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Abstract
Although the widespread use of agrochemicals by smallholder farmers has contributed to improved crop production, their inappropriate application has raised serious concerns regarding human health and environmental degradation. The study aimed to understand the smallholder farmers' risk perceptions of agrochemical use in Morogoro District, Tanzania. The study employed a convergent parallel mixed-methods research design. It used a systematic random sampling technique to select 387 household heads to participate in the study. In addition, purposive sampling technique was used to select 7 key informants for in-depth interviews and 21 participants for the focus group discussions. The data were collected through in-depth interview of key informants, focus group discussions and a household questionnaire survey. Descriptive and inferential statistical techniques were used to analyses quantitative data through IBM SPSS Statistics Version 20, whereas qualitative data were analysed through qualitative content analysis using NVivo Version 12. The results show that respondents had a moderate perception of the environmental and human health risks associated with agrochemical use (overall weighted mean = 3.15). Additionally, ordinal logistic regression results showed that respondents' risk perceptions of agrochemical use were significantly ($p < 0.05$) influenced by age, education level, extension services, farmer group membership, awareness of environmental regulations, and training on chemical use. The study concludes that farmers had moderate risk perceptions of agrochemical use, and these perceptions were influenced by socio-economic and institutional factors. It is recommended that the government strengthen extension services and awareness programmes to promote safer agrochemical practices.

Introduction

Agriculture is fundamental to global food security and livelihoods, but its productivity is increasingly threatened by pest infestations, weeds, and climate variability (Islam, 2025). To address these challenges, farmers widely use chemical fertilisers, pesticides, herbicides, and fungicides to improve crop yields and food security (Alam et al., 2022). However, the misuse and overuse of these chemicals contribute to environmental degradation and pose significant risks to human health (Raimondo et al., 2022).

In Africa, smallholder farmers constitute the majority of agricultural producers and rely heavily on chemical inputs to enhance productivity (Demi & Sicchia, 2021). However, many farmers have limited knowledge of the environmental and human health risks posed by fertilisers, pesticides, and

herbicides (Tabikam et al., 2024). Furthermore, the misuse of agricultural chemicals in these contexts has led to soil degradation, contamination of surface and groundwater, human health problems, and declines in populations of beneficial organisms, such as pollinators and soil microbes (Shen, 2023).

In Tanzania, agriculture remains the backbone of the national economy, contributing significantly to gross domestic product (GDP) (Anami, 2026). Smallholder farmers produce both staple and cash crops (Pallangyo et al., 2019). The use of chemical fertilisers, herbicides, and pesticides has increased over recent years to improve crop yields and ensure household food security. However, inappropriate application and overreliance on these inputs have raised serious concerns about human health and environmental degradation (Olirk et al., 2026). Morogoro District is a major agricultural area where fertilisers and pesticides are extensively used. However, limited empirical evidence exists on farmers' perceptions of the environmental and human health risks associated with agrochemical use. Understanding farmers' perceptions in this context is crucial for planning effective awareness programmes, extension services, and policies that promote environmentally and human health-accountable farming practices.

This study, therefore, focused on Smallholder Farmers' Risk Perceptions of Agrochemical Use in Morogoro District, Tanzania. Specifically, it focused on identifying the types of agricultural chemicals used by smallholder farmers; examining farmers' perceptions of environmental and human health risks associated with chemical use; and determining socio-economic and institutional factors influencing those perceptions.

Theoretical Framework

This study was guided by the Health Belief Model (HBM). The Health Belief Model explains that individuals' perceptions of health and environmental risks influence their decisions to adopt preventive or protective behaviours (Rosenstock, 1974). The model posits that people are more likely to take protective action when they perceive themselves to be susceptible to a hazard.

In the context of this study, the Health Belief Model provides a useful framework for understanding how smallholder farmers perceive the environmental and human health risks associated with agrochemical use. Farmers who perceive greater risks from improper agrochemical handling and application are more likely to adopt safer practices. On the other hand, farmers who perceive the risks to be low may be less likely to implement these safety measures. The model also recognises that individual behaviour is influenced by modifying factors such as socio-economic characteristics and institutional factors. In this study, variables including farmers' age, education level, access to agricultural extension services, membership in farmer groups, and access to training on agrochemical use were considered important factors that may influence farmers' perceptions of agrochemical-related environmental and health risks. These factors shape farmers' knowledge and awareness, which ultimately affect their perceptions and decisions regarding agrochemical use.

Methodology

This study adopted a convergent parallel mixed-methods research design to examine smallholder farmers' risk perceptions of agrochemical use in Morogoro District Council. The design was appropriate as it allowed quantitative and qualitative data to be collected concurrently, analysed independently, and integrated during interpretation to provide a comprehensive understanding of farmers' risk perceptions of agrochemical use. The research was conducted in the Morogoro District Council, specifically in the Mkambalani and Mikese wards. The district is located between latitudes $6^{0}00'00''$ and $8^{0}00'00''$ south of the Equator, and between longitudes $37^{0}00'00''$ and $39^{0}00'00''$ east of the Greenwich Meridian. The district is predominantly rural and engages in crop production, including maize, beans, and vegetables, which are prone to pest infestations.

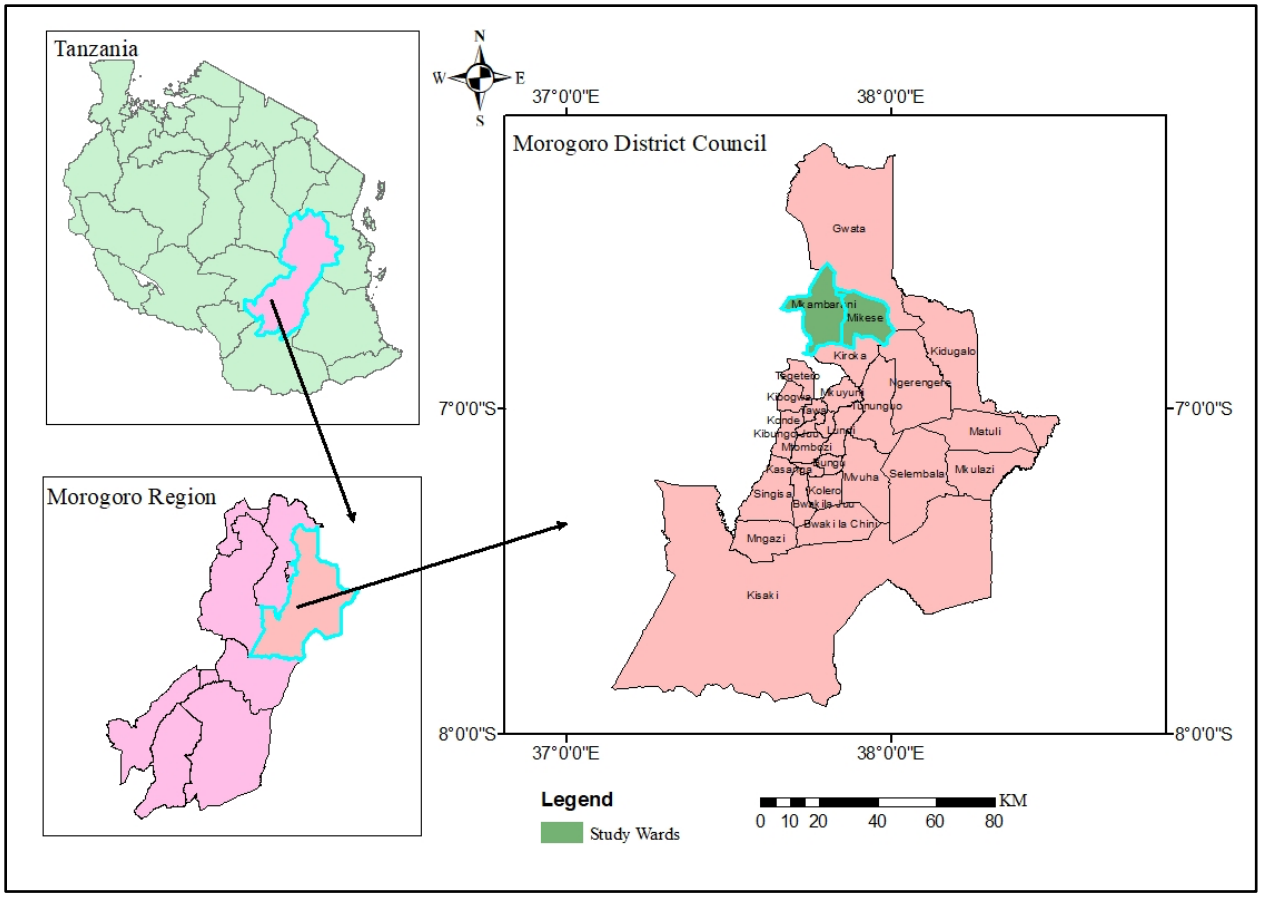

Figure 1: Location of the study area
Source: Survey data, 2025

The target population were the smallholder farmers involved in crop production in Morogoro District. Key informants such as agricultural extension officers, local government officials, and representatives from farmer groups were also included. The study used a sample size of 387 respondents that was determined by Yamane's (1967) formula, and expressed as: $n = \frac{N}{1+N(e)^2}$

Where n = sample size, N = population size and e = the level of precision (5%).

Therefore $n = \frac{11,577}{1+11,577(0.05)^2}$ =

$$n = \frac{11,577}{1 + 11,577(0.0025)} = 387\ respondents$$

The proportional allocation formula by Kothari (2004) was used to determine the number of respondents for the study wards. The formula is expressed as: $ni = \frac{Ni}{N} x\ n$

Where *ni* represents the sample size for the i^{th} ward, *Ni* is the population of the i^{th} ward, *N* is the total population of all selected wards, and *n* is the overall sample size for the study (Table 1).

Table 1: Population and sample size for the study

Wards	Population	Households	Sample ($ni = \frac{Ni}{N} x\ n$)	(%)
Mkambalani	18,388	5,267	176	45
Mikese	23,637	6,310	211	55
Total	**42,025**	**11,577**	**387**	**100**

Source: National Bureau of Statistics, 2022

Regarding the sampling procedure, the study used purposive sampling to select two wards and four villages, with two villages from each ward. These were purposively selected due to their intensive agricultural activities and agrochemical use. Systematic random sampling was used to select 387 household heads. In addition, purposive sampling was used to select 7 key informants for in-depth interviews based on their roles, knowledge, and experience with agrochemical use. The technique was also used to select 21 smallholder farmers, divided into three focus group discussions of seven (7) participants each, based on their experience with agrochemical use. The primary and secondary data were collected. The primary data sources were extension officers, local government officials, household heads, and farmer group representatives. The sources of secondary data were both the published and unpublished documents. The data were collected in March 2026 through household questionnaire surveys, in-depth interviews, and focus group discussions. These data were on the types of agricultural chemicals used by smallholder farmers, farmers' risk perceptions of agrochemical use, and the socio-economic and institutional factors influencing those perceptions.

The questionnaire was pretested with a small group of smallholder farmers from an area with characteristics similar to the study area but not included in the actual study. The pre-test aimed to assess the clarity and relevance of the questions. Feedback from the pre-test was used to revise the questionnaire. The household questionnaire collected data on key variables related to smallholder farmers' risk perceptions of agrochemical use. The dependent variables focused on farmers' risk perceptions of agrochemical use, while independent variables included socio-economic characteristics such as age, sex, and education level, as well as institutional factors such as access to agricultural extension services, training in safe agrochemical use, and membership in farmer groups.

The qualitative data from interviews and focus group discussions were analysed using qualitative content analysis supported by NVivo Version 12. Descriptive statistics and an ordinal logistic regression model were used to analyse quantitative data collected through a household questionnaire survey, using the Statistical Package for the Social Sciences (SPSS) software version 20. Furthermore, ordinal logistic regression was used to identify the socio-economic and institutional factors influencing farmers' perceptions of environmental and human health risks associated with chemical use. The model was expressed as:

$Y = \beta 0 + \beta_1 (AG) + \beta_2 (EDU) + \beta_3 (SE) + \beta_4 (AES) + \beta_5 (MFG) + \beta_6 (AER) + \beta_7 (ATC) + \ldots\ldots\ldots\ldots\ldots\beta_Z.$

Where Y = Farmers' perceptions of environmental and human health risks related to chemical use, B_0 = Constant, B_1-B_z = Coefficient of the explanatory variables, AG= Age of the household head, ED = Educational levels of the household head, SE = Sex of the household head, AES = Access to extension service, MFG = Membership in Farmer Groups, AER = Awareness of environmental regulations, and ATC = Access to Training on safe chemical use.

The dependent variable in this model was the farmers' risk perceptions of agricultural chemical use (Y) with three categorical possible outcomes; such that Y = 0 when the households have low risk perceptions of agricultural chemical use, Y = 1 when the households have moderate risk perceptions of agricultural chemical use, and Y = 2 when the households have high risk perceptions of agricultural

chemical use. The model's independent variables were the socio-economic and institutional factors influencing farmers' risk perceptions of agricultural chemical use (Table 2).

Table 2: Description of Independent Variables Used in the Model

Independent variables	Coding
Age of the household head	0 = Below or equal to 45 years, 1 = Above 45 years
Educational levels	0 = Below or Primary, 1 = Secondary & above
Sex of the household head	0 = Female, 1= Male
Access to extension service	0 = No access, 1 = Access
Membership in Farmer Groups	0 = Non-member, 1= Member
Awareness of environmental regulations	0 = Not aware, 1= Aware
Access to Training on safe chemical use	0 = No access, 1 = Access

Source: Field data, 2025

Ethical Considerations

Permission to conduct the study was obtained from the Mwalimu Nyerere Memorial Academy, Karume Campus, Zanzibar and from the relevant authority in Morogoro Region. Before participating in the study, smallholder farmers were informed about its purpose and procedures. Confidentiality and anonymity were maintained throughout the research process by ensuring that participants' identities were not disclosed and that the collected information was used strictly for academic purposes.

Results and Discussion

Types of food crops grown in the study area

The results from the in-depth interviews and focus group discussions revealed that farmers cultivated a wide range of food crops to meet household food needs and generate income. The commonly grown crops included maize, beans, vegetables, rice, cassava, sorghum, cowpeas, and pigeon peas, while some farmers also cultivated fruits. One participant in the focus group discussion stated:

Maize and beans are the main crops we grow because they are our staple foods. We also plant vegetables to earn income and support our families (Female farmer, 40 years in Mikese ward).

Another participant added:

We do not depend on one crop. We grow rice, cassava, sorghum, pigeon peas, and sometimes fruits because different crops perform differently depending on rainfall, pests, and weather conditions (Male farmer, 51 years in Mikese ward). Similar results were reported by Nyamwero et al. (2026) farmers in Mvomero district, who cultivated a diverse range of food crops, including maize, rice, sorghum, common beans, pigeon peas, vegetables, cassava, and tropical fruits such as oranges, bananas, and mangoes.

Types of agricultural chemicals used by the respondents

Herbicides were used by 54% of respondents (Table 3). Herbicides were used to control weeds that compete with crops for nutrients, water, and sunlight. The commonly used herbicides included glyphosate (Roundup) and 2,4-D. The chi-square test results indicated no statistically significant difference ($\chi^2 = 0.262$, $p = 0.609$) in herbicide use between the two wards. This suggests that herbicide adoption rates were similar in both wards.

Table 3: Types of agricultural chemicals used by the respondents

Agricultural chemicals	Used/not used	Ward of Residence		Total	χ^2 P- Value
		Mkambalani	Mikese		
		%	%	%	
Herbicides	Not used	44	47	46	0.262
	Used	56	53	54	0.609
Insecticides	Not used	30	32	31	0.121
	Used	70	68	61	0.728
Fungicides	Not used	34	36	35	0.157
	Used	66	64	65	0.692
Fertilisers	Not used	28	29	29	0.012
	Used	72	71	71	0.914
Other chemicals such as rodenticides and post-harvest storage chemicals	Not used	40	45	43	0.695
	Used	60	55	57	0.404

***Significant at 5%*
Key: χ^2= Chi-square test
Source: Survey data, 2026

Insecticides were used by 61% of respondents. Insecticides were used to control insect pests that damage crops. The commonly used insecticides included sumithrin, celecron (profenofos), and chlorfenapyr. The Chi-square test results indicated no statistically significant difference ($\chi^2 = 0.121$, $p = 0.728$) in insecticide use between the two wards. The results from the focus group discussions indicate that farmers have faced pest problems and are using various insecticides, including sumithrin, profenofos, and chlorfenapyr, to control crop-damaging insects. Participants explained that pest infestations remain a major challenge to agricultural productivity, making pesticide application an essential farming practice. One participant stated:

In general, we have been facing the problem of pests destroying our crops. Honestly, I would say farming here cannot succeed without pesticides. We have been using pesticides such as sumithrin, profenofos, and chlorfenapyr to control destructive pests while crops are still in the field. Although these pesticides are expensive, we continue to struggle to use them because they are the main way of protecting our crops (Female farmer, 50 years in Mkambalani ward).

Fungicides were used by 65% of respondents. Fungicides were used to prevent and control fungal diseases affecting crops. The commonly used products included propineb, metalaxyl, mancozeb, and cymoxanil. The Chi-square test results indicated no statistically significant difference ($\chi^2 = 0.157$, $p = 0.692$) in fungicide use between the two wards. This suggests that fungicide application patterns were consistent across the study area. Similarly, Mergia et al. (2021) reported that farmers in Ethiopia were using fungicides such as metalaxyl and mancozeb to control fungal diseases in crops.

Most of the respondents (71%) reported using fertilisers. They were used to improve soil fertility and enhance crop growth. The commonly used fertilisers included urea, NPK fertilisers (Nitrogen, Phosphorus, and Potassium fertilisers), diammonium phosphate (DAP), calcium ammonium nitrate (CAN), and sulphate of ammonia (SA). The chi-square test results indicated no statistically significant difference ($\chi^2 = 0.012$, $p = 0.914$) between the two wards in fertiliser use. This suggests that fertiliser application practices were similar across the two wards. Mahuma et al. (2024) reported that in Tanzania, fertilisers are applied at different stages of crop production. For example, diammonium phosphate (DAP), nitrogen, phosphorus and potassium fertiliser (NPK), triple superphosphate (TSP),

and Minjingu phosphate are used at the planting season, while urea, sulphate of ammonia (SA), and calcium ammonium nitrate (CAN) are used during the crop growth period.

Also, the results from in-depth interviews with key informants show that farmers use a variety of fertilisers, such as DAP, CAN, SA, and Minjingu, to improve soil fertility and increase crop production. One of the key informants reported:

In this ward, we are using various fertilisers, including DAP, CAN, SA, and Minjingu, to improve soil fertility and increase crop production. Minjingu is commonly used because it is affordable and accessible to many farmers (Male farmer, 62 years in Mikese ward).

Also, one of the Agricultural Extension Officers said:
Most farmers in this area use fertilisers as a major input to improve crop performance and restore soil nutrients. The commonly used fertilisers include urea, NPK fertilisers, diammonium phosphate (DAP), calcium ammonium nitrate (CAN), and sulphate of ammonia (SA). Farmers are encouraged to apply the recommended fertiliser types and quantities, as improper use may harm soil health and increase production costs (Agricultural Extension Officers, in Mkambalani ward).

Other agricultural chemicals, including rodenticides and post-harvest storage chemicals, were used by 57% of respondents. The Chi-square test results indicated no statistically significant difference ($\chi^2 = 0.695$, $p = 0.404$) between the two wards in the use of these agricultural chemicals. This implies that the observed differences between wards were not significant.

Smallholder farmers' Risk Perceptions of Agricultural Chemical Use

The results on smallholder farmers' risk perceptions of agricultural chemical use, measured on a five-point Likert-scale and summarised as weighted means and standard deviations, are presented. The interpretation of the results was guided by a five-point Likert-scale class-interval approach. In this framework, mean scores ranging from 1.00 to 1.80 represented strongly disagree, 1.81 to 2.61 represented disagree, 2.62 to 3.42 represented neutral or moderate, 3.43 to 4.23 represented agree, and 4.24 to 5.04 represented strongly agree (Alkharusi, 2022). In this study, the weighted mean scores ranging from 1.00 to 2.61 indicate low perception, 2.62 to 3.42 indicate moderate perception, and 3.43 to 5.04 indicate high perception. The overall results (Table 4) indicate that respondents had a moderate risk perception of agrochemical use (weighted mean = 3.15). This suggests that although respondents were generally aware of the negative effects of agrochemicals, their awareness varied across the aspects examined. These results corroborate those of Emeribe et al. (2023) who reported that farmers in Nigeria exhibited a moderate level of awareness of the public health effects associated with pesticide use.

Table 4: Respondents' Risk Perceptions of Agricultural Chemical use

Items	SD	D	N	A	SA	Mean	σ	Decision
Agrochemicals can cause headaches, dizziness, or nausea.	69 (18%)	35 (9%)	71 (18%)	139 (36%)	73 (19%)	3.29	1.36	Moderate
Farmers are at risk when spraying or handling agrochemicals.	65 (17%)	144 (37%)	59 (15%)	63 (16%)	56 (15%)	2.74	1.31	Moderate
Children may be harmed by agrochemical exposure.	75 (19%)	135 (35%)	49 (13%)	57 (15%)	71 (18%)	2.78	1.40	Moderate
Not using protective equipment (gloves, masks) increases health risks.	35 (9%)	35 (9%)	70 (18%)	143 (37%)	104 (27%)	3.64	1.22	High
Agrochemicals can make the soil less fertile and reduce crop growth.	64 (17%)	81 (21%)	65 (17%)	108 (28%)	69 (17%)	3.10	1.36	Moderate
Agrochemicals can pollute rivers and other water sources.	64 (17%)	74 (19%)	38 (10%)	175 (45%)	36 (9%)	3.12	1.29	Moderate
Agrochemicals can kill useful insects, like bees and other pollinators.	36 (9%)	36 (9%)	71 (18%)	142 (37%)	102 (27%)	3.63	1.23	High
Agrochemical residues can stay in the environment for a long time.	72 (19%)	144 (37%)	76 (20%)	49 (13%)	46 (11%)	2.62	1.26	Moderate
Agrochemicals can harm livestock, wildlife, and reduce biodiversity.	42 (11%)	71 (18%)	35 (9%)	169 (44%)	70 (18%)	3.40	1.27	Moderate
Overall weighted mean						**3.15**		**Moderate**

Key: *SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree, and σ = Standard Deviation.*
Source*: Survey data, 2026*

The results further revealed that smallholder farmers had a high perception that not using protective equipment such as gloves and masks increases health risks associated with agrochemical use (M = 3.64). This shows that many farmers were aware that handling agrochemicals without personal protective equipment can expose them to serious health problems. These findings support the Health

Belief Model, which posits that individuals who perceive themselves to be susceptible to health risks and recognise the seriousness of those risks are more likely to adopt protective behaviours, such as using personal protective equipment. Similarly, smallholder farmers had a high perception that agrochemicals can kill useful insects such as bees and other pollinators (M = 3.63). This indicates that many respondents recognised the harmful effects of agrochemicals on beneficial insects and ecosystem services such as pollination. According to Singh et al. (2024), respondents perceived that the benefits of pesticides do not outweigh their health and environmental impacts. They also recognised that pesticides adversely affect non-target organisms, including beneficial insects, as well as human, terrestrial, and aquatic life. During the focus group discussion, participants reported that smallholder farmers were aware of several environmental and human health risks associated with agricultural chemical use. One of the participants said:
Agrochemicals do not only affect people; they also kill useful insects like bees and other pollinators. When agrochemicals are used improperly, they can reduce the number of beneficial insects that support crop production. In addition, chemical residues may affect the environment and soil quality, creating long-term challenges for farming activities (Female farmer, 41 years, in Mkambalani ward).

On the other hand, the findings revealed that smallholder farmers had a moderate perception that agrochemicals can harm livestock and wildlife and reduce biodiversity (M = 3.40). This suggests that many farmers were aware of the broader environmental consequences of agrochemical use. Likewise, respondents had a moderate perception that agrochemicals can cause headaches, dizziness, or nausea (M = 3.29), indicating a reasonable understanding of the immediate health effects associated with agrochemical exposure. Smallholder farmers also had a moderate perception that agrochemicals can pollute rivers and other water sources (M = 3.12). This shows that many respondents recognised the environmental risks posed by agrochemical runoff and contamination of water resources. In addition, farmers demonstrated moderate perception that agrochemicals can make the soil less fertile and reduce crop growth (M = 3.10). This implies that respondents had some awareness of the potential long-term effects of agrochemicals on soil quality and agricultural productivity. Similarly, smallholder farmers had a moderate perception that agrochemical residues can remain in the environment for a long time (M = 2.62). According to most farmers in Sri Lanka, pesticides were reported as beneficial; however, they also reported adverse effects associated with their use. The most commonly reported health-related symptoms included headaches, dizziness, and itching (De Costa et al., 2021).

Moreover, the results indicated that smallholder farmers had a moderate perception that farmers are at risk when spraying or handling agrochemicals (M = 2.74). This suggests that respondents had some awareness of occupational health risks associated with direct exposure to agrochemicals during application and handling. Similarly, farmers had a moderate perception that children may be harmed by agrochemical exposure (M = 2.78), indicating some recognition of the potential risks they face. These findings do not support those of Akinsete et al. (2026), who reported that most farmers do not adopt precautionary measures during pesticide application due to low perceived health risks associated with agrochemical exposure to farmers and children. The difference may be attributed to variations in farmers' access to agricultural information and extension services, as well as their awareness of agrochemical risks, across different study contexts.

Respondents' Overall Risk Perceptions of Agricultural Chemical Use
The results in Table 5 revealed that the majority of respondents (44%) had a moderate perception of the risk of agrochemical use. This suggests that most respondents possessed a reasonable level of awareness regarding the potential risks associated with agrochemical use. These findings are consistent with Emeribe et al. (2023), who found that farmers in Nigeria had a moderate understanding of the public health impacts associated with pesticide use.

Table 5: Respondents' Overall Risk Perceptions of Agricultural Chemical Use

Overall perceptions	Sex of the respondents			χ^2_{df}
	Female (%)	Male (%)	Total (%)	P- Value
Low perception	29	31	30	0.228
Moderate perception	45	43	44	2
High perception	26	26	26	0.892
Total	**100**	**100**	**100**	

***Significant at 5%*
Source: Survey data, 2026

The chi-square test showed no statistically significant association between sex and respondents' risk perceptions of agrochemical impacts ($\chi^2 = 0.228$, df = 2, p = 0.892). This suggests that both female and male respondents had a moderate level of risk perception regarding agrochemical use.

Factors Influencing Respondents' Risk Perceptions of Agricultural Chemical Use

In this section, the results from the ordinal logistic regression model in examining the factors influencing respondents' risk perception of agricultural chemical use are presented. The model fitting results (Table 6) show that the final model provides a significantly better fit to the data than the intercept-only model. The Chi-square test ($\chi^2 = 43.977$, df = 7, p = 0.000) was statistically significant. This indicates that the independent variables included in the model significantly improve the prediction of the dependent variable. Therefore, the model is suitable for explaining variation in the outcome variable.

Table 6: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept-Only	641.883			
Final	597.906	43.977	7	.000

Source: *Survey data 2026*

The ordinal logistic regression results indicate that respondents' age significantly influenced their risk perceptions of agrochemical use (Estimate = 0.018, Sig. = 0.017, Exp (B) = 1.018). The odds ratio of 1.018 implies that for every one-year increase in age, the odds of belonging to a higher perception category increased by 1.8%. This finding suggests that older respondents were more likely to have greater awareness and understanding of the impacts of agrochemical use than younger respondents.

Table 7: Factors Influencing Respondents' Risk Perceptions of Agricultural Chemical Use

		Parameter Estimates							
		Estimate	Std. Error	Wald	df	Sig.	Exp (B)	95% C.I. for EXP(B) Lower Bound	Upper Bound
Threshold	[Overall = .00]	-2.306	.577	16.000	1	.000	0.100	0.032	0.309
	[Overall = 1.00]	-.263	.564	.217	1	.641	0.769	0.255	2.323
Location	AG	.018**	.007	5.746	1	.017	1.018	1.003	1.033
	[Se =.00]	-.097	.247	.154	1	.695	0.908	0.559	1.474
	[Se =1.00]	0[a]	.	.	0	.	.	.	.
	[Ed =.00]	-.539**	.267	4.080	1	.043	0.583	0.346	0.984
	[Ed =1.00]	0[a]	.	.	0	.	.	.	.
	[AES =.00]	-.513**	.248	4.287	1	.038	0.599	0.369	0.973
	[AES =1.00]	0[a]	.	.	0	.	.	.	.
	[MFG =.00]	-.723**	.299	5.833	1	.016	0.485	0.270	0.873
	[MFG =1.00]	0[a]	.	.	0	.	.	.	.
	[AER =.00]	-.471**	.238	3.897	1	.048	0.624	0.391	0.997
	[AER =1.00]	0[a]	.	.	0	.	.	.	.
	[ATC =.00]	-.547**	.274	3.993	1	.046	0.579	0.338	0.990
	[ATC =1.00]	0[a]	.	.	0	.	.	.	.

Note: ***Significant at 5%*
Key: *SE = Sex of the household head, AG= Age of the household head, ED = Educational levels of the household head, AES = Access to extension service, MFG = Membership in Farmer Groups, AER = Awareness of environmental regulations, and ATC = Access to Training on safe chemical use.*
Source: *Survey data 2026*

The results further indicate that respondents' sex did not significantly influence their perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.097, Sig. = 0.695, Exp (B) = 0.908). The odds ratio of 0.908 indicates that female respondents had 9.2% lower odds of belonging to a higher-perception category than male respondents. The difference in perceptions could be associated with greater access to relevant information among male respondents compared to female respondents. These results corroborate those of Kpienbaareh et al. (2023) who reported that female famers were less likely to perceive the effects of agrochemical use on human health and environment compared to male farmers.

Education level significantly influenced respondents' perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.539, Sig. = 0.043, Exp (B) = 0.583). The results suggest that respondents with below primary education had 41.7% lower odds of belonging to a higher perception category than those with secondary and above education. This finding suggests that respondents with higher levels of education were more likely to have greater awareness and understanding of the environmental and human health impacts associated with agrochemical use than those with lower education levels. Similarly, results were reported by Keleb et al. (2024), showing that farmers with lower levels of education had limited knowledge of the impacts of pesticide use on human health.

Access to extension services significantly influenced respondents' perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.513, Sig. = 0.038, Exp (B) = 0.599). The findings indicates that respondents without access to extension services had 40.1% lower odds of belonging to a higher perception category. This finding suggests that access to extension services enhances farmers' awareness and understanding of the environmental and human health consequences of agrochemical use.

Membership in farmer groups significantly influenced respondents' perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.723, Sig. = 0.016, Exp (B) = 0.485). This implies that non-members had 51.5% lower odds of belonging to a higher perception category. This finding suggests that participation in farmer groups increases opportunities for information exchange, learning, and awareness creation regarding agrochemical-related risks. The findings of Sanusi et al. (2024), indicated that respondents' risk perceptions of agrochemical use were largely shaped by shared experiences among farmers within their community or farmer groups.

Awareness of environmental regulations significantly influenced respondents' perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.471, Sig. = 0.048, Exp (B) = 0.624). The findings indicate that respondents lacking awareness of environmental regulations had 37.6% lower odds of belonging to a higher perception category. This finding suggests that awareness of environmental regulations plays an important role in improving farmers' understanding of the potential impacts of agrochemical use.

Access to training on chemical use significantly influenced respondents' perceptions of the environmental and human health impacts of agrochemical use (Estimate = -0.547, Sig. = 0.046, Exp (B) = 0.579). The results imply that untrained respondents had 42.1% lower odds of belonging to a higher perception category. This finding suggests that training programmes contribute significantly to improving farmers' risk perception of agrochemical use. Mitku et al. (2024), reported that farmers who had received training were more likely to store pesticides safely compared to those without training.

Limitations of the study

The study was conducted in Morogoro District among smallholder farmers, and this may limit the extent to which the findings can be generalised to other areas with different agricultural and institutional contexts. Despite this limitation, the study provides valuable insights into farmers' perceptions of agrochemical risks and the factors that influence them.

Conclusion

The study concludes that smallholder farmers in Morogoro District have a moderate perception of the environmental and human health risks associated with agrochemical use, with greater awareness of immediate than long-term risks. Risk perceptions were significantly influenced by age, education, extension services, farmer group membership, awareness of environmental regulations, and training. The study recommends that the Government strengthen agricultural extension services and provide targeted training on the safe use of agrochemicals, while local government authorities promote farmer groups to enhance information sharing and the adoption of safer agrochemical practices.

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