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ORIGINAL RESEARCH ARTICLE

Factors affecting awareness on good agriculture practices among citrus growers in Palpa, Nepal: Through binary logistic regression approach

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ABSTRACT

Being an indigenous high-value commodity, with significant market demand in the mid-hills of Nepal, citrus requires the incorporation of sustainable techniques in orchard to increase fruit production. For farmers in Nepal, Good Agricultural Practices (GAP) is a novel concept. The majority of farmers are unaware of it, and those who are aware also have not fully embraced the techniques. Therefore, the study was conducted in summer 2022 to assess the factors that affect the awareness of GAP among the farmers at Palpa, Nepal. Rainadevi Chahara and Ribdikot rural municipality of Palpa district, Nepal was purposively selected, and altogether, 64 commercial citrus growers from the municipalities were taken by simple random sampling technique. The binary logistic regression model was used for analyzing the effect of different variables on the awareness of GAP among citrus growers. Different demographic and socioeconomic variables have been found associated for odds of being GAP aware. The findings revealed that, farmers' who are GAP aware have an access to trainings and contact with extension agents, 4.164 and 10.293 times higher than those farmers who are GAP unaware respectively. Therefore, the study suggests that farmers knowledge on GAP can be further expanded through trainings and frequent contact with extension agents as they are the major factors affecting commercial citrus growers' awareness to GAP in Palpa district, Nepal.

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INTRODUCTION

The process of adopting new technology is diverse, since not all farmers embrace them in the same way. According to Dearing (2021), adoption is impacted by socioeconomic factors such as gender, family size, caste, occupation, livestock ownership, farm size, farming experience, and educational attainment. For farmers in Nepal, Good Agricultural Practices (GAP) is a novel concept. The majority of farmers are unaware of it, and those who are aware also have not fully embraced the techniques. Food safety has become more and more important throughout time as a result of its effect on consumer health as well as the expansion of domestic and international food trade (Liguori *et al*., 2022). Therefore, it is crucial to start addressing food safety at the agricultural level. For the purpose of ensuring a safe food supply, effective production techniques must be implemented both during production on farms and afterward. Good Agricultural Practices (GAP), as defined by Food and Agricultural Organizations of United Nations, are a "collection of principles to apply for on-farm production and post- production processes, resulting in safe and healthy food and non-food agriculture products, while taking into account economic, social and environmental sustainability". Hence, the Ministry of Agriculture and Livestock Development prepared Nepal GAP implementation directives on October 15, 2018 as a first crucial step towards improving food safety and trade facilitation.

Citrus is one of the indigenous fruits of Nepal contributing 22.95% of total fruit production (MOAD, 2021) and share 3 % of total fruit export by volume Pandey *et al.* (2017). The mid-hills of Nepal, which range in elevation from 800-1500 m, have

favorable agroclimatic conditions for the production of high-quality citrus fruit Rokaya *et al.* (2019). Despite the fact that Nepal is home to a variety of citrus species, only mandarin (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis* Osbeck), and acid lime (*Citrus aurantifolia* Swingle) are produced on a large-scale for commercial purposes. Nepal produces 311,188 Mt. of citrus annually (MOAD, 2021); however, 41,314.3 Mt. citrus—oranges, grapefruit, lemons, pomelos, limes, fresh/dried citrus fruit— were imported to meet the domestic demand; with the export of 2.6 Mt of citrus—lemons, limes, oranges fresh/dried, citrus fruit; prepared/preserved— (MOF, 2020). Hence, the large domestic demand. is reflected by the unfavorable trade balance for citrus *spp.*

Despite experiencing a decrease in export rates within a specific year, prioritizing higher sustainability standards in the production of goods can yield multiple benefits. These include the potential to command better prices for the products and incentivize producers to adopt improved practices, ultimately leading to increased production in subsequent years. As consumer knowledge grows regarding sustainability and environmental impact, there is an increasing demand for products that are produced in a more sustainable and responsible manner (Wang *et al.*, 2019). Consequently, products produced using unsustainable practices may be viewed unfavorably and be perceived as less competitive compared to products that meet higher sustainability standards. This impact on competitiveness can occur in both the home market (where the product is produced) and foreign markets (where the product is exported). In the home market, consumer preferences for sustainable products can influence purchasing decisions, leading to reduced demand for goods produced in an unsustainable manner. Similarly, in foreign markets, where sustainability concerns are often important, products that do not meet sustainability standards may face barriers to entry, such as stricter regulations, lower market demand, or limited market access.

To say that, if an orchard does not implement all the necessary horticultural practices—pruning, irrigation, fertilization, pest control, and disease management—, its ability to produce fruits or crops will be significantly compromised. Therefore, GAP is slowly being a prerequisite for numerous countries importing products. It will open the international market for trade, increasing the prospects of export promotion (Kharel *et al.*, 2022) and safeguard the food safety of the people within the country. Henceforth, present study evaluated the various factors that affect GAP awareness among the citrus growers at Palpa, Nepal. The study aims to provide institutions, organizations, and stakeholders direction and guidelines for emphasizing factors that would enhance GAP awareness because, according to (Vejlgaard, 2018) awareness and knowledge are the first steps in adopting a new technology.

MATERIALS AND METHODS

Study site

The study was carried out in Palpa district of Lumbini province, Nepal; in the command area of the Prime Minister Agriculture Modernization Project (PMAMP), Project Implementation Unit (PIU), Citrus Zone, Palpa. Among the 3 rural municipalities—Bagnaskale, Ribdikot and Rainadevi Chahara—under citrus command zone, commercial farmers of Rainadevi Chahara (Ward No. 4 and 5) and Ribdikot rural municipality (Ward No. 3 and 7) were selected purposively. These regions were chosen for the study because they constitute the primary citrus growing domain and the highest number of registered commercial farmers on the zone.

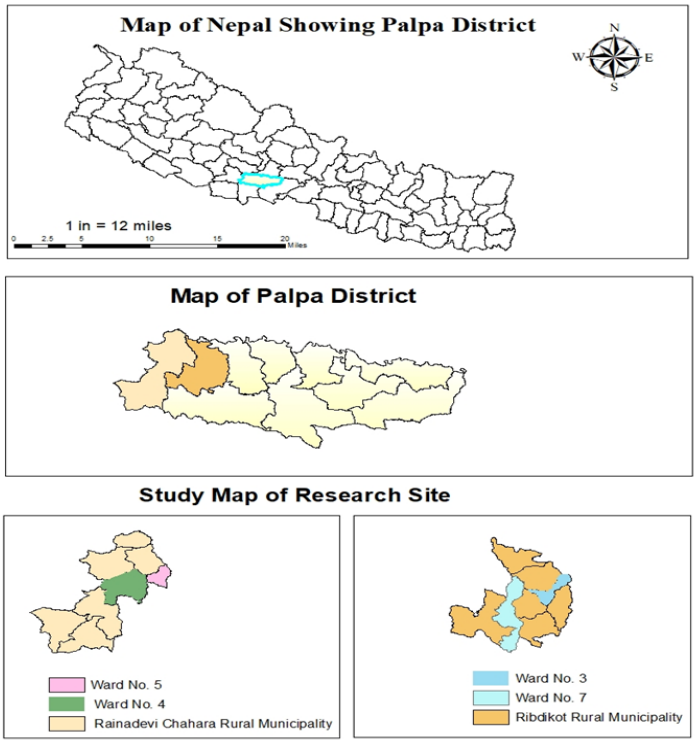

Figure 1. Study area map of Palpa district, Nepal (Source: Arc GIS).

Sampling procedure and determination of sample size

A list of citrus growers from selected rural municipalities was provided by citrus zone, PMAMP, PIU, Palpa and the list was used as the sampling frame to select the respondent farmers. Simple random sampling techniques without replacement was followed. For this, lottery system of sampling procedure was applied. Sample size was estimated using Cochran formula for smaller population (Cochran, 1997).

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where,

n_0 = Cochran's sample size recommendation i.e 68.06 (at 90% confidence level)

N = population size

n = adjusted sample size

of the 986 commercial mandarin growing farmers, total sample of 64 farmers was selected.

Research design

Personal interviews were used for the data collection process. The respondents were questioned in order to gather the desired information based on the interview schedule and checklist. To complement the data and information from the scheduled interviews and to gather more qualitative data, Key Informant Interviews (KII) and Focus Groups Discussions (FGD) were conducted. Data from both primary and secondary sources were gathered and examined. The primary sources of information were primarily citrus growers obtained through pre testing, questionnaire survey, FGD. Secondary data was gathered from the documents of several organizations and entities.

Study variables

The farmers were categorized into two groups: Aware of GAP and Unaware of GAP. The data analysis and comparisons were made on these categories in order to derive results. Farmers that comply to at least seven of the given ten parameters were considered GAP aware and are illustrated in Table 1. Awareness of GAP (1= aware, 0=unaware) was taken as dependent or predicted variable. Independent or predictor variables were classified into dummy and continuous type. Socio - demographic and economic variables including area of citrus cultivation (Ha), farming experience as a farm worker (years), education of respondents (years) was under continuous type. Similarly, sex (1=male, 0= female); frequent contact to government extension agents (1=yes, 0= no), access to governmental/ non-governmental trainings related to GAP (1=yes, 0=no), commodity demand and high production levels— one of the motivating factors for farmers to adopt GAP in orchard— were kept under dummy type. The frequency and nature of contact with the extension agent can vary based on the needs, objectives, and circumstances of the farmers. However, those farmers who admit to the fact that they at least consulted with extension agents once every month were considered a factor for GAP aware. Likewise, those farmers who admit to the fact that the citrus demand is high in the market and it has higher production potential were considered a motivation factor to be GAP aware. These factors were discovered after a thorough assessment of the available literature and discussions with the relevant expertise (Kunwar *et al.*, 2018; Dearing, 2021). Other socio-economic variables used were ethnicity and family type to see whether they influence the awareness level of farmers.

Data analysis

The data gathered from the field survey was entered in the Statistical Package of Social Sciences (SPSS-19) software and analyzed using SPSS-19 and Microsoft Excel-2019. For the analysis of factors affecting awareness of GAP among citrus growers, binary logistic regression model was used. Chi-square test was employed as a bivariate analysis to evaluate the relationship between each independent variable and the outcome variable. Results were deemed statistically significant if the p-value < 0.05 and < 0.01 at 5% and 1% level of significance respectively.

Table 1. Parameters for categorization of GAP aware and unaware farmers.

Parameters	Criteria to be GAP aware
Planting materials	Practices of using disease free seedlings
Plantation method	Must dig pit of $1m^3$
Soil management and fertilization	Apply FYM and chemical fertilizers about 75% to 100% of recommended dose
Water management	Irrigate orchard at least in 3 stages: new growth and flowering, fruit setting, fruit harvest and early stage of fruit growth if the soil is dry and must manage drainage system
Crop protection	Integrate IPM system and knowledge of use of registered pesticides only
Other management practices	Carry out training pruning and weeding practices
Harvest and on-farm processing and storage	Must consider maturity indices, use ladder crates, bags during harvesting and must sort and grade fruits and store fruits in appropriate environment after harvesting
Hygiene and environmental management	Safe disposal of pesticides containers, separate decomposable and non-decomposable wastes and minimize non-recyclable wastes
Human welfare	Provide decent wages and appropriate working hours
Document and records	Maintain records of farm

Statistical model

Binary logistic regression was used since the outcome or predicted variable of interest in this situation is dichotomous. Farmers' awareness or unawareness of GAP was the study's dependent variable, with values of 1 (if farmer is aware of GAP) and 0 (if farmer is unaware of GAP). The logit of the dependent variable (awareness of GAP) is predicted by the logistic model from independent variables. The possibility of farmers becoming aware of GAP is predicted by odds (Y=1), which is the ratio of the probability that Y equals 1 to the probability that Y does not equal 1:

$$Odds\ (Y) = \frac{P}{1-P}$$

The binary logistic regression model is specified as follow:

$$\ln\left[\frac{P}{1-P}\right] = \alpha + \sum \beta_n X_n$$

This can be expanded as:

$$e^{\ln\frac{P}{1-P}} = e^{\alpha+\sum\beta_n X_n}$$

Or

$$P = \frac{1}{1+e^{-(\alpha+\sum\beta_n X_n)}}$$

Where,

Y = dependent variable (awareness) with 1= aware and 0 = not aware

α = intercept

β_n = coefficient of independent variables

X_n = the independent variables

P = probability of being aware of GAP

1-P = probability that a farmer is not aware of GAP

For each independent variable in the logistic regression model, the model produced an odds ratio (OR), which has been reported.

Goodness of fit of the model

Among different tests, Hosmer and Lemeshow test (Hosmer and Lemeshow, 1980) and Omnibus test of model coefficients have been used to evaluate the binary logistic regression model's goodness of fit. These tests are frequently used to evaluate the model's quality of fit and accepts any number of independent variables. Omnibus test of model coefficients shows a good fit if the model is significant; however, Hosmer - Lemeshow statistic indicates a poor fit if the significance value is less than 0.05.

R^2 – statistics

In a binary logistic regression model, the variation of the dependent variable owing to variation in the independent variables has been presented by the coefficient of determination based on likelihood, an approach pioneered by (Nagelkerke, 1991). The Nagelkerke R^2 has also been calculated and published in this study. Nagelkerke R^2 value ranges from 0 to 1. Values closer to 1 tends to explain the goodness of fit of the model.

Prediction accuracy

Prediction accuracy is the most fundamental diagnostic of a logistic regression and can be discovered using a classification table. To determine whether instances can be correctly classified (i.e., predicted) from the independent variables, binomial logistic regression is frequently used. As a result, a technique for comparing the efficacy of the expected classification to the actual classification becomes necessary (Nasser, 2020).

RESULTS AND DISCUSSION

Awareness of farmers about GAP

Out of 64 respondents of study areas only 31.25% respondents were aware about good agricultural practices; while 68.75% respondents were unaware about good agricultural practices. Because there were no GAP-focused trainings provided in the study area, farmers were less aware of the issue. Also, among GAP aware farmers approximately 90% were found to have learned through government extension agents and rest through social media/newspaper which is similar to the findings of Joshi *et al.* (2019).

Socio-economic and demographic characteristics and its relationship with farmer's category of the sampled households

The responses about sex, ethnicity, education status, family type, farming experiences, access to training and commodity status were collected and described in the Table 2. In the study area, among GAP aware 60% were male and 40% were female and among GAP unaware 61.4% were male and 38.6% were female. The ethnicity was categorized as Brahmin, Chhetri and Janajatis. Table 2. revealed that among the GAP aware respondents 30% were from Brahmin community, 30% were from Chhetri community and 40% from Janajati and among GAP unaware respondents 25.0% were from Brahmin, 38.6% from Chhetri community and 36.4% from Janajati. Regarding the education status of GAP aware, 45%, 25%, 30%, attained primary to lower secondary education i.e., from class 1 to 8, SLC and +2/certificate education respectively and among GAP unaware 52.3%, 25%, 22.7% have attained primary to lower secondary, SLC and +2/certificate education respectively as shown in Table 2 above. Similarly, 80% of GAP aware had nuclear family while the value is 72.7% for GAP unaware family. Likewise, 27.3% of GAP unaware had joint family and 20% of GAP aware had joint family. Therefore, among the categorical variables; farming experience, access to training, commodity demand and high production levels— one of the factors motivating farmers to citrus farming in Palpa— were found to have significant association with the GAP awareness farmers.

Table 2. Bivariate analysis of the categorical variables with farmer's category.

Variables	Overall (n=64)	Farmers' category		Chi-square value
		GAP aware (n=20)	GAP unaware (n=44)	
Sex				
Male	39	12 (60.0)	27 (61.4)	0.011^{ns} (df=1,p=0.92)
Female	25	8 (40.0)	17 (38.6)	
Ethnicity				
Brahmin	17	6 (30.0)	11 (25.0)	0.46^{ns} (df=2,p=0.79)
Chhetri	23	6 (30.0)	17 (38.6)	
Janajati	24	8 (40.0)	16 (36.4)	
Education status				
Primary-lower secondary (1-8)	32	9 (45.0)	23 (52.3)	0.436^{ns} (df=2,p=0.804)
SLC	16	5 (25.0)	11 (25)	
+2/ certificate	16	6 (30.0)	10 (22.7)	
Family Type				
Nuclear family	48	16 (80.0)	32 (72.7)	0.388^{ns} (df=1,p=0.53)
Joint family	16	4 (20.0)	12 (27.3)	
Farming Experience				
10-20yrs	28	4 (20.0)	24 (54.55)	9.768***(df=2,p=0.008)
20-30yrs	19	6 (30.0)	13 (29.55)	
30-40yrs	17	10 (50.0)	7 (15.9)	
Access to training				
Yes	40	17 (85.0)	23 (52.3)	6.284**(df=1,p=0.012)
No	24	3 (15.0)	21 (47.7)	
Commodity demand and High production levels				
Yes	36	16 (80.0)	20 (45.5)	6.67**(df=1 p=0.010)
No	28	4 (20.0)	24 (54.5)	

Note: Figures in the parenthesis indicate percentage value. ***,** indicates 1% and 5%, level of significance respectively.

Table 3. Binary logistic regression results for factors affecting GAP aware commercial farmers.

Determinants	GAP aware(1=Yes)					95% CI for Exp(B)		
	B	S.E	Wald	df	p- value	Odds Ratio (OR) Exp (B)	Lower	Upper
Sex (1=Male, 0=Female)	0.252	0.652	0.149	1	0.700	1.286	0.358	4.614
Education (Years)	0.089	0.261	0.116	1	0.733	1.093	0.655	1.824
Area of Citrus Production (ha)	-0.042	0.035	1.427	1	0.232	0.959	0.896	1.027
Contact with extension agents (1=yes,0=no)	1.426	0.708	4.062	1	0.044**	4.164	1.040	16.667
Commodity demand and high market price (1=yes,0=no)	0.408	0.675	0.366	1	0.545	1.504	0.401	5.646
Training (1=attended, 0=not attended)	2.331	0.886	6.918	1	0.009***	10.293	1.811	58.483

Note: **, *** indicates 5% and 1% level of significance respectively.

Factors affecting awareness of GAP among commercial citrus growers

Before performing the regression, diagnostic tests were carried out to check the multicollinearity problem in the independent variable. Multicollinearity among predictor variables can complicate the calculation and identification of the independent effects of these variables on the outcome. This complication arises because collinear predictor variables share overlapping information, making it difficult to distinguish their individual contributions to the outcome variable (Vatcheva *et al.*, 2016). The Variance Inflation Factor (VIF) is a measure used to assess multicollinearity in a regression model which was found to be 1.14. Therefore, VIF value of 1.14 suggests that there is relatively low multicollinearity among the predictor variables in the regression model. Generally, a VIF value below 5 is considered acceptable, indicating that multicollinearity is not a significant concern (James *et al.*, 2017).

Various factors such as socio-demographic —sex; education; area of citrus production; frequent contact to extension agents— access to trainings, commodity demand and high market price affect the awareness of GAP. The study analyzed the effect of such independent variables on the awareness of GAP and among them contact with extension agents and access to training had a significant effect at 5% and 1% level of significance respectively. Therefore, for a unit increase in contact with extension agent and access to trainings, the log odds of being GAP aware increases by 4.164 (OR) and 10.293(OR) respectively.

Table 4. Test statistics for GAP aware farmers.

Test model	Omnibus test			Nagelkerke R^2	-2 log likelihood	Hosmer and Lemeshow test		
	Chi square value	df	p- value	0.337	61.956[a]	Chi-square value	Df	p-value
GAP Aware	17.543	7	0.014**			10.996	8	0.202

Note: ** indicates 5% level of significance.

Table 5. Prediction accuracy classification able.

Observed	Predicted		Percentage correct
	GAPs Unaware	GAPs Aware	
GAPs unaware	37	7	84.1
GAPs aware	9	11	55.0
Overall percentage			75.0

In other words, we can say that the farmers' who are GAP aware have an access to trainings and frequent contact with extension agents, 4.164 and 10.293 times higher than those farmers who are GAP unaware respectively. Therefore, the observed results also support Kumar *et al.*, (2020); Tega and Bojago (2023) who emphasized the necessity of better extension services and training for adoption of new technology. Similarly, demand of citrus fruits and its higher production levels in the orchard have influenced farmers 1.504 times more on awareness of GAP (95%CI: 0.40 to 5.64). Table 4 represents the Omnibus test, Hosmer and Lemeshow test, and test of overall significance of the binary logistic regression model. The model is significant as the p value for Omnibus test (0.014) is less than 0.05; while, greater than 0.05 for Hosmer and Lemeshow test (0.202). Hence, model's Chi square value (X^2) and -2 log likelihood ratio of 61.956 indicates that all the variables in the model significantly influence the probability of awareness of GAP at 5% level of significance.

The pseudo R^2 value of 0.337 indicates that about 33.7% of decision to adopt GAP is governed by tabulated variables i.e., the model fits 33.7% to the given data. In general, a higher R-squared value indicates a better fit of the regression model to the data. On the other hand, in certain domains where there is substantial variability in the dataset, even a lower R-squared value, such as 0.3, might be considered acceptable (Zach, 2019). Hence, the fit for a model can be considered moderate. Also, with the independent variables added, the model correctly classifies 75% of the cases overall as indicated in Table 5. With the 84.1% of the farmers who were GAP unaware were correctly predicted by the model that they are not GAP aware—termed as specificity for the model. Likewise, 55% of the farmers who were GAP aware are correctly predicted by the model to fall into that group—termed as sensitivity for the model.

Respondents in the study area has not received proper trainings specifically on good agricultural practices in citrus fruits. However, they have had encountered several trainings on production technology of fruits and vegetables which helped them gain few insights on GAPs as well. Among various socio-economic factors studied, farming experience; as a farm worker— and access to trainings— has had a significant impact on the awareness level of farmers about good practices in farm. Among them, 50% of respondents have more than 30 years of farming experiences. As a result, farmers who began growing citrus 30 years ago are significantly more advanced in terms of commercial and good citrus farming practices. The study supports the findings of Kunwar *et al.* (2018; Tega and Bojago, 2023) who stated that years of experience has a positive relation with awareness level and adoption of new technology. Therefore, people with experience of over 30 years made up 65.9% of the population, demonstrating the importance of citrus cultivation in the Palpa district.

The most critical factors that affect the farmers' knowledge of GAP is determined by the accessibility in guidance and services they get from the responsible institutions. Among the respondents, 85% of GAP aware took guidance or supervision from PMAMP, PIU, Palpa while only 15% of GAP aware took no such initiative. Access to trainings will certainly have a positive impact on adoption of improved orchard management practices which in turn helps increasing yield; which supports the findings of Joshi *et al.* (2019); Liu *et al.* (2022); Sedhai *et al.* (2022). Another factor affecting farmers awareness in incorporating good agricultural practices in farm includes the high demand of the commodity; as a result of higher quality fruits, and also the increase in fruit production levels due to better adoption of orchard management practices. Hence, is supported by the findings of *Leong et al.* (2020; Dorji *et al.*, 2016). Therefore, study also showed that among those farmers who were GAP aware they agreed to the fact that citrus demand and its higher production levels have influenced them to adopt the practices more.

Among the socio- economic factors, societal norms and expectations regarding gender roles can influence the types of activities and responsibilities assigned to men and women within agricultural contexts. Also, study showed that the farmers who are GAP aware and Male are 1.286 times more than the farmers who are GAP unaware and are female (95% CI: 0.358 to 4.614). This might be due to traditionally greater involvement of men in decision-making, receiving trainings, and interacting with extension services—they may have greater exposure to new agricultural practices, leading to higher awareness levels. Thus, the results supports Suvedi *et al.* (2017); Dearing (2021); who stated that the awareness of farmers to newer practices are affected by gender. However, the values of gender were not significant in the study.

Also, result showed 33.7% of decision to adopt GAP is governed by independent variables. However, the other prospective variables might also increase the likelihood of being GAP aware and hence, it shouldn't be ignored. Social networks and peer influence; supportive government policies, incentives, subsidies, and agricultural extension programs; cultural beliefs, traditions, and local customs —neither of them was studied in the survey— could be some prospective aspects to look for in further studies.

Conclusion

Adoption of any agricultural innovation necessitates prior knowledge. Farmers' awareness, on the other hand, can change depending on a range of variables and circumstances. Good Agricultural Practices (GAP) are a relatively new concept to Nepalese farmers, and the vast majority are unaware of it. Therefore, the study's findings suggest that communication between farmers and extension agents and access to trainings should be strongly prioritized because these are the two main elements influencing farmers' awareness on GAP. Additionally, policymakers should consider implementing supportive policies, incentives, and subsidies to encourage farmers to adopt GAP. Government initiatives can promote trainings, awareness campaigns, and provide resources to enhance farmers' knowledge. Further research could explore the influence of social networks, government policies, and cultural factors in farmers' awareness of GAP. Some practices may align with traditional knowledge and beliefs, making them more readily accepted, while others may require more cultural adaptation and awareness-building efforts. Henceforth, exploring these variables in more depth could provide valuable insights into their impact on farmers' awareness of GAP.

Conflict of interest

Author declares no conflict of interest.

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