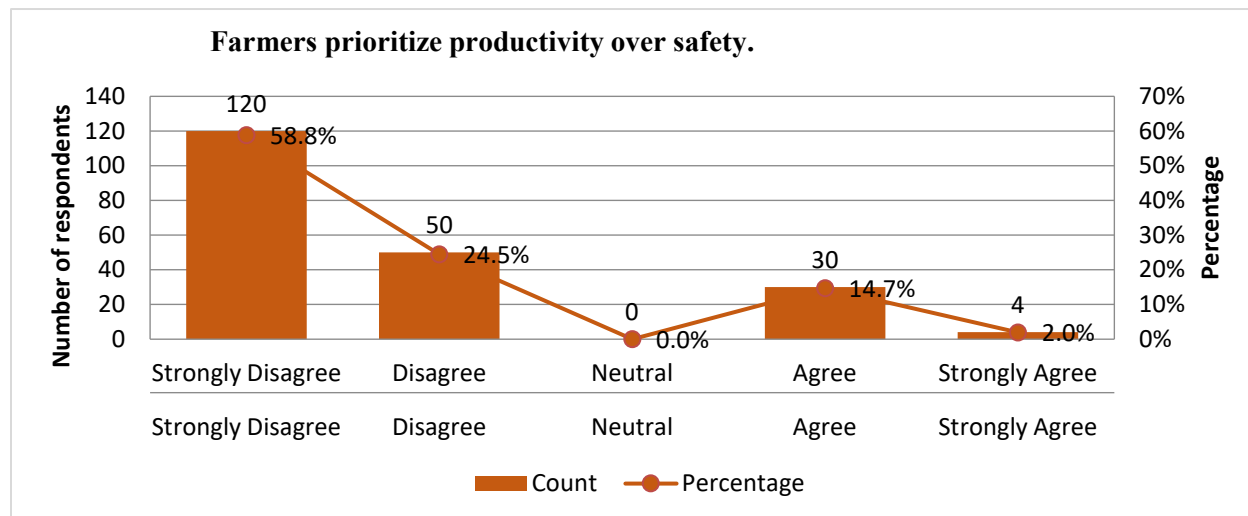


Figure 7. Farmers prioritize productivity over safety

The finding that 58.8% of farmers strongly disagreed and 24.5% disagreed that productivity is prioritized over safety suggests that most farmers value safe pesticide use alongside maintaining crop productivity. This is consistent with Migheli (2021), who found that farmers' perceptions of pesticide risks and safety practices influence their decisions regarding pesticide use. However, the finding that 14.7% agreed that productivity is prioritized over safety supports the observations of Sharma et al. (2022), who reported that economic pressures, the desire to maximize yields, and limited financial resources may lead some farmers to neglect recommended pesticide safety measures.

Table 4. Health Effects and Incidents (N = 204)

Attributes	Characteristics	Frequency	%
Ever experienced any health problems after using pesticides?	Yes	120	58.8
	No	84	41.2
Which symptoms did you experience?	Headache	84	41.2
	Dizziness	70	34.3
	Skin irritation	50	24.5
Have you ever sought medical treatment due to pesticide exposure?	Yes	120	58.8
	No	84	41.2
Have you ever received first-aid training for pesticide poisoning?	Yes	189	92.6
	No	15	7.4

The finding that 58.8% of farmers experienced health problems after pesticide use, with headache (41.2%), dizziness (34.3%), and skin irritation (24.5%) as the most common symptoms, is consistent with Mamane et al. (2021), who reported that pesticide exposure among agricultural workers is associated with acute health symptoms

such as headaches, dizziness, and skin irritation. Similarly, Mostafalou et al. (2021) found that occupational pesticide exposure among farmers was associated with adverse health effects, emphasizing the need for safer handling practices. The finding that 58.8% sought medical treatment after pesticide exposure is consistent with Sharma et al. (2022), who observed that farmers experiencing pesticide-related health problems may seek healthcare when symptoms occur, although access to appropriate treatment can remain limited in some rural areas. Furthermore, the finding that 92.6% had received first-aid training contrasts with Tambo et al. (2021), who reported gaps in pesticide safety knowledge and training among pesticide users, highlighting that the high level of training observed in the present study reflects improved pesticide safety awareness and extension efforts.

Table 5. Access to Extension and Information Services (N = 204)

Attributes	Characteristics	Frequency	%
How often do you receive visits from agricultural extension officers?	Monthly	140	68.6
	Quarterly	54	26.5
	Once a year	10	4.9
Main source of information on pesticide use	Extension officers	94	46.1
	Fellow farmers	45	22.1
	Agrochemical dealers	14	6.9
Do you think extension services improve compliance with pesticide safety standards?	NGOs	51	25.0
	Yes	175	85.7
	No	17	8.4
	Not Sure	12	5.9

The finding that 68.6% of farmers receive monthly extension visits and 26.5% receive quarterly visits indicates that most farmers have regular contact with extension personnel. This is consistent with Ma et al. (2021), who reported that frequent extension contact enhances farmers' knowledge and adoption of improved agricultural and pesticide management practices. The finding that extension officers (46.1%) are the main source of pesticide information, followed by NGOs (25.0%), is supported by FAO & WHO (2021), which found that public extension services remain an important channel for disseminating agricultural technologies and safe farming practices in developing countries. However, the relatively low reliance on agrochemical dealers (6.9%) contrasts with Tambo et al. (2021), who reported that pesticide retailers were an important source of pesticide information among farming communities. Furthermore, the finding that 85.7% of farmers believe extension services improve compliance with pesticide safety standards agrees with Migheli (2021), who concluded that effective extension and training can improve farmers' adoption of recommended agricultural and pesticide safety practices.

CONCLUSION

This study concludes that smallholder farmers in Suakoko District generally demonstrate good knowledge of pesticide safety standards and satisfactory compliance with recommended pesticide handling practices. Most farmers received pesticide safety training, understood pesticide labels and recommended dosages, regularly used personal protective equipment, and acknowledged the important role of agricultural extension services in promoting safe pesticide use. These findings suggest that government and stakeholder interventions have contributed positively to improving farmers' awareness and adoption of safe pesticide practices.

Despite these positive findings, important challenges remain. The high cost and limited availability of personal protective equipment, inadequate pesticide safety information from agrochemical dealers, and the continued occurrence of pesticide-related health problems indicate that compliance is not yet optimal. Strengthening extension services, improving access to affordable protective equipment, enhancing the capacity of agrochemical dealers to provide accurate safety information, and promoting safer pesticide disposal and health monitoring will further improve compliance with pesticide safety standards and reduce health and environmental risks among smallholder farmers.

RECOMMENDATIONS

The Ministry of Agriculture, the Environmental Protection Agency, and development partners should strengthen farmer training through regular extension visits, continuous pesticide safety education, and community awareness campaigns. Efforts should also focus on increasing the availability and affordability of quality personal protective equipment through subsidies or farmer support programs. In addition, agrochemical dealers should receive mandatory training and certification to ensure they provide accurate guidance on pesticide selection, handling, and safe use. Future studies should employ analytical designs, such as regression analysis, to identify the key predictors of compliance with pesticide safety standards and should include larger study populations across multiple counties in Liberia. Further research should also assess long-term health outcomes associated with pesticide exposure and evaluate the effectiveness of extension and policy interventions in improving pesticide safety compliance.

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