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Bangladesh Agriculture: A Review of Modern Practices and Proposal of a Sustainable Method †

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Abstract: Agriculture is the largest economic and employment sector in Bangladesh, accounting for 23 percent of its gross domestic product and 65 percent of its labour force. It has a total land area of 14,570 km^2, with cultivated land accounting for 60% of the total land area. The population is still growing at a 1.37 percent annual rate, but cultivated land is shrinking at the same time. The agricultural land is being converted as a result of uncontrolled urbanization, industrialization, and an increase in human activity. Modern sustainable agricultural methods approach to agricultural innovations and farming practices that increase farmers' efficiency and reduce the use of natural resources. This study uses secondary information to provide a general view on modern practices used in Bangladesh for sustainable agriculture (i.e., crop diversification, change in cropping pattern and rotations, integrated farming systems, etc.) and suggests a sustainable method (polyculture and crop rotation) based on SWOT and PESTEL analysis. This paper recommends that Bangladesh should adopt polyculture and crop rotation more to improve soil health and for higher crop resistance to plant pests that will hedge against a loss in agricultural sustainability.

Keywords: sustainable agriculture; environment; polyculture and crop rotation; modern practices

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1. Introduction

An integrated system of plant and animal production practices, known as sustainable agriculture, produces sufficient quantities of high-quality food while protecting natural resources in an environmentally safe and profitable manner [1]. Bangladesh agriculture is deteriorating due to degradation of land and water resources and the excess use of toxic chemicals. This is the reason the government of Bangladesh has adopted sustainable agricultural methods to protect environment stability and economic profitability. Crop diversification, integrated farming systems, changes in cropping pattern and rotations, adoption of new crop varieties, modifying sowing dates, polyculture and crop rotations, and other modern cropping practices are all being employed in Bangladesh to ensure food self-sufficiency and environmental sustainability.

A conventional farming technique where crops are cultivated together or separately (at either short or long intervals) on the same field is known as crop rotation. Crops are grown using this method because of its high productivity, high revenue level, and adaptability for combination management practices. Crop rotation is currently the foundation of agriculture systems around the world, allowing for the efficient use of environmental resources [2]. Crop rotation provides various advantages over monoculture planting in terms of agronomy, economics, and the environment. In the long run, crop rotation can increase soil organic matter and soil structure, as well as minimize soil degradation. Water and nutrients are better retained when there is more soil organic matter. Using crop rotation, weeds and diseases can be controlled, as well as insect and other pest infestations, reducing pesticide consumption [3]. Another possibility is for the farmer to cultivate two or more crops at the same time in a same place. This system is known as polyculture.

Increased diversity in cultivated species, but mostly in the soil, promotes the possibility of ecological equilibrium. As opposed to monocultures, polycultures offer better protection against soil deterioration and the expansion of pests, pathogenic bacteria, and fungus than monocultures do. In addition, this system has a favorable economic impact on the size of inputs and outputs and the stabilization of the food chain. Even though polyculture is not often practiced in developed countries, it has a major impact on food security in the developing world [2].

Most of the studies reviewed in this paper discussed the sustainability, challenges, acceptance, advantages and disadvantages, and profitability of polyculture and crop rotation. Very few attempts have so far been made to analyze the environmental impacts and external–internal aspects of this process. The overall goal of this research paper is to review modern agricultural practices used in Bangladesh and suggest polyculture and crop rotation as a comparatively effective agricultural practice for sustainability that reduces environmental consequences.

2. Methodology

The data for this review were gathered from a variety of secondary sources, including national or international peer reviewed journals, relevant books, articles, and other sources. As the topic of this paper has rarely been linked and considered, a broad search query was used with limited constraints on years or titles. With the search string TITLE-ABS-KEY ("sustainable agriculture", "polyculture and crop rotation"), academic publications were searched in Google Scholar and PubMed, databases of abstracts and citations of peer reviewed scientific journal articles. The review of modern practices in Bangladesh is based on literature search and the proposed method mainly relies on SWOT and PESTEL analysis. Environmental implications have been studied utilizing the SWOT analysis process in order to achieve a systematic approach to decision making in the case of polyculture and crop rotation. The impacts will be classified using the SWOT analysis framework, which stands for strengths, weaknesses, opportunities, and threats. The PESTEL model will provide an external assessment of polyculture and crop rotation in terms of political, economic, social, technological, environmental, and legal aspects.

3. Review of Modern Practices Used in Bangladesh

Strengthening agricultural production systems for greater sustainability and higher economic returns is a crucial strategy for enhancing income and food and nutrition security in underdeveloped countries [4]. In Bangladesh, there is no way to expand agricultural land. Furthermore, due to increased population pressure, net crop acreage is shrinking at an alarming rate. It is crucial to identify and investigate major cropping trends [5]. To enrich and sustain soil fertility, increase crop productivity, and improve crop sequences, Bangladesh has adapted some modern agricultural practices such as:

- Crop diversification: Crop diversification is a cropping method that adds new crops to agricultural production on a specific farm in order to assist the farming community to thrive economically. This agricultural approach lessens farmers' reliance on a single crop and mitigates unforeseeable climate catastrophes such as the appearance of pests and the unexpected advent of frost or drought [6]. Lack of market access, established soil conditions, flood depth levels, and decreased rainfall are some of the obstacles to crop diversification [7]
- Change in cropping pattern and rotations: The distribution of a farm's land to various crops cultivated over the course of a year is referred to as cropping pattern. It entails allocating land to different crops at different times of the year [8]. Cropping pattern is essentially a yearly strategy for maximizing agronomic and economic production while being sustainable and also an essential measure of a locality's land use, environment, and socioeconomic elements of its farmers [5].
- Integrated farming system: The integration of various agricultural enterprises, such as cropping, animal husbandry, fishery, forestry, and so on, into the farming system

has great potential in the agricultural economy [9]. Integrated farming with crops, livestock, and aquaculture has the potential to increase yields and provide financial benefits, extend the harvest period and alleviate seasonal food shortages, improve the stability of household food access, and reduce erosion risks [10]. Since the final customers and processing industries are so far apart, a large upfront investment is required [11].

4. Analysis of Polyculture and Crop Rotation

4.1. SWOT

Polyculture and crop rotation have a significant impact on soil, water, climate, and pest and disease control, hence those are the sectors that have been considered for the SWOT analysis (Figure 1) and discussed below:

	Strengths	Weaknesses
Soil	1.Prevent soil biodiversity loss 2.Variety of plants grow in the fields and increase crop productivity. 3.Provide habitat and food for more species 4.Higher soil enzyme and microbial activity 5.Lower risk of soil erosion.	1.Requiring tillage and ploughing has a negative impact on soil biodiversity. 2.Pesticide-intensive crop rotations have a negative influence on wildlife above the soil.
Water	1.Increase soil nitrogen availability by reducing N leaching. 2.Reduce water erosion depending on soil cover provided by crops. 3.Reduce ground water contamination.	1.Crops that are heavily reliant on pesticides during wet seasons may leach more residues into groundwater and rivers.
Climate	1.Conserve water in water-stressed regions to prevent excessive evaporation. 2.Rotations that do well without irrigation help conserve water. 3.Reduces nitrogen loss through leaching and reduces environmental pollution.	1. Influence the emission of greenhouse gases.
P&D control	1. Disrupt pest biology and control damage and disease. 2. Increased plant diversity benefit pest management. 3.Entire farm is not at danger if a disease strikes.	1. fungal and bacterial soil-borne disease pathogens can live on crop leftovers are difficult to control. 2. Poor management skill
	Opportunities	**Threats**
Soil	1.Rotations that maintain a cover throughout the year benefit soil microbes and earthworms. 2.Planting crops on the margins of fields and cutting them with grasses and flowers benefit biodiversity.	1. As a result of pesticide use, genetic diversity is reduced. 2. Short rotations reduce the ability of rotations with many years to build a good structure.
Water	1. crops with high soil cover index reduce losses of water. 2.Crops with a long vegetation period develop large mass of roots.	1. Crop with short vegetation period have a negative impact.
Climate	1.Beneficial if it contains legumes and crops that require low or no N fertilization.	
P&D control	1.Encourage biological control agents manage crop pests. 2.Pests and weeds are managed with fewer chemical pesticides using multiyear, multi crop rotations.	

Figure 1. SWOT Analysis of environmental impacts of polyculture and crop rotation [12–14].

4.2. PESTEL

4.2.1. Political Aspects

Food security is a huge concern in a world where the agricultural area is shrinking, soil fertility is declining, and the population is growing. As a result, it is critical to place a special emphasis on productivity increase. The National Agriculture Policy 2018 is developed from all relevant laws, policies, development plans, and perspective plans for the agricultural

sector's development. Its fundamental goal is to ensure sustained food and nutrition security while also ensuring safe and profitable agriculture. For sustainable production and conservation of natural resources, this policy promotes and inspires ecologically friendly technology, consistent pest management, soil microorganism protection, and minimum tillage methods [15]. Development of the agricultural sector in Bangladesh has somehow been hindered by corruption activities like bribery or unauthorized payments, embezzlement, etc. According to a state-wide survey on corruption by Transparency International Bangladesh (TIB) in Bangladesh, 20.4 percent of service recipients in the agricultural sector reported corruption [16].

4.2.2. Economic Aspects

Profitability is used to compare the economic performance of crop rotation systems on a micro-level from the farmer's perspective. Pricing and profitability are interdependent and are calculated by subtracting the total cost of production from the value of production [12]. Profitability is not the only factor that risk-averse farmers consider. Agricultural prices will not be significantly affected by individual farmers because agriculture resembles a perfectly competitive sector [17]. Crop rotation contributes to the economic and social consequences of farming systems in a variety of ways, including uniformity of crop planting areas, a reduction in equipment costs and different skill sets, and increased interaction with the local community for labor [18]. In order to reduce agriculture's dependence on external inputs, crop rotation systems are considered to be one of the most important cropping system alternatives. They do this by recycling nutrients internally, maintaining the long-term productivity of the land, and disrupting weed and disease cycle [17].

4.2.3. Social Aspects

In many agriculturally based developing countries, cultivation systems and farmers' income are the most important issues. Polyculture farming systems increase farmers' income from a financial standpoint and generate a higher income than monoculture. Decreased economic losses due to fluctuating product prices are another benefit of polyculture. Agricultural production cost efficiency can be improved by reducing operational costs, such as labor and plant maintenance in a polyculture system. Thus, farmers' losses due to price fluctuations would be reduced, while the potential benefit from production cost efficiency would be increased [19]. Because the market determines the price of monoculture crops, farmers' earnings are solely based on yields. A crop grown in rotation will have an average output price that is equal to the average yield-weighted price of all crops combined. A farmer can alter the average output price of their production by changing the crop structure in rotational cropping [12].

4.2.4. Technological Aspects

Crop rotation and polyculture approaches can benefit from technological advancements. In this process, advances in sensing devices and embedded systems can help to enhance tillage and crop yields. Farmers may find that resource management efficiency and autonomous data collecting are essential. Field measurements of crop requirements, as well as planned improvements in crop productivity and resource consumption, are all moving towards more sustainable ideas and lowering environmental consequences [20]. In terms of researcher numbers and qualifications, research and development efforts in Bangladesh's agriculture sector are worsening. In Bangladesh, further research and investment in polyculture and crop rotation studies will help this system thrive and expand. As a result, the environment will be more sustainable [21].

4.2.5. Environmental Aspects

Polyculture and crop rotations could be a useful tool for climate change adaptation and mitigation. High biomass production crops contribute to CO_2 sequestration, whereas low biomass production crops, such as legumes, are good for reducing N_2O emissions

since they do not require N fertilization, which adds to N_2O losses [12]. Bangladesh's food security depends on sustainable agricultural development and management, as the country faces a gradual loss in the productivity and quantity of agricultural land, as well as the negative consequences of climate change. Some policies are incorporated in the National Environmental Policy 2018 to ensure food security and sustainable agricultural management. As per the policies, technologies and development activities for agricultural development must be implemented in an environmentally friendly manner. Farmers should be encouraged to diversify their crops, employ green manure derived from legumes, and use legumes in crop rotation in their farms in order to increase food output [22]. These policies provide a clear concept for sustainable agriculture. In Bangladesh, NGOs such as PROSHIKA-MUK, Friends in Village Development Bangladesh (FIVDB), CARE International, and Rangpur Dinajpur Rural Service (RDRS) promote environmentally friendly farming system in which community members maximize the utilization of their resources through traditional, indigenous, as well as modern science [23].

4.2.6. Legal Aspects

Bangladesh is a Least Developed Country that is heavily reliant on agriculture. Plant breeding, seed commercialization and exchange, and farmers' traditional knowledge (TK) are central to the country's agricultural development. Among the laws, the Patents and Designs Act of 1911 contains provisions for patentable inventions involving plant varieties and seeds, while the Trademarks Act of 2009, the Geographical Indication of Goods Act of 2013, and the Seeds Ordinance of 1977 are considered to be only relevant for seed trading. Furthermore, these laws are not initially regarded as significant in terms of farmers' rights, food security, sustainable agriculture, and plant genetic resources (PGRs). As a member of the TRIPS, the country acknowledges these issues with the adoption of the WTO agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) providing intellectual property rights (IPRs). Because these laws are treaty specific, they frequently fail to address local needs and situations, impeding farmers' ability to make a living and causing problems for sustainable agriculture [24]. By implementing the Plant Varieties Protection (PVP) Act Bangladesh can promote plant varieties and sustainable use of plant genetic resources.

5. Recommendation

SWOT analysis indicates that, as a sustainable agricultural method with some limitations, polyculture and crop rotation has numerous advantages and future prospects. Most of the benefits of polyculture and crop rotation include increased productivity, improved soil health, reduced pest and disease problems, increased soil N availability, and reduced water erosion. The PESTEL study indicates that the National Agriculture Policy 2018, the National Environmental Policy 2018, and the Plant Varieties Protection Act are the policies and act that encourage and support Bangladesh's sustainable agriculture. In terms of economic profitability, social status, and environmental quality improvements, polyculture and crop rotation are valuable practices to implement. Polyculture and crop rotation are effective methods for achieving more sustainable crop production from an environmental and economic standpoint. However, combining these methods can make them more long lasting. Changing crop rotations quickly and drastically disrupts the natural balance of weeds, insect pests, and disease. Consequently, a polyculture that incorporates crop rotation will have greater crop productivity and soil health. In other words, by combining crop rotation with polyculture, Bangladesh can achieve a sustainable agricultural goal over the long term.

6. Conclusions

Polyculture and crop rotation are excellent techniques to make the most of natural resources while also protecting the environment. Alone or in combination, this procedure will boost environmental elements and strengthen sustainability. Based on internal–external analysis, this research suggests polyculture and crop rotation as a sustainable method.

Through the transformation of agricultural production into environmental advantages, this technology will contribute to green agriculture and promote sustainable agriculture.

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