Prospects and Challenges of Good Agricultural Practices for Vegetables Production: In Context of Sustainable Agriculture in Bangladesh

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Abstract

Over the recent few decades, agriculture has consistently been recognized as one of the largest economic sectors in Bangladesh, and the vegetable sector provides immediate income, nutrition, and food security while also contributing significantly to the economy. In recent decades, the unsystematic use of agrochemicals for commercializing output has threatened the sustainability of vegetable sectors. Adopting Good Agriculture Practices (GAP) could reduce the usage of agrochemicals in commercial vegetable production, allowing for more sustainable agriculture. This study is being conducted to identify the historical development of sustainable agriculture in Bangladesh and the assessment of GAP on vegetable production in Comilla district of Bangladesh. The study used a mixed-method approach that combined quantitative and qualitative data, including farmer face to face surveys with prescribed questionnaires. According to the results, the effectiveness in sociodemographic characteristics, including gender, age, education, farm size, income, farming experience, training to predict farmer intensions to adopt GAP. Farmers are able to reduce unsystematic agrochemicals by implementing various GAP, such as cropping techniques, soil fertility management practices, and integrated pest control practices. The study's findings imply that trained farmers are more conscious about the benefits of GAP. Furthermore, the study reveals that farmers face several challenges including lack of knowledge, inadequate training facilities, market facilities, government incentives, postharvest facilities when implementing GAP. The result suggests market-based remedies such as raising customer awareness, ensuring premium prices with quality assurance procedures, and supporting more comprehensive adoption of GAP-based production. This study intends to generate data on a sustainable and safe vegetable production model, which will be essential for Bangladesh to institutionalize GAP.

Keywords: Agrochemicals, sustainable, soil fertility, pesticides, questionnaires

1. Introduction

The agricultural sector plays a vital role in enhancing productivity, ensuring sustainable food security, and generating employment opportunities. As per the provisional calculation by BBS, agriculture contributes approximately 11.50 percent to the GDP in FY 2021-22 (BER, 2022) and employs 40.60% of the total workforce (BBS, 2021). Bangladesh has achieved significant milestones in agricultural production, becoming the world's largest exporter of jute, the second-largest producer of jackfruit, the third-largest producer of vegetables and rice, the seventh-largest producer of mangoes and potatoes, and the eighth-largest producer of guavas (AIS, 2022). The country has nearly 9.9 million hectares of cultivated land with a cropping intensity of 197%. Over the past two decades, there has been a notable increase in cropping intensity due to policies that prioritize the cultivation of high-value horticultural crops, particularly vegetables and fruits. In fact, approximately 100 types of vegetables are grown on just 0.94 million hectares of land (AIS, 2021).

Bangladesh has faced challenges due to its high population growth and density, leading to increased demand for food. This has put significant pressure on the country's 16,562,974 farm households (Rahman and Barmon, 2019). In response to the growing population needs and the expansion of vegetable exports to the global market, farmers have been relying on traditional or conventional farming methods to meet the demand. However, conventional agriculture in Bangladesh has become heavily reliant on synthetic fertilizers and pesticides since the Green Revolution. Unfortunately, this reliance has resulted in various risks to human health and the environment, posing threats to food safety.

There have been reports of widespread misuse of synthetic agrochemicals and fertilizers among farmers (Gautam et al., 2017). The usage of chemical fertilizers in Bangladesh has seen a significant increase, rising from 15kg per hectare in 1970 to 279.22 kg per hectare in 2014 (BBS, 2018; FAO, 2017). However, the recommended dose of chemical fertilizers, according to the Bangladesh Agricultural Research Institute, is 60.22kg per hectare (Rahman and Zhang, 2018; Savci, 20112). It is concerning that only 4% of farmers have received formal training in pesticide use, while over 47% of farmers tend to overuse pesticides in Bangladesh. (Dasgupta, et al. 2005). Recognizing the importance of sustainable agricultural systems, Bangladesh has placed significant emphasis on expanding such practices, acknowledging the interconnectedness of social, economic, and environmental aspects of agriculture.

Sustainable agriculture in the context of the environment aims to maintain and enhance the health and resilience of ecosystems, conserve natural resources, and mitigate environmental degradation (FAO, 2018). Its goal is to establish a harmonious balance between agricultural production and environmental conservation to ensure the long-term sustainability of agricultural systems. Good Agricultural Practices (GAPs) provide a sustainable approach to vegetable production, with a focus on minimizing environmental impacts, ensuring food safety, and improving farmers' livelihoods (FAO, 2019). These practices encompass a variety of techniques and strategies that aim to optimize crop yield while minimizing negative environmental effects. They include efficient water management, integrated pest management, proper nutrient management, soil conservation, and the use of organic fertilizers (FAO, 2020). Implementing GAP in vegetable production not only enhances crop quality and productivity but also reduces reliance on chemical inputs, mitigates soil degradation, and protects natural resources (FAO, 2021). So, it is important to gain insights into farmers' adoption of GAP, their perspectives, implementation challenges, and potential for nationwide expansion. Additionally, there is a need for further academic and scientific research on safe and sustainable vegetable production.

2.Review of Literature

Many studies have been conducted worldwide to assess the impact and effectiveness of Good Agricultural Practices (GAP) in promoting sustainable farming systems. In the context of Bangladesh, there is a notable lack of comprehensive studies on Good Agricultural Practices (GAP). Conventional agriculture in Bangladesh heavily relied on synthetic inputs, posing risks to food safety and the environment. However, sustainable farming offers benefits such as stable crop yields, improved soil fertility, and higher profitability. It aims to reduce chemical use and restore degraded land and enhancing farmers market access by meeting the demand for environmentally and socially responsible agricultural products (Ferdous, et al. 2021).

Good Agricultural Practices (GAPs) provide a sustainable method for cultivating vegetables, with a focus on reducing harm to the environment, ensuring the safety of the food produced, and enhancing the well-being of farmers. This approach encompasses various techniques and strategies to maximize crop yield while minimizing any adverse effects on the environment. GAP promotes the efficient utilization of resources, such as pesticides, fertilizers, and water, and safeguards the health of agricultural workers by preventing the improper use of chemicals and pesticides (Joshi, 2020).

The adoption of Good Agricultural Practices (GAP) by large-scale farmers resulted in a 1.7 times higher income compared to farmers who did not implement GAP (Islam, 2012).

GAP production improves agriculture product reliability and quality, facilitating easier export to foreign markets. It utilizes local resources, enhancing productivity, household food security, and resilience (Osman, et al. 2020).

Farmers who practice Good Agricultural Practices (GAP) in growing asparagus receive higher prices compared to those who do not follow GAP. This is because importers have more confidence in the quality of GAP products and are willing to pay a premium for safe and high-quality produce (Laosutsan et al. 2019).

Organizing comprehensive training programs for farmers involved in commercial farming is crucial for promoting the adoption of Good Agricultural Practices (GAP). Training plays a vital role in enhancing farmers' knowledge, skills, and understanding of sustainable agricultural practices, including GAP principles and techniques (Narrod, et al. 2017; Parikhani, et al. 2015)

There are several obstacles that can hinder the implementation of Good Agricultural Practices (GAPs) technologies. These barriers include challenges related to infrastructure, education, institutional support, personal factors, and economic constraints (Parikhani, et al. 2015).

3. Objectives

This study aims to assess the environmental and economic benefits of Good Agricultural Practices (GAP) in Bangladesh, highlighting its potential to improve farmer incomes and livelihoods through increased market access, premium prices for sustainable goods, and to analyze the effectiveness of GAP training by DAE (Department of Agricultural Extension) while identifying challenges and suggestions for promoting its widespread implementation.

4. Study Design

4.1. Study sites

Administratively, Bangladesh is divided into 64 districts, each with its unique characteristics and agricultural practices (Niaz, 2023). This study focuses on Barura upazila, situated within Cumilla district, which spans an expansive area of 3146.3 km^2 (DAE, 2023). Cumilla district is one of the largest districts in Bangladesh, located approximately 84 km from the capital city, Dhaka. It shares a border with Tripura, a state in India. Geographically, Barura upazila is positioned between $23^0$27' N to $91^0$12' E (DAE, 2023). Barura upazila is significant in terms of its size, covering an area of 241.65 km^2. The total population of Barura is approximately

4,117,118, with a literacy rate of 56%. The agricultural sector plays a crucial role in the local economy, with a total agricultural land area of 14,500 ha and a cropping intensity of 291%. The region exhibits a diverse range of cropping patterns, with 20 different patterns observed. Major crops cultivated in Barura include rice, potato, maize, sugarcane, and vegetables. Among the cultivable land in Barura, vegetables are grown on approximately 11,790 ha, contributing to an annual average production of about 30,000 Mt (UAO, 2022).

4.2 Methods

4.2.1. Data collection

Data will be collected from the farmers of 16 unions of Barura upazila in Cumilla district from October 2023 to November 2023. The farmers at the selected site will be interviewed by using a semi-structed questionnaire. To estimate the appropriate sample size for analyzing, this study will apply Slovin's formula as shown below:

$$n = N/1+Ne_2$$

where, n: sample size, N: total population, e: marginal error (10%)

(Vo, et al. 2021)

4.2.2. Data analysis

This study utilizes a combination of quantitative and qualitative approaches. The quantitative approach will be employed to examine the relationships between output variables and predictors, while the qualitative approach will be used to interpret the significance of the predicted numerical data (Dinh, et al. 2023). The data will be analyzed using a binary logistic regression model, with the farmers' intention to adopt GAP practices as the dependent variable. The explanatory variables will include socio-demographic factors, economic and environmental benefits, and challenges related to GAP extension.

5. Results and Discussion

5.1 Historical development of sustainable agriculture in Bangladesh

Sustainable agriculture practices in Bangladesh have undergone significant changes in response to social, economic, and environmental challenges (Faroque, et al., 2011). Over time, the country has shifted from conventional agricultural methods to more sustainable approaches that emphasize ecological balance, conservation of resources, and improved livelihoods for farmers (Tabassum and Rezwana, 2021). Prior to the advent of chemical fertilizers in Bangladesh, farmers in the country relied on a variety of natural resources such as cow dung, compost, green manure, crop residues, bio-fertilizers, ash, rice barn, husk, poultry litter, biogas slurry, and slaughterhouse waste, among other materials, to provide essential nutrients for plants (Sarkar, 2010). After the "Green Revolution" in 1960s, the farmers started to use chemical fertilizers and pesticides for efficient crop management (Hossain, 2001). As a result, in agriculture the production has increased. As the time went on, however, farmers could not have as much production as they expected due to topsoil degradation and reduced microbial activities in the soil (Hossain et al., 2007). One significant milestone in the development of sustainable agriculture in Bangladesh was the introduction of the Integrated Pest Management (IPM) approach in the 1980s. IPM aimed to reduce chemical pesticide use by promoting natural pest control methods, such as biological controls and cultural practices. The success of IPM in reducing pesticide use and improving crop yields led to its widespread adoption across the country (Kabir and Rainis, 2023).

The Department of Agricultural Extension (DAE) has implemented various projects to promote sustainable agriculture. One of these projects is the "Safe Crop Production through

Environmentally Friendly Strategies" (2018-2023), which involves the establishment of 35,560 demonstration farms. Additionally, 6,340 farmer field schools and 317 Integrated Pest Management (IMP) schools have been set up to provide training to farmers on safe crop production methods (Krishi Diary, 2022). Over the past two decades, the agriculture sector in Bangladesh has witnessed significant achievements in various aspects for sustainable development, including growth driven by inputs such as high-yielding variety (HYV) seeds, irrigation, fertilizers, pesticides, and crop diversification. These advancements have been made possible through the implementation of several policy initiatives, such as the National Agriculture Policy (2009), New Agricultural Extension Policy, National Food Policy (2006), National Integrated Pest Management (IPM) Policy (2002), Fertilizer Management Act (2009), Pesticide Act (2009), and Rural Credit Policy (2010) (Quddus, 2018). Additionally, the recently introduced "Bangladesh Good Agricultural Practices Policy 2020" by the Ministry of Agriculture has further contributed to these successes (MOA, 2020). Several non-governmental organizations (NGOs) including PROSHIKA, UNINIG, BARCIK, and Hunger Free World CARITAS have contributed in conducting research and promoting sustainable agriculture through extension activities (DFID, 2001).

5.2. Sociodemographic characteristics on the adoption of Good Agricultural Practices (GAP)

Sociodemographic characteristics can impact the adoption of Good Agricultural Practices (GAP). Higher education levels are associated with increased GAP adoption. Younger farmers are more open to adopting new practices, while older farmers may face barriers. Gender influences adoption, with women often having limited access to resources, but empowering them can lead to increased adoption. Farm size affects adoption, with larger-scale farmers having more resources. Access to reliable information and extension services increases the likelihood of GAP adoption. Higher income makes GAP more affordable, enables better risk tolerance, provides access to resources, and indicates better market access, motivating farmers to adopt GAP. The impact of sociodemographic characteristics on the adoption of agricultural practices can vary depending on the context and specific practices being considered (Rizzo, et al. 2023; Diaz, et al. 2022; Thompson, et al. 2023).

5.3. Benefits of Good Agricultural Practices (GAP) for vegetable production

5.3.1. Knowledge benefits

Adoption of GAP leads to increased awareness and knowledge of sustainable agricultural practices among farmers, enabling them to make informed decisions and implement effective GAP strategies. GAP adoption enhances farmers' technical skills, including pest management, soil fertility management, and irrigation practices, resulting in improved agricultural productivity and resource management.

5.3. 2 Social network benefits

GAP adopters actively participate in knowledge-sharing networks, such as farmer groups, cooperatives, or extension services, facilitating the exchange of experiences and best practices, leading to enhanced GAP adoption and effectiveness. Farmers with a strong social network have improved access to resources like credit, inputs, and technical assistance, which are vital for successful GAP implementation.

5.3.3 Environmental benefits

GAP adoption was found to significantly reduce the use of chemical pesticides and fertilizers, leading to a healthier environment with reduced water and soil pollution and minimized

negative impacts on biodiversity. GAP practices, such as crop rotation, cover cropping, and proper water management techniques, contribute to improved soil health, reduced erosion, and enhanced water conservation.

5.3.4 Economic benefits

Farmers who adopted GAP reported higher vegetable yields and improved profitability compared to non-adopters. This increase in productivity and profitability can be attributed to the effective management of resources, reduced input costs, and improved market access. Farmers practicing GAP have better market access, as there is a growing consumer demand for sustainably produced vegetables. This market demand allows GAP adopters to command premium prices, leading to increased profitability.

The adoption of GAP not only enhances farmers' knowledge and technical skills but also facilitates knowledge sharing, improves environmental sustainability, and contributes to increased productivity and profitability (Kilic, et al. 2020; Danquah, et al. 2015; Gimrie, et al. 2012; Mohammad, et al. 2012; bairagi, at al. 2019; Jat, et al. 2019; Borreilli, et al. 2016)

5.4 Learning from training by Department of Agricultural Extension on Good Agricultural Practices for sustainable agriculture

Knowledge acquisition: Farmers reported a higher level of awareness about sustainable agricultural practices, including soil management, pest control, water conservation, and biodiversity conservation, after participating in the training. The training programs provided farmers with a comprehensive understanding of GAP principles, including the use of organic fertilizers, integrated pest management, crop rotation, and water-efficient irrigation techniques.

Skill development: Trained farmers demonstrated improved skills in implementing GAP techniques effectively. This includes the proper use of organic fertilizers, biological pest control methods, precision irrigation, and soil conservation measures.

Application of GAP for sustainable agriculture and environment: Trained farmers implemented soil management practices, such as organic matter incorporation, cover cropping, and crop rotation, resulting in improved soil health, nutrient cycling, and reduced soil erosion. Trained farmers demonstrated a reduced reliance on chemical inputs, adopting integrated pest management strategies and organic fertilizers. This led to a decrease in chemical residues, minimized environmental pollution, and improved ecosystem health. Trained farmers implemented water-efficient irrigation techniques, such as drip irrigation and mulching, leading to reduced water consumption and improved water conservation. This result also supported by (Ghimire, et al. 2021; Parikhani, et al. 2015; Islam, et al. 2012), who highlighted that importance of strengthening training programs, providing ongoing support and technical assistance, and promoting knowledge sharing among farmers to enhance learning outcomes and facilitate the adoption of GAP for sustainable agricultural practices to maintain healthier environment.

6. Challenges in the Extension of GAP for Sustainable Vegetables Production in Bangladesh

One of the key challenges is the limited awareness and knowledge about Good Agricultural Practice (GAP) among farmers. Many farmers have a lack of understanding about the principles and benefits of GAP, which hinders its adoption. The availability of training programs and technical support on GAP is also inadequate, resulting in a limited dissemination of knowledge and skills among the farming community. In addition to these knowledge-related challenges, there are also significant issues regarding access to necessary resources and inputs for implementing GAP. Farmers face difficulties in obtaining certified seeds, organic fertilizers,

and biocontrol agents, which are essential for GAP implementation. The absence of a well-organized market structure and government incentives, as well as limited access to easy loan facilities, further impede farmers from adopting GAP. Moreover, the lack of post-harvest facilities and a reliable GAP certification system contribute to a decreased interest among farmers in embracing GAP practices. Islam, et al. 2012; Banzon, et al. 2013; Brandi, et al. 2015; Parikhani, et al. 2015; Kleinwechter and Grethe, 2006 identified various challenges in the adoption of Good Agricultural Practices (GAP). These include limited awareness and knowledge about GAP, inadequate training programs and technical support, difficulties in accessing necessary resources and inputs, absence of a well-organized market structure and government

7. Conclusion

The implementation of Good Agricultural Practices (GAP) for vegetable production in Bangladesh offers promising prospects for sustainable agriculture. GAP provides benefits such as reduced agrochemical use, improved pest management, enhanced soil fertility, and increased productivity and farm income. However, challenges such as limited knowledge, input access, and supportive policies must be addressed. Training programs and input availability should be improved, and policies should provide incentives and support. Easy loan facilities with flexible repayment terms and low-interest rates should be established for farmers adopting GAP. Investment in post-harvest facilities such as storage, processing, and packaging units is necessary to maintain the quality and value of GAP produce. Strengthening market linkages and establishing premium prices can encourage long-term GAP adoption. Addressing these challenges will contribute to the sustainability and resilience of Bangladesh's agricultural sector. As our study is conducted in only one region of Bangladesh, further research and field demonstrations are required to validate our findings.

Future work involves collecting more review papers and collecting data through questionnaire surveys and analyzing the data by using SPSS statistics software.

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