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SAFEGUARDING SUSTAINABILITY: EXPLORING SAFETY PRACTICE ADHERENCE AMONG URBAN VEGETABLE FARMERS IN GHANA

Amos Mensah[1]✉, Faizal Adams[1], Fred Nimoh[1], Foster Frempong[1], Edward Ebo Onumah[2], Nartey Bernice Nartekie[1]

[1]Kwame Nkrumah University of Science and Technology, Ghana
[2]University of Ghana, Ghana

Abstract
Purpose: This research investigates safety practice compliance among urban vegetable farmers in Ghana's Ashanti Region and its implications for the environment, farmers' health, and consumer safety.
Design/methodology/approach: An empirical approach was adopted, utilizing field survey data from 387 urban vegetable farmers in key vegetable-producing communities. The study employed various data analytical techniques, including frequency distributions, a Bonferroni multiple comparisons test, and ordered logistic regression.
Findings: The research emphasizes the need for enhanced awareness and education among farmers to ensure adherence to safety practices. It reveals a significant positive relationship between farmers' awareness and compliance, underlining the role of informed decision-making and knowledge dissemination. Additionally, higher gross margin values are associated with increased compliance, indicating the motivating influence of profitability in allocating resources for safety measures. Furthermore, farming experience is positively linked to compliance, emphasizing the importance of practical knowledge and expertise.
Practical implications: Based on the findings, the research offers policy recommendations to promote compliance with safety practices. These include enhancing farmer education and awareness programs, improving profitability and market access, fostering knowledge-sharing platforms, addressing affordability concerns, and strengthening enforcement and monitoring. Implementing these measures will enhance compliance, safeguarding the well-being of farmers, consumers, and the environment, thereby ensuring the long-term sustainability and growth of Ghana's urban vegetable sector.
Research limitations/implications: While this study focused specifically on urban vegetable farmers, pesticide usage extends beyond vegetable production in Ghana. Future research should incorporate essential crops like maize, cassava, and rice to provide a more comprehensive assessment of pesticide practices and their implications in the broader agricultural context.

Keywords: compliance levels, safety practices, awareness, gross margin, farming experience, affordability, vegetable farming, Ashanti Region, Ghana.

INTRODUCTION

The increasing use of pesticides in vegetable production in Ghana has become a significant concern among stakeholders due to its negative impact on the environment, farmers, and consumers (Allegretti et al., 2017; Ganeshkumar et al., 2021; Horowitz and Lichtenberg, 1993; Zhang and Xue, 2005). The rise in pesticide usage is attributed to the demand for vegetables and healthy food to support the growing global population (Ciji and Akhtar, 2021; Ganeshkumar et al., 2021). However, in their pursuit of higher farm output, vegetable farmers have increased the frequency and volume of pesticide

✉Amos Mensah, Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, e-mail: mensahamos@yahoo.co.uk, https://orcid.org/0000-0002-5912-7634

application to control diseases and pests on their farms (Denkyirah et al., 2017; Osabohien, 2022; Pacini et al., 2003; Skevas et al., 2014). Disturbingly, some farmers still resort to the use of banned pesticides like Lindane, Endosulfans, and Dichlorodiphenyltrichloroethane (DDT) to combat diseases and pests on their vegetable farms (Damalas and Eleftherohorinos, 2011; Jaga and Dharmani, 2003; Mariyono et al., 2018). Research has shown that farmers who use pesticides face a higher risk of developing cancer, respiratory diseases, and reproductive disorders (Denkyirah et al., 2017; Loureiro, 2009; Onwona Kwakye et al., 2019; Osabohien, 2022; Pacini et al., 2003). The misuse of such chemicals poses grave environmental concerns and threatens the well-being of farmers (Belpomme et al., 2007; Jaga and Dharmani, 2003; Mariyono, 2023). Indiscriminate pesticide use not only affects the environment but also compromises the quality and safety of vegetables for consumption (Ding and Zhang, 2023; Jain et al., 2021; Kori et al., 2018; Meena et al., 2020). Pesticide residues in vegetables pose serious risks to consumer safety, leading to food poisoning and reduced vegetable consumption (Carbajal-Hernández et al., 2022; Coulibaly et al., 2011; De Roos et al., 2003; Ortiz-Ordoñez et al., 2011; Tarazona et al., 2017).

In Ghana, many farmers routinely apply pesticides on their farms without understanding the negative effects of pesticide misuse on their health and the environment, making them vulnerable to pesticide poisoning (Dapaah Opoku et al., 2020; Denkyirah et al., 2017; Okonya et al., 2013; Rano and Singh, 2021; Youm et al., 1988). Prolonged exposure to these pesticides has been associated with health issues, including endocrine disorders (Blodgett and Feld, 2021; Jaga and Dharmani, 2003; Onwona Kwakye et al., 2019). The misuse of certain banned pesticides, such as DDT, has raised significant environmental concerns (Meena et al., 2020; Okoffo et al., 2016b; Fosu-Mensah et al., 2022). The misuse of pesticides has become a national issue that demands immediate attention. It is crucial to address instances where farmers fail to comply with safety recommendations, exposing themselves to pesticide poisoning (Dapaah Opoku et al., 2020; Fosu-Mensah et al., 2016; González-Andrade et al., 2010; Okonya et al., 2013).

In addition to its human health impact, pesticide misuse has severe environmental consequences (Afari-Sefa et al., 2015; Zhou et al., 2020). Pesticides contaminate soil, bodies of water, and the air, leading to the death of beneficial organisms like pollinators and soil microorganisms essential for plant growth (Islam et al., 2020; Khan and Damalas, 2014; Mariyono et al., 2018). Furthermore, the development of pesticide-resistant pests and pathogens reduces the effectiveness of pest control strategies, necessitating increased pesticide use and leading to further environmental damage (Denkyirah et al., 2016; Flower et al., 2004; González-Andrade et al., 2010). Notably, the misuse of pesticides has also affected the marketability of Ghanaian vegetables both domestically and in export markets (CBI, 2009; Coulibaly et al., 2011; Fulano et al., 2021). Excessive pesticide residues in fresh vegetable shipments led to trade restrictions on vegetable exports, resulting in significant revenue loss for the country (Adjei et al., 2017; Fulano et al., 2021; Lydecker and Drechsel, 2010; Yayra Fosu-Mensah et al., 2022). Moreover, the profits of vegetable farmers may be undermined by increased costs from excessive spraying and potential rejection of produce with high pesticide residue levels (Adeyemo and Akinola, 2010; Chattopadhyay et al., 2017; Dinham, 2003; Yayra Fosu-Mensah et al., 2022). To address the adverse effects of pesticide misuse on the environment, farmer well-being, and vegetable production safety in Ghana, this study examines factors driving compliance with safety practices. By offering policy recommendations to enhance compliance with safety practices, the research aims to inform policymakers about the regulation needed to control pesticide usage in Ghana's vegetable production.

METHODS – STUDY AREA

Kumasi, the capital of Ghana's Ashanti Region, is the country's second-largest city, covering approximately 250 km². Around 40% of this territory comprises fertile land suitable for vegetable and other arable crop farming. Kumasi is renowned for its rich and fertile soil and is particularly suitable for vegetable farming due to its favorable weather conditions (Afari-Sefa et al., 2015; Dapaah Opoku et al., 2020; Lydecker and Drechsel, 2010). The region experiences a semi-humid tropical climate within Ghana's tropical forest zone, receiving an average annual rainfall of 1,420 mm over 120 days (Fosu-Mensah et al., 2016; Hutchins et al., 2015; Ndamani and Watanabe, 2016). The rainfall pattern follows two distinct seasons, with a major rainy season from March to July and a minor rainy season in September and October. Numerous prominent streams and rivers flow through the research area, including the Owabi River in Anloga suburb, the Subin River in Kaasi and Ahensan, and the Wiwi River running through the Kwame Nkrumah University of Science and Technology (KNUST) campus. These bodies of water, along with their tributaries, contribute to the presence of numerous water sources within the study area. Consequently, the low-lying agricultural lands adjacent to these water sources, with relatively shallow groundwater levels, provide ideal conditions for urban vegetable production.

Vegetable farming thrives in both urban and peri-urban Kumasi, with over 10,000 hectares of land dedicated to year-round vegetable production. However, the largest concentration of vegetable farms is found in the lowlands surrounding the KNUST campus and nearby areas, benefitting from continuous vegetable cultivation throughout the year due to the presence of water in streams and ponds. The fertile soil and the availability of water through the many streams and rivers scattered across these areas make them suitable for year-round vegetable cultivation (Darkwah et al., 2019; Issahaku and Abdulai, 2020; Naab et al., 2017).

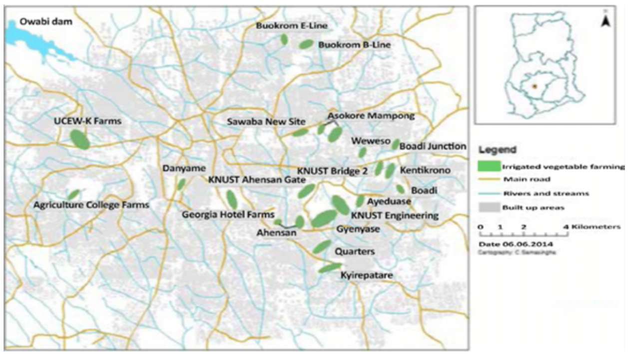

Fig. 1. A map of Kumasi vegetable production sites
Source: Danso et al., 2014.

Data

The study utilized a mixed-methods approach to collect data from 387 vegetable farmers across the main production areas in the Ashanti region (Table 1 and Fig. 1). Proper documentation of the total number of registered vegetable farmers in each community was lacking due

Table 1. Study area with number of farmers interviewed

Production communities	Number of respondents	Commonly grown vegetables	Water sources	Commonly used irrigation methods
Gyenyase	84	tomatoes, onions, green pepper, chili pepper	streams, rivers and dugouts / well	watering cans, water hose, trenches
KNUST (Engineering & Ahensan gates)	61	lettuce, cabbage, carrots, green pepper, tomatoes, onion, spring onions	streams, rivers	watering cans, water hose
Asokore Mampong	55	tomato, chili pepper, garden eggs, okra	streams, rivers and dugouts / well	watering cans, water hose
Kentinkrono	43	lettuce, cabbage, carrots, and green beans, garden eggs, okra	streams, rivers and dugouts / well	watering cans, water hose, trenches
Danyame	51	tomatoes, onion, spring onions, cabbage, lettuce, pepper, spinach, garden eggs	streams, rivers and dugouts / well	watering cans, water hose, trenches
Buokrom (E & B lines)	59	tomatoes, onions, cabbage, and carrots garden eggs, okra	streams, rivers and dugouts / well	watering cans, water hose, trenches
Kyirepatare	21	tomatoes, onions, okra, garden eggs and pepper	streams, rivers and dugouts / well	watering cans, water hose
Boadi	13	tomatoes, onions, and pepper	streams, rivers	watering cans, water hose
Total	387			

Source: study findings based on 2022 field survey data.

to the transient nature of many farmers who cultivate vegetables on available lands for temporary periods. These migrant workers frequently change their production locations due to urbanization encroaching on farmland, leading to eviction by landowners for residential or commercial development. Despite these challenges, the study area still maintains a significant number of vegetable farmers, although the exact count remains unknown. To ensure statistical accuracy during analysis, the study used Cochran's formula to determine an appropriate sample size. The following statistical assumptions were made: 95% confidence level, 5% margin of error, and a standard normal deviate of 1.96 (corresponding to a 95% confidence level). The proportion of vegetable farmers using pesticides in the study communities was assumed to be 50%. The sample size using the Cochran formula was 385.

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

$$n = \frac{(1.96)^2(0.5)(0.5)}{0.05^2} \quad (1)$$

$$n = 385 \text{ respondents}$$

where:

- n – the sample size
- Z – the abscissa of the normal curve that cuts off an area α at the tails (1 – α equals the desired confidence level, e.g., 95%)
- p – the estimated proportion of the attribute within the population (50% use pesticide)
- e – the desired level of precision (margin of error)
- q = 1-p.

Data was collected through a cross-sectional survey employing a mixed-methods approach, including structured questionnaires and key informant interviews. The structured questionnaire consisted of closed and open-ended questions covering household and farm-level factors. Household-level data focused on socioeconomic and institutional factors, while farm-level data included input usage, such as pesticide types and compliance with safety practices, as well as output and postharvest management practices. The questionnaire also gathered data on farmers' awareness and adherence to recommended safety practices, exploring the factors influencing their compliance level.

Theoretical underpinning

This study aims to investigate how farmers perceive, become aware of, and adopt recommended safety practices related to pesticide usage in vegetable production. To guide our research, we draw upon the decomposed theory of planned behaviour proposed by Taylor and Todd (1995). This theory suggests that farmers' perception and awareness of the potential benefits associated with safety practices significantly influence their decision-making process, determining whether they will adopt or ignore these practices. Within the decomposed theory of planned behaviour, three key factors influence a vegetable farmer's progression from intention (in terms of awareness and perception) to actual behavioural change (i.e., adopting or not adopting safety practices). The first of these factors is attitude. Farmers' attitudes towards the adoption of specific farming practices are influenced by their awareness and perception of the expected benefits, risks, and advantages associated with safety practices. The second factor is subjective norms. Social and environmental pressures within the farmers' community also influence their decision-making process. These norms may shape their perception of the appropriateness and desirability of adopting safety practices. The third factor is perceived behaviour control. Farmers' awareness and perception of the benefits of adopting safety practices, along with the availability of necessary resources, also play a significant role in determining whether they will implement these practices on their farms.

We hypothesize that perception and awareness of the benefits of safety practices play a crucial role in farmers' decision-making process regarding their adoption. However, the existing literature lacks comprehensive documentation on urban vegetable farmers' perception of recommended safety practices, the reasons for non-adoption, and their impact on farm outcomes. This study aims to address this knowledge gap and contribute valuable insights to this field of research. By employing the decomposed theory of planned behaviour, we seek to provide a theoretical foundation for understanding the factors influencing farmers' decision-making regarding the adoption of recommended safety practices. Through the application of the decomposed theory of planned behaviour, our study aims to establish a solid theoretical framework to comprehend the factors that shape urban vegetable farmers' decision-making process concerning the adoption of recommended safety practices. Using this framework, policymakers and stakeholders can gain valuable insights into the factors that influence farmers' choices and their adherence to these safety practices. With this enhanced understanding, policymakers can develop targeted and effective strategies to encourage the widespread adoption of sustainable and safe practices in urban vegetable production not only in Ghana but also in a broader African context. Ultimately, our research aspires to contribute to the advancement of agricultural practices that promote both environmental sustainability and the well-being of farmers and consumers.

Analytical procedure

To obtain empirical estimates, various analytical approaches were employed. The study employed descriptive statistics such as frequency distributions with percentage tables to depict the socioeconomic characteristics of farmers, input usage including the dominant types of pesticides applied, farmers' perception and farmers' compliance with recommended safety practices. In farming communities in Ghana, farmers' compliance with the recommended safety practices regarding pesticide usage is influenced by their traditional beliefs and perceptions. These beliefs and perceptions play a crucial role in shaping their practices and behaviors related to pesticide use, which in turn have far-reaching consequences for the well-being of farmers, the environment, and the overall success of agricultural operations. Consequently, it is essential to gain a comprehensive understanding of how vegetable farmers in the study area perceive and comprehend the recommended safety practices. This understanding is crucial for developing effective policy initiatives that promote compliance. By gaining insight into farmers' perceptions, policymakers can design measures that are relevant, appropriate, and capable of effectively addressing issues such as misapplication or abuse of pesticides. Tailoring strategies to the specific needs and challenges faced by farmers becomes possible when their perceptions are well understood. This approach allows policymakers to implement targeted interventions that effectively promote the adoption of recommended safety practices, safeguarding the well-being of farmers and the environment.

To assess farmers perception and understanding of pesticide use and compliance with safety measures, a survey consisting of several statements related to different aspects of effects of pesticide misapplication on farmers' health, crop growth and productivity and the environment were presented to them, and they were asked to rate their agreement or disagreement with each statement on a 3-point Likert scale: 1 = agree, 0 = neutral, –1 = Disagree (see Table 8). The perception index for each statement was determined using the following formula:

$$\text{Perception index} = \frac{(\text{freq of agree} \cdot 1) + (\text{freq of neutral} \cdot 0) + (\text{freq of disagree} \cdot -1)}{(\text{Total number of respondents } (n))} \quad (2)$$

A perception index value of 1 indicates that the majority of respondents strongly agree with the statement (positive perception), while a value of 0 indicates a neutral perception, and a value of -1 indicates strong disagreement (negative perception).

In order to evaluate farmers' level of compliance with the recommended safety practices, they were asked to indicate their compliance through a series of binary response questions (1 = yes or 0 = no). The compliance statements covered various compliance aspects of pesticide application, including its impact on farmers' health, crop growth and productivity, and the environment. A compliance score was calculated for each farmer by summing up the number of safety practices they acknowledged complying with ("yes" responses). The compliance score ranged from 0 to 15, reflecting the level of compliance with the recommended safety practices. Based on their compliance scores, farmers were categorized into three groups (compliance level):

1. High compliance group: This group consisted of farmers who reported complying with nearly all the recommended safety practices (a compliance score ranging from 10 to 15).
2. Medium compliance group: Farmers in this group indicated partial compliance with the recommended safety practices (a compliance score ranging from 5 to 9).
3. Low compliance group: This category included farmers who demonstrated limited or no compliance with the recommended safety practices (a compliance score ranging from 0 to 4).

An ordered logistic regression was used to assess the factors influencing the level of compliance with the recommended safety practices. Ordered logit models are used to estimate relationships between an ordinal dependent variable and a set of independent variables. An ordinal variable is a variable that is categorical and ordered (for instance, "High compliance group", "Medium compliance group", and "Low compliance group") which might indicate a farmer's compliance outcome. In ordered logit, an underlying score is estimated as a linear function of the independent variables and a set of cutpoints. The probability of observing outcome i corresponds to the probability that the estimated linear function, plus random error, is within the range of the cutpoints estimated for the outcome:

$$\Pr(outcome_j = i) = \Pr(K_{i-1}) < \beta_1 x_{1j} + \beta_2 x_{2j} + \ldots + \beta_k x_{kj} + u_j \leq k_i \quad (3)$$

u_j – is assumed to be logistically distributed in ordered logit. We estimate the coefficients β_1 β_2 and β_k together with the cutpoints k_1 and k_2 …, k_{k-1}, where k is the number of possible outcomes. k_0 is taken as $-\infty$, and k_k is taken as $+\infty$. All of this is a direct generalization of the ordinary two-outcome logit model. Category $i = 1$ is defined as the minimum value of the variable "Low compliance group", $i = 2$ as the "Medium compliance group", and $i = 3$ as the "High compliance group" for the empirically determined k categories. The coefficients and cutpoints are estimated using the maximum likelihood approach.

The Bonferroni multiple comparisons test is employed to analyse the differences in profitability levels among the three compliance categories. The main objective is to understand how compliance impacts farm profitability, which is a crucial farm outcome. By using multiple-comparison tests, we can address the challenge of conducting numerous tests while minimizing the risk of erroneously rejecting each hypothesis at the α level. This approach prevents the accumulation of risk with each additional test. For more comprehensive insights into multiple-comparison procedures, readers should refer to the works of Skillings (1983) and Skillings and Mack (1981), as well as Cicchetti (1994) and Hochberg (1988). The Bonferroni significance level is determined by the following formula:

$$e_b = \min(1, en) \text{ where } n = \frac{k(k-1)}{2} \text{ is the number of comparisons} \quad (4)$$

RESULTS AND DISCUSSION

Table 2 presents an overview of the socio-demographic characteristics of the urban vegetable farmers in our dataset. The data shows that a significant majority of the farmers (81.1%) were male, indicating male dominance in urban vegetable production within the Ashanti Region. Concerning educational background, a notable proportion of the farmers (60.47%) had no formal education, while a small percentage (6.45%) had received a senior secondary education. This finding raises concerns about adherence to safety measures, as higher education levels are generally associated with better compliance with recommended safety practices. Low levels of education may hinder farmers' understanding of the detrimental consequences of pesticide misapplication

Table 2. Socio-demographic characteristics of farmers

Categorical variables	Frequency	Percentage		
Gender				
Male	314	81.1		
Female	73	18.9		
Level of education				
No education	234	60.47		
Primary school	92	23.77		
Junior high school	36	9.30		
Senior high school	25	6.46		
Literacy (read and write)				
Yes	54	13.95		
No	333	86.05		
Membership of FBOs				
Yes	140	36.18		
No	247	63.82		
Extension contacts				
Yes	125	32.30		
No	262	67.70		
Continuous variables	**Mean**	**Std. deviation**	**Minimum**	**Maximum**
Age of farmer (years)	46.86	12.59	25	75
Vegetable farm experience (years)	10.19	7.64	2	45
Household size (number)	5.89	2.71	1	17
Farm size (acres)	0.26	0.23	0.02	0.99
PPEs Prices (cedis)	15.00	2.95	10.00	40.00

Source: study findings based on 2022 field survey data.

on their health, the environment, and overall farm outcomes. Additionally, a significant proportion of the farmers (63.82%) were not affiliated with any farmer-based organizations (FBOs), and the majority had no contact with extension agents (67.70%). FBOs and extension agents play a crucial role in educating farmers about various farming practices, including proper pesticide usage. A lack of access to extension agents and FBOs may negatively impact farmers' compliance with recommended safety practices.

These findings highlight the importance of targeted education and support systems for urban vegetable farmers in the Ashanti Region. By accessing training and resources through farmer-based organizations and extension services, farmers can enhance their awareness of safety practices, leading to better compliance and safer agricultural practices. Policymakers and stakeholders should consider these factors when designing interventions to promote sustainable and safe vegetable production in the region.

The farmers participating in the study have an average age of approximately 47 years and possess around 10 years of farming experience. This indicates that the majority of participants have significant expertise, having been engaged in vegetable production for a decade. However, there is a wide range of age and farming experience among the farmers, suggesting a diverse group in the study area. This diversity could influence their level of compliance with recommended safety practices. It is expected that more mature and experienced farmers will demonstrate greater adherence to safety guidelines, as they likely understand the importance of sustainable practices. Conversely, younger and more ambitious farmers may be more willing to take risks to maximize production, which could potentially affect their compliance with safety measures. The interplay between age, experience, and compliance warrants further investigation to understand how these factors influence farmers' decision-making regarding safety practices in vegetable production.

Table 3 provides insights into the diversity of vegetable production per season. The largest proportion of farmers (37.47%) cultivated two types of vegetables, while 29.2% reported growing four different types. Only 4% of farmers engaged in the production of five types of vegetables. Conversely, 13.7% specialized in cultivating a single type of vegetable per season. During data collection, farmers revealed that their choice

Table 3. Diversity of vegetable production per season

Type of vegetable produced per season	Frequency	%
One type of vegetable per season		
Spring onion	26	6.72
Cucumber	1	0.26
Chili pepper	5	1.30
Lettuce	12	3.10
Green pepper	4	1.03
Okra	5	1.29
	53	13.70
Two types of vegetables per season		
Spring onion and lettuce	90	23.26
Spring onion and cabbage	7	1.81
Lettuce and cabbage	5	1.29
Spring onion and okra	15	3.88
Onion and lettuce	15	3.88
Lettuce and cauliflower	13	3.36
	145	37.47
Three types of vegetables per season		
Spring onion, lettuce and cabbage	33	8.53
Spring onion, lettuce and okra	20	5.17
Spring onion, lettuce and bell pepper	2	0.52
Lettuce, green pepper and tomatoes	3	0.78
Spring onion, lettuce and cucumber	6	1.55
Chili pepper, tomatoes and garden eggs	7	1.81
Okra, tomatoes and bell pepper	14	3.62
Cabbage, cucumber and bell pepper	5	1.29
Spring onion, lettuce and cauliflower	14	3.62
Lettuce, cauliflower and chili pepper	9	2.33
	113	29.20
Four types of vegetables per season		
Spring onion, lettuce and cauliflower and bell pepper	20	5.17
Spring onion, lettuce, cucumber and cabbage	14	3.62
Spring onion, lettuce, cabbage and garden egg	7	1.81
Spring onion, onion, lettuce and cucumber	6	1.55
Spring onion, lettuce, cabbage and radish	2	0.52
Spring onion, lettuce, cauliflower and cucumber	10	2.58
Spring onion, lettuce, cauliflower and cabbage	13	3.36
	72	18.60
Five types of vegetables per season		
Spring onion, lettuce, cabbage, bell pepper and chili pepper	4	1.03
Total	387	100

Source: study findings based on 2022 field survey data.

of vegetables to grow was influenced by market demand and prices. However, female farmers highlighted that labor availability posed challenges, particularly for labour-intensive crops like bell pepper, cucumber, and spring onion. These vegetables require constant care, including regular watering and weed removal, to ensure they grow well and produce a good yield. To effectively manage weed growth, insect pests, and diseases, farmers often resort to the use of various pesticides. Unfortunately, the heavy reliance on pesticides to control diseases and pests and ensure a high yield may lead to the misuse or overuse of these chemicals. This can have adverse effects on the environment, farmer health, and the quality of the produce.

Table 4 provides an overview of the primary pesticides utilized by urban vegetable farmers in the study area. The most commonly used insecticides reported by the majority of farmers are Dalton (63%) and Attack (52%), both containing Emamectin Benzoate as their active ingredient, effectively combating insect infestations on vegetable crops. For weed control, Gramoquat, containing paraquat dichloride as its active ingredient, is the dominant choice, targeting both broad-leaf weeds and grasses on the farm. A few selected farmers use Furadan as the sole nematicide to manage soil and foliar pests. In total, farmers reported using around 15 different pesticide brands for vegetable production. This considerable variability in pesticide usage highlights the significance of farmers adhering to the recommended safety practices (Ding and Zhang, 2023). Following these practices is essential to safeguard the health of farmers, preserve the environment, and ensure that the vegetables have acceptable levels of pesticide residues (Coulibaly et al., 2011; Damalas and Eleftherohorinos, 2011; Kariathi et al., 2017; Odewale et al., 2022; Syed et al., 2014). By adopting proper safety measures in pesticide use, farmers can mitigate potential risks associated with overuse or misuse of these chemicals.

Tables 2, 3, and 4 provide summary information about farmers' socio-demographic and farm-level characteristics. However, they do not offer insights into farmers' perceptions regarding the impact of pesticides on health, the environment, and farm outcomes, and nor do they indicate the level of compliance with recommended safety measures. To address this gap, we conducted a detailed examination of farmers' perceptions and compliance with safety practices. Additionally, we explored farmer-specific and farm-level variables that could influence compliance decisions. Finally, we assessed the impact of compliance on farm profitability and explored the constraints farmers encounter as they strive to adhere to the recommended safety measures.

Table 4. The most common types of pesticides used by vegetable farmers in the Ashanti Region

Common name	Description	Active ingredient	Frequencies	Percentage
Dalton	Insecticide	Emamectin Benzoate	242	62.53
Attack	Insecticide	Emamectin benzoate	201	51.94
Gramoquat	Herbicide	Paraquat dichloride	97	25.06
Bypel	Insecticide	Perisrapae Granulosis Virus	84	21.71
Adwumapa	Herbicide	Glyphosate	83	21.44
Golan	Insecticide	Acetamiprid	82	21.19
Buffalo	Insecticide	Acetamiprid	73	18.86
Gramozone	Herbicide	Paraquat dichloride	73	18.86
Adwumawura	Herbicide	Glyphosate	69	17.83
Confidor	Insecticide	Imidacloprid	67	17.31
Multifos	Insecticide	Chlorpyrifos	62	16.02
Lambda	Insecticide	Lambda Cyhalothrin	62	16.02
Champion	Fungicide	Copper Hydroxide	48	12.40
Topsin	Fungicide	Thiophanate methyl	47	12.14
Furadan	Nematicide	Carbofuran	41	10.59
Condemn	Herbicide	Pendimethalin	40	10.34

Source: field survey, 2022.

To assess farmers' awareness, we used positively worded statements, where agreement indicated higher awareness and disagreement suggested a lack of awareness. The overall awareness index of -0.56 in Table 5 indicates that a significant majority of farmers have limited awareness of the harmful effects of pesticide misuse on health, crop growth, and the environment. This

Table 5. Perceived awareness of pesticide impacts on health, crop growth, and the environment

Perception statements	Agree 1	Neutral 0	Disagree –1	Index
Farmers health				
Improper handling or misapplication of pesticides can lead to acute poisoning among farmers	65 (16.8%)	56 (14.5%)	266 (68.7%)	–0.51
Direct exposure to concentrated pesticide can cause hormone disruption and certain types of cancers	109 (28.2%)	77 (19.9%)	201 (51.9%)	–0.24
Contact with pesticides, especially without proper protective clothing, can cause skin irritation and dermatitis among farmers	106 (27.4%)	81 (20.9%)	200 (51.7%)	–0.24
Inadequate respiratory protection while handling or spraying pesticides can lead to causing coughing, wheezing, shortness of breath, and in some cases, chronic respiratory conditions such as asthma	80 (20.7%)	62 (16.0%)	245 (63.3%)	–0.43
Improper use or mishandling of pesticides without wearing appropriate eye protection can result in eye irritation, chemical burns, corneal damage, and even vision loss	85 (21.9%)	63 (16.3%)	239 (61.8%)	–0.40
Perception index for farmers health				–0.36
Crop growth and crop yield				
Pesticides misapplication may cause leaf burn, stunted growth, discoloration, or even crop death, directly impacting crop yield and quality	72 (18.6%)	33 (8.5%)	282 (72.9%)	–0.54
Improper timing or frequency of pesticide application can lead to reduced crop yields leading to financial losses for farmers	90 (23.3%)	26 (6.7%)	271 (70.0%)	–0.47
Mishandling of pesticides can result in excessive residue accumulation on crops leading to rejection or lower prices in the market	40 (10.3%)	15 (3.9%)	332 (85.8%)	–0.75
Overuse or misuse of pesticides can contribute to the development of pesticide resistance in target pests making it harder to control them and resulting in reduced crop yield	75 (19.4%)	16 (4.1%)	296 (76.5%)	–0.57
Inappropriate pesticide application, especially during flowering periods, can harm pollinators crucial for crop pollination and yield	35 (9.0%)	21 (5.4%)	331 (85.5%)	–0.76
Perception index for crop growth and yield				–0.62
Environment:				
Pesticide misapplication can infiltrate into groundwater or runoff into nearby streams, rivers, and lakes, causing pollution and negatively impacting aquatic ecosystems.	37 (9.6%)	10 (2.6%)	340 (87.9%)	–0.78
Improper pesticide application techniques can affect soil fertility, disrupt beneficial soil microorganisms, and accumulate in the soil, posing long-term risks to agricultural productivity and the overall health of the ecosystem	31 (8.0%)	14 (3.6%)	342 (88.4%)	–0.80
Improper spraying techniques, such as spraying during windy can lead to pesticide drift and air pollution (Pesticide particles and vapors can travel through the air, potentially affecting nearby communities and sensitive ecosystems)	31 (8.0%)	7 (1.8%)	349 (90.2%)	–0.82
Misapplication of pesticides can lead to imbalances in the ecosystem, allowing pest populations to increase and requiring more intensive pesticide use to control them	70 (18.1%)	17 (4.4%)	300 (77.5%)	–0.59
The perception index for the environment				–0.75
Overall perception index				–0.56

Source: field survey, 2022.

observation aligns with recent literature, emphasizing the urgent need for improved awareness and education about the negative impacts of pesticide misapplication. For instance, studies by Blodgett and Feld (2021), Coulibaly et al. (2011), Islam et al. (2020), Okonya et al. (2013), and Onwona Kwakye et al. (2019) revealed that farmers' knowledge of health risks related to pesticide exposure was generally low, underscoring the importance of enhancing awareness among agricultural communities.

The awareness index for farmers' health statements (–0.36) indicates a negative perception among the majority of farmers regarding the severe consequences of pesticide misapplication on their health. This finding is consistent with studies conducted by Dapaah Opoku et al. (2020), Lehberger and Becker (2021), Mariyono et al. (2018), and Okonya et al. (2013), which revealed inadequate knowledge among farmers regarding the potential health hazards posed by pesticide exposure. Similarly, the negative awareness indices of –0.62 for crop growth and yield indicate a lack of awareness among farmers regarding the detrimental effects of pesticide abuse on crop productivity.

This finding is supported by recent studies by Awunyo-Vitor et al. (2016), Mariyono et al. (2018), and Meena et al. (2020), which highlighted the importance of farmers having a comprehensive understanding of the adverse effects of pesticides on crop growth and yield. The environmental index of -0.75 also demonstrates a concerning trend of farmers' limited awareness regarding the harmful effects of pesticide misapplication on the environment, including soil organisms and water contamination. This observation aligns with research by Carbajal-Hernández et al. (2022), Islam et al. (2020), Khan and Damalas, (2014), and Yayra Fosu-Mensah et al. (2022) emphasizing the need to educate farmers about the environmental impacts of pesticide use to promote sustainable agricultural practices.

The study highlights a concerning lack of awareness (negative perceptions) among urban vegetable farmers, which has a significant impact on their decisions regarding the adoption of recommended safety practices. This underscores the urgent need for proactive measures to improve education and awareness among farmers. The low educational background of many farmers and limited interaction with extension agents likely contribute to this trend of low awareness (negative perceptions) (Blodgett and Feld, 2021; Wu and Hou, 2012). To address this issue, the district extension directorate in the Ashanti Region should intensify educational efforts on pesticide use and promote compliance with recommended safety measures. Previous studies by Ali et al. (2018), Denkyirah et al. (2016), Mrema et al. (2017), and Yayra Fosu-Mensah et al. (2022) have emphasized the critical role of extension services in disseminating accurate information about pesticide safety to farmers and enhancing their awareness of best practices. Ultimately, improving farmers' awareness and understanding of the detrimental effects of pesticide misapplication on health, crop growth, and the environment is essential to safeguard the well-being of farmers, consumers, and the environment (Adjei et al., 2017; Coulibaly et al., 2011; Dapaah Opoku et al., 2020; Mariyono et al., 2018).

Tables 6 and 7 provide an overview of farmers' compliance with recommended safety practices in pesticide usage. Compliance was assessed through binary response questions, and a compliance score ranging from 0 to 15 was calculated based on the number of acknowledged safety practices. The results reveal that a significant majority of farmers did not adhere to the recommended safety practices, resulting in low compliance scores. Specifically, Table 7 shows that 65.6% of farmers demonstrated low compliance, while only 7% were classified as having high compliance. These findings are concerning and highlight the urgent need for stakeholders in the vegetable sector to prioritize educational and outreach programs. Recent studies by Blodgett and Feld (2021), Donkor et al. (2016), Fulano et al. (2021), Mrema et al. (2017), Onwona Kwakye et al. (2019), Purkait et al. (2009), and Yayra Fosu-Mensah et al. (2022) underline the importance of comprehensive pesticide education initiatives to improve farmers' understanding of proper usage, handling, and disposal methods, ultimately safeguarding the industry.

Addressing the lack of compliance requires collaborative efforts to promote awareness, provide training, and establish robust monitoring and enforcement systems for adherence to recommended safety practices (Ali et al., 2018; Darko et al., 2022; Fulano et al., 2021; Jaga and Dharmani, 2003; Onwona Kwakye et al., 2019; Qiu et al., 2021; Wang et al., 2018). By adopting such methods, the vegetable sector can enhance its sustainability, protect farmers' well-being, and mitigate potential environmental risks associated with pesticide misuse (Abdelrazek and El Khafif, 2022; Abou Zeid et al., 2017; Blodgett and Feld, 2021; de Backer et al., 2009; Fulano et al., 2021; Ho et al., 2018; Pacini et al., 2003).

Table 6. Distribution of compliance with the recommended safety measures on pesticide usage

Compliance statements	Yes	No
I always use designated equipment for measuring and mixing pesticides	16	371
I only purchase pesticides that are in their original containers with the label attached	15	372
I always avoid spraying during windy or rainy conditions to prevent drift or runoff	121	266
I always mix pesticides in well-ventilated areas and avoid inhalation of fumes	35	352
I always spray in the direction of the wind as recommended the extension agent	95	292
I always wear protective footwear (boots) during spraying	254	133
I always wear protective goggles during spraying	44	343
I always wear protective clothing during spraying	144	273
I always wear a nose mask/respirator during spraying	86	301
I always wear gloves during spraying & handling pesticides	45	342
I always avoid eating, smoking and drinking during spraying	23	364
I always avoid storing pesticides near food, beverages or animal feed	22	365
I always store pesticides in a locked cabinet area, away from children	14	370
I always clean equipment and containers before and after use	23	364
I always wash hands and exposed skin immediately after handling pesticides	359	28

Source: field survey, 2022.

Table 7. Distribution of compliance levels

Level of compliance	Frequency	Percentages (%)
Low level of compliance (score: 0–4)	254	65.6
Medium level of compliance (score: 5–9)	106	27.4
High level of compliance (score: 10–15)	27	7.0

Source: field survey, 2022.

The study utilized a chi-square statistical test of association to examine the link between farmers' awareness and their compliance levels. A p-value less than the chosen significance level (usually $p < 0.05$) indicates a statistically significant relationship. Table 8 presents strong evidence of a significant association between farmers' awareness and compliance levels, as indicated by the Fisher's exact and Pearson's p-values. To further quantify the strength and direction of this relationship, a Pearson correlation test was employed, revealing a coefficient value of 0.77 with a p-value of 0.000. These results suggest a significant positive relationship between farmers' awareness and their compliance levels (Fulano et al., 2021; Qiu et al., 2021).

Recent studies by Haden and Johnson (1989), Mishra et al. (1999), Nin-Pratt et al. (2011), and Sanz Sanz et al. (2018) found a similar positive relationship between awareness and compliance among farmers, highlighting the significance of awareness in promoting adherence to safety practices. These findings underscore the need for targeted interventions aimed at increasing farmers' awareness regarding safety practices, as greater awareness is associated with higher compliance rates. By providing education and raising awareness about the importance of following recommended safety measures, stakeholders can promote safer agricultural practices and protect the well-being of farmers and the environment.

Table 9 presents the impact of compliance on farm outcomes, specifically focusing on gross margin per acre as a measure of profitability. The data reveals a strong and statistically significant difference between the medium compliance level group and the low compliance level group. Similarly, there is a significant difference when

Table 8. Relationship between awareness (knowledge & education) and compliance level

Awareness level	Compliance level			Total
	low compliance	medium compliance	high compliance	
Low awareness	232	7	0	239
Medium awareness	13	92	10	115
High awareness	9	7	17	33
Total	254	106	27	387
Pearson chi2(4) = 374.9743	Pr = 0.000	likelihood-ratio chi2(4) = 354.7776	Pr = 0.000	
Kendall's tau-b = 0.7960	ASE = 0.032	Fisher's exact = 0.000		
Correlation between awareness and compliance level				
Correlation	Pearson coefficient		*p*-value	
Awareness/Compliance	0.77		0.000	

Source: field survey, 2022.

Table 9. Gross margin distribution across the compliance levels

Compliance level	Gross margin (cedis/acre)		
	mean	std. dev.	frequency
Low compliance level	0.58	0.32	254
Medium compliance level	0.70	0.23	106
High compliance level	0.89	0.10	27
Total	0.64	0.30	387
Observed gross margin differentials between compliance levels (Bonferroni)			
Row mean – Column mean	Low compliance level *(p-value)*	Medium compliance level *(p-value)*	
Medium compliance level	0.12 (0.001) **		
High compliance level	0.31 (0.000) **	0.18 (0.09) **	
Bartlett's test for equal variances: chi2(2) = 14.0862 Prob>chi2 = 0.001			

Note: values in parenthesis are P-values.
****p* <0.01; ***p* < 0.05; **p* < 0.1.
Source: field survey, 2022.

comparing the high compliance level group with the low and medium compliance level groups. On average, for each acre of land cultivated, the high compliance level group achieves a 31% higher profit compared to the low compliance level group. Additionally, a significant difference is observed between the high compliance level group and their medium compliance counterparts, with the high compliance group generating 18% more profit on average.

These findings underscore the positive relationship between compliance with safety practices and farm profitability in vegetable production. This observation aligns with recent research, which emphasizes the significance of adhering to recommended safety practices in agriculture and its subsequent impact on farm profitability. Several notable studies (Dapaah Opoku et al., 2020; Fulano et al., 2021; Ho et al., 2018; Okonya et al., 2013) provide evidence supporting the positive correlation between compliance with safety practices and financial performance within the agricultural sector, further affirming the findings presented in Table 9. A valuable tool for assessing the financial implications of various compliance levels is Gross Margin Analysis (Mensah et al., 2021). This analytical approach offers valuable insights into profitability by considering the cost-revenue dynamics associated with pesticide usage and compliance (Adeyemo and Akinola, 2010; Bannor et al., 2020; Darko-Koomson et al., 2020; Park and Davis, 2011; Gyawali, 2018).

Gross Margin Analysis considers the difference between the total revenue generated from the sale of vegetables produced and the direct costs associated with production. Excessive pesticide usage beyond the recommendation can increase production costs (Adeyemo and Akinola, 2010; Darkwah et al., 2019; Rao et al., 2011; Wongnaa et al., 2019). Therefore, by conducting a thorough evaluation of the profitability of vegetable production and considering factors such as resource allocation, pesticide usage, and investment in agrochemicals, farmers can make well-informed decisions to optimize their financial outcomes (DeLay et al., 2022; Eskelinen and Kuosmanen, 2013; Mensah et al., 2021; Wang et al., 2020).

Understanding the relationship between compliance levels and gross margin empowers farmers to assess the financial viability of their farming practices, including pesticide usage (Adeyemo and Akinola, 2010; Darko-Koomson et al., 2020; Rao et al., 2011). Armed with this knowledge, vegetable farmers can make informed decisions aimed at enhancing profitability and promoting sustainability in their agricultural operations. By prioritizing compliance with recommended safety practices, farmers can safeguard their financial well-being while contributing to a more environmentally responsible and sustainable vegetable production sector (Fulano et al., 2021; Gautam and Andersen, 2016; Mariyono et al., 2018; Wilson, 2000).

The study examined the factors influencing compliance with recommended safety practices in urban vegetable production in the Ashanti Region of Ghana. This assessment involved considering both farmer-specific and farm-level attributes. The results, presented in Table 10, include coefficients, odds ratios, and average marginal effects with their standard errors, providing valuable insights into the drivers of compliance. Additionally, the pseudo-R^2, chi-squared test, and log-likelihood values offer information about the overall model fit and goodness of fit statistics, helping to evaluate the accuracy of the results. The results indicate that the overall model is statistically significant ($p < 0.0000$), as are most of the predictor variables ($p < 0.01, 0.05, 0.1$). There are two cutpoints for this model because there are three levels of the outcome variable (high, medium, low).

One of the most significant findings of the study is the positive and significant correlation between farmers' level of awareness regarding recommended safety practices and their compliance. This implies that farmers who possess higher awareness are more likely to adhere to safety guidelines, emphasizing the degree to which knowledge influences their decisions. This finding aligns with previous research by Baah Annor (2018), Ho et al. (2018), Jaga and Dharmani (2003), and Okonya et al. (2013). Furthermore, the analysis of factors driving compliance reveals a positive relationship between higher gross margin values and adherence to safety practices. This suggests that farmers with greater profitability are more inclined to invest in understanding and implementing recommended safety measures. These measures may include sourcing information or implementing strategies to reduce pesticide misuse, as these practices directly impact their sales and profit margins.

This observation is supported by studies conducted by Damalas and Eleftherohorinos (2011), Dinham (2003). Schreinemachers et al. (2012), Yayra Fosu-Mensah et al. (2022), Zhang and Yu (2021), and Zhou et al. (2020). The results highlight the crucial role of awareness and profitability in influencing farmers' compliance with safety practices in vegetable production. This valuable knowledge can guide policymakers and stakeholders in implementing targeted interventions to enhance awareness and promote profitability among farmers. Ultimately, these efforts will lead to safer and more sustainable agricultural practices (Baah Annor, 2018; Babu et al., 2018; Kassie, 2018; Meena et al., 2020; Ofori et al., 2015; Pacini et al., 2003; Tessema et al., 2016).

The analysis also indicates that farming experience plays a role in compliance, with more experienced farmers demonstrating higher levels of adherence to safety practices compared to those with less experience. This

Table 10. Drivers of compliance with the recommended safety practices

Compliance level (low, medium and high)	Coefficient (std. err.)	Odds ratio (std. err.)	Average marginal effects (dy/dx)		
			low compliance	medium compliance	high compliance
Awareness Level					
Medium	5.97***	392.73***	–0.53***	0.46***	0.06***
	(0.77)	(301.52)	(0.05)	(0.05)	(0.01)
High	4.15***	63.38***	–0.30***	0.25***	0.04***
	(0.96)	(60.68)	(0.09)	(0.09)	(0.01)
Education					
Primary	1.39**	4.01**	–0.07**	0.04**	0.02**
	(0.57)	(2.31)	(0.03)	(0.02)	(0.01)
JHS	3.48***	32.45***	–0.19***	0.13***	0.06***
	(0.97)	(31.64)	(0.07)	(0.06)	(0.01)
SHS	5.06***	157.31***	–0.34***	0.25***	0.09***
	(1.36)	(214.12)	(0.15)	(0.13)	(0.02)
Literacy (1 = yes)	19.67	3.48	–0.66***	0.56***	0.11***
	(2107.52)	(7.33)	(0.01)	(0.02)	(0.01)
Extension (1 = yes)	2.03***	7.63***	–0.07***	0.25***	0.03***
	(0.14)	(4.66)	(0.02)	(0.09)	(0.01)
Gender (1 = female)	0.23	1.26	–0.01	0.01	0.01
	(0.63)	(0.80)	(0.02)	(0.01)	(0.01)
FBO (1 = yes)	1.15*	3.15*	–0.03*	0.06*	0.09*
	(0.63)	(1.97)	(0.01)	(0.03)	(0.05)
Gross margin (cedis)	2.38**	10.79**	–0.08**	0.05**	0.03**
	(1.03)	(11.10)	(0.03)	(0.02)	(0.01)
Farming experience (years)	0.12***	1.13***	–0.004***	0.003***	0.002***
	(0.04)	(0.04)	(0.002)	(0.001)	(0.0004)
Farm size (acres)	0.92	2.50	–0.03	0.02	0.01
	(0.99)	(2.48)	(0.03)	(0.02)	(0.01)
Farmer Age (years)	0.99	0.99	0.0005	–0.0003	–0.0001
	(0.02)	(0.02)	(0.0007)	(0.0005)	(0.0002)
Price of PPES (cedis)	–0.10**	0.91**	0.003**	–0.002**	–0.001**
	(0.04)	(0.04)	(0.001)	(0.001)	(0.0005)

Number of obs. = 387. LR chi2(10) = 505.90. Prob > chi2 = 0.0000. Pseudo R2 = 0.8002. Log likelihood = –63.165211.
Note: (*) dy/dx is for discrete change of dummy variable from 0 to 1.
Note: values in parenthesis are standard errors.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.
Source: field survey, 2022.

finding suggests that practical knowledge and experience acquired over time contribute to the adoption of safety practices on farms (Afari-Sefa et al., 2015; Beyens et al., 2017; Dinham, 2003; Fulano et al., 2021; Hasen Ahmed et al., 2018; MacCarthy et al., 2018; Majumder and Kaviraj, 2019).

Conversely, the coefficients related to the price of Personal Protective Equipment (PPE) show a negative relationship with compliance. Higher prices of PPE are associated with lower compliance levels, indicating that cost considerations may influence farmers' ability to invest in and use proper protective equipment (Abou Zeid et al., 2017; Jepson, 2006; Mafuru et al., 1999; Katinila et al., 1998; Okoffo et al., 2016a).

These findings underscore the importance of raising awareness among farmers, improving measures to enhance profitability in the vegetable sector, and addressing affordability concerns related to safety equipment. By understanding the factors that influence compliance, policymakers and stakeholders can develop targeted interventions to promote and support the adoption of recommended safety practices in vegetable production, ultimately enhancing the well-being of farmers and the sustainability of the sector.

A path regression analysis was employed to delve into the intricate causal relationships, encompassing both direct and indirect effects, among production inputs, farming practices, and their impact on farm outcomes, specifically the gross margin per acre. This analytical approach serves as a tool to elucidate the intricate interplay of variables within a theoretical framework, as visually represented in Fig. 2. The double-headed arrows in the diagram signify correlations between variables, while single arrowheads indicate the direction of direct and indirect effects, delineating causative relationships.

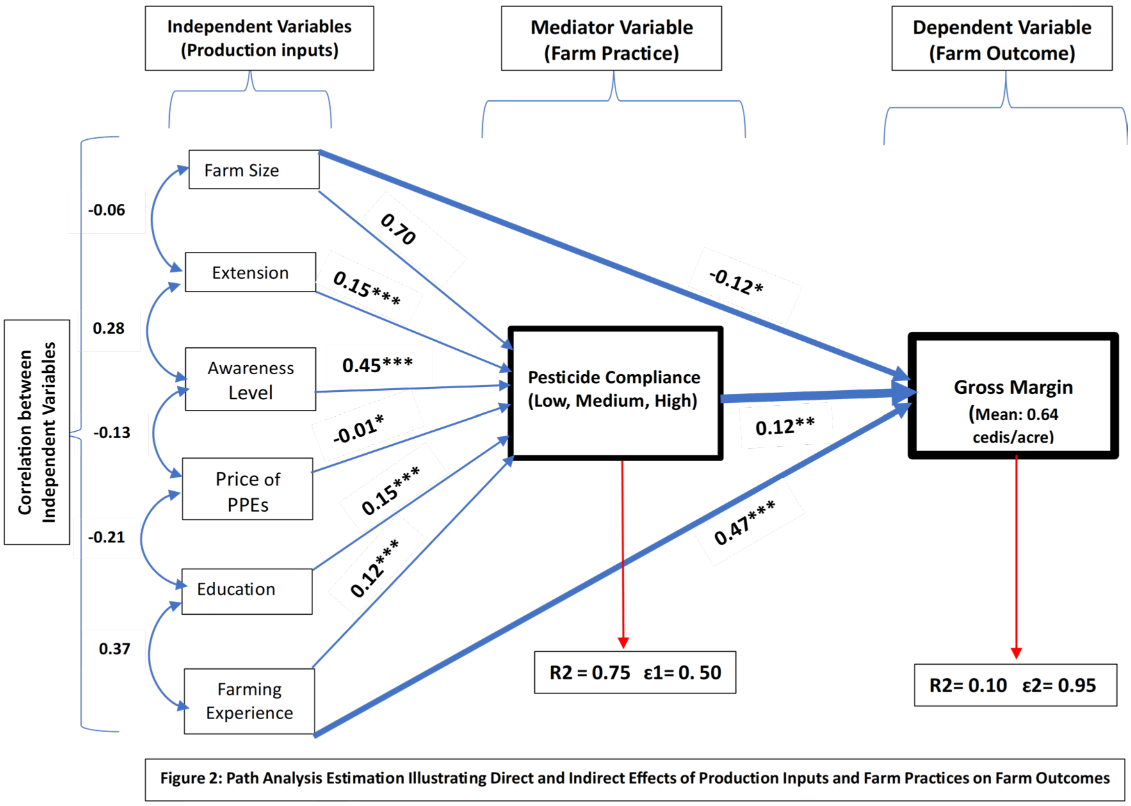

Fig. 2. Path analysis estimation illustrating direct and indirect effects of production inputs and farm practices on farm outcomes
Source: own elaboration, 2022.

Regarding adherence to recommended pesticide usage practices in farming, the results of the path regression analysis reveal several influential factors. Regular interactions with extension officers, higher levels of farmer awareness, increased education levels, and greater experience in vegetable farming all positively impact adherence to recommended safety practices. Conversely, an increase in the price of PPE is associated with reduced adherence. These findings align with the results obtained from the ordered logistic regression analysis, providing evidence that the observed relationships are robust.

Furthermore, the analysis demonstrates that increasing levels of compliance with safety practices and increasing farming experience have a positive influence on farm outcomes, specifically the gross margin per acre. This highlights the substantial impact of adhering to safety requirements. Intriguingly, as farm size increases, there is a negative effect on farm outcomes. The observed negative relationship between increased farm size and decreased gross margin may be attributed to greater labor and input requirements as farms grow in size. As farm size increases, the efficiency of labor and other variable input usage may decline, significantly affecting overall farm outcomes.

CONCLUSION AND RECOMMENDATION

This study provides valuable insights into the complex relationship between compliance levels and factors influencing safety practices among urban vegetable farmers in Ghana's Ashanti Region. The findings emphasize the urgent need for improved awareness and education among vegetable farmers to enhance their adherence to recommended safety practices. The results of all the analytical approaches used demonstrate a significant positive relationship between farmers' awareness levels and their compliance, highlighting the importance of informed decision-making and knowledge dissemination. Moreover, the econometric analysis reveals that higher gross margin values are associated with increased compliance, indicating that profitability motivates farmers to allocate resources towards implementing safety measures. Additionally, farming experience was found to positively influence compliance, suggesting that practical knowledge and expertise acquired over time contribute to the adoption of safety practices. However, the study also identifies affordability as a challenge to compliance, particularly in relation to the cost of PPE. This highlights the importance of addressing cost considerations and ensuring that safety equipment is affordable and accessible for farmers.

Based on the key findings, practical policy actions can be taken to address challenges and promote compliance with recommended safety practices in urban vegetable production in the Ashanti Region:

- **Enhance farmer education and awareness programs:** Stakeholders, including the district extension directorate, farmer-based organizations, and non-governmental organizations, should collaborate to design and implement targeted training programs, workshops, and extension services. Utilizing simple illustrative videos in local languages can improve farmers' understanding and awareness of recommended safety practices. Empowering farmers with knowledge and skills in their native language will enable them to effectively implement the recommended safety measures.
- **Promote profitability and market access:** Stakeholders should devise initiatives to improve the profitability of vegetable farming. This includes facilitating market access, promoting sustainable production techniques, and providing financial and technical assistance. Enhancing farmers' economic prospects will enable them to allocate resources towards safety practices.
- **Facilitate knowledge-sharing and exchange:** Establish user-friendly platforms for farmers to share experiences and best practices. Initiatives such as farmer field schools, peer-learning networks, and digital platforms can encourage the exchange of practical knowledge and experiences, fostering a culture of continuous learning and improvement.
- **Address affordability concerns:** Implement measures to reduce the cost of PPE through government subsidy programs, FBO bulk procurement arrangements, and collaborations with manufacturers. Making safety equipment more accessible and affordable will remove financial barriers to compliance.
- **Strengthen enforcement and monitoring:** The Ministry of Agriculture should develop and enforce robust regulatory frameworks to ensure compliance with safety practices. Regular inspections, penalties for non-compliance, and the establishment of monitoring systems will promote accountability and encourage farmers to prioritize safety

measures. Additionally, educating opinion leaders and pivotal stakeholders in farming communities on proper pesticide usage is crucial. Empowering them with the necessary authority will enable them to enforce recommended safety practices among farmers effectively.

By implementing these recommendations, policymakers, stakeholders, and urban vegetable farmers can collectively work towards improving compliance with recommended safety practices in urban vegetable production. This will protect the well-being of farmers, consumers, and the environment, ultimately contributing to the long-term sustainability and growth of the vegetable sector in the Ashanti Region of Ghana.

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