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IMPORTANCE AND UTILIZATION OF TECHNOLOGY IN AGRICULTURAL ECONOMICS: EVALUATING THE CHALLENGES & PROSPECT FOR BANGLADESH

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Abstract

In order to liquidate Bangladesh's agricultural industry to meet rising productivity demands, resource restrictions, and climatic issues, it is imperative that sophisticated technology be integrated into agricultural economics. In order to transform farming methods and guarantee food security, this study investigates the application of biotechnology, the Internet of Things, and artificial intelligence (AI). Crop yield optimization can be achieved through AI-driven farming and real-time monitoring, while competitive positioning and effective resource usage are encouraged by market tactics including value chain analysis and strategic management. Economic constraints, infrastructure deficiencies, and the sluggish adoption of digital technology are impeding Bangladesh's agricultural economy. This essay assesses the potential and difficulties of integrating technology into Bangladeshi agriculture, highlighting how these advancements have the opportunity to revolutionize production and sustainability. The report highlights the potential of technology to address important agricultural restrictions and foster environmental resilience by showcasing case studies in shrimp illness detection, salt-tolerant rice farming, and biogas production.

Keywords: Economics in Agriculture, IoT applications in agriculture, Regression Analysis, Time Series Analysis.

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1. INTRODUCTION

Bangladesh is a developing nation with enormous agricultural economic potential, especially in light of the introduction and development of artificial intelligence (AI) technology. Among the many difficulties facing the nation's agricultural industry, which is essential to its economy, are the need for greater production and environmentally friendly methods. Traditional approaches are becoming less and less effective due to a growing population, scarce resources, and the negative effects of climate change (1). However, the integration of AI and other advanced technologies offers promising solutions to these issues (2).

With real-time data on soil conditions, weather patterns, and crop health, artificial intelligence (AI) technology like precision farming can help farmers in Bangladesh maximize crop output. This can be further improved by Internet of Things (IoT) devices, which enable ongoing monitoring of agricultural surroundings and result in better informed decision-making. Furthermore, advancements in biotechnology can aid in the creation of crop types that are more resistant to environmental stresses, enhancing food security. To fully take advantage of these prospects, Bangladesh must embrace new market strategies and strategic management techniques in addition to technology developments. We can see the growth of agriculture in Bangladesh being slower comparing the GDP through recent years. Similarly, it is visually represented in Figure 1 that how the contribution of agriculture is reducing in the GDP of Bangladesh. The nation can more effectively negotiate the intricacies of international agricultural markets by adopting contemporary market techniques like value chain analysis and market diversification. Conversely, strategic management will be necessary to guarantee that resources be used effectively and sustainably, which will eventually result in higher economic growth (3).

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Year	Total GDP	Agriculture	Share of Agriculture(%)
2015	195.15	28.84	14.8%
2016	265.22	25.48	9.6%
2017	293.73	26.21	8.9%
2018	321.36	27.01	8.4%
2019	351.22	28.03	8.0%
2020	373.28	31.20	8.4%
2021	416.27	32.15	7.7%
2022	460.13	32.85	7.1%
2023	437.52	33.34	7.6%
2024	446.35	33.93	7.6%

Table 1 Total GDP of Bangladesh, Agriculture portion and share in the time span of 2015-2024

This paper's main objective is to investigate how technology, market tactics, and strategic management might be integrated within Bangladesh's agricultural economy to increase sustainability and productivity. The study looks at these interrelated variables in an effort to provide readers a thorough grasp of how they might work together to promote agricultural growth in Bangladesh. The study will specifically concentrate on the latest technical developments in the agricultural sector and how they might be used in conjunction with smart market positioning and efficient management techniques. Moreover, the study will pinpoint the distinct obstacles and possibilities linked to this integration in Bangladesh and provide practical suggestions for those involved in the nation's agriculture industry.

The continually changing agricultural environment of Bangladesh makes this study especially pertinent. Understanding how technology, market strategies, and strategic management interact is essential for Bangladeshi farmers, agribusiness owners, policymakers, and researchers to make well-informed decisions

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that improve sustainability and productivity. Adopting cutting-edge technologies that increase crop productivity and efficiency while reducing environmental effect will greatly help Bangladeshi farmers. Agribusinesses can improve product positioning, access both home and foreign markets, and boost profitability by utilizing strategic market techniques. Insights from this integration can be used by policymakers to create and carry out laws that support sustainable farming methods and guarantee Bangladesh's food security. By focusing on these critical areas, the paper aims to contribute to the broader effort of transforming Bangladesh's agricultural sector into a more productive, sustainable, and resilient pillar of the national economy.

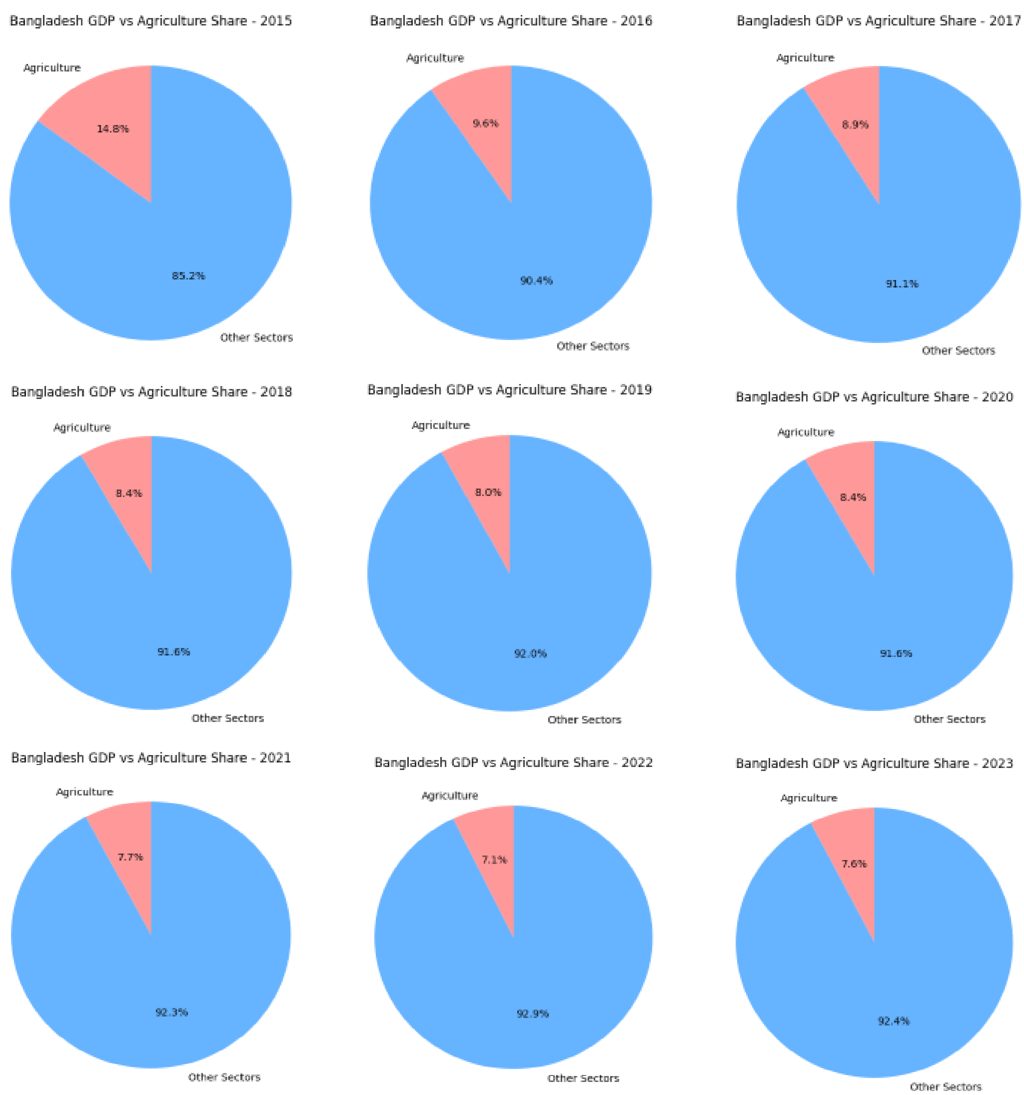

Figure 1 Share of Agriculture and other sectors in the GD

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The main contributions of this paper are as follows:

- This study extensively explores the potential of emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and biotechnology to transform the agricultural sector in Bangladesh. The research highlights how AI-driven precision farming, smart irrigation systems, and real-time disease detection can enhance resource optimization and improve crop yields, providing a sustainable solution to long-standing agricultural challenges.
- The paper includes detailed case studies to illustrate the practical application of advanced technologies. Examples include biogas production, the cultivation of salt-tolerant rice, and AI-based shrimp disease detection. These case studies underscore the potential of these technologies to address key agricultural constraints, improve environmental resilience, and promote rural economic development.
- Through regression and time series analysis, the paper demonstrates how the adoption of AI, IoT, and biotechnology can significantly improve agricultural productivity. The paper also evaluates the economic benefits for farmers, showing how technological adoption can lead to increased profitability while supporting sustainable agricultural practices.

2. ROLE OF TECHNOLOGY IN AGRICULTURE ECONOMICS

2.1 *Overview of current technologies*

Technological progress has transformed agriculture, providing groundbreaking solutions to long-standing challenges and creating opportunities for greater productivity and sustainability. For instance, Uddin et al. have found that a range of viable policy interventions, including advisory services and training organized by local development agencies such as the Department of Agricultural Extension, to enhance knowledge, create awareness, develop skills, and motivate the growers about Good Agricultural Practice (GAP) for vegetable cultivation (1). Another study indicates that the productivity of Boro rice is significantly lower in saline areas compared with non-saline areas.

Received: 28.02.2025 Accepted: 14.05.2025 Published:29.08.2025

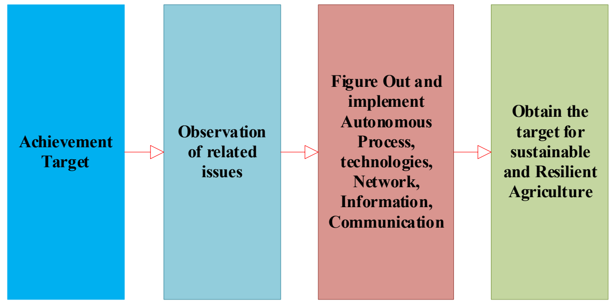

Figure 2 Technology integration process in Agriculture

The larger rice yield reduction creates a challenge for farmers to continue rice farming, with risk-taking farmers more likely to allocate their farming land to traditional rice and risk-averse farmers are more likely to allocate their land to salt-tolerant rice. Policies that promote integrated rice-fish farming and access to better salt tolerant rice varieties would be useful to address the rice yield decline in salinity affected areas (4). Then, Saha et al. found that, among the renewable energy sources, biogas from the poultry and dairy industries is an increasingly growing and promising sector, but the biogas plants operating in Bangladesh are at a loss as currently no subsidies are provided. The outcome of the SWOT analysis identified high initial investment, lack of technical knowledge, lack of local technology, poor management, and proper bio-slurry handling technology as the main barriers to disseminating biogas technology in Bangladesh (5). Then, Ahsanuzzaman et al. conducted a field study analyzing the adoption of Bt eggplant in Bangladesh and compared the results of previous RCTs. They have found that Bt eggplant raises yields, lowers total cost and pesticide costs and generates a price premium compared to non-Bt eggplant, increasing profits by 23% (6). Apart from various algorithmic technology, AI has been a game changer in Agro-economics Perspectives. Such as, robotics has been a key technology in terms of Agro-Economics perspectives of Bangladesh. For example, Bangladeshi manufacturers are beginning to explore how automation technologies can improve productivity in Figure 2, reduce errors, and ensure consistent product quality essential components for staying ahead in a fiercely competitive market. The implementation of automation in Bangladesh's apparel production is a calculated step to future-proof the sector and a reaction to competitive challenges. Emerging technologies such as automated sewing lines and robotic fabric cutting are indicating a move towards less labor-intensive and more efficient production techniques (7).

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2.2. Impact on Economy

The economy of Bangladesh has been significantly impacted by the use of these technological developments in Bangladeshi industry and agriculture. Aside from increasing agricultural productivity, the implementation of Good Agricultural Practices (GAP) has equipped farmers with the information and abilities needed to carry out sustainable farming methods. Better crop yields and higher profitability are the outcome, which is crucial for rural communities' financial security. The advent of salt-tolerant rice varieties and the encouragement of integrated rice-fish farming have given farmers in saline-prone locations viable alternatives to traditional rice farming, thereby reducing the negative impact of salinity on rice output. By protecting farmers' livelihoods in impacted areas, these policy initiatives have improved food security and economic resilience. The growing biogas industry has a lot of promise to help Bangladesh achieve its renewable energy targets, despite present obstacles brought on by a lack of funding and technical know-how. Local economies might be stimulated by the effective adoption of biogas technology, which could lessen reliance on traditional energy sources, cut greenhouse gas emissions, and open up new business opportunities in rural areas. Bt eggplant's introduction has significantly increased yields, decreased production costs, and improved profitability, revolutionizing vegetable farming in Bangladesh. In addition to increasing farmers' incomes, this technical advancement has improved food security and decreased the need for chemical pesticides, which has benefits for the environment and public health.

Furthermore, the use of automation technology in the clothing manufacturing industry, such as automated sewing lines and robotic fabric cutting, has greatly increased output and product quality. By moving towards automation, Bangladesh is putting itself in a position to maintain its competitiveness in the global market and secure the long-term survival of its core sectors. The agricultural sector has been further strengthened by the use of deep learning technology in agriculture, such as disease identification in prawns and crops, which has enhanced disease management and resulted in better harvests and lower losses.

In order to further analyze the impact on economy, we have conducted regression and time series analysis, which is shown below:

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2.2.1 Regression Analysis Model

Regression Analysis has been done, based on the equation below:

$$TotalGDP = \beta 0 + \beta 1 \times AgricultureGDP + \beta 2 \times ShareofAgriculture + \epsilon \qquad (1)$$

Where, β0 is the intercept (constant), β1 is the coefficient for Agricultural GDP, β2 is the coefficient for the Share of Agriculture, and ϵ is the error term.

Table 2 Regression Analysis Overview

Variable	Coefficient	Std. Error	t-Statistic	p-value
Agriculture (Billion USD)	15.80555	.9492577	16.65	0.000
Share of Agriculture	-243.811	134.6034	-18.23	0.000
_cons	99.55445	34.85818	2.86	0.024

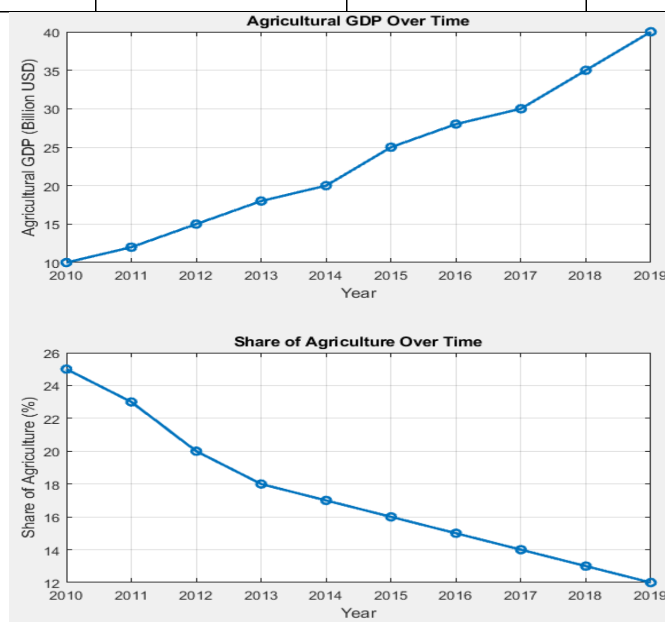

Figure 3 Relationship between Agricultural GDP and Share of Agriculture

Ten observations make up the regression analysis, according to the model summary, and the model is statistically significant based on the F-statistic of 498.16 (with a p-value of 0.0000). With an R-squared of 0.9930, the independent variables of agricultural GDP and the percentage of agriculture may account for about 99.3% of the variance in the overall GDP. The robustness of the

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model is further shown by the corrected R-squared value of 0.9910.According to the coefficient of 15.80555, the GDP as a whole rise by roughly 15.81 billion USD for each billion USD in agriculture GDP. The substantial importance of agriculture to the total economic output is highlighted in Figure 3, by this robustly positive relationship.

The coefficient of -2453.811 indicates that the GDP as a whole fall by around 2453.81 billion USD for every percentage point increase in the agricultural sector's part of the economy. This inverse link may suggest that economies with a higher proportion of agriculture are less productive or diverse and that agriculture itself may not provide as high of a return on investment as other sectors. The constant term of 99.55445 indicates that the model projects a total GDP of roughly 99.55 billion USD if both independent variables are zero. Practically speaking, though, this is implausible as agricultural GDP and its share would normally not be zero.

2.2.2 Time Series Analysis

To comprehend how GDP and agricultural GDP have changed over time, look at their historical trends. In developing countries, a growing agricultural sector can serve as a leading predictor of general economic growth; in industrialized countries, a diminishing percentage could be a sign of economic diversification. Seasonality: Because planting and harvesting occur in cycles, agricultural output frequently displays seasonal patterns. Seasonality analysis of the time series data can shed light on the cyclical nature of agricultural output and how it affects GDP.

To capture delayed effects in time series analysis, consider lagged variables. For example, a change in agricultural output might not have an immediate impact on GDP overall; adding lagged variables could improve the model's ability to explain changes in this regard. Cointegration: As is common in the economic time series, determine whether there is a long-term equilibrium link between the agricultural variables and the overall GDP. Using an error correction model could improve comprehension of the short-run dynamics while preserving the long-run equilibrium relationship if cointegration is present.

The regression analysis highlights in Figure 4, the significance of the agricultural sector in economic growth by revealing a strong statistical link between total GDP and agricultural output. On the other hand, the adverse effect of the proportion of agriculture implies that excessive dependence on it could impede the advancement of wider economic growth. To have a greater understanding of the dynamic interaction between these variables across time, trends, seasonality,

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and potential lag effects must all be taken into account when conducting time series analysis. Future research should focus on how shifts in agriculture production influence overall economic performance and the essential policy implications for fostering a balanced economic growth trajectory.

3. CASE STUDIES

3.1. Agricultural Biomass Based Energy

Bangladesh's fast industrialization and urbanization are driving up energy consumption. Given that 89% of its electricity comes from natural gas and only 5% comes from renewable sources, sustainable alternatives must be investigated (8). By turning crop leftovers into biogas for energy production, agricultural biomass—a valuable resource in the nation—offers a possible option. With an emphasis on anaerobic digestion (AD) technology, this study investigates the techno-economic and environmental viability of biomass-based energy generation in Bangladesh. Despite their abundance, Bangladesh frequently underutilises agricultural leftovers such maize husks, jute stalks, and rice straw. Bangladesh has the potential to produce significant amounts of renewable energy by using anaerobic digestion to turn these wastes into biogas. According to the study, the nation's agricultural leftovers could generate 1,33,815 million cubic meters of biogas each year, or 9231.60 megawatts (MW) of electricity, which would cover 88% of the nation's energy requirements. The biggest source, rice straw, provides 1,547,116.68 to 1,862,107.20 terajoules (TJ) of energy; maize and jute also have substantial energy potential. This proves that agro biomass may be a significant source of renewable energy in Bangladesh.

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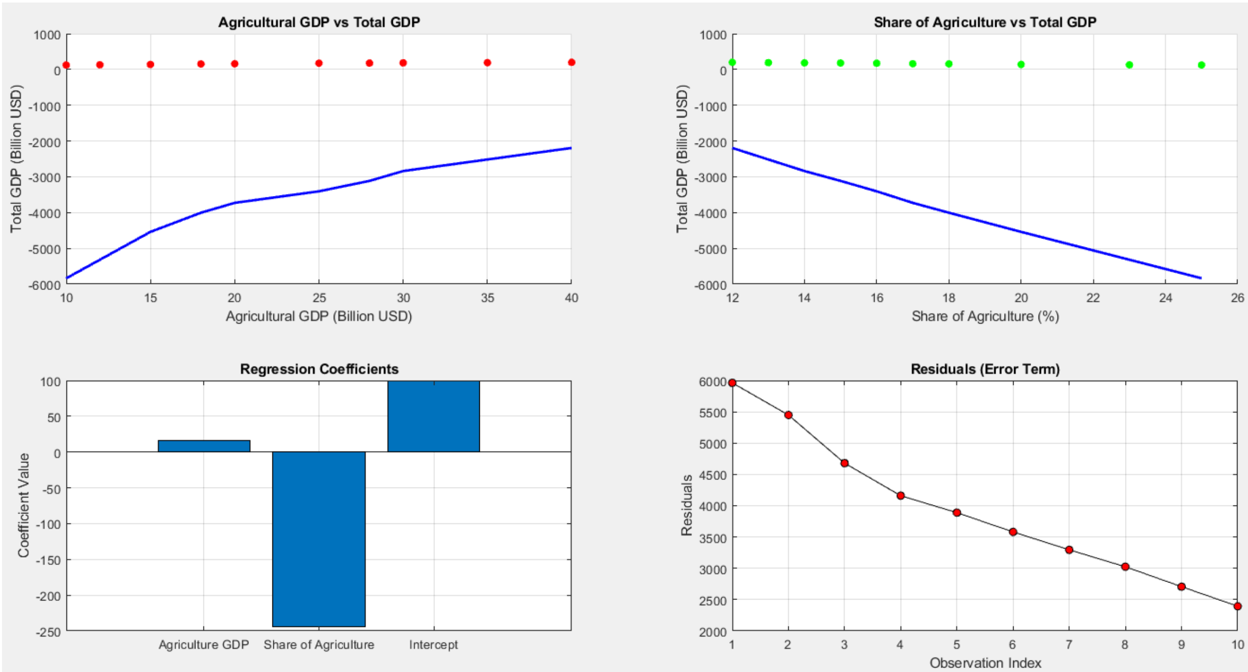

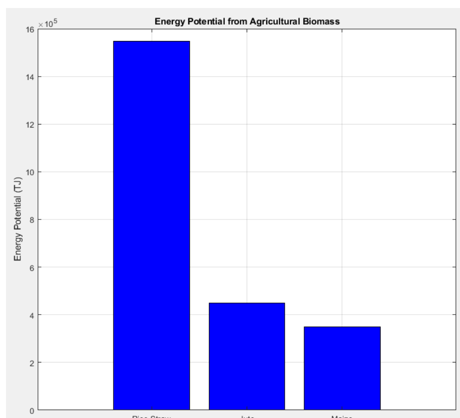

FIGURE 4 ENERGY POTENTIAL FROM AGRICULTURAL BIOMASS

The study illustrated in Figure 5 demonstrates the cost-effectiveness of biogas-based electricity generation, with a competitive levelized cost of electricity (LCoE). The advantages for the environment are also substantial. Anaerobic digestion creates biofertilizer, which enhances soil health, and lowers carbon dioxide (CO_2) emissions by 156 tons per year. Biogas plants have a very short payback period (between 2.93 and 3.75 years), which makes the technology economically appealing for rural regions.

A case study was carried out in the Cumilla district's Debidwar Upazila to confirm the viability of this strategy. 82,695 families were able to get enough biogas from the anaerobic digestion

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system to suit their demands for power and cooking. The technology demonstrated the potential of agricultural biomass to supply clean, reasonably priced energy in rural Bangladesh by producing 571 MWh of electricity yearly. Bangladesh's energy problems can be sustainably resolved with the help of agricultural biomass. The nation can lessen its need on fossil fuels, cut emissions, and enhance rural energy availability by turning crop leftovers into biogas. Agricultural biomass-based energy offers Bangladesh a feasible route to a cleaner, more resilient energy future with its substantial economic and environmental advantages.

3.2. Rice Cultivation in Saline Prone Areas

Bangladesh’s coastal regions are highly affected by salinity, which reduces rice productivity significantly (9). High salinity can cause significant crop failures for traditional rice types. Farmers in these regions frequently struggle with the decision of whether to switch to more hardy rice types or keep growing conventional rice. AI-guided precision farming methods have been used in some areas to address this problem. The local Department of Agricultural Extension implemented smart irrigation systems and early detection methods for soil salinity levels using data from satellite-based remote sensing and artificial intelligence (AI)-driven predictive models (10). Rice fields were equipped with Internet of Things (IoT) sensors to offer real-time information on salinity, moisture content, and soil health. When combined with AI algorithms, these devices provided farmers with personalized advice on when and how to irrigate their fields, guaranteeing the best possible growth circumstances for rice varieties that can withstand salt.

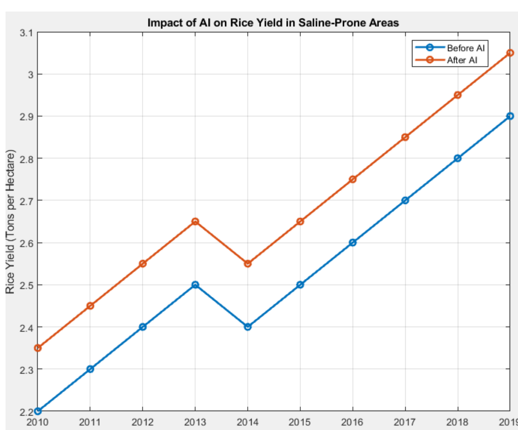

FIGURE 5 IMPACT OF AI ON RICE YIELD IN SALINE-PRONE AREAS

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Here Figure 6 shows the impact of AI on rice yield specifically in saline prone areas. By successfully cultivating salt-tolerant rice varieties, farmers were able to lessen the negative consequences of soil salinity thanks to an AI-powered method. In addition to increasing water efficiency, the implementation of integrated rice-fish farming systems increased farmers' revenue diversification. Rice yields in saline-prone regions consequently rose by more than 15%, enhancing both food security and economic resilience. Additionally, the AI systems promoted sustainable farming methods by lowering pesticide and water waste.

3.3. Disease Detection of Shrimps

An important sector of Bangladesh's economy is the prawn farming business. However, prawn growers have suffered significant losses due to diseases like white spot syndrome. In order to identify infections, farmers frequently rely on eye observation, which may be too late for efficient action (11). AI-driven deep learning algorithms were implemented in partnership with regional research institutes to track and identify prawn diseases early. AI-powered picture recognition and underwater drones have made it possible to continuously monitor shrimp farms for signs of sickness. Technology can recognize disease symptoms like discoloration or unusual swimming patterns since it trained its algorithm on a large sample of disease photos. By detecting diseases in their early stages and enabling farmers to take prompt preventive action, the application of AI for disease detection dramatically decreased prawn death rates. Broadly speaking, farms that used this technology reported a 30% decrease in the usage of chemical treatments and a 25% rise in prawn yields (12). This not only boosted farm profitability but also improved the overall sustainability of shrimp farming by minimizing environmental impact. Also, another study conducted on, "Smart Aquaculture Analytics: Enhancing Shrimp Farming in Bangladesh through Real-Time IoT Monitoring and Predictive Machine Learning Analysis" introduces an advanced system designed to address key challenges in shrimp farming by integrating Internet of Things (IoT) technologies and machine learning (ML) (11).

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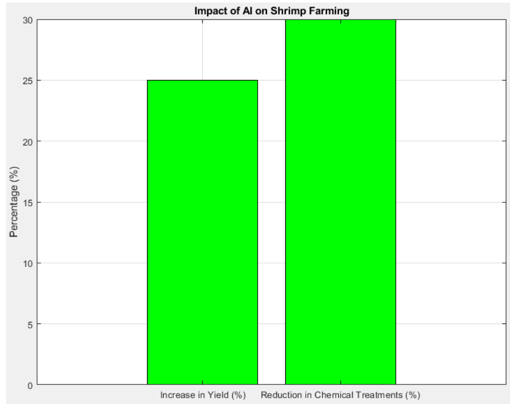

FIGURE 6 IMPACT ON SHRIMP FARMING

The study emphasizes that shrimp farming, a vital economic sector in Bangladesh, faces issues such as environmental degradation and poor water quality, leading to reduced shrimp production. To combat this, the proposed system employs real-time monitoring of critical water parameters—pH, temperature, salinity, electrical conductivity, and total dissolved solids (TDS)—using sensors and microcontroller-based devices. The data is processed through predictive ML models, offering farmers forecasts of water quality and shrimp production levels. Through Figure 7, it is clear this system significantly improves traditional manual monitoring by providing automation and real-time feedback, which helps farmers take proactive measures. It integrates multiple linear regression for predictive analysis and various classification algorithms (e.g., Random Forest, Logistic Regression) to forecast shrimp production. The system ensures ideal circumstances for prawn growth by delivering alarms using a web-based application and smartphone notifications, with a high success rate (97.84% accuracy by Random Forest). According to the findings, this Internet of Things-based strategy can increase prawn yield, lower production costs, and support sustainable aquaculture methods. The report does, however, recognize several issues that must be resolved for broader use, such as startup costs, scalability, and data gaps brought on by network instability. However, the creative application of technology promises to revolutionize Bangladesh's prawn farming sector, guaranteeing both financial and ecological gains. This all-inclusive solution is a major step towards more intelligent, sustainable aquaculture since it not only increases production efficiency but also gives farmers useful insights.

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3.4. Robotic Automation in Dairy Industry

Bangladesh's dairy business confronts a number of difficulties, such as low production, ineffective large-scale farm management, and restricted access to contemporary technologies. Manual labor-intensive chores are a common problem for small-scale dairy farmers, which restricts their capacity to increase output and sustain profitability (13). Larger dairy farms in the northern provinces of Bangladesh were equipped with robotic milking systems in order to overcome these difficulties. The milking process was automated using AI-powered milking robots that included sensors. These systems keep track of each cow's health and milk production in addition to managing milking. Artificial intelligence (AI) systems examine data from every milking session to spot patterns, identify diseases, and adjust feeding regimens for increased milk production (14). Due to farmers' enhanced efficiency and regularity in milking cows, the dairy industry saw a 20% rise in milk production once robotic automation was implemented. By enhancing herd management and offering early indications of health problems, automated monitoring also lessens disease outbreaks. In addition to lowering labor expenses, this technical advancement enabled farms to expand while maintaining a constant level of milk quality (15). The success of these farms shown in Figure 8, has encouraged other large dairy producers in Bangladesh to adopt similar AI and robotic technologies.

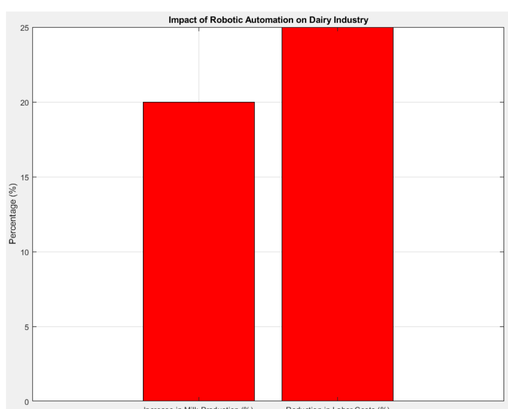

FIGURE 7 IMPACT OF AUTOMATION IN DAIRY INDUSTRY

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4. FUTURE DIRECTIONS ON STRATEGIC PLAN

A revolutionary route to sustainable growth is provided by the incorporation of digital advances, as Bangladesh's agriculture sector faces difficulties ranging from climate change to rising food demand. Digital tools have greatly increased agricultural productivity and resilience, as seen by global trends (16), Bangladesh is on the verge of a revolution in agriculture. The nation needs adopt cutting-edge technology like blockchain, artificial intelligence (AI), precision farming, and the Internet of Things (IoT) in order to realize this potential. In addition to increasing production, these developments will guarantee that farming methods are resilient and sustainable in the face of economic and environmental difficulties.

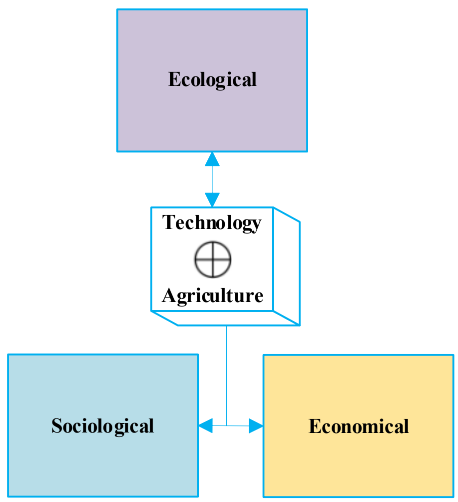

FIGURE 8 OBTAINABLE DIMENSIONS OF TECHNOLOGY INTEGRATION INTO AGRICULTURE.

In agriculture, the combination of market tactics, technology, and strategic management produces deep synergies that greatly increase sustainability and productivity throughout the value chain (17). Technology operates as a pivotal enabler, Figure 8 driving innovation within both market strategies and strategic management frameworks. On the other hand, technological developments are smoothly incorporated with market demands and in line with the overall goals of the organization when strategic management is done well. Advanced technologies like drones, biotechnology, IoT, artificial intelligence, and precision agriculture provide vital data and insights that support well-informed strategic decision-making in the agricultural industry. Precision farming technology, for example, enables farmers to allocate resources optimally based on real-time information, increasing operating efficiency and reducing expenses. Conversely, AI-powered

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prediction models provide profound understanding of consumer behavior and market dynamics, enabling agribusinesses to improve their marketing tactics, proactively address changing consumer preferences, and ultimately maximize profitability (18).

By integrating technical breakthroughs into comprehensive strategies, strategic management frameworks could help Bangladeshi agricultural firms take advantage of these developments. Adoption of technology is matched with long-term national objectives through strategic planning, which aids in spotting chances for innovation and giving the agriculture industry a competitive edge. In order to provide a seamless integration that promotes sustainable growth, effective management also handles potential risks related to the implementation of new technology, such as worries about data security or operational difficulties. Furthermore, market strategies make use of these technical developments to enhance client involvement, distribution networks, and product positioning (19). In highly competitive markets, agricultural firms in Bangladesh are able to differentiate their products and increase their value through strategic market positioning that is informed by technology insights.

Adopting digital technologies that optimize resource utilization and enhance farming decision-making is one of Bangladesh's main objectives in terms of future orientation to realize its full potential. With the use of technologies like precision agriculture, which makes use of data from sensors, satellites, and drones, farmers can adjust the amount of water, fertilizer, and pesticide they use to meet the unique requirements of their crops. Precision agriculture may increase output while minimizing environmental damage in a nation like Bangladesh, where farming is mostly dependent on periodic rains and effective resource management is essential. These technologies assist farmers in making well-informed decisions on the timing and application of resources, hence decreasing waste and expenses, by facilitating data-driven decision-making (20). Furthermore, using digital tools into Bangladesh's agricultural industry helps promote environmentally friendly farming methods. Deforestation and soil degradation are two major environmental issues facing the nation that endanger long-term agricultural productivity. Bangladesh can transition to greener practices by implementing AI-powered robotics and self-sufficient agricultural systems. For example, AI systems may track crop health in real time, allowing for prompt interventions that minimize harm and maximize output, while autonomous weeding robots can lessen the need for chemical pesticides (21). In addition to reducing environmental damage, this move towards digital farming will increase Bangladesh's agricultural systems' ability to withstand climatic fluctuations.

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Enhancing market accessibility for Bangladeshi farmers is another crucial area where digitalization can have a significant influence. The supply chain's lack of traceability and transparency now makes it difficult for many smallholder farmers to reach international markets. However, Bangladesh's agricultural products can more easily reach consumers abroad with the use of digital marketing platforms and blockchain technology. Customers can track the origin of agricultural products thanks to blockchain, which in particular guarantees transparency in the production and distribution process. This boosts customer confidence and demand for Bangladeshi commodities. Furthermore, producers may charge greater prices for their products by connecting with consumers directly through digital channels, eliminating the need for middlemen (22).

Another urgent issue facing Bangladesh's agriculture industry is climate change adaptation, and digital technology can be extremely helpful in boosting resilience. The nation is extremely susceptible to climate-related hazards, like droughts and floods, which jeopardize agricultural output (23). Farmers can obtain early warnings of extreme weather events and modify their farming techniques accordingly by implementing remote sensing technologies and AI-based predictive models. For instance, farmers can use predictive analytics to determine when to water to lessen the effects of drought or when to plant crops to prevent floods. Furthermore, localized digital insurance systems can offer smallholder farmers protection against climate-related losses, boosting their financial stability and facilitating a speedier recovery from unfavorable occurrences (24).

Bangladesh must also address the issue of the digital divide in order to guarantee that the advantages of digital agriculture are widely available. The bulk of agricultural workers are smallholder farmers, who frequently lack the funds to purchase pricey technology gear. Because large-scale farmers are more likely to profit from technical developments, there is a risk that inequality within the sector will increase. Bangladesh may address this issue by promoting cooperative investment models and shared technology platforms that provide small farmers with cheaper access to digital tools (25). One way to guarantee that smallholder farmers profit from these advancements is through farm machinery cooperatives, in which farmers pool their resources to purchase digital tools and equipment. Many European nations have successfully adopted this concept, lowering the cost of digital agricultural instruments for small-scale farmers through the use of shared technology platforms (26).

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Furthermore, incorporating digital innovations that improve resilience, sustainability, and productivity is crucial to Bangladesh's agro-economic future. Bangladesh can tackle the urgent issues of resource management, environmental degradation, and climate change by implementing technologies like blockchain, AI, digital insurance, and precision farming. Furthermore, bridging the digital divide and fostering equitable growth in the agriculture industry will be made possible by guaranteeing smallholder farmers' access to these advances via cooperative structures and shared platforms. These digital technologies will be crucial in helping Bangladesh develop a more resilient and sustainable agricultural sector in the future.

5. CONCLUSION

The ability of Bangladesh's agricultural sector to adopt and incorporate digital breakthroughs like AI, IoT, and precision farming will determine its future. In addition to optimizing resource management, these technologies guarantee resilience against economic and environmental stresses. Despite the challenges that the shift to digital farming presents, especially for smallholder farmers, there is no denying the advantages in terms of efficiency, sustainability, and market accessibility. Bangladesh can greatly increase food security, lessen the effects of climate change, and increase agricultural output by utilizing these technologies. Policymakers, agribusinesses, and farmers must work together to close the digital divide, promote cooperative investment models, and put long-term growth-ensuring tactics into place if these technologies are to be successfully adopted. In the end, safeguarding Bangladesh's future as a robust and successful agricultural economy would depend heavily on the incorporation of cutting-edge technologies into agricultural operations.

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DISCLOSURE OF CONFLICT

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