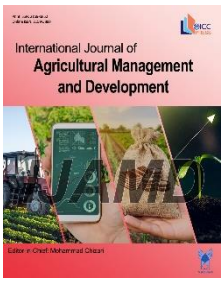

Volume 15, Issue 2, 152507 (56-63)

International Journal of Agricultural Management and Development (IJAMD)

https://doi.org/10.57647/ijamad.2025.1502.07

Access to Advisory Services and Agrochemical Guideline Implementation Among Farmers in Chuka Sub-County, Kenya

Irene Nyanchoka Okiamba[1], Raphael Mwiti Gikunda[2], Haggai O. Ndukhu[2], Michael Kanyi[3,*]

[1] *St. Marks Ena Secondary School, Po Box 2489 Embu*
[2] *Chuka University, Po Box 109-60400, Chuka*
[3] *Imperial Valley College, California, USA*

***Corresponding author:** michael.kanyi@imperial.edu

Original Research

Received:
12 October 2024
Revised:
7 February 2025
Accepted:
12 February 2025
Published in Issue:
30 June 2025

Abstract

Effective utilization of agrochemical guidelines and practices among farmers depends on steady access to private and public sector advisory services. Despite the government having put in place policies and laws governing the use of agrochemicals, little empirical evidence exists on access to advisory services and effective adoption of agrochemical guidelines and practices among farmers. The population comprised 22,245 farmers distributed throughout the three wards of the sub-county, namely Mugwe, Karingani, and Magumoni. Using a correlational research design, the study employed a semi-structured questionnaire to gather data. A proportionate stratified random sampling technique was used to select a sample size of one 100 respondents. Pearson's correlation was used to determine relationships between variables, while one-way ANOVA was used to determine if farmers differed significantly in their access to agrochemical information from private and public sector extension providers. The study established that most small-scale farmers (98%) used agrochemicals. Access to advisory services and effective utilization of agrochemical guidelines and practices were found to have a weak positive correlation ($r = 0.24$). A one-way ANOVA revealed a non-significant effect of the type of extension provider on access to agrochemical information, $F(2, 72) = 0.37$, $p > 0.05$. Effective dissemination and utilization of agrochemical information rely upon all sectors and sometimes both private and public combined. We recommend that public and private extension providers continue to work collaboratively to supplement the agrochemical information provided to farmers by manufacturers. Additionally, the extension service should assist farmers in interpreting chemical labels and user specifications.

Keywords: Advisory services; Agrochemicals; Guidelines

Cite this article: Okiamba, I.N. , Gikunda, R.M. , Ndukhu, H.O. , Kanyi, M. , (2025). Access to Advisory Services and Agrochemical Guideline Implementation Among Farmers in Chuka Sub-County, Kenya. *International Journal of Agricultural Management and Development*, 15(2), 56-63.

INTRODUCTION

The rising demand for food supply driven by population growth has resulted in increased use of agrochemicals, particularly fertilizers and pesticides (United Nations Environment Program, 2022). Agrochemicals are used to control pests and pathogens and to provide nutrients for crops and livestock. Their use has led to increased crop and animal yields. The world's annual consumption of pesticides alone is estimated at 3.53 million metric

tons. In 2021, Brazil was the largest consumer of pesticides globally, at 719.51 thousand metric tons, while the USA was the second largest, at 457 thousand metric tons. Asia is the largest consumer of nitrogenous inorganic fertilizers, while Oceania and Africa consume the least (FAO, 2023).

Africa is projected to be the fastest-growing market for inorganic fertilizers (International Fertilizer Association, 2021). Growing dependency on agricultural chemicals and the pressure to increase land productivity are key factors driving this trend on the continent. In 2020, Nigeria's pesticide purchases (147,446 tons) surpassed the total imports of Southern Africa (87,403 tons) and North Africa (109,561 tons) (Heinrich Böll Stiftung, 2023). Agrochemical imports to Kenya have also been on the rise; for example, pesticide imports increased from 6,400 tons in 2015 to 15,600 tons in 2018 (Heinrich Böll Stiftung, 2022). It is common for farmers in Kenya to use agrochemicals, particularly highly hazardous pesticides. These pesticides and other agrochemicals can pose various health and environmental risks, including toxicity, flammability, corrosiveness, irritancy, and explosiveness (Food and Agriculture Organization of the United Nations and World Health Organization, 2019). Therefore, agrochemical users must strive to select products that minimize risks to themselves and others. When choosing agrochemicals, farmers should always rely on the information and advice provided on product labels and by both private and public sector extension services (Gikunda et al., 2022).

Public extension services, private sector extension services, agricultural input retailers (agrovets), and agrochemical manufacturing companies, both individually and collectively, provide farmers with information on safe and sustainable food production practices (FAO, 2022; Gikunda et al., 2022). The selection of protective equipment for applying agrochemicals should be guided by information provided by extension agents (Okoffo et al., 2016). Safety and health concerns related to agrochemical use have been a primary focus of international organizations and governments.

Certain agrochemicals, such as pesticides, pose significant health risks to farmers (Demi & Sicchia, 2021). However, these chemicals can be used safely if appropriate precautions are observed. Previous research has primarily addressed agrochemical contamination and its environmental impacts (Demi & Sicchia, 2021; Devi et al., 2022), with limited attention given to the role of private and public sector extension services in promoting the safe use of agrochemicals. Various private extension providers, as well as public extension services, play a vital role in disseminating information among farmers in Kenya (Kanyi et al., 2017). This research aimed to determine whether the information provided by public sector extension differs from that offered by private sector extension providers.

Theoretical and conceptual framework

This research hypothesized that the type of extension provider influences access to agrochemical information; specifically, farmers served by public extension providers are more likely to have better access to such information, and vice versa. It further postulated that improved access to advisory services leads to the effective utilization of agrochemical use guidelines and practices. The dependent variables were the effective utilization of guidelines and practices, while the independent variables included the type of extension provider and access to advisory services, as illustrated in Figure 1.

Social Learning Theory (SLT)

The study is grounded in Albert Bandura's Social Learning Theory (SLT), which posits that learning occurs through observation, direct instruction, imitation, and modeling. Farmers acquire knowledge through direct experience, observing others' attitudes and behaviors, the outcomes of those behaviors, and group-based interactions (Bandura, 2009; Rumjaun & Narod, 2020). SLT explains how environmental and cognitive factors work together to influence an individual's learning and behavioral patterns. Farmers obtain information by interacting with other farmers and agricultural extension agents during demonstrations, field visits, training sessions, agricultural shows, and other activities (Khatam et al., 2013).

Purpose and objectives of the study

This research aimed to generate information that clarifies the roles of private and public sector extension providers in disseminating agrochemical information. The objectives of this research were to:

1. Determine whether farmers differed significantly in their access to agrochemical information from private sector extension providers, public sector extension providers, or both.
2. Examine the relationship between access to advisory services and the effective use of agrochemical guidelines and practices.

Hypotheses of the study

The hypotheses of the study were as follows.

HO_1: Farmers in Chuka Sub- County did not differ significantly in access to agrochemical information based on extension service provider.

HO_2: there was no significant association between access to advisory services and effective utilization of agrochemical guidelines and practices.

METHODOLOGY

The study was conducted in Chuka Sub-County, Tharaka Nithi County, Kenya. This sub-county is among the regions where horticultural and other crops are cultivated, necessitating the frequent use of agrochemicals. The population consisted of 22,245 farmers distributed across the three wards of the sub-county: Mugwe, Karingani, and Magumoni.

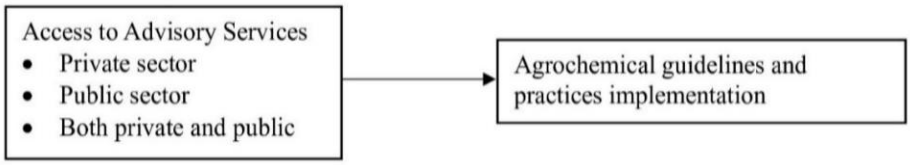

Figure 1. Conceptual Framework

A correlational research design guided the data collection and analysis. This design was deemed appropriate because the study aimed to determine the relationship between farmers' access to advisory services and the effective utilization of agrochemical guidelines and practices (Fraenkel et al., 2015). A total of 100 farmers were sampled using stratified random sampling from the three wards: Mugwe (36), Karingani (20), and Magumoni (44). Stratified sampling was employed because the study area was divided into homogeneous groups of farmers within each ward (stratum). According to Fraenkel et al. (2015), a sample size of 100 participants is adequate for survey research. Data were collected using a peer-reviewed, semi-structured questionnaire comprising five-point Likert scale items. The questionnaire consisted of five sections: Section A covered demographic characteristics such as age, gender, and education level; Section B measured farm characteristics; Section C assessed agrochemical use among farmers; Section D addressed agrochemical guidelines and their contribution to safe agrochemical use; and Section E focused on safe agrochemical practices.

Before the instrument's actual administration, a pilot study involving twelve participants was conducted in Kyeni North Ward. The resulting Cronbach alpha coefficients of the main study variables were access to advisory services (α = 0.914, 12 items), access to agrochemical use information (α = 0.780, 4 items), and effective utilization of agrichemical guidelines and practices (α = 0.810, 4 items). The coefficients of the variables were above the recommended minimum of 0.7 (Hajjar, 2018). The study variables were constructed from summated Likert-scale items. Data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS).

Pearson's correlation test was conducted to determine the association between access to advisory services and effective utilization of agrochemical guidelines and practices, while a one-way Analysis of Variance (ANOVA) was utilized to determine if farmers differed significantly in access to agrochemical use information from private and public sector extension providers or both. Before the ANOVA was run, the assumptions were checked and met.

Levene's test for homogeneity of variances was insignificant, $F(2, 70) = 0.11$, $p > 0.05$.

RESULTS

Farmer characteristics

Table 1 summarizes the characteristics of farmers who were involved in the research.

The study involved 100 small-scale farmers from Chuka Sub-County, consisting of 57 percent females and 43 percent males. The respondents' ages ranged from 21 to 95 years, with a mean age of 47 years. The study revealed that 95 percent of the respondents had formal education, whereas 5 percent had received informal education. Farmers in Chuka Sub-County owned small plots of land, with an average size of 1.7 acres. Most farmers (98%) applied agrochemicals to fight pests and diseases and improve soil nutrition, while a few farmers (2%) practiced organic farming without using agrochemicals.

Type of extension providers

The study assessed the type and number of extension providers in the sub-county as shown in Table 2.

When asked to indicate the agrochemical information provider, seventy-three farmers out of 100 responded, indicating that they got information from the public sector (n = 42, 57.5%), private sector extensionists (n = 11, 15.1%), and both (n = 20, 27.4%), as shown in Table 1.

This showed that a majority of the farmers received advice on agrochemical use mainly from public sector extensionists. However, it would have been expected that the private sector would be at the top of the list since they mainly provide the information while marketing their products.

A significant number of farmers (27%) did not receive advice from either public or private sector extension providers. The public sector extensionists included national and county government extension agents, public universities, and research stations, while the private sector included non-governmental organizations, community-based organizations, agrovets, input dealers, and manufacturers such as Bayer, Osho, Amiran, Syngenta, etc. (Gikunda et al., 2021).

Table 1. Farmer Characteristics (n = 100

Gender	Freq. (*f*)	Percent
Male	43	43
Female	57	57
Education		
Formal	95	95
Informal	5	5
Application of agrochemicals		
Yes	98	98
No	2	2

Mean acreage = 1.7 acres, mean age = 47 years

Table 2. Type of Extension Providers (n = 100)

Type	Freq. (*f*)	Percent (%)
Public	42	57.5
Private	11	15.1
Both (private and public)	20	27.4

Table 3. Farmers' Access to Agrochemical Information (n = 100)

Statement[a]	*M*	*SD*
Agrochemical information diffused is adequate	3.37	1.00
Access to agrochemical information is easy	3.61	1.06
Farmers and extension agents constantly interact	2.77	1.23
Agrochemical information is delivered timely	3.61	.88
Agrochemical information is delivered at the right season	3.76	.79
Agrochemical information provided is up to date	3.79	.80
The information meets the farmer's needs	3.88	.83
The information is easy to apply	3.53	1.10
Extension providers use local language to ease understanding	3.94	1.16
Labels are written in simple language	3.15	1.15
On-farm and field demonstrations conducted	2.75	1.15
Seminars and workshops are organized to provide information	3.20	1.44

Note [a] = 1= Strongly Disagree, 2 = Disagree, 3 = Moderate, 4 = Agree, 5 = Strongly Agree

Access to Agrochemical Information

Effective utilization of farm inputs requires adequate access to information; thus, the study assessed the availability of information on agrochemicals. Table 3 presents the respondents' agreement or disagreement regarding a set of items on access to agrochemical information.

As shown in Table 3, access to agrochemical information was moderately accessible, as farmers moderately indicated that the information diffused to them was adequate (M = 3.37, SD = 1.00), and access to the information was easy (M = 3.61, SD = 1.06). This may have resulted from a lack of constant interaction between farmers and extension agents (M = 2.77, SD = 1.23). The extension-to-farmer ratio is very high (1:1500). The county governments have not hired extension agents for a long time, which has created the deficit. The results further indicated that information was moderately delivered in good time (M = 3.61, SD = 0.88), at the right season (M = 3.76, SD = 0.79), and it was up to date (M = 3.79, SD = 0.80). Most of the agrochemical information is shared at the beginning of a planting season when farmers are purchasing farm inputs or when they are being distributed by extension agents. It is during this time that they are advised on how, when, and how much to apply. The information provided moderately met the needs of the farmers (M = 3.88, SD = 0.83). The information was also easy to apply, as noted by many of the farmers (M = 3.53, SD = 1.10), since extension providers used local languages to ease understanding (M = 3.93, SD = 1.16). According to the farmers, the labels were written in simple language (M = 3.15, SD = 1.15).

Although labels are one of the main sources of agrochemical information, they are in English and thus were not easy to understand, especially among farmers without formal education (Wang'ombe, 2014).

The labels, if possible, should be written in Kiswahili, a language that is understood by many people, including those who have not gone to school. Few on-farm and field demonstrations were conducted, as indicated by the respondents (M = 2.75, SD = 1.15). The seminars and workshops meant to share information on agrochemicals were also minimal (M = 3.20, SD = 1.44). The demonstrations, seminars, and workshops were inadequate due to insufficient resources. The extension workers, especially in the public sector, are few and overwhelmed. The county government had also failed to provide funds, materials, and human resources to organize adequate demonstrations, seminars, and workshops. The extension services provided by universities and research institutions were supplementary and issue-focused.

Objective one

Objective one sought to determine if farmers differed significantly in access to agrochemical information from private and public sector extension providers, or both. A one-way ANOVA was performed to evaluate the relationship between the kind of extension provider and access to agrochemical information, as shown in Table 4.

Table 4. One-Way ANOVA for Kind of Extension Provider and Access to Agrochemical Informationa (n = 73)

Type of provider	*N*	*M*	*SD*	*df*	*F*	*P*
Public	42	54.12	8.03	2	0.19	0.83
Private	11	53.27	8.00	70		
Both	20	55.65	8.24	72		

Note.[a] 1= Strongly Disagree, 2 = Disagree, 3 = Moderate, 4 = Agree, 5 = Strongly Agree; $p < .05$

Table 5. Distribution of Smallholder farmers by Access to Information (n = 100)

Access to advice	No (%)	Yes (%)
Types of agrochemicals to use in crop and livestock production	14.0	86.0
Benefits of agrochemicals	9.0	91.0
Agrochemical dosage	14.0	86.0
Agrochemical mixing	13.0	87.0
Time of agrochemical application	11.0	89.0
Agrochemical application technique	14.0	86.0
Use of personal protective equipment	21.4	78.6
Hygiene after using agrochemicals	21.0	79.0
Agrochemical's storage	14.0	86.0
Agrochemical package disposal	16.0	84.0
Pre-harvest interval after application	14.0	86.0
Effects of agrochemicals on the environment	34.0	66.0

A one-way ANOVA revealed a non-significant effect of the kind of extension provider on access to agrochemical information, $F(2, 72) = 0.19$, $p > 0.05$. This implies that farmers in Chuka Sub-County accessed almost the same amount of information from the public (n = 42, M = 54.12, SD = 8.03), private (n = 11, M = 53.27, SD = 8.00), and both (n = 20, M = 55.65, SD = 8.24) providers. Additionally, the information diffused by private, public, and both extension providers is similar. Any of the providers advise the farmers on the amount to be applied, when, and where to apply the agrochemicals (Gikunda et al., 2022).

In addition, the providers guide the farmers on the safe use of agrochemicals, including the appropriate utilization of protective equipment when applying them. Even though there was no significant difference in the dissemination of agrochemical information, the extension providers played a key role in sharing information.

The information provided supplemented that which is indicated on the labels by manufacturers. Besides, private and public extensionists helped to simplify, translate, and guide illiterate farmers on the use of agrochemical utilization guidelines and practices.

Access to Advisory Services

The study sought to determine if farmers had access to advice and training on safe agrochemical use. Table 5 presents the percentage of farmers who had access to agrochemical use information and technical advice.

Most respondents had access to advice on various aspects of agricultural production. Most of the respondents (86%) confirmed having received technical advice on the suitable agrochemicals to use in crop and livestock production, the benefits of agrochemicals (91%), agrochemical dosage (86%), mixing (87%), and the timing of agrochemical application (89%). Most of this information came from retail shops (agrovets) and agrochemical companies' agronomists when trying to market their products. Whenever they walked into the shops, they inquired about the various agrochemicals that were available and could address their farming problems. The farmers' inquiries were then addressed by the shop assistants (trained extensionists), who provided advice on the suitability of the products they had in stock. The agronomists working for the agrochemical companies had the opportunity to advise farmers during home and farm visits, field days, and agricultural shows. Most of the farmers also indicated that they had received advice on agrochemical application techniques (86%), use of personal protective equipment (78.6%), hygiene after using agrochemicals (79%), agrochemical storage (86%), agrochemical package disposal (84%), and the effects of agrochemicals on the environment (66%). This form of advice is vital to farmers to avoid wastage and contamination, as poor agrochemical handling and storage can result in safety hazards and high production costs. Much of the advice about these issues was provided by government (public) and private extension agents, including agrochemical marketers and agrovets. The advice was relayed through farm visits, seminars, short training programs, field days, television, radio, print media, and agricultural shows. Television programs such as Shamba Shape Up and Kilimo Biashara played a key role in sharing information. This

implies that farmers from the subcounty had access to technical advice from various sources. Print media such as leaflets produced as labels, pamphlets, and newspapers were also utilized to share information. Most of the print media were written in English, which troubled some of the farmers, especially the illiterate—a finding that was in line with that of Jallow et al. (2017).

Effective agrochemical utilization

The study further sought to determine the effectiveness of agrochemical utilization among small-scale farmers. The aspects assessed revolved around the safe use, application method, time, and rates. Farmers were asked to indicate their level of effectiveness regarding a number of items relating to the use of agrochemicals, as shown in Table 6. The results indicated that farmers were effective in the method (M = 4.21, SD = .56) and time of application of the agrochemicals (M = 4.17, SD = .55). This may have been contributed to by the need to maximize the effect of the agrochemical on either the crop or the livestock and fear of failure and the call for repeated application. When selling the product to the farmers, agrochemical dealers, including agrovets attendants, often emphasized the method and time of application. This may also have improved the effectiveness level of the farmers.

Although the amount of agrochemicals to be applied was also emphasized by the dealers of the products, most farmers were found to be moderately effective in applying the correct amount of agrochemicals as prescribed on the agrochemical labels (M = 3.77, SD = 0.85). Most farmers would have wanted to apply the right amount but may have faced challenges when calibrating. Most farmers were using a fifteen-liter knapsack sprayer, although most rates were based on a twenty-liter sprayer. Additionally, many farmers are unable to quantify the amount of fertilizer to be applied per plant. The findings agree with those of Jallow et al. (2017), who found that some farmers overdose or underdose agrochemicals.

The results further indicated that farmers were moderately effective in the use of PPE to prevent agrochemical contamination (M = 3.72, SD = 1.10). A substantial number of farmers were not using PPE when applying agrochemicals, although the side effects of contamination were clearly stated on the labels (Wang et al., 2017). Some of these farmers couldn't afford PPE, while others ignored the advice of the extensionists. Farmers were also moderately effective in applying agrochemicals in the correct areas (M = 3.70, SD = 0.75). The effectiveness of agrochemicals in controlling pests, weeds, and diseases is greatly increased when applied to the target areas. Agrochemical application to the affected regions prevented agrochemical drift to unintended areas, such as water bodies.

Objective two

Objective two sought to examine the association between access to advisory services and the effective utilization of agrochemical guidelines and practices. Pearson's correlation was run to establish the relationship between the two variables, as indicated in Table 7. The findings revealed that the association between farmers' access to advisory services and effective utilization of agrochemical guidelines and practices was positive but weak, r = 0.24. The relationship was statistically significant, as the p-value was 0.033, less than the significance level of 0.05. This meant that access to information by the farmers was likely to improve the utilization of agrochemical guidelines and practices.

Table 6. Effective Agrochemical Utilization (n = 100)

Aspect[a]	*M*	*SD*
Using the right application method	4.21	.56
Timely application of agrochemicals	4.17	.55
Application of the right amount of agrochemical as prescribed on the labels	3.77	.85
Use of PPE to prevent contamination with agrochemicals	3.72	1.10
Correct application areas (crops and livestock)	3.70	.76

Note. [a]1 = Ineffective, 2 = Slightly Effective, 3 = Moderate, 4 = Effective, 5 = Very Effective

Table 7. Correlation between Access to Advisory Services and Agrochemical Guidelines and Practices

Variable	1	2
Access to advisory services	-	-
Utilization of agrochemical guidelines	0.24*	-

Note.[1&2] 1= Strongly Disagree, 2 = Disagree, 3 = Moderate, 4 = Agree, 5 = Strongly Agree; p <.05

Agrochemical stores and dealers need to hire more technical staff to improve the provision of advisory services to farmers so that they can improve the adoption of necessary guidelines. The current ratio of extension staff to farmers, 1:1500, is too high (Gikunda et al., 2021). More contact between government extension agents and farmers would boost the provision of advisory services.

CONCLUSION AND IMPLICATIONS

Increased demand for food production has made the use of agrochemicals indispensable among small-scale farmers. Agrochemicals are commonly used to increase crop and livestock production. It is evident that both public and private sector extensionists are involved in providing information related to the use of agrochemicals. Public sector extensionists include government, research, and university staff, while private sector agents encompass extensionists from agrochemical dealers, non-governmental organizations, and community-based organizations. The information is moderately adequate and accessible. More extension agents are needed, especially those employed by the county government, to lower the ratio from 1:1500 to the

recommended 1:400. This would also improve access to agrochemical information related to utilization guidelines and practices. The information disseminated by private, public, and both extension providers is of a similar nature and amount. Therefore, there is a need for collaboration between the two categories to improve the adequacy of the information delivered.

Public and private sector agricultural extension agents provided advisory services that led to moderate utilization of agrochemical guidelines and practices. They played a crucial role in providing technical advice to farmers regarding the safe use of agrochemicals. However, the advice provided was not adequate to ensure that the farmers were effective in adopting the agrochemical practices and guidelines, although some farmers ignored the advice of the agents. Since the farmers received advice on the rates, timing, and methods of application from dealers, including agrovets, more qualified extension agents should be hired by agrochemical companies and stores to ensure sufficient provision of advisory services to farmers. This will, in turn, improve the farmers' effectiveness in utilizing the recommended guidelines and practices. Labels should be written in local languages to ease the understanding of the guidelines, especially for illiterate farmers. There is a need for further study to quantify the number of farmers who have been affected by agrochemicals in the area and the costs involved in treating the contamination.

Acknowledgement

I am grateful to the almighty God for being my provider and giving me the strength and hope to do this work.
I sincerely thank Chuka University management for grating me the opportunity to study a Master of Science Degree in Agricultural Extension. I would like to sincerely appreciate bmy supervisors Dr. Mwiti Raphael and Dr. Ndukhu O. Haggai for their keen guidance and support in the development of this research paper.

Authors Contribution
All authors have contributed equally to prepare the paper.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests
There is no conflict of interest regarding the publication of this paper.

REFERENCES

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychology, 3*(3), 265–299. http://ereserve.library.utah.edu/Annual/COMM/7610/Coe/bandura2001.pdf

Demi, S. M., & Sicchia, S. R. (2021). Agrochemicals use practices and health challenges of smallholder farmers in Ghana. *Environmental Health Insights, 15*, 11786302211043033. DOI: https://doi.org/10.1177/11786302211043033

Devi, P. I., Manjula, M., & Bhavani, R. V. (2022). Agrochemicals, environment, and human health. *Annual Review of Environment and Resources, 47*, 399–421. DOI: https://doi.org/10.1146/annurev-environ-120920-111015

Food and Agriculture Organization. (2023). *Pesticide use and trade 1990–2021* (FAOSTAT Analytical Briefs and Series No. 70). Rome. DOI: https://doi.org/10.4060/cc6958en

Food and Agriculture Organization of the United Nations, & World Health Organization. (2019). *Global situation of pesticide management in agriculture and public health: Report of a 2018 WHO-FAO survey*. Rome and Geneva. https://apps.who.int/iris/handle/10665/329971

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2015). *How to design and evaluate research in education* (9th ed.). McGraw-Hill Education. https://saochhengpheng.wordpress.com/wp-content/uploads/2017/03/jack_fraenkel_norman_wallen_helen_hyun-how_to_design_and_evaluate_research_in_education_8thedition_-mcgraw-hill_humanities_social_sciences_languages2011.pdf

Gikunda, R., Jepkurui, M., Kiptoo, S., & Baker, M. (2022). Quality of climate-smart agricultural advice offered by private and public sector extensionists in Mbeere North Sub-County, Kenya. *Advancements in Agricultural Development, 3*(1), 32–42. DOI: https://doi.org/10.37433/aad.v3i1.161

Gikunda, M. R., Lawver, D. E., Baker, M., Boren-Alpizar, A. E., & Guo, W. (2021). Extension education needs for improved adoption of sustainable organic agriculture in Central Kenya. *American Journal of Geographic Information System, 10*(2), 61–71. DOI: http://article.sapub.org/10.5923.j.ajgis.20211002.01.html

Hajjar, S. T. (2018). Statistical analysis: Internal-consistency reliability and construct validity. *International Journal of Quantitative and Qualitative Research Methods, 6*(1), 27–38. https://www.academia.edu/download/88115056/Statistical-Analysis-Internal-Consistency-Reliability-and-Construct-Validity.pdf

Heinrich Böll Stiftung. (2023). *Pesticide use in Africa: Increasingly vulnerable*. https://ng.boell.org/en/2023/04/19/pesticide-use-africa-increasingly-vulnerable

Heinrich Böll Stiftung. (2022). *Pesticide use in Kenya: A toxic business*. https://ke.boell.org/en/2022/10/31/pesticide-use-kenya-toxic-business#:~:text=According%20to%20the%20Agrochemical%20Association,%2C%20animals%2C%20and%20the%20environment

International Fertilizer Association. (2021). *Public summary: Medium-term fertilizer outlook 2021–2025*. https://www.ifastat.org/market-outlooks

Jallow, M. F., Awadh, D. G., Albaho, M. S., Devi, V. Y., & Thomas, B. M. (2017). Pesticide knowledge and safety practices among farm workers in Kuwait: Results of a survey. *International Journal of Environmental Research and Public Health, 14*(4), 340. https://www.mdpi.com/1660-4601/14/4/340/pdf

Kanyi, M., Lawver, D. E., Ulmer, J., Ritz, R., & Murimi, M. (2017). Attitudes and adoption of rainwater harvesting: Influence of gender, awareness, and social status. *Journal of International Agricultural and Extension Education, 24*(1), 63–73. DOI: https://doi.org/10.4148/2831-5960.1297

Khatam, A., Muhammad, S., Ashraf, I., & Pervez, A. K. (2013). Effectiveness of group contact methods in diffusion of agricultural technologies among the farming community. *Journal of Biodiversity and Environmental Sciences, 3*, 264–268. https://www.researchgate.net/profile/Akm-Pervez/publication/284727634

Okoffo, E. D., Mensah, M., & Fosu-Mensah, B. Y. (2016). Pesticide exposure and the use of personal protective equipment by cocoa farmers in Ghana. *Environmental Systems Research, 5*, 17. DOI: https://doi.org/10.1186/s40068-016-0068-z

Rumjaun, A., & Narod, F. (2020). Social learning theory: Albert Bandura. In *Science education in theory and practice: An introductory guide to learning theory* (pp. 85–99). Springer. https://link.springer.com/chapter/10.1007/978-3-030-43620-9_7

United Nations Environment Programme. (2022). *Environmental and health impacts of pesticides and fertilizers and ways to minimize them* (No. 978-92-807-3929-9). https://www.fao.org/fileadmin/user_upload/soils/publications/pesticides.pdf

Wang, W. J. (2017). Gender differences in pesticide use knowledge, risk awareness, and practices in Chinese farmers. *Science of the Total Environment, 590*, 22–28. https://www.sciencedirect.com/science/article/pii/S0048969717305582