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CLIMATE CHANGE AND AGRICULTURE IN BANGLADESH: IMPACTS AND ADAPTATION STRATEGIES

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Abstract

The interrelationship between climate change and agriculture has been widely studied in Bangladesh. Bangladesh is predominantly an agricultural nation where farming is highly dependent on natural conditions such as temperature, rainfall, soil quality, and water availability. However, Bangladesh frequently faces extreme climatic events, including droughts and floods, which are further exacerbated by global climate change, threatening agricultural productivity and food security. This study employs a bibliometric approach to critically analyze existing academic literature on climate change and agricultural adaptation in Bangladesh. The primary objectives of the study are to (1) assess the impact of climate change on Bangladesh agriculture and (2) evaluate the effectiveness of current adaptation strategies. Data were sourced from Scopus, yielding 1,052 relevant documents, including 765 scholarly articles. VOSviewer software was used to map bibliometric connections, highlight key authors, and extract insights from journals and other sources. The study revealed that there are inconsistencies between agricultural policies and climate change adaptation strategies. To bridge this gap, the study recommends policy improvements, including targeted subsidies and pricing mechanisms that encourage farmers to adopt location-specific adaptation strategies, enhancing climate resilience in agriculture.

Keywords: Adaptation, Agricultural extension, Rainfall, Rural, Technologies.

Introduction

Climate change is an undeniable reality, with historical evidence indicating its ongoing presence for thousands of years (Kotir, 2011; Mercuri, 2025). For instance, the Sahara Desert was once tropical 6,000–7,000 years ago (Brown *et al.,* 2018). Today, observable signs of climate change include rising temperatures, shifting rainfall patterns, frequent extreme weather events, the melting Arctic ice cap, and consequent sea level rise. Changes in the distribution of birds and plants, altered migration patterns, and earlier leaf falls in deciduous trees further underscore this transformation (Navarro-Velez and Dhondt, 2025).

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Reports from the Intergovernmental Panel on Climate Change (IPCC) warn of severe social, environmental, and economic hazards. The IPCC has confirmed that global warming is real, accelerating, and nearing a tipping point beyond human control. Findings indicate rising ocean and air temperatures, widespread ice cap melting, and intermediate sea level increases worldwide (Siegert *et al.,* 2020).

Climate change profoundly impacts the environment, biodiversity, human health, and food systems. Water cycles and supply sources are shifting, exacerbating water stress, extreme temperatures, and unpredictable weather conditions, all of which challenge agriculture (Blanc *et al.,* 2017; Jun *et al.,* 2011). The adverse effects on farming are particularly concerning, as agriculture depends heavily on climatic stability. Temperature fluctuations, daylight variations, and inconsistent rainfall patterns pose significant challenges to farmers worldwide. Rapid climate shifts have intensified droughts and floods, jeopardizing food security by damaging crops, displacing farmers, and degrading land. Rising water temperatures disrupt aquatic ecosystems, affecting fish populations and food sources in many countries (Dasgupta *et al.,* 2017; Pham *et al.,* 2019).

Climate models predict substantial declines in crop yields due to global warming. Under the RCP8.5 scenario, winter wheat yields could drop by up to 21%, winter barley by 17.3%, and spring barley by 33.6% (Gammans *et al.,* 2017). A mere 1°C rise in global air and water temperatures may reduce cereal production by 5-10% (Hatfield and Maher, 2009). Extreme heat exceeding 30°C damages plants, while temperatures above 37°C compromise seed storage quality (Wahid *et al.,* 2007). Precipitation anomalies further threaten food production, as 80% of the world's cropped areas rely on rain-fed agriculture (Ghose *et al.,* 2021).

Bangladesh is particularly vulnerable, ranking eighth on the Climate Risk Index 2020 for weather extremes (Eckstein *et al., 2020*). Predictions suggest global sea temperatures will rise by 1.2-3.2°C by 2100, accompanied by a sea level increase of up to 1.3 meters between 2090 and 2099 (Schickhoff *et al.,* 2022; Mojid, *et al.,* 2025). Even a modest 0.3-meter rise would increase coastal flood-risk areas by 15.3%, deepening inundation by 22.7% (Karim and Mimura, 2008).

Climate change also drives intranational migration. The World Bank projects that by 2050, 13.3 million people in Bangladesh may be displaced due to climate change (Podesta, 2019). Agricultural productivity is particularly threatened, with significant declines in staple crop yields across all three rice-growing seasons (Sarker *et al.,* 2014). One model forecasts that a 5.32°C temperature rise by 2100 would reduce potato, rice, and wheat yields by 38.6%, 67.8%, and 47.6%, respectively.

Salinity intrusion exacerbates Bangladesh's agricultural challenges, increasing from 83.3 million hectares in 1973 to 105.6 million hectares in 2009 (Islam *et al.,* 2021). Coastal salinity has damaged crop, fish, and livestock production (Alam *et al.,* 2022). More than 35 million people live in Bangladesh's 19 coastal districts, constituting 32% of the country's land area (Rabbani & Huq, 2011). Extreme weather events occur frequently—at least one disaster strikes the nation every three years (Rahman *et al.,* 2021).

As a developing nation reliant on agriculture, Bangladesh's food security is deeply intertwined with its farming sector. Agriculture contributes 13.82% of GDP (Talekar *et al.,*

2020) and employs 37.75% of the population (BER, 2017). Thus, urgent research is needed to assess climate change's effects on Bangladeshi agriculture and evaluate existing adaptation strategies. Although studies on this subject exist, a bibliometric analysis of climate change's impact on agriculture in Bangladesh remains unexplored. This study aims to fill that gap by reviewing the current agricultural status, climate change impacts, and the effectiveness of adaptation efforts.

Materials and Methods

The primary objective of this research is to conduct a thorough analysis of existing data to gain a deeper understanding of (i) how climate change is affecting agriculture in Bangladesh and (ii) the effectiveness of current adaptation strategies.

This study relies on data sourced from the Scopus database. The initial search terms—("climate change" AND "impact" AND "agriculture" AND "Bangladesh")—were used to ensure relevant materials were identified. To enhance the study's scientific rigor, extraneous materials were excluded, and selected references underwent verification. Additionally, supplementary data were obtained from news reports and publicly accessible websites.

A bibliometric approach was employed to compile literature on climate change's impact on Bangladeshi agriculture from the Scopus database, using TITLE-ABS-KEY ("climate change" AND "impact" AND "agriculture" AND "Bangladesh"). This search covered 34 years (1988–2022), yielding 1,052 documents, of which 765 were scholarly articles. The highest number of publications occurred in 2021, with 170 papers.

Bibliometric analysis requires comprehensive literature reviews and rigorous methodologies to ensure high-quality information and reliable outputs (Inamdar *et al.,* 2020; Souza & Bueno, 2022). Accordingly, VOSviewer software was utilized to map bibliometric sources, identify leading authors, and extract refined insights from academic journals (Nobanee *et al.,* 2021; Yu *et al.,* 2022).

Bibliometric methods offer several advantages. First, data-driven analyses provide greater credibility than subjective assessments, as traditional reviews often rely on critical written summaries. Second, bibliometric approaches facilitate broader overviews of research landscapes (Li *et al.,* 2021). To achieve research objectives and maintain bibliometric standards, an evaluation review was conducted to ensure logical consistency in mapping sustainability and risk dimensions. Microsoft Excel was employed for data analysis, complemented by VOSviewer for visual mapping.

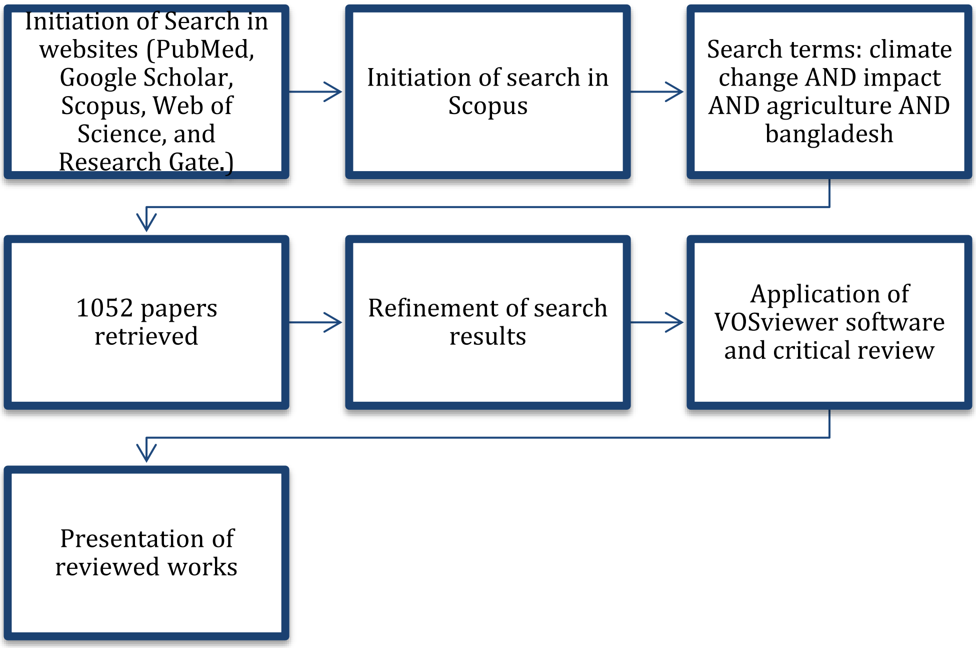

Fig. 1. Search and review process.

Results and Discussions

Climate change and agriculture in Bangladesh

A total of 5,200 keywords were used in the complete counting co-occurrence analysis. Figure 2 presents the network map illustrating the connections among keywords in the analyzed articles. The analysis identified eight distinct groupings representing various research perspectives on climate change and agriculture.

Each node in the figure corresponds to a keyword, with node size reflecting keyword frequency. The number of connecting lines indicates the extent of co-occurrence, while line thickness represents the strength of keyword associations (Tan *et al.*, 2021). Larger nodes with thicker connecting lines signify higher keyword co-occurrence and stronger interconnections.

The top 20 most frequently co-occurring keywords were Climate Change, Bangladesh, Agriculture, Adaptation, Food Security, Rice, Adaptive Management, Climate Effect, Vulnerability, Human, Coastal Zone, Crop Production, Drought, Salinity, Rain, Agricultural Robots, Floods, and Livelihood. Each of these keywords appeared more than 23 times, with a minimum link strength of 97.

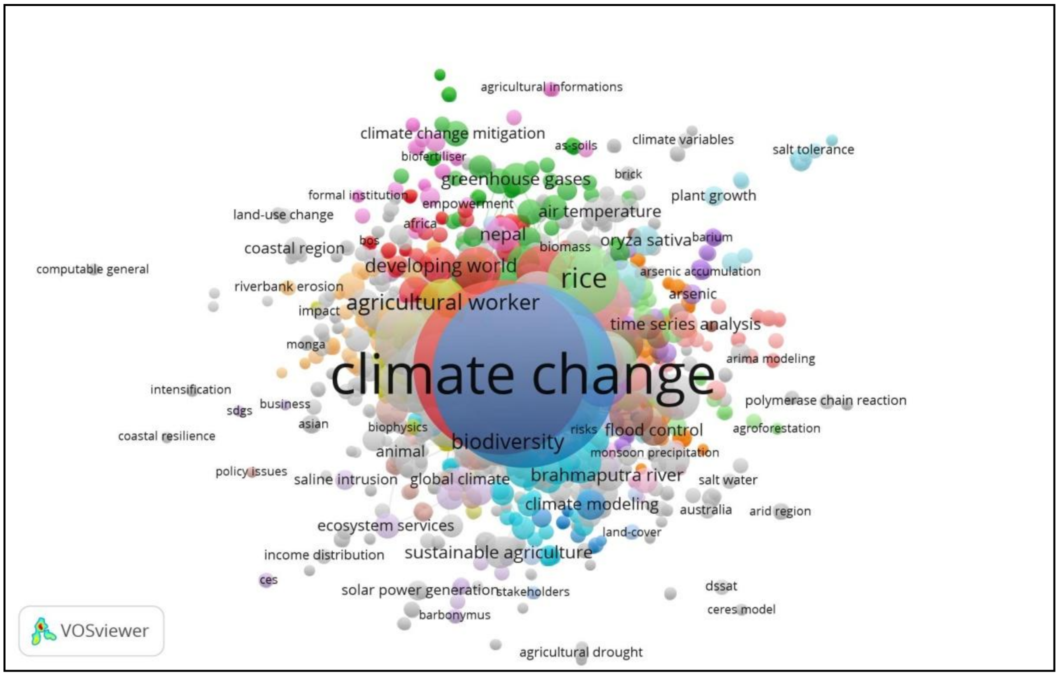

Fig. 2. VOSviewer co-occurrence network visualisation mapping of most common terms (minimum six occurrences) on the "Bangladesh agriculture-climate change" study.

Table 1. Hotspot areas of work on the topics

Keyword	Occurrences	Total Link Strength
Climate Change	253	891
Bangladesh	227	869
Agriculture	152	620
Article	48	295
Adaptation	43	188
Food Security	41	177
Rice	39	225
Adaptive Management	34	180
Climate Effect	31	146
Vulnerability	30	144
Human	28	174
Coastal Zone	27	145
Crop Production	27	162
Drought	27	151

Keyword	Occurrences	Total Link Strength
Salinity	26	150
Rain	25	157
India	24	128
Agricultural Robots	23	104
Floods	23	108
Livelihood	23	97

Fig. 3 presents the top nineteen authors contributing to research on Bangladesh's agriculture-climate change nexus from 1988 to 2022, ranked by citation frequency. The five most frequently cited authors were Gopal, B.; Monirul Qader Mirza, M.; Shahid, S.; Alam, G.M.M.; and Miyan, M.A., collectively amassing over 765 cited papers during this period.

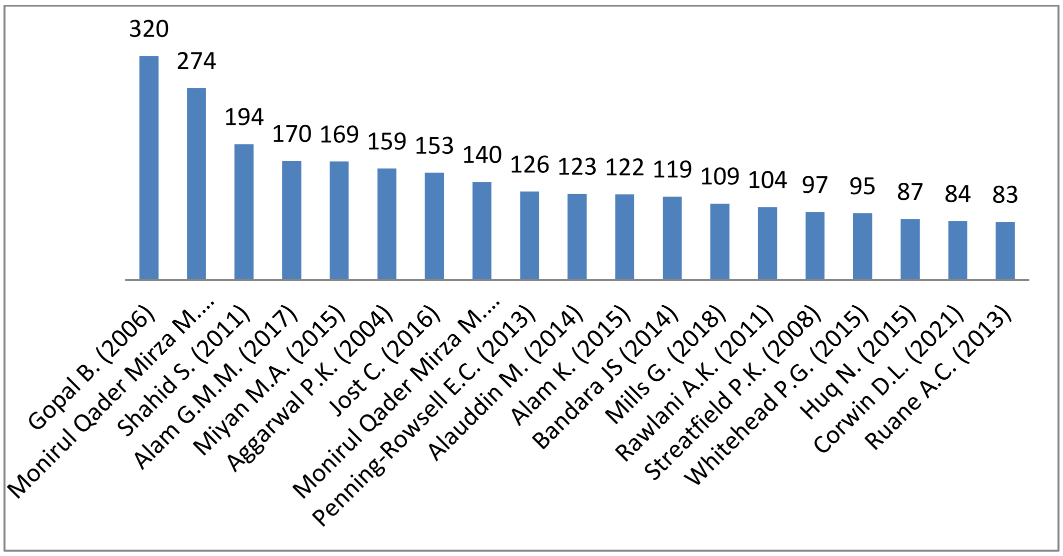

Fig. 3. From 1988 to 2022, the top 19 writers cited by authors in agriculture-climate change nexus in Bangladesh.

Bangladesh's climate change outlook

Bangladesh is highly vulnerable to climate change due to its flat, low-lying, deltaic geography (Ayers *et al.*, 2014), combined with high population density, poverty levels, and reliance on agriculture. Frequent natural disasters, inadequate infrastructure, and a population density of 1,368 people per sq. km (Bangladesh Population 2023, n.d.) further amplify its exposure, risk, and vulnerability. Additionally, large portions of the country endure annual cyclones, floods, and erosion, creating significant socioeconomic and environmental challenges that hinder national progress.

As climate change intensifies, extreme weather events—such as heavy rainfall, rising sea levels, and tropical cyclones—will become more frequent, threatening agriculture, water security, food systems, human health, and housing. For instance, Bangladesh's sea level is projected to rise by 0.30 meters by 2050, potentially displacing up to 900,000 people, and by 0.74 meters by 2100, putting 2.1 million people at risk of displacement (Davis *et al.*, 2018).

Bangladesh is already experiencing shifts in weather patterns due to global warming, with hotter summers, unpredictable monsoons, and reduced dry-season precipitation. These seasonal disruptions result in excessive rainfall during wet months, leading to flooding and landslides, while dry spells cause severe drought. Consequently, Bangladeshi farmers increasingly face a double crisis—crop failure due to drought followed by flooding losses of remaining crops.

Climate variability occurs when a region's climatic variables deviate from long-term averages (Beck *et al.*, 2007). This means annual fluctuations in temperature and precipitation, with some years recording below-average rainfall while others experience excess precipitation. For instance, Rajshahi, in northern Bangladesh, receives an annual rainfall of 1,494 mm (Dey *et al.*, 2011). Significant climate vulnerability exists in central and western coastal regions, the northwestern highlands, and the major river basins, identified as climate change hotspots (Das *et al.*, 2020).

Variations in temperature

Between 1976 and 2019, Bangladesh's average temperature increased by 0.5°C (Roy *et al.*, 2020), although this rise has not been uniform across regions. In the eastern parts of the country, maximum temperatures increased by 0.9°C, while the central regions, including Dhaka, Chattogram, and Sylhet divisions, recorded a 0.5°C increase during the same period (Abedin and Khan, 2022).

Additionally, summers are lengthening, winters are warming, and monsoons are becoming more unpredictable. Projections indicate that Bangladesh's annual average temperature will rise between 1.0°C and 1.5°C by 2050, even if global mitigation strategies, such as the Paris Climate Agreement, are implemented (Brown *et al.*, 2018).

Changing precipitation patterns

Rainfall patterns, both global and regional, are shifting due to climate change. Bangladesh remains one of the most flood-prone countries in the world, with droughts emerging as a growing concern in the northern regions. Understanding precipitation trends is crucial for disaster prevention, agriculture, and water resource management.

Bangladesh's average annual rainfall is 2,488 mm, varying from 1,527 mm in the west to 4,197 mm in the east, with a west-to-east rainfall gradient of 7 mm/km (Shahid, 2012). More than 89% of annual precipitation occurs between May and October (Shahid, 2012), highlighting the country's seasonal rainfall distribution.

Most regions experience a humid climate, with the northeast classified as a wet zone and the central-west region as sub-humid. The coefficient of variation in annual rainfall suggests moderate fluctuations, with deviations ranging between +408 mm and -586 mm over the past 50 years (Kaur *et al*., 2021).

Variations in humidity and wind

Humidity levels in northern Bangladesh show a long-term increasing trend. During the study period, the average annual maximum humidity was 216.75%, and the average minimum was 71.92%.

From 1960 to 2017, average annual precipitation increased, with March recording the lowest relative humidity of 57% in Dinajpur. The driest months in eastern Bangladesh are January through March, with Brahmanbaria registering the lowest monthly average humidity of 58.5% in March (Mahmud and Chowdhury, 2021). Between June and September, relative humidity remains consistently above 80%, reaching 78.1% in Cox's Bazar and 70.5% in Pabna.

Wind patterns in Bangladesh vary seasonally. Summer winds predominantly flow from the south, southwest, or southeast, with speeds ranging between 8–16 km/h, compared to winter winds averaging 3–6 km/h. Atmospheric pressure also fluctuates, with January's average pressure at 1,020 millibars, dropping to 1,005 millibars between March and September

Present status of agriculture in Bangladesh

Agriculture remains a cornerstone of Bangladesh's economy, covering more than 70% of the country's land area and employing nearly half of its population. In 2021, the sector contributed 11.6% to GDP growth (Bangladesh Population 2023, n.d.).

Rice and jute are the country's dominant agricultural products, though maize and vegetable cultivation has gained traction in recent years (Ali *et al.,* 2019). The expansion of irrigation networks has encouraged wheat farmers to shift toward maize production, particularly for poultry feed. In northeastern Bangladesh, tea is the primary agricultural product. Bangladesh's abundant land and water resources enable rice harvesting three times a year. The country ranks third in cultivated rice exports and fifth in farmed fish exports (Golub *et al.,* 2014). From 2000 to 2008–09, cereal production surged from 32.89 million metric tons to 45.50 million metric tons, marking a 38% increase over 12 years (Krishi Diary, 2022). The most substantial growth was recorded in maize (775%), pulses (375%), and vegetables (578%)

Table 2. Comparison of changes in production and growth of crops

Crops	Production (million metric tons)		Growth (%)
	2008-09	2020-21	
Rice (husked)	31.31	38.6	23
Wheat	0.84	1.23	45
Maize	0.73	5.66	775
Potato	5.26	10.61	101
Pulses	0.19	0.93	375
Oilseeds	0.66	1.19	81
Vegetables	2.90	19.91	578

Krishi Diary, 2022

Agriculture remains Bangladesh's most vital economic sector but faces escalating challenges, including loss of arable land, population expansion, climate change, poor management methods (inadequate fertilizer, water, outbreaks of pests & diseases), lack of quality seeds, inadequate credit assistance to farmers, unjust product pricing, and insufficient research. Between 1983 and 1996, Bangladesh lost 1 million hectares of farmland. Bangladesh's current arable land is only 0.04 hectares per capita, which will be around 0.033 (Kanak Pervez *et al.,* 2017). The amount of land is inadequate to ensure food security in this country. In addition, climate change will worsen the lives of the rural poor in Bangladesh and exacerbate food insecurity.

Additionally, climate change disproportionately impacts the rural poor, exacerbating food insecurity. Rising temperatures, erratic weather patterns, and extreme climatic events further strain agricultural productivity, making sustainable farming increasingly difficult.

Bangladesh's agriculture and climate change

Changes in temperature and precipitation patterns are significantly impacting agriculture in Bangladesh. A 4°C increase in average temperature is projected to reduce rice and wheat production by 28% and 68%, respectively (Impact of Climate Change on Agricultural | The Financial Express, n.d.). Additionally, droughts and delayed monsoons have altered the rain-fed Aman rice season, potentially causing rice and wheat yields to decline by 8% and 32% by 2050 due to insufficient rainfall (Islam *et al.,* 2013).

A 10°C rise in maximum temperature during the vegetative, reproductive, and ripening stages reduced Aman rice yields by 2.94, 53.06, and 17.28 tons, respectively (Islam *et al.,* 2021). Similarly, a 1mm increase in precipitation during these growth stages led to yield reductions of 0.036, 0.230, and 0.292 tons (Kaczan & Orgill-Meyer, 2020).

The Bangladesh Agriculture Development Corporation (BADC) currently provides only 56% irrigation coverage, leaving farmers vulnerable to erratic rainfall. Climate change has also intensified floods and flash floods. In March 2017, flash floods devastated crops in the hoar (lowland) regions, impacting 0.14 million hectares of cropland and 423,000 farmers (DAE, 2018).

Rising sea levels are accelerating saltwater intrusion into coastal farmland. Bangladesh's coastline experiences a 3mm annual sea level rise, contributing to a 27% increase in salinity intrusion between 1973 and 2009. Coastal seawater contamination has affected 1.1 million hectares of land, reducing freshwater availability and damaging soil fertility (SRDI, 2010; Pervez *et al.,* 2020).

The northwestern region of Bangladesh frequently experiences droughts, with broadcast rice suffering 40% drought-related damage. The Kharif season (mid-March to mid-October) sees drought damage across 2.32 million hectares of T. Aman rice fields, while the Rabi season (mid-October to mid-March) affects over 1.2 million hectares of farmland (Dey *et al.,* 2011).

Climate change adaptation and research gaps

Bangladesh lacked a formal climate change adaptation strategy until 2010, when several key policies were introduced to mitigate vulnerability. However, due to the absence of global consensus on climate change mitigation and the long-term inertia of climatic systems, adaptation remains essential for protecting agriculture in climate-vulnerable nations like Bangladesh (Groom, 2012).

Despite contributing minimal global carbon emissions, Bangladesh faces significant risks from climate change and must focus on adaptation strategies rather than mitigation. The country has several agricultural adaptation options, including:

- Mixed-crop livestock farming systems
- Adjusting planting and harvesting schedules
- Developing drought-resistant cultivars
- Introducing high-yield, water-sensitive crops
- Modifying irrigation methods and crop selection
- Diversifying animal farming (Bradshaw *et al.,* 2004).

Bangladesh's Vision 2021 emphasizes environmental protection through strategies such as planned foreign migration, disaster resilience in vulnerable regions, pollution reduction, and sustainable waste management. Safeguarding forests, waterways, and rivers is critical for building climate resilience. Initiatives like strengthening flood-prone communities in Gaibandha, developing drought and flood adaptation strategies, and implementing LACC programs in arid areas are key components of this transition.

Current adaptation techniques

Bangladeshi farmers are increasingly adopting climate-resilient crop varieties to mitigate the effects of climate change (Moniruzzaman, 2015). Many are shifting from Aman rice, which relies heavily on rainfall, to Boro rice, which is more irrigation-dependent. Integrated agriculture, combining livestock, fish, and crop farming, has gained popularity as a strategy to optimize resource use and enhance productivity. Rice-fish farming, in particular, improves efficiency and food security by outperforming monoculture systems in terms of resource utilization, diversity, yield quality, and overall output (Ahmed & Garnett, 2011).

Cage aquaculture has emerged as an alternative fishing method, particularly useful after floods or storms. Traditional aquaculture farms often suffer perimeter damage during extreme weather events, disrupting fish growth. In response, biofloc fish farming is becoming increasingly popular among small and marginal farmers, particularly in urban areas. Additionally, raising ducks in waterlogged or flooded regions provides a viable solution for utilizing submerged land efficiently.

Adapting agriculture to climate change requires short-, medium-, and long-term planning that relies on accurate, localized projections and adaptable strategies. Policymakers should integrate migration policies into development, environmental planning, and climate resilience efforts to reduce risks and enhance mobility. Indigenous, family-based, and community-driven adaptation techniques remain essential for fostering resilience.

The gap in research

Most available studies rely on historical climate patterns to predict future trends, focusing on outcome-based vulnerability assessments. However, limited research has explored how agricultural workers in Bangladesh personally perceive climate change. A perception-based approach could provide critical insights into farmers' adaptability and inform strategic investments in short- and long-term climate resilience.

While some studies examine climate impacts on agriculture and fisheries, few address vulnerability dynamics in relation to climate change and market globalization. Additionally, minority groups, women, and youth remain underrepresented in discussions on climate adaptation policies and their socio-economic consequences.

Further localized, system-based research could better inform adaptation decisions for Bangladesh's agricultural sector. Understanding how adaptation-related information is developed, exchanged, and implemented across different levels—including formal and informal networks—could enhance horizontal and vertical collaboration in climate resilience efforts (Davies *et al.,* 2019).

Conclusion

Bangladesh's agriculture, highly dependent on natural conditions such as weather, soil, and water flow, faces annual disruptions from climate-related disasters. Local communities have developed and implemented various adaptive strategies, often without formal theoretical guidance, to cope with these changes. However, planning, policy development, and adaptation strategy execution remain in their early stages. The Government has established institutional frameworks and allocated funding to mitigate climate risks, but further efforts are needed.

Research indicates that future temperature and precipitation fluctuations will significantly impact crop yields in Bangladesh, necessitating the adoption of climate-resistant or climate-insensitive crops to maintain production levels. Crop switching could play a vital role in stabilizing food security amid climate challenges.

To support climate adaptation in agriculture, the distribution system for agricultural inputs—such as seeds and fertilizer—should incentivize climate-resilient farming practices. Policies should favor farmers who select crops suited to their respective agro-ecological zones while reducing support for those who do not.

Additionally, the Government should continue subsidizing fertilizer, fuel, and irrigation but restructure agricultural subsidies to encourage climate-responsive farming decisions. A pricing structure for farming inputs that promotes climate-resilient crop choices would be a practical way to integrate climate change policy into agricultural policy, ensuring the sector remains viable despite environmental challenges.

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Author’s contribution

Both authors contributed equally to the preparation of the manuscript. The search initiation, retrieval, refinement of search results, application of VOSviewer software for critical review, and final presentation of reviewed works were collaboratively conducted by the first and second authors simultaneously. The second author prepared the final copy, which was approved by the first author for submission.

Conflict of Interest

The authors affirm that there are no conflicts of interest related to the publication of this manuscript

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