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RESEARCH

Investigating Eco-Friendly Practices in Vegetable Cultivation: A Comprehensive Analysis of Knowledge and Use among Farmers in Narsingdi, Bangladesh

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Abstract

The widespread use of pesticides is a major barrier to sustainable agriculture, polluting vital resources. In this context, eco-friendly agriculture offers a holistic farming approach that promotes health and sustainability. This study aimed to assess vegetable farmers' knowledge of eco-friendly farming, examine how often they practice these methods, and identify factors influencing their awareness and adoption. A pre-tested structured interview was conducted with 112 vegetable farmers, 50% of the total, in the Shibpur sub-district of Narsingdi, Bangladesh, between January and April 2023. The study focused on farmers' knowledge and use of environmentally friendly practices. Bloom's Taxonomy was used to evaluate their knowledge, while use was measured on a 4-point scale (no, rarely, occasionally, frequently). Data analysis involved descriptive and inferential statistics. Results showed that 71.4% of farmers had moderate knowledge, scoring 78.56% at the application level of Bloom's Taxonomy. Additionally, 64.3% demonstrated medium-level utilization of eco-friendly practices. Factors such as education, experience, training, and extension contact influenced both knowledge and practice. To increase farmers' understanding and stimulate adoption, the Department of Agricultural Extension (DAE) and the Ministry of Education (MoE) should establish adult education and training initiatives and boost extension contact.

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Statement of Sustainability: Reaching zero hunger through ensuring food and nutrition safety is one of the most significant Sustainable Development Goals (SDGs). Eco-friendly practices are essential for producing safe and high-quality vegetables. The present study reveals key factors influencing the adoption of sustainable agricultural practices. Findings show that while growers have a moderate level of understanding and practice, determinants such as education, experience, training, and extension contact significantly impact their engagement. This research highlights the urgent need for targeted adult education programs and training initiatives to empower farmers and foster sustainable agriculture in the region.

1. Introduction

Feeding the projected 11 billion people by the century's end presents a significant global challenge (Hasan et al., 2024; Khamis et al., 2025). Although the green revolution offers advanced agricultural technologies that could potentially boost food production per capita by 40% (Shanka, 2020), these methods require substantial capital investments and infrastructure. Bangladesh, with a population of 166.5 million, is one of the most densely populated countries, and its population is growing at 1.32% annually (BBS, 2022). Over the past decade, Bangladesh has maintained a robust economic growth rate of 5.24%, significantly advancing its human development (Hasan et al., 2024). The agricultural sector plays a crucial role in the economy, contributing 12.44% of GDP and employing approximately 48.4% of the workforce (FAO, 2022). To meet food needs, the country relies on 14.3 million hectares of cultivable land (BBS, 2022), having enhanced food grain production from about 8.1 million hectares. Nevertheless, agricultural productivity remains relatively low compared to other nations, and the sector's GDP share has declined from 14.06% in 2016 to 12.44% in 2020 (BBS, 2022). Despite this trend, agriculture continues to drive non-agricultural growth and overall economic development (Rahman, 2017).

In Bangladesh, farming is predominantly small-scale, and over half the population depends on agriculture for their livelihoods (Quddus and Kropp, 2020). Many farmers rely on traditional methods, leading to persistent poverty and food insecurity (Kumar et al., 2020). A lack of knowledge regarding new farming technologies and insufficient efforts to diversify crops contribute to low productivity. However, significant strides have been made toward food grain self-sufficiency via improved practices. Since the 1980s, the usage of synthetic fertilizers and insecticides has expanded (Sharma et al., 2023), although this has raised concerns regarding human health and environmental pollution (Giller et al., 2021; Kamrujaman et al., 2023).

A World Bank study indicated that Bangladesh's crop yields are stagnating or declining due to overreliance on fertilizers and pesticides, continuous irrigation, and the removal of plant materials from fields, leading to soil erosion and reduced fertility (World Bank, 2017). The escalating use of pesticides has resulted in increased resistance among pests, driving up production costs and sidelining sustainable agricultural practices (Shammi et al., 2020). This heavy reliance on chemicals contaminates air, water, and food, posing health risks (Zhang et al., 2015). To mitigate environmental harm, the government initiated the 'Safe Vegetable Production through Eco-friendly Approaches' project. Therefore, this study aims to gather data on farmers' knowledge and use of eco-friendly practices towards sustainable vegetable farming methods. The objectives include assessing growers' knowledge, frequency of eco-friendly practice use, and the factors influencing these practices.

2. Methodology

2.1. Study Location

The research was carried out in Baghabo Union, Shibpur sub-district, Narsingdi district (Figure 1). This area was chosen for its diverse vegetable cultivation (Parvin et al., 2017) and experienced farmers.

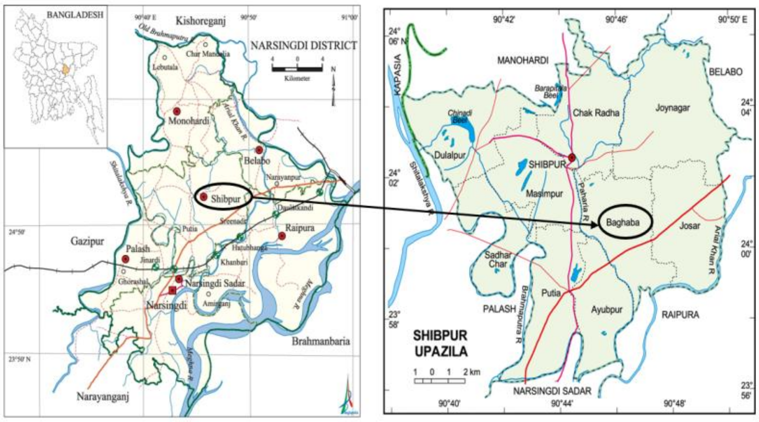

Figure 1. A map displaying the Narsingdi district and Shibpur sub-district with the designated study location.

2.2. Population, Sampling, and Data Collection

The study examined 223 vegetable growers, with 112 randomly selected for data collection, representing 50% of the total population. Data was gathered through face-to-face interviews using a semi-structured schedule from January to April 2023. A pilot test with 10 farmers was conducted to validate the questionnaire.

2.3. Measurement of Focus Variables

Knowledge was assessed using Bloom's Taxonomy, focusing on its six cognitive levels: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson and Krathwohl, 2001; Kabir et al., 2022). To facilitate a comparison of knowledge among vegetable growers, a standardized knowledge index (SKI) was calculated for each cognitive level. The formula for the SKI is as follows:

$$SKI = (TCS / TPS) \times 100$$

In this equation, CS represents the total computed scores achieved for a specific stage of knowledge, and PS represents the total possible scores for that level. The SKI can range from 0 to 100, where a score of 0 reflects no knowledge and a score of 100 indicates a very high level of knowledge. A four-point rating scale (no use=0, rarely use=1, occasionally use=2, and frequently use=3) was employed to examine farmers' use of eco-friendly practices in vegetable cultivation (Haque et al., 2019; Santaweesuk et al., 2020; Ukwuaba et al., 2025). The total score for ranking is calculated using the equation below:

$$Total\ score = (Nf \times 3) + (No \times 2) + (Nr \times 1) + (Nn \times 0)$$

Here, N_f = Number of growers who responded frequently use; N_o = Number of growers who responded occasionally use; N_r = Number of growers who responded rarely use; N_n = Number of growers who responded no use; The computed index score for each use aspect may have a number between 0 and 336, with 0 indicating no use at all and 336 indicating frequent use.

2.4. Data Analysis

Different types of descriptive statistics were employed, including rank order, frequency, mean, and percentage (Podder et al., 2022; Kowsari et al., 2022). To discern factors affecting farmers' knowledge and usage of eco-friendly vegetable cultivation methods, a multiple linear regression analysis was performed. Additionally, a stepwise regression approach was used to eliminate variables that were not statistically significant from the model. The multiple regression analysis was conducted using the formula below:

$$ß = ß0 + ß1X1 + ß2X2 + ß3X3 + ß4X4 + ß5X5 + ß6X6 + ß7X7 + ß8X8 + ß9X9 + e$$

In this equation, ß represents the dependent variable (farmers' knowledge and application of eco-friendly practices), ß0 is the regression constant; e signifies the error term; X denotes the independent variables; where X1 is Age, X2 is Educational Status, X3 is Household Size, X4 is Experience in Vegetable Farming, X5 is Vegetable Cultivation Area, X6 is Annual Family Income, X7 is Training Exposure, X8 is Attitude Towards Eco-friendly Practices, and X9 is Extension Contacts.

3. Results and Discussion

3.1. Personal and Socio-Economic Characteristics of Vegetable Growers

Table 1 summarizes the socioeconomic and personal traits of the vegetable growers. According to the data, respondents had an average age of 38.43 years, putting them largely in the middle-aged category. When the survey was conducted, the average duration of education was 5.48 years. Mithun et al. (2020) note that educational institutions can help farmers improve their technical skills and problem-solving capabilities.

Table 1. Personal and socio-economic characteristics of the vegetable growers (n=112).

Characteristics	Mean	Standard Deviation
Age (Years)	38.43	9.493
Educational status (Years)	5.48	2.16
Family size (Number)	5.89	2.451
Vegetable farming experience (Years)	16.14	8.437
Area under vegetable cultivation (Hectare)	0.579	0.458
Annual family income (000 BDT)	595.36	147.86
Training exposure (Days)	3.64	1.752
Attitude towards eco-friendly practices (Scores)	6.00	1.698
Extension contacts (Scores)	13	4.69

BDT = Bangladeshi Taka

The vegetable growers had an average family size of 5.89, exceeding the national average of 4.26 members (HIES, 2022). They had spent an average of 16.14 years working in vegetable farming, mostly with moderate experience. Greater farming experience can lead to a positive outlook and better knowledge about the field (Hyland et al., 2018). The average cultivated area was 0.579 hectares, slightly less than the national average of 0.60 hectares (HIES, 2022). The families surveyed reported an average income of 595.36 BDT, roughly 4,961 USD, which is significantly higher than the national average of 2,749 USD (HIES, 2022). Regarding training, vegetable growers participated in an average of 3.64 days of instructional programs. Training duration is vital for promoting eco-friendly farming practices, offering enough time to learn sustainable techniques, soil health management, and chemical-free pest control. Their attitude towards eco-friendly practices averaged 6.00 with a standard deviation of 1.698. Such attitudes are crucial because they influence the willingness to adopt and maintain these practices. A positive outlook encourages learning, innovation, and environmental responsibility. Most farmers had limited contact with extension media, with an average score of 13, but access to extension agents remains a key factor in expanding agricultural knowledge (Podder et al., 2022).

3.2. Farmers' Knowledge of Eco-Friendly Practices for Vegetable Cultivation

Figure 2 indicates that 71.4% of vegetable growers have a moderate knowledge of eco-friendly practices, while 28.6% possess a high level, with none reporting poor knowledge. Similar findings were noted by Dhivya et al. (2024) regarding turmeric cultivation in Tamil Nadu, and Kabir et al. (2022) found that 65% of vegetable farmers in Gopalganj, Bangladesh, have fair knowledge of botanical pesticide application.

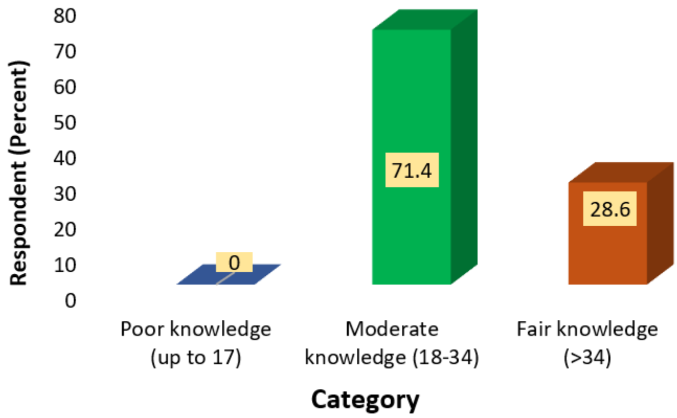

Figure 2. Farmers' knowledge of eco-friendly practices for vegetable cultivation.

In the Shibpur sub-district of Narsingdi, the moderate knowledge among growers is influenced by factors such as middle age, secondary education, and moderate farming experience. Their relatively high annual income allows for investment in eco-friendly practices, though challenges like insufficient training, limited production space, and high costs hinder complete understanding.

3.3. Percent Response to Various Stages of Bloom's Taxonomy

The knowledge of the vegetable growers on eco-friendly practices was measured using Bloom's taxonomy. The result displayed in Figure 3 indicates that the highest average score (78.56%) was obtained from the respondents in the 'applying' level, followed by 71.02% from the 'remembering' level.

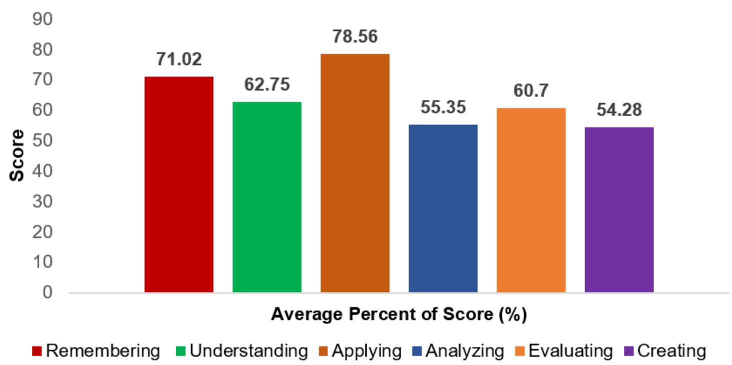

Figure 3. Percent response to various stages of Bloom's taxonomy.

Compared to the rest of the levels, creating levels showed a poor average score (54.28%). Farmers can handle problems more successfully by assuring greater knowledge and confidence through more advanced training oriented toward the more advanced stages of the Bloom hierarchy (Whitehair et al., 2022).

3.4. Farmers' Use of Eco-Friendly Practices for Vegetable Cultivation

Figure 4 illustrates the eco-friendly practices among vegetable growers, revealing that 64.3% utilize these practices at a medium level, while 35.7% have a high usage. Notably, there are no respondents with low usage. Similar studies indicate a trend toward moderate eco-friendly practices among farmers, such as Haque et al. (2019) in Bangladesh, who found 62% of fish farmers at a medium level, and Ukwuaba et al. (2025) in Nigeria, reporting 71% among vegetable farmers. The moderate adoption of eco-friendly methods among Bangladeshi vegetable farmers is primarily attributed to a lack of knowledge, higher initial costs, concerns over yield stability, limited access to sustainable inputs, and insufficient market demand and government support.

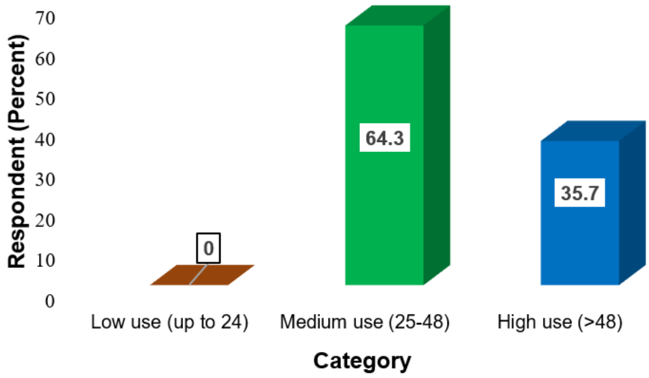

Figure 4. Categories of farmers based on their current use of environmentally friendly techniques.

3.5. Rank Order of Growers' Usage of Environmentally Friendly Techniques

The total score in Table 2 illustrates the environmentally friendly crop production practices adopted by vegetable growers in Bangladesh. The top eco-friendly practice is the use of pheromone traps, scoring 312. This method effectively manages pests while safeguarding the environment, making it a preferred choice among farmers. Hasan et al. (2024) identified the sex pheromone trap as the second-ranked method in their research, highlighting its cost-effectiveness and ease of use.

Table 2. Rank order of the environmentally friendly techniques used by the vegetable farmers (n=112).

Aspects	Extent of use				Total score	Rank
	F (3)	O (2)	R (1)	N (0)		
Selection of resistant/responsive variety	36	72	0	4	252	9
Seed treatment	56	56	0	0	280	6
Soil treatment	76	36	0	0	300	3
Adoption of ideal spacing	68	40	4	0	288	5
Adoption of the ideal planting method	44	64	4	0	264	8
Application of farm yard manure	20	36	48	8	180	14
Application of green leaf manure	4	4	8	24	28	18
Application of neem cake/neem oil	4	4	4	100	24	19
Application of cow dung	92	12	0	8	300	3
Use of crop rotation	72	40	0	0	296	4
Irrigation: intermittent supply	12	96	4	0	232	10
Irrigation: continuous submergence	64	20	20	8	252	9
Regular pest management	32	48	28	4	220	11
Integrated weed management	76	32	4	0	296	4
Using pheromone traps	92	16	4	0	312	1
Using light traps	32	20	16	44	152	15
Using yellow sticky traps	20	24	20	48	128	16
Introduction of bio-pesticide	28	32	48	4	196	12
Use of vermicompost	16	36	60	0	180	14
Conservation of natural enemies	16	48	44	4	188	13
Destruction of infected plant parts	76	36	0	0	300	3
Using hand nets for insect control	80	4	20	8	268	7
Use of natural soil mulch	12	12	28	60	88	17
Use of poly-tunnels	84	24	4	0	304	2

F= Frequently, O= Occasionally, R= Rarely, and N= Not at all

The second-ranking practice is the utilization of poly-tunnels, with a total score of 304. Polytunnels provide a controlled environment, shielding crops from extreme weather and pests without chemical pesticides. This technique enhances crop growth by stabilizing temperatures and humidity, thereby boosting yields while reducing synthetic input reliance.

Scoring 300, three practices share the third rank: soil treatment, application of cow dung, and destruction of infected plant parts. Soil treatments, like solarization and organic amendments, improve soil health, while cow dung enriches the soil with nutrients. Collectively, these practices demonstrate farmers' dedication to sustainable agriculture, improving soil fertility, minimizing chemical use, and fostering natural plant health.

3.6. Factors Influencing Farmers' Knowledge of Eco-Friendly Practices

Table 3 shows the results of the linear regression analysis. At $p < 0.05$, the F-test statistic was 24.913, indicating a statistically significant model. The value of 0.711 adjusted R-squared suggests the model fits the data well, and all parameters had significant effects.

Table 3. Multiple linear regression analysis of knowledge of eco-friendly practices (n=112).

Explanatory variables	Unstandardized coefficients		Standardized coefficients	t-value	Sig.
	B	Std. Error			
(Constant)	4.014	5.348	-	0.651	0.562
Age (X1)	0.048	0.056	0.061	0.850	0.397
Educational status (X2)	0.513	0.166	0.126	3.092	0.001
Family size (X3)	0.329	0.216	0.072	1.524	0.130
Vegetable farming experience (X4)	0.502	0.092	0.334	5.455	0.000
Area under vegetable cultivation (X5)	0.037	0.048	0.050	0.760	0.449
Annual family income (X6)	0.008	0.005	0.086	1.816	0.072
Training exposure (X7)	0.502	0.092	0.334	5.455	0.000
Attitude towards eco-friendly practices (X8)	0.435	0.089	0.313	4.014	0.001
Extension contact (X9)	0.541	0.086	0.445	6.215	0.000
R=0.831, R^2= 0.711, Adjusted R^2=0.671, F-value=24.913					

The analysis from Table 3 reveals strong positive relationships between vegetable growers' education, experience, training, attitude, extension contacts, and their knowledge of eco-friendly practices, all statistically significant at the 0.05 level. Education notably increases knowledge, with a coefficient of 0.513, indicating that more educated farmers better understand sustainable cultivation. This is likely because they interact more with extension agents, media, and model farmers, which enhances their awareness and application of eco-friendly techniques. Similarly, farming experience shows a significant positive impact (0.502), as practical involvement deepens understanding of resource optimization, crop rotation, and soil health, reducing reliance on chemicals and supporting biodiversity. Exposure to training also boosts knowledge (0.502), equipping farmers with valuable skills for sustainable practices such as soil health management and water conservation.

Furthermore, positive attitudes towards eco-friendly practices significantly influence knowledge levels (0.435), as environmentally conscious growers are more inclined to adopt and innovate sustainable methods. Lastly, extension contacts have the highest impact (0.541), providing access to expert advice, resources, and tailored solutions that promote eco-friendly techniques like organic farming and pest management. These interactions facilitate the transfer of research into practice, aiding farmers in increasing productivity while minimizing environmental harm. Overall, the findings emphasize that education, experience, training, attitude, and extension services are crucial in enhancing farmers' knowledge of sustainable practices. Encouraging growth in these areas can promote more environmentally responsible vegetable farming, ensuring productivity, resource conservation, and ecological balance for the future.

To ascertain the contribution of each of the significant variables in accounting for the variability in the farmers' knowledge of eco-friendly practices for vegetable cultivation, a step-wise multiple regression analysis was conducted (Table 4). The results revealed that training exposure (X_7) expresses the focus variable by 64.4%, extension contact (X_9) expresses 5.9%, vegetable farming experience (X_4) expresses 4.1%, educational status (X_2) expresses 3.3% and attitude towards eco-friendly practices (X_8) expresses 1.2% farmers' knowledge of eco-friendly practices for vegetable cultivation.

Table 4. Step-wise regression analysis for farmers' knowledge of eco-friendly practices (n=112).

Model	Variables entered	Coefficient of determination	Adjusted R^2	Percent of increase in adjusted R^2
Constant+X7	Training exposure (X7)	0.658	0.642	64.4
Constant+X7+X9	Extension contact (X9)	0.723	0.701	5.9
Constant+X7+X9+X4	Vegetable farming experience (X4)	0.759	0.742	4.1
Constant+X7+X9+X4+X2	Educational status (X2)	0.782	0.775	3.3
Constant+X7+X9+X4+X2+X8	Attitude towards eco-friendly practices (X8)	0.801	0.787	1.2

3.7 Factors Influencing Farmers' Use of Eco-Friendly Practices

The linear regression results displayed in Table 5 are compelling. The model has a p-value below 0.05 and an F-test statistic of 24.913, indicating statistical significance. The model fits the data well, as evidenced by the adjusted R-squared of 0.711, with no factors exhibiting negligible effects. Notably, four factors, educational status, vegetable farming experience, training exposure, and extension contact, stood out as significant contributors.

Table 5. Multiple linear regression analysis of farmers' use of eco-friendly practices (n=112).

Explanatory variables	Unstandardized coefficients		Standardized coefficient	t-value	Sig.
	B	Std. Error			
(Constant)	5.318	4.168	-	0.713	0. 613
Age (X1)	0.061	0.022	0.061	0.791	0.481
Educational status (X2)	0.423	0.198	0.221	4.084	0.000
Family size (X3)	0.375	0.202	0.064	1.221	0.162
Vegetable farming experience (X4)	0.419	0.087	0.381	5.356	0.000
Area under vegetable cultivation (X5)	0.051	0.053	0.044	0.665	0.503
Annual family income (X6)	0.019	0.014	0.073	1.946	0.067
Training exposure (X7)	0.537	0.081	0.392	5.724	0.000
Attitude towards eco-friendly practices (X8)	0.021	0.016	0.069	1.946	0.064
Extension contact (X9)	0.501	0.076	0.419	5.512	0.000
n=112, R=0.840, R^2= 0.716, Adjusted R^2=0.683, F- value=26.742					

Table 5 presents valuable insights into the factors that influence vegetable growers' adoption of eco-friendly practices. The correlation between educational status and the use of sustainable methods stands at 0.423. This positive relationship indicates that more educated growers tend to embrace eco-friendly farming techniques, understanding the long-term benefits such as soil conservation and efficient resource use. Experience also plays a significant role, with a correlation of 0.419. Seasoned farmers often possess practical knowledge that enhances their ability to apply sustainable practices like crop rotation and organic fertilization. Their hands-on experience helps them optimize resources and reduce chemical inputs, making their farming methods more environmentally friendly. Training is another key factor, boasting a correlation of 0.537. Access to training sessions empowers farmers by enhancing their understanding of organic farming, pest management, and sustainable resource utilization. This knowledge equips them to adopt innovative techniques that promote environmental sustainability.

Moreover, regular contact with extension services shows a positive correlation of 0.501. These interactions provide farmers with expert advice and up-to-date information on sustainable practices, enabling them to effectively implement eco-friendly methods in their cultivation. Engaging with extension media can significantly alleviate challenges faced by farmers, as noted by Kabir et al. (2022).

Overall, education, experience, training, and extension services are vital for promoting sustainable vegetable farming. They equip farmers with the necessary knowledge and resources to adopt environmentally responsible practices. Uddin et al. (2024) emphasize that a grower's awareness and ability to make informed decisions are largely shaped by their educational background, hands-on experience in vegetable cultivation, access to training, and the area they cultivate. A stepwise multivariate regression approach was carried out to ascertain the role that each significant variable played in explaining the variation in farmers' adoption of environmentally friendly methods for growing vegetables (Table 6). The analysis revealed that training exposure (X_7) accounts for 65.1% of the variance, extension contact (X_9) explains 8.1%, educational status (X_2) accounts for 2.9%, and vegetable farming experience (X_4) explains 2.1% of the farmers' use of eco-friendly practices for vegetable cultivation.

Table 6. Step-wise regression analysis for farmers' use of eco-friendly practices (n=112).

Model	Variables entered	Coefficient of determination	Adjusted R^2	Percent of increase in adjusted R^2
Constant+X7	Training exposure (X7)	0.673	0.651	65.1
Constant+X7+X9	Extension contact (X9)	0.731	0.732	8.1
Constant+X7+X9+X2	Educational status (X2)	0.763	0.761	2.9
Constant+X7+X9+X2+X4	Vegetable farming experience (X4)	0.791	0.782	2.1

4. Conclusions and Recommendations

Most vegetable growers (71.4%) showed a moderate understanding of eco-friendly cultivation methods. Bloom's taxonomy analysis revealed that respondents scored highest (78.56%) at the application level. Additionally, 64.3% of growers reported a medium level of engagement with eco-friendly practices. Factors like educational background, farming experience, training exposure, attitudes, and contact with extension services significantly influenced their knowledge. These same factors also affected their adoption of eco-friendly practices. To improve knowledge and skills, especially regarding eco-friendly methods, adult education and targeted training programs are vital. The Department of Agricultural Extension in Bangladesh must ensure all farmers receive adequate extension services and updated information. Awareness campaigns can help foster a more positive attitude toward sustainable vegetable cultivation.

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