Assessing the Role of Safe Agricultural Practices in Enhancing Farmers' Income from Vegetable Cultivation

Abstract

In Bangladesh, farmers grow both general and high-value vegetables, which are essential for providing necessary vitamins and minerals and are cultivated throughout the year across different seasons. However, due to limited knowledge of modern farming techniques, many farmers are hesitant to produce high-value vegetables. This study aims to examine the development of vegetable farming after the implementation of safe cultivation methods for both general and high-value crops, along with the resulting changes in farmers' income. The research utilized and restructured data collected during various baseline and impact assessments to meet the study objectives. By using structured questionnaires, the study gathered key insights into the socio-economic conditions, land use for agriculture, farming techniques, marketing, and financing practices during the project period. The findings reveal that average vegetable production, revenue, and profits have significantly increased since the project's inception. The adoption of safe farming methods and improved marketing strategies has led to higher employment, better-quality vegetables free from harmful substances, enhanced soil quality, and greater income for farmers. Raising awareness and providing appropriate training along with logistical support will enable farmers to commercially grow and process both general and high-value vegetables.

Keywords: Vegetable cultivation, High-value vegetables, Safe Method, Agricultural Employment, Farmers' income

JEL Classification: J43, M31, Q13, Q16

1. Introduction

Agriculture is the largest employment sector in Bangladesh (CIA, 2019), with most of the productive land dedicated to growing crops (FAO, 2021). Although agriculture is one of the largest sectors in Bangladesh, with a lack of diversity in crop production and inefficient infrastructure, it remained largely subsistence-based, limiting farmers' ability to commercialize their production fully. Due to multiple factors, labor-intensive agriculture has continuously increased food production despite unfavorable weather conditions. The steady growth of agriculture has been driven by irrigation, high-yielding crop varieties, human capital, infrastructural development, mechanization, policy reforms, and investments in agriculture research (The World Bank, 2016). Despite having enviable progress in agriculture, poor people suffered heavily due to the lack of dietary diversity, reduced micronutrients, and malnutrition (Nahar, et. al, 2024). Diversified vegetables especially off-season vegetables can fill the gap of food

diversity and nutritional security as it is a good source of vitamins and minerals. By producing and selling the diversified varieties of vegetables, poor people can generate income, and reduce poverty and unemployment (Schreinemachers, et. al, 2018). With an exponential increase in population and a changing diet of people, vegetable intake can help both rural and urban dwellers meet their need for healthy foods (Ampim, et. al., 2022).

Vegetables can be vital in elevating the nutritional status of Bangladeshi people suffering from severe malnutrition. The area of vegetable cultivation is less than three percent of the total cropped areas; from this small proportion, Bangladesh produces less than two lac metric tons of vegetables annually (DAE, 2016). This lower level of productivity has been ensured by a lack of good seeds, good varieties, and incentives, the reluctance of the growers to use agrichemicals, and due to improper marketing facilities. Farmers use various pesticides and imported seeds in Bangladesh, creating more economic pressure. In Bangladesh, there are different types of agricultural markets through which agricultural products are exchanged, which include the rural primary market, rural assembly market, rural secondary market, and urban retail market. Middleman plays a vital role as the vegetables are sold to wholesalers and retailers before reaching the consumers causing a lower income level for the farmers; although consumers are paying a higher price.

Producing vegetables requires special attention and a different set of productive capacities for the farmers. Conventionally, farmers of Bangladesh use traditional methods for vegetable production as they do not practice safe cultivation methods. They need to know how to apply an appropriate number of fertilizers and pesticides and irrigate the land with different vegetables. Farmers are used to cultivating low-value vegetables instead of high-value vegetables such as summer tomatoes, cherry tomatoes, capsicum, and lettuce. Despite knowing the negative impact of chemical fertilizers, they increasingly depend on these as they need more expertise in poison-free vegetable cultivation methods such as vermicomposting, pheromone traps, Trichoderma, and Trichogramma. Most significantly, like other sectors of Bangladesh, they do not know how to market their products and lack the knowledge of proper marketing channels and keeping records of their incomes and expenditures. Globally, Bangladesh is third in vegetable production, and vegetables and fruits are now exported to more than forty countries around the world (Haque & Hoque, 2021). The government of Bangladesh with the help of NGOs took the initiative for the development of this sector by implementing projects that can help the farmers produce high-value vegetables by using safe cultivation methods. This study tries to find out the effectiveness of these safe methods in increasing soil quality, higher employment, better marketing, and higher income levels for the farmers. Safe vegetable farming methods focus on using sustainable and eco-friendly practices to enhance agricultural productivity, improve product quality, and ensure the well-being of farmers, consumers, and the environment. Over the past few decades, numerous

studies have examined the potential benefits of adopting safe farming methods, especially for vegetable cultivation.

2. Literature Review

To provide healthy diets for all groups of people, society needs to prioritize investments in vegetables, and increase opportunities for smallholder farmers (Schreinemachers, *et. al.*, 2018). Poverty alleviation can be indirectly linked to vegetable production through food diversification, food security, and self-reliance (Leone, 2016). Scholars conducted different studies on the causes, consequences, and different methods of vegetable farming. These studies indicate that stronger competitiveness, higher prices, increasing productivity, and lower costs may significantly improve the income, sustainability, and welfare of the farmers and entrepreneurs (Hoang, 2021). Among the different causes, sunburn and birds can be the cause of poor vegetable production. To solve the lack of production diversity problem during paddy wheat rotation, vegetable cultivation emerges as the major alternative for farmers (Sidhu, *et. al.*, 2009). While reviewing alternative vegetable production methods, Ampim, *et. al.*, (2022) stress the need for exploring plant growth factors, energy costs, and the prospects of indoor vegetable production methods. The literature suggests that the implementation of different projects such as the installation of shade nets can reduce the damage caused by sunburn and birds (Baliyan, 2014).

Due to the excessive use of chemical pesticide sprays, non-point source pollution, and pesticide residues in vegetables are increasing rapidly (Wang, *et. al.*, 2022). To ensure the yield, safety, and quality of the vegetables, there is a need to find an alternative to chemical pesticide use. Soil-less vegetable cultivation is an alternative method for healthy vegetable production free from disease, insects, and pests; in which the inorganic nutrients are supplied through irrigation water. Using this method ensures off-season production with higher productivity and quality (Waiba, *et. al.*, 2020). Protected cultivation of high-value vegetables like tomato, cucumber, capsicum, and lettuce can create avenues at a higher level, and increase the productivity level for smaller landholdings (Sabir & Singh, 2012). Chanda, *et. al.*, (2020) identified that low local market prices, disease infestation, middlemen, capital and labor crises, and lack of storage, communication facilities, modern technology, and training play a significant role in the lower levels of high-value vegetable production; although high-value vegetables production were found to be profitable. Safe vegetable farming practices focus on maintaining and improving soil health, which is critical for sustainable farming. Singh et al. (2018) highlighted those farmers using safe farming methods, such as integrated nutrient management (INM), reported improved soil quality and better long-term sustainability of vegetable production. According to Uppal and Sharma (2015), organic farming practices, by minimizing the use of synthetic chemicals, significantly improve farmers' health and reduce the occurrence of pesticide-related illnesses.

The shift to safe vegetable farming practices significantly reduces the environmental footprint of farming activities. Studies by Ghosh et al. (2016) show that safe farming methods, such as organic farming and the use of biological pest control, result in less pollution of soil, water, and air compared to conventional methods. The off-season cultivation of crops ensures better profits for farmers and more choices for consumers, but there is a need for a safe and sustainable pest management system (Schreinemachers, et. al, 2016). Crop diversification is another aspect that the researchers put their emphasis on and identified that crop diversification ensures food security (Nahar, et.al, 2024). On the other hand, the use of chemical fertilizers and pesticides can harm vegetable production (Leone, (2016). For better production of vegetables, the productivity of land is so essential, and to increase the land productivity or maintain it for a long time, organic cultivation methods are a very good option for farmers (Rego, 2014). In the case of processed vegetables, Ramos, *et. al.*, (2013) tried to analyze the advantages and limitations of alternative and traditional techniques and argued that preservation and shelf-life are crucial for the food industry. According to Jongman& Korsten (2018), the microbial quality of source water for irrigation is central to hygienic vegetable cultivation. Different studies show that untreated wastewater irrigation can increase the health risks of vegetable consumers (Keraita, *et. al.*, 2012). The cost of producing high-quality and environmentally friendly agricultural products is estimated to be higher than the traditional production (Ezov, *et. al.*, 2020).

A study by Rahman et al. (2018) found that farmers in Bangladesh who adopted safe farming practices experienced a significant increase in vegetable yields and, consequently, their income. Similarly, Sivapalan et al. (2019) reported that safe vegetable farming practices like crop rotation and organic fertilization not only increased vegetable yields but also reduced input costs, improving overall profitability. Safe farming methods also contribute to the production of high-quality vegetables, free from toxic chemicals. The reduction or elimination of chemical fertilizers and pesticides is one of the cornerstones of safe farming. According to Chaudhary and Sharma (2017), the adoption of organic farming methods led to the production of healthier, more nutritious vegetables with fewer pesticide residues. Farmers who implement safe farming methods often gain access to premium markets that prioritize the sale of pesticide-free and organically grown produce. Srinivasan et al. (2017) noted that organic vegetables fetch higher prices in both domestic and international markets, creating new income opportunities for farmers. Studies by Mahapatra et al. (2017) emphasize the role of training and awareness programs in empowering farmers, particularly women, by providing them with the knowledge and resources to improve their farming techniques and increase their incomes. The adoption of safe farming methods can also lead to the generation of additional employment opportunities, both directly and indirectly. According to Ali and Khan (2019), safe farming practices, including organic farming, require more labor-intensive activities, such as manual weeding and pest control, which can create jobs for local workers.

If the farmers can move towards high-value vegetables, they can increase their income (Singh, et al., 2007). Ndungu and others (2013) suggested that the promotion of an organic production system can have a positive impact on vegetable production. The organizational structure of the projects, combined production and marketing, contract farming, and credit access can ensure efficient and sustainable vegetable production (Raleting& Obi, 2015). Successful implementation of projects can increase the income of the farmers of the northwest region of Bangladesh and empower women (Dueñas & Maekawa, 2010). It is to be estimated whether similar results can be achieved in the other areas of the country, and the effectiveness of these safe methods in increasing soil quality, generating employment, and increasing income levels for the farmers.

3. Objectives of the Study

The overall objective of the study is to assess the impact of the safe method for vegetable cultivation and the consequential change in the income of vegetable farmers. It will also try to assess how the employment of the farmers has been generated through the production and marketing of high-value and harmful chemical-free vegetables adopting modern techniques and commercially viable methods. Thus, the specific objectives of the study are as follows:

- To measure how much general and high-valued vegetables the farmers can produce using modern technology;
- To find out the safe method for vegetable production by avoiding excess use of chemical fertilizer and insecticide;
- To assess the impact on employment generation in this sub-sector; and
- To find a way to increase income by ensuring the proper marketing of high-valued vegetables.

4. Methodology

4.1 Description of the Data

Due to the nature of the study and for a comprehensive understanding of the situation, both secondary and primary data were required. A review of similar study documents, databases, and relevant reports has facilitated the gathering of secondary data. Sources of secondary data included, but not be limited to, studying PACE project documents of IFAD, project concept documents, government reports, other agencies' similar survey reports, and other available and relevant materials.

Instead of collecting primary data separately, this study collected the primary data during different baseline and impact studies conducted by NGOs who were implementing projects in different areas of Bangladesh. These impact studies were the assessments of the status of the small vegetable farmers and micro-entrepreneurs who were involved in vegetable cultivation after the successful implementation of the sub-project. These studies were designed to provide an understanding of the project's overall impact by monitoring the production and marketing process towards the expected result. The primary data in this study incorporate some distinct approaches to Participatory Rapid Appraisal (PRA). The

PRA approaches include a) In-depth interviews, household interviews/surveys in the selected stakeholders; b) Focus Group Discussions in farmers' communities and c) Key informant interviews (KII) of the vegetable farmers and other value chain actors like input sellers, output buyer, and government agriculture officials. The data collection process was participatory with all types of key stakeholders. Both qualitative and quantitative data were gathered.

4.2 Data Collection and Management

Sampled farmers were surveyed to conduct the study on vegetable farmers under different projects. This study used simple random sampling to determine the study area. These surveys were carried out in Shahjahanpur, Dhunot, and BoguraSadarUpazila of Bogura district, and Zanjira, Vedorganj, Naria, and SadarUpazila of Shariatpur district. Out of the 766 relevant samples, 633 of them were general farmers, and 133 were Lead farmers.

All the collected data were processed and analyzed according to the study objectives. Data management and processing also include code construction, coding, verification, quality control, data punching, and data processing to ensure the proper data analysis. Keeping the objectives of the study view in mind, the study used the most suitable program Excel Data Analyzer.

4.3 Analytical Approach

This study pursued both quantitative and qualitative approaches while collecting information about the status of the project target groups (vegetable farmers) and understanding the overall scenario of the target groups. The analysis was done using descriptive statistics like percentage, frequency distribution, mean, and tabulation. For making a sensible analysis of collected data, the descriptive summary statistics, graphical representation, and confidence intervals for crucial variables were checked. Based on the output generated by the data analysis, the frequency tables were prepared for all the variables and necessary cross tables consistent with the study objectives were prepared.

5. Results and Discussion

5.1 Vegetable Production and the Price of the Vegetables

Farmers hire manpower to enhance their agricultural activity. Sometimes family members also help them in farming. Farmers cultivate different types of vegetables; among them are tomato, eggplant, bitter gourd, pumpkin, cucumber, snake gourd, bottle gourd, cauliflower, cabbage, bean, okra, radish, lettuce, broccoli, capsicum, squash, and beetroot. This study has been categorized according to the amount of land used for the cultivation of different types of vegetables. The maximum amount of land (97.5 decimal per farmer) has been used for cauliflower cultivation. The second largest portion, 32.16 decimal lands per farmer, was used for tomato cultivation whereas the third largest portion 25.92 decimal lands per farmer, was used for bitter gourd cultivation. The smallest

portion of land, only 12.78 decimal lands per farmer, is used for string bean cultivation.

Table 1: Average production of vegetables by the farmers in Kg/decimal

Name of Vegetables	Production (Kg/Decimal)			Name of Vegetables	Production (Kg/Decimal)	
	Baseline	End line			Baseline	End line
Tomato	64.4	86.0		Bean	47.5	90.2
Eggplant	61.6	66.5		Radish		133.4
Bitter gourd	54.3	56.8		Palwal	66.2	71.8
Sweet gourd	91.6	100.0		String bean	66.5	105.2
Cucumber	59.5	79.1		Red Cabbage		130.9
Snake gourd	67.6	145.0		Broccoli	83.6	86.9
Cauliflower	24.5	36.2		Lettuce	35.0	113.3

In Table 1, we can see the detailed comparison of the average production of vegetables by farmers during the baseline and the ending. During the end line, on average 3,178.0 kilograms of different types of vegetables have been produced by each farmer on 33 decimals of land. It also shows that snake gourd has a higher production of 145.0 kg per decimal land a year. Okra has the second largest productivity of 140.0 kg per year whereas radish has the third largest average productivity of 133.4 kg per year. The overall productivity is 96.3 kg of vegetables per year.

Table 2: Average selling price of vegetables by farmers in BDT

Name of Vegetables	Average Price (BDT)			Name of Vegetables	Average Price (BDT)	
	Baseline	End line			Baseline	End line
Tomato	22.4	31.2		Bean	27.6	35.2
Eggplant	21.2	43.0		Radish		19.2
Bitter gourd	22.2	36.6		Palwal	31.7	32.6
Sweet gourd	15.5	39.2		String bean	34.2	30.4
Cucumber	19.6	37.2		Red Cabbage		27.7
Snake gourd	28.2	30.5		Broccoli	20.5	53.0
Cauliflower	21.1	38.2		Lettuce	18.4	38.8

In Table 2, we can see the details of the average selling price of vegetables for farmers during the baseline and the end line. Different vegetables have different average prices but capsicum has the highest average price of 195.00 BDT per kilogram followed by 53.00 BDT per kilogram broccoli for the second highest and 43.83 BDT per kilogram by short cucumber for the third highest average price at the end. It also shows that radish has the lowest average price of 19.24 taka per kilogram. So, the average selling prices of high-valued vegetables are relatively higher than the other vegetables that the farmers cultivated, and the overall price of vegetables has increased during the last two years.

5.2 Revenue, Expenditure, and Profit of Entrepreneurs

Revenue, expenditure, and profit play an important role in any kind of production process. A higher level of income or profit increases the motivation of farmer to enhance their production. Increasing expenditure may sometimes demotivate farmers and consequentially, may reduce the production of vegetables.

Table 3: Comparison of farmers' average revenue in different seasons

	Summer (in BDT)	Winter (in BDT)	Others (in BDT)	Yearly (in BDT)
Baseline	30,948	41,636	16,370	88,954
End Line	55,412	53,623	26,669	135,704

* Considering 33 decimals of land for each farmer.

The average revenue of the farmers increased in every season. From Table 3, it can be seen that in 2019 the average revenue in summer was 30,948 BDT, in winter it was 41,636 BDT and, in another season, it was 16,370 BDT. After the implementation of the projects in 2023, the average revenue in summer, winter, and other seasons becomes 55,412 BDT, 53,623 BDT, and 26,669 BDT respectively.

Table 4: Item-wise average costs of vegetable production (at End line) by the farmers in different seasons

	Chemical Fertilizers	Vermin compost	Cow dung	Seeds	Chemical Pesticides	Organic Pesticides	Labor	Water	Others	Total
Summer	2,439	2,617	2,522	2,441	1,852	2,164	3,373	2,344	7,631	27,384
Winter	2,839	3,321	3,222	3,241	2,467	2,727	4,202	3,243	9,566	34,827
Others	1,247	1,637	1,606	1,622	1,059	1,445	2,159	1,433	5,893	18,101

* Considering 33 decimals of land for each farmer.

Table 4 shows the item-wise average costs of vegetable production by the farmers in different seasons in a simplified way after the implementation of the projects. The total costs can be categorized according to the costs for chemical fertilizers, vermicomposting and cow dung, seeds, chemical and organic pesticides, labor, water, and some other aspects. As the farmers cultivate more land in winter, both the total production cost and labor cost are higher in that season. Every season the farmers have to bear a significant amount of cost for chemical fertilizers which

has reduced in the last two years as the farmers are moving towards vermicomposting. Throughout the year which includes every season, the total costs of production are distributed among labor (12 percent), chemical fertilizer (08 percent), chemical pesticides (07 percent), seeds (09 percent), water (09 percent), and cow dung (09 percent). The expenditures in different sectors in summer are not as similar as in winter. In winter, compared to summer, the expenditure on labor increases whereas the expenditure on chemical pesticides reduces significantly.

Table 5: Average profit of farmers in different seasons of the year

	Summer (in BDT)	Winter (in BDT)	Others (in BDT)	Yearly (in BDT)
Baseline	18,571	12,400	6,506	37,477
End Line	28,028	18,796	8,568	55,392

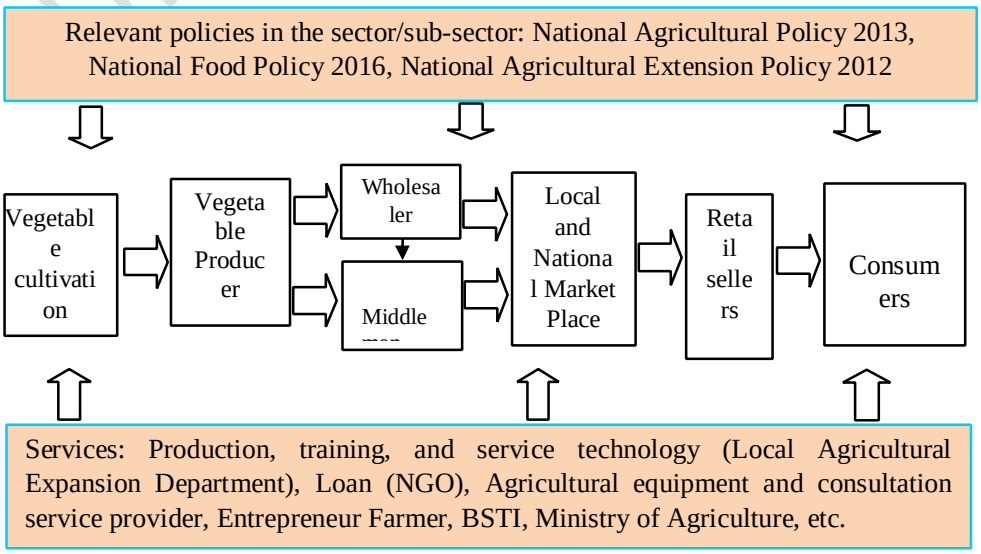
* Considering 33 decimals of land for each farmer.

In Table 5, we can see the comparative profits of the farmer in the baseline studies and impact studies. In winter the total profit was around 18,571 BDT, which is now 28,028 BDT and in summer it was 12,400 BDT which is now 18,796 BDT. In other seasons, for an average farmer, the profit was 6,506 BDT and now during the impact study, it is 8,568 BDT.

5.3 Marketing of the Vegetables and the Value Chain Structure

We all know that farmers have different forms of marketing sources, which include wholesalers, middlemen, local markets, regional markets, and national markets. None of the farmers of the target areas are looking forward to the international market as they do not have access to it. Most of the farmers in the study areas are not eager to sell their products to middlemen, regional markets, or even national markets. They depend mostly on wholesalers and local markets. Access to the different markets for the farmers may ensure increased revenue and proper pricing of the vegetables. The following figure shows the total value chain map of the ecology-friendly safe vegetable farming techniques.

Figure 1: The value chain map of ecology-friendly safe vegetable farming



The value chain map indicates that the vegetable producers collect the equipment from the service provider and sell their products to either the wholesaler or middlemen. Then the vegetable moves to the local or national market through the middlemen, and finally, it reaches the consumers through retail sellers. Access to the local or national market, or even retail sellers, could benefit both the vegetable producers and the end consumers. The producers can benefit by getting higher value for their products, and the consumers can benefit by consuming fresh vegetables at a lower price.

5.4 Area-wise Impact of the Project

Table 6: Incapsulated impact of the safe vegetable production method

Target area	**Baseline status**	**End line status**	**Changes**
The production of vegetables	Average 7,173 kg per farmer	Average 8,608 kg per farmer	20 Percent increase
The average revenue of an entrepreneur	The average revenue of 88,954 BDT a year by a farmer	The average revenue of 135,704 BDT a year by a farmer	53 Percent increase
The average profit from vegetable cultivation of the entrepreneur	The average profit 37,477 BDT a year	The average profit 55,392 BDT a year	48 Percent increase
Full-time employment	The number of full-time employees was 1,825	The number of full-time employees was 2,383	31 Percent increase
Farmers cultivating high-value vegetables	No farmers cultivated high-value vegetables before the project started.	491 Farmers cultivating high-value vegetables	491 New farmers
Farmers checking soil quality and the level of pesticides required	No farmer has an idea or does soil testing	352 Farmers checking soil quality and pesticide level	352 New farmers

* Considering 33 decimals of land for each farmer.

Table 6 shows the encapsulated impact of the safe vegetable production methods after their implementation in the target areas. All the concerned indicators such as vegetable production, revenue and profit of the entrepreneurs, and employment generation show a positive inclination. There are some reassuring facts that the farmers became interested in producing high-value vegetables and those who were not checking the soil quality started checking it.

5.5 The Policy Interventions

For the successful implementation of these value chain projects and to improve the quality of the vegetables and consequential increase in the income of the farmers, following policy intervention is needed.

Table 7: The visions for change of ecology-friendly safe vegetable farming sub-sector

Entrepreneur	The availability of necessary inputs and raw materials for safe vegetable cultivation will increase production, and certification of GGAP/GAP/MRL will enhance export opportunities.
Service Provider	Establishing the backward (agricultural input) and forward (retailers, wholesalers, and exporters) linkages by different producers will strengthen their capacity to produce safe vegetables.
Support Function	Market Expansion for bio-fertilizers and bio-pesticides; local agents for product and services expansion; capacity building for entrepreneurs; IoT traceability services; increased certifying agency and assurer are needed.
Business Policy	New loan products, technical services, mobile app and teleservice by GoB, safe vegetable certification, and reduction of chemical fertilizer and pesticide usage are also required.

6. Conclusion

Despite diversifying the economy rapidly in the last few decades, Bangladesh is still largely dependent on agriculture. Nowadays, the land size is decreasing and as a result, agriculture is moving more and more towards modernized and tech-intensive, large commercial farming of agriculture becomes inevitable. It is observed from this study that there is a possibility that the production of vegetables may increase if harmless safe methods in commercial vegetable farming are implemented properly.

A large number of people in Bangladesh are engaged in homestead gardening. However, a significant portion of them is engaged in commercial vegetable cultivation. Most vegetable farmers are too reliant on traditional farming methods and only a few are now cultivating high-value vegetables. This study indicates that safe vegetable farming methods offer numerous benefits for farmers, ranging from increased productivity and profitability to improved environmental sustainability and better health outcomes. By adopting practices that emphasize sustainability, soil health, and the reduction of toxic inputs, farmers can enjoy long-term economic gains while also contributing to the health of their communities and the preservation of the environment. Policymakers and development organizations should focus on promoting safe farming practices through education, training, and support for farmers to maximize these benefits

and create a more sustainable agricultural future. It is very essential to continue the progress, and farmers need special training, proper market information, access to the different markets, availability of factors of production, and social awareness.

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