

Climate Change, Agricultural Performance, and Resilience in Bangladesh: An Empirical Analysis

Samira binte Saif¹*¹Islami Bank Bangladesh PLC* samiraoct1984@yahoo.com

ARTICLE INFO

Keywords:

Agriculture
Climate Change
Sustainable
Farming
Food Security
Mitigation

Received:

12 October 2025

Received in revised
form:

10 December 2025

Accepted:

17 December 2025

Available online:

20 December 2025

ABSTRACT

As the impacts of climate change grow more severe, Bangladesh is pioneering green agriculture to secure its agricultural future. This approach embraces sustainable farming practices, enabling farmers to adapt to shifting environmental conditions while safeguarding food security and protecting natural resources. Climate change is significantly impacting Bangladesh's agriculture sector, leading to reduced crop yields, increased salinity, and shifts in rainfall patterns. These changes threaten food security and livelihoods, particularly for coastal communities. However, Bangladesh is also pioneering green agriculture and adaptation strategies to mitigate these effects. Climate change poses significant challenges to Bangladesh's agriculture sector, but the country is actively working towards adaptation and mitigation strategies to build resilience and ensure food security. By promoting green agriculture, implementing water management techniques, and supporting farmers with the necessary resources and knowledge, Bangladesh can strive to overcome the challenges of climate change and build a more sustainable agricultural future. In this paper the author analysis the impact of environmental change on agriculture of Bangladesh. The study used trend analysis, Chi square test, and regression analysis for data analysis purposes.

1. Introduction

As climate change intensifies globally, low-lying delta countries such as Bangladesh face rising temperatures, erratic rainfall, sea-level rise, coastal salinity intrusion and more frequent extreme events, all of which already reduce yields and undermine food systems. (IPCC, 2022; Alotaibi, 2023; Sheikh, 2025). Bangladesh's agro-based economy remains central to food security, employment and GDP, yet is increasingly exposed to these climate shocks, with evidence of declining crop productivity and heightened production risk, particularly for smallholder farmers (Chowhan et al., 2023; Ahmed et al., 2024; Sheikh, 2025). Recent studies highlight how salinity in coastal zones, changing rainfall patterns and recurrent floods are reshaping cropping systems and threatening rural livelihoods (Bhuyan & Raju, 2018; Hasan et al., 2018; Rahman et al., 2022; Bhuyan et al., 2024). In response, Bangladesh has begun to promote a range of green and climate-smart agricultural (CSA) practices, including

improved water management, crop diversification, stress-tolerant varieties and resilient technologies, supported by national programs and investment projects (Hasan et al., 2018; Chapagain et al., 2023; Nandi et al., 2024; World Bank, 2024). Building on this context, the present study analyses the impacts of key environmental changes on Bangladeshi agriculture, using trend analysis, chi-square tests and regression models to examine the links between climate stressors and agricultural performance and to draw implications for future resilience strategies (Rahman et al., 2022; Sheikh, 2025).

The general objectives of this research are threefold: to identify the key environmental factors affecting agriculture in Bangladesh, to evaluate long-term agricultural trends within the country, and to assess the specific impact of climate change on agricultural productivity and sustainability (Habib et al., 2025; Uddin and Hoque, 2025). These are refined into specific objectives: first, to pinpoint the multifaceted factors affecting the agriculture of Bangladesh; second, to evaluate the historical and contemporary agricultural trends of the nation; and third, to

assess the tangible impact of environmental change on the agricultural sector (Rahman and Rahman, 2019; Saleem et al., 2025).

A growing body of literature firmly establishes that Bangladesh's agriculture, while vital, is significantly compromised by climate change, necessitating the immediate implementation of climate-resilient strategies (Chowdhury et al., 2022; Kibria et al., 2022; Majumder et al., 2024). The country's high vulnerability to climate-induced disasters such as floods, cyclones, and sea-level rise poses a direct threat to national food security and rural livelihoods (Rahman et al., 2024; Akter and Nasher, 2025; Tasnim et al., 2025). The impacts are multifaceted and severe. The increased frequency and intensity of extreme weather events including floods, droughts, cyclones, and heatwaves routinely disrupt agricultural production cycles and damage critical infrastructure (Rahman and Rahman 2019; Habib et al., 2025;). Concurrently, sea-level rise drives salinity intrusion into coastal soil and water sources, rendering vast tracts of previously arable land less productive (Miah et al., 2020; Ashrafuzzaman et al., 2022; Feist et al., 2025). Furthermore, erratic rainfall patterns, oscillating between prolonged dry spells and excessive downpours, create unreliable growing conditions that negatively affect crop growth and productivity (Uddin and Hoque, 2025; Saleem et al., 2025). These changing climatic conditions also foster increased pest and disease outbreaks, creating new challenges for crop protection (Pathak et al., 2018; Majumder et al., 2024). Cumulatively, these factors project a worrying trend of reduced agricultural productivity and overall output for Bangladesh (Chowdhury et al., 2022; Habib et al., 2025).

In recognition of these threats, the literature documents a range of climate-resilience measures being deployed in Bangladesh's agricultural sector. A cornerstone of this effort is the development and dissemination of climate-resilient crop varieties, such as those bred for flood tolerance, drought resistance, and salt tolerance (Debsharma et al., 2024). Parallel to this is the promotion of climate-smart agricultural practices, including techniques like alternative wetting and drying (AWD) irrigation, deep placement of urea fertilizer, and the incorporation of crop residues to enhance soil health and water use efficiency (Ruba et al., 2024). Strengthening disaster preparedness through early warning systems and robust response mechanisms is also deemed essential, particularly in highly exposed haor regions where recent flash floods have highlighted farmers' vulnerability and adaptation needs (Ferdushi et al., 2019). Other critical strategies include diversifying crops and farming systems to spread risk, promoting sustainable water

management to address scarcity, and enhancing agricultural research and development for long-term adaptation (Debsharma et al., 2024; Ruba et al., 2024). Empowering farmers through training and extension services, integrating valuable indigenous knowledge, and establishing supportive policy and institutional frameworks are all identified as vital components of a comprehensive resilience strategy (Ferdushi et al., 2019; Ruba et al., 2024).

Beyond the direct impacts of climate change, the sector contends with a host of other persistent challenges. Land degradation, driven by the loss of arable land to urbanization and industrialization, soil degradation from the overuse of agro-chemicals, and riverbank erosion, continues to shrink and impoverish the country's productive land base (Khan & Shoumik, 2022; Islam & Eusuf, 2025). In coastal zones, salinity intrusion and changes in ecosystem services further undermine agricultural potential and human well-being (Hossain et al., 2016). A rapidly growing population exerts immense pressure on food production systems, demanding increased output from a limited resource base, while recurrent riverbank erosion displaces farming households and disrupts production systems. These environmental stresses interact with climate variability to create increasingly fragile production conditions and raise the risk of crop failure (Habib et al., 2025).

Despite these formidable challenges, agriculture remains a cornerstone of the Bangladeshi economy, contributing significantly to GDP and employing a large portion of the workforce (Pervez et al., 2024). While its relative share of GDP is gradually decreasing with the growth of other sectors, its absolute importance for food security, poverty reduction, and rural development is undiminished (Habib et al., 2025). At the same time, most producers are smallholders who face persistent constraints in access to credit, technology, and markets, which limit their capacity to respond to these changes (Quddus & Kropp, 2020; Rayhan et al., 2023). Deficiencies in agricultural marketing and infrastructure, such as poor storage facilities, inadequate transportation, and post-harvest losses, further reduce profitability and raise income risk (Bhuya & Raju, 2018; Quddus & Kropp, 2020). The sector's future trajectory therefore hinges on its ability to navigate the dual demands of enhancing productivity to feed a growing nation while simultaneously adapting to and mitigating the effects of a changing climate (Pervez et al., 2024; Habib et al., 2025). This research contributes to this imperative by quantitatively examining the relationships between environmental stressors and agricultural outcomes, thereby providing evidence-based insights that can guide policy and practice in

building a climate-resilient agricultural future for Bangladesh.

The methodological approach of this study relies entirely on secondary data. District- and national-level information on cropped area and production for the six main crops was taken from the published statistics and reports of the relevant Bangladeshi agencies (e.g., agricultural sample survey reports and statistical yearbooks). These institutions already apply their own established sampling and estimation procedures to produce official area estimates. In the present study, we do not conduct any primary data collection; rather, we analyze only the aggregated figures reported in these official sources to examine long-term trends and relationships. For each crop, the area within sampled clusters is calculated, and the compiled data from cluster reports are analyzed at the Bangladesh Bureau of Statistics (BBS) headquarters.

The total acreage for a crop at the district level is subsequently derived using the method of ratio estimation, providing a reliable foundation for tracking agricultural trends and measuring impacts. Although a large body of work has examined the impacts of climate change on Bangladeshi agriculture, most existing studies are either local case studies focusing on a single hazard or crop, or they rely on simulation models without systematically linking observed environmental changes to long-run agricultural outcomes. Very few studies analyze national time-series data that combine multiple environmental stressors with area and production statistics for the main crops, and even fewer employ a consistent empirical framework to compare how different factors shape agricultural trends over several decades. Moreover, most of the literature discusses climate-smart or resilience strategies in qualitative terms, without grounding these discussions in an empirical assessment of how climatic and other environmental pressures are already reflected in aggregate agricultural performance.

This study fills these gaps in three ways. First, it compiles and harmonizes long-run, nationally representative secondary data on cropped area, production and yield for Bangladesh's six major crops together with key environmental indicators. Second, it applies to a transparent empirical strategy that combines trend analysis, chi-square tests and regression models to quantify the association between environmental stressors and agricultural outcomes at the national level. Third, by linking these empirical results to the ongoing policy discourse on climate-smart agriculture, the study provides evidence-based insights that can inform the prioritization of adaptation measures and investment in resilience. In doing so, the paper contributes a

country-level, data-driven perspective to the literature on climate change and agricultural sustainability in Bangladesh.

2. Materials and Methods

This study adopts a purely quantitative approach, relying exclusively on secondary numerical data and applying statistical techniques such as trend analysis, chi-square tests and regression models to examine the relationships between environmental stressors and agricultural outcomes.

Data Sources

The analysis primarily relies on secondary data obtained from reputable national sources. Key datasets include comprehensive agricultural statistics, damage reports, and production estimates published by the Bangladesh Bureau of Statistics (BBS). Furthermore, data from the Seed Wing of the Ministry of Agriculture and the Bangladesh Meteorological Department were utilized. These official sources provide a reliable and longitudinal basis for the study. The study adopts a purely quantitative approach, relying exclusively on these secondary numerical datasets and applying statistical techniques such as trend analysis, chi-square tests, and regression models.

Analytical Techniques

The data were subjected to a series of statistical analyses to address the research objectives.

Trend Analysis

Long-term changes in crop yields, climatic variables, and area allocations were examined using trend analysis. This technique was applied to data spanning multiple years (e.g., 2005-06 to 2020-21 for seed supply, and 2019-20 to 2022-23 for land use and crop production) to identify patterns of growth, decline, or stability in key agricultural indicators.

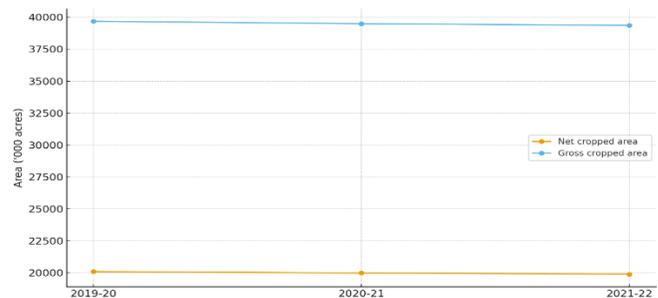


Figure 1. Trends in net and gross cropped area in Bangladesh, 2019–20 to 2021–22.

The line graph in figure 1 shows a mild but consistent decline in both net and gross cropped areas over the three-year period. Net cropped area fell from 20,081 to 19,875 thousand acres, while gross cropped area declined from 39,678 to 39,358 thousand acres, indicating gradual contraction of cultivated land and overall cropping intensity.



Figure 2. Changes in cropping pattern (single to quadruple cropped area), 2019–20 to 2021–22.

All categories of cropped areas declined slightly. Single-cropped land decreased from 5,216 to 5,084 thousand acres, double-cropped from 10,194 to 10,149, triple-cropped from 4,613 to 4,592, and quadruple-cropped from 56 to 50 thousand acres. This points to a modest reduction in multiple cropping and overall cropping frequency.

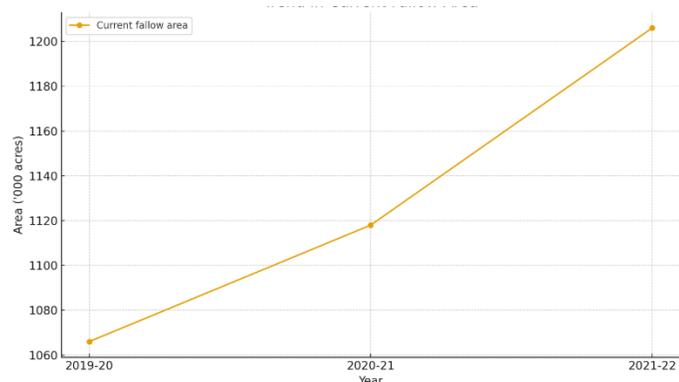


Figure 3. Trend in current fallow area, 2019–20 to 2021–22.

Current fallow land increased steadily from 1,066 to 1,206 thousand acres, suggesting that more land is being left uncultivated, possibly due to soil, water, labor, or profitability constraints.

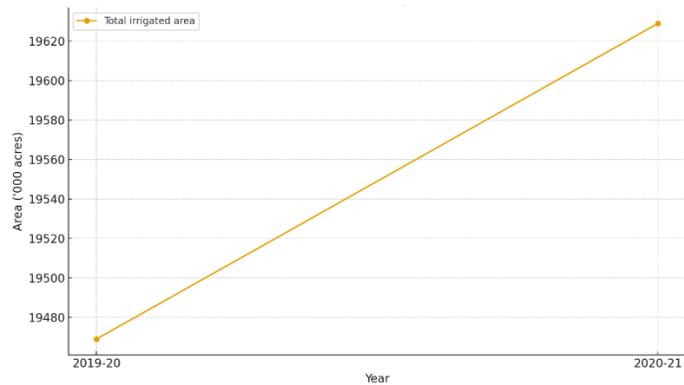


Figure 4. Trend in total irrigated area, 2019–20 to 2020–21.

Total irrigated area rose slightly from 19,469 to 19,629 thousand acres, indicating a modest expansion of irrigation coverage, although data for 2021–22 are not available.

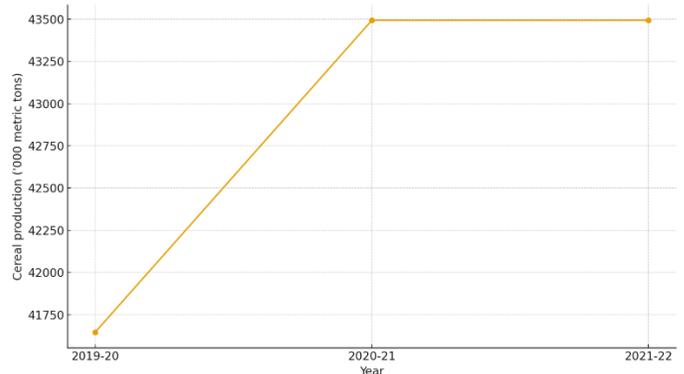


Figure 5. Trend in total cereal production in Bangladesh, 2019–20 to 2021–22.

Total cereal production increased from 41,647 to 43,493 thousand metric tons between 2019–20 and 2020–21 and then remained stable in 2021–22. This suggests that yield improvements or efficiency gains are compensated for by the decline in cropped areas.

Regression Analysis

Linear regression analysis was employed to quantify the relationship between continuous variables. Specifically, it was used to model the relationship between time and the demand and supply of seeds, providing a predictive understanding of future gaps. The model takes the form of $Y = a + bX$, where Y is the dependent variable (e.g., demand), and X is the independent variable (time).

Descriptive and Comparative Analysis

A significant portion of the analysis involves descriptive presentation and comparative examination of data. This includes comparing area, yield, and production figures for

major crops (Aus, Aman, Boro, oilseeds, spices, narcotics) across different years and districts. In the Bangladeshi context, *Aus*, *Aman* and *Boro* are the three major seasonal rice ecosystems, defined by their sowing and harvesting periods rather than by specific varieties. Aus rice is typically sown in the pre-monsoon (March–April) and harvested in June–July; Aman rice is transplanted during the monsoon (July–August) and harvested in November–December; Boro rice is irrigated dry-season rice, transplanted in December–January and harvested in April–May. In contrast, oilseeds, spices and narcotics in this study refer to crop groups: oilseeds (e.g., mustard, sesame), spices (e.g., chilli, onion, turmeric) and narcotic crops (e.g., tobacco). Damage data from specific natural disasters (e.g., Cyclone Bulbul, 2022 floods) were also analyzed to assess localized impacts on different crop types.

Scope and Data Treatment

The study covers multiple agricultural seasons and a wide range of crops central to food security in Bangladesh. All data, including tables on crop estimates and disaster damage, are presented and analyzed in their original form without alteration. References to specific data source, Chowdhury et al. (2022), are retained as provided in the original text.

3. Results and Discussion

Results

This section presents the findings from the comprehensive data analysis, followed by an integrated discussion that interprets these results in the context of Bangladesh's climate resilience challenges and strategies.

Table 1: Estimates of Total Area by Type of Aus Crops:

Variety	2021-22		2022-23		Percentage (%) changes over previous year
	Area (In acres)	Area (In Hectors)	Area (In acres)	Area (In Hectors)	
Local	248505	100569	209921	84954	(-)15.53%
HYV	2615582	1058511	2412484	976319	(-)7.76%
Total (Local+ HYV)	2864087	1159080	2622404	1061273	(-)8.44%

Aman Crop Analysis

The analysis of the Aman season revealed a more complex picture. While the total area under Aman cultivation remained nearly stable (+0.082%), the distribution among different cultivation methods changed significantly. The

Statistical Associations between Crop Varieties and Outcomes

The Chi-square tests revealed significant associations between crop varieties and agricultural performance metrics, underscoring the dynamic nature of agricultural decision-making in response to environmental and economic pressures.

Aus Crop Analysis

For the Aus season, a highly significant association was found between the variety of seeds (Local vs. HYV) and area allocation between 2021-22 and 2022-23 ($\chi^2 = 775.26$, $df=1$, $p < 0.05$). This is reflected in the data, which shows an 8.44% overall decrease in the area under Aus cultivation, with Local varieties declining more sharply (-15.53%) than HYVs (-7.76%) (Table 1: Estimates of Total Area by Type of Aus Crops). This suggests farmers are abandoning Aus cultivation, particularly local varieties, potentially due to lower profitability or heightened climate vulnerability early in the season.

A significant relationship was also confirmed between crop type and yield per area ($\chi^2 = 8.78$, $df=1$, $p < 0.05$). As shown in the yield table, HYV Aus consistently yielded significantly more (2.846 MT/Hectare in 2022-23) than local varieties (1.438 MT/Hectare). Despite this yield advantage for HYVs, which increased by 5.60% overall, total Aus production fell by 3.32% due to the substantial reduction in cultivated area. The association between variety and production distribution between the two years was also significant ($\chi^2 = 100.17$, $df=1$, $p < 0.05$), confirming that the decline was not uniform across varieties.

Chi-square test confirmed a significant association between the type of Aman crop and the distribution of area between years. The data shows a marked shift: the area under Broadcast (traditional) methods and Local Transplant (L.T.) decreased by 11.77% and 5.05%, respectively, while the area under HYV Aman increased by 1.48% (Table 2:

Estimates of Total Area by Type of Aman Crops). This indicates a clear transition towards more productive and potentially more resilient hybrid varieties, a key adaptation strategy.

Table 2: Estimates of Total Area by Type of Aman Crops

Variety	2021-22		2022-23		Percentage (%) changes over previous year
	Area (in acres)	Area (in Hectors)	Area (in acres)	Area (in Hectors)	
Broadcast	614084	248528	541716	219264	(-)11.774%
Local Transplant (L.T)	1785670	722663	1695485	686164	(-)5.050%
High Yielding Variety (HYV)	11732031	4748936	11906085	4819394	(+)1.484%
Total (Broadcast+L.T.+HYV)	14131786	5720127	14143347	5724822	(+)0.082%

Furthermore, yield rates improved across all categories in 2022-23, with the most substantial gain seen in L.T. (+7.44%), suggesting that improvements in agronomic practices are benefiting both traditional and modern methods. Consequently, despite the damage from Cyclone Bulbul noted in the methodology, total Aman production increased by 3.13%, driven overwhelmingly by the growth in HYV output (+3.51%).

The Overarching Impact of Climate Change and Extreme Weather

The regression analysis of seed demand and supply from 2005-06 to 2020-21 reveals a critical long-term challenge. The demand for seeds is increasing at a rate of approximately 42,856 MT per year ($\text{Demand} = 42,856x + 896,509$), while supply is increasing at a much slower rate of 13,264 MT per year ($\text{Supply} = 13,264x + 162,702$). This growing gap underscores the intensifying pressure on the

agricultural system to meet the needs of a growing population amidst environmental constraints.

Salinity Intrusion

Projections of sea-level rise (SLR) present a grave threat. By 2050, a 50 cm SLR is predicted, coupled with a temperature increase of up to 1.8°C in winter (Table 3: Prediction of SLR and temperature). This directly contributes to salinity intrusion, with devastating effects. Data shows that between 1990 and 2030, total rice production losses due to salinity are projected to increase by 38.5%, from 196.40 thousand tons to 272.00 thousand tons (Table 4: Prediction of possible loss of rice production due to salinity). The Aman season is disproportionately affected, with losses projected to surge by 50%. This aligns with the Chi-square results showing the sensitivity of Aman cultivation methods, highlighting salinity as a primary driver of crop vulnerability, particularly in coastal regions.

Table 3: Prediction of SLR and temperature in 2030 and 2050 in Bangladesh

Year	Climate change Scenarios: Sea level rise(cm)	Temperature Increase (Degree Celcius)
2030	30	+0.7 in monsoon; +1.3 in winter
2050	50	+1.1 in monsoon; +1.8 in winter

Source: On base year (1990): average winter temp: 19.90C and average monsoon temp:28.7 degree Celsius.

Sea level rise is projected to accelerate over time, with levels expected to be about 20 cm higher by 2050 than they are in 2030, representing roughly a 66.7% increase. Temperatures are also expected to climb, with monsoon temperatures rising by around 0.4°C (about 57% above the 2030 level) and winter temperatures increasing by about 0.5°C (approximately 38.5% above the 2030 level). Overall, these

trends suggest that climate change impacts intensify rather than grow in a straight line, with both sea-level rise and warming appearing to speed up over time (Rahman & Rahman, 2019). Winter warming is projected to remain higher than monsoon warming in both years, although the monsoon period shows a faster rate of increase between 2030 and 2050 (Rahman & Rahman, 2019).

Table 4. Prediction of possible loss of rice production due to salinity:

Year	Loss of rice production due to salinity (in'000 ton)		
	Aus	Aman	Total
1990(Base Year)	65.60	130.80	196.40
2030	75.80	196.20	272.00

Floods and Cyclones

The impact of extreme weather events is profound and recurrent. Between 2015 and 2020, natural disasters caused crop damage worth BDT 517,961 million (BBS, 2022). Analysis of historical flood data (2007-2016) shows that all

three major rice seasons Aus, Aman, and Boro have suffered massive losses in different years (Table 5: The losses of crop production due to recent floods in Bangladesh). For instance, the Boro crop, a dry-season crop reliant on irrigation, experienced a loss of 369,591 MT in 2009-10, demonstrating that no season is immune to climatic shocks.

Table- 5. The losses of crop production due to recent floods in Bangladesh:

Crop's name	Loss in production (M.ton) due to floods from 2007 to 2015:						
	2007-08	2008-09	2010-11	2009-10	2011-12	2014-15	2015-16
Aus	94164	990	--	---	7519	7077	17395
Aman	230681	113465	12580	--	70014	125250	102254
Boro	--	--	--	369591	--	--	97592
Jute	46145	--	-	--	--	--	--
Sugarcane	116387	--	--	--	--	-	--
Vegetables	99614	670	--	--	5242	79	--
Banana	7014	--	--	--	--	--	-
Pineapple	2815	--	--	--	--	--	--
Papaya	2386	30034	--	--	--	--	--
Maize	1743	745	--	--	--	--	--
Ginger	1084	--	--	--	--	--	--
Chilies	2204	622	--	--	2542	--	--

M. Ton= Metric Ton

The damage reports from specific events in the study period provide granular insight. For example, in the July 2022 floods, HYV Aman was the most severely affected crop in absolute terms, with a total production loss of 812,454 MT across Bangladesh, with districts like Rangpur and Naogaon being epicenters of damage (Table 6: Damage of different

crops due to flood and excessive rain). Conversely, Cyclone Bulbul in 2019-20 caused significant damage to high-value crops like Ripe Banana in Pirojpur, resulting in a loss of 3,881 MT. This illustrates the diverse nature of climatic threats, from widespread inundation that devastates staple grains to localized cyclones that destroy cash crops.

Table 6: Damage of different crops due to flood and excessive rain in the month of July & August;

Name of crops & region	Area damaged (Acres)		Percentage of partial damage	Area in terms of full damage (Caused by partial damaged	Total area damaged (Acres (Col 2	Yield per acre (Kg	Production loss in Metric Ton
	Fully	partially					
Local Aus							
Rangamati	989	1356	18.00	244	1233	15.30	704
Sylhet	344	655	35.00	230	574	16.20	347
Sirajganj	132	--	---	--	132	13.20	65
Bangladesh	1465	2011	24.00	474	1939	15.42	1116
HYV Aus							
Noakhali	1434	1550	3.00	52	1486	23.63	1311
Rangamati	187	392	26.00	102	289	22.30	241
Maulvibazar	1257	2053	40.00	821	2078	30.30	2350
Sylhet	2391	4518	38.00	1717	4108	28.00	4294
Sirajganj	178	609	44	268	446	26.79	446
Rajshahi	24811	2382	63.00	1507	26318	29.20	28686
Naogaon	17152	7170	30.00	2151	19303	29.39	21176
Chapai	257	9729	45.00	4378	4635	28.10	4862
Nawabganj							
Bangladesh	47667	28403	39.00	10996	58663	28.94	63366
Total Aus (Local+ HYV)							
Noakhali	1434	1550	3.00	52	1486	23.63	1311
Rangamati	1176	1748	20.00	346	1522	16.63	945
Maulvibazar	1257	2053	40.00	821	2078	30.30	2350
Sylhet	2735	5173	38.00	1947	4682	26.55	4641
Sirajganj	310	609	44.00	268	578	23.68	511
Rajshahi	24811	2382	63.00	1507	26318	29.20	28686
Naogaon	17152	7170	30.00	2151	19303	29.39	21176
Chapai	257	9729	45.00	4378	4635	28.10	4862
Nawabganj							
Bangladesh	49132	30414	38.00	11470	60602	28.50	64482
Broadcast (Aman)							
Sirajganj	3022	9817	36.00	3534	6556	13.60	3328
Bangladesh	3022	9817	36.00	3534	6556	13.60	3328
HYV Aman							
Jamalpur	67516	41795	45.00	18808	86324	28.90	93123
Sherpur	4711	6944	52.00	3611	8322	27.96	8685
Netrokona	15182	25328	34.00	8612	23794	28.70	25490
Mymensingh	18127	51470	12.00	6176	24303	28.80	26126
Joypurhat	14089	13839	44.00	6135	20224	31.60	23855
Rajshahi	5197	1031	51.00	529	5726	32.20	6882
Naogaon	99144	28896	38.00	10980	110124	32.95	135446

Chapai Nawabganj	937	1631	37.00	603	1540	31.17	1792
Rangpur	254421	473641	26.00	123147	377568	30.64	431828
Gaibandha	28277	49915	53.00	26455	54732	28.99	59227
Bangladesh	507601	694490	29.00	205056	712657	30.54	812454
Total Aman (Broadcast+ HYV)							
Sirajganj	3022	9817	36.00	3534	6556	13.60	3328
Jamalpur	67516	41795	45.00	18808	86324	28.90	93123

Here is a comparative analysis of the damaged crop data. The comparison is structured by crop type (Local Aus, HYV Aus, Aman - Broadcast, Aman - HYV, and Total Aman) and key metrics such as area damaged, production loss, and yield impact.

Trends in Land Use and Crop Production

The trend analysis of agricultural land from 2019-20 to 2021-22 reveals several concerning patterns.

- **Net Cropped Area:** Decreased from 20,081 to 19,875 ('000 acres).
- **Current Fallow Area:** Increased from 1,066 to 1,206 ('000 acres).
- **Gross Cropped Area and Cropping Intensity:** All categories (single, double, triple) showed a minor decline.

These trends suggest a contraction in active agricultural land, likely due to urbanization, land degradation, and the salinization of arable land. The increase in fallow land is particularly alarming, potentially indicating farmer discouragement due to climate-induced losses or soil fertility issues. However, this is juxtaposed with a steady increase in total cereal production, which plateaued at 43,493 ('000 M.Tons) in 2020-21 and 2021-22. This indicates that productivity gains through the adoption of HYVs and improved practices are, for now, offsetting the loss of cultivated areas, but this trend may be unsustainable.

Resilience and Adaptation: Evidence from Diversified Sectors

Analysis of non-cereal sectors reveals important insights into agricultural adaptation and economic diversification.

Oilseeds and Spices

The oilseed sector shows promising growth. The grand total area under oilseed increased by 10.25% from 2020-21 to 2022-23, and production surged by 17.67%. This growth was primarily driven by Rape & Mustard, which saw a 38% increase in production, and Soybean, which saw an 18% increase. Similarly, the production of spices and condiments

grew consistently, with total output rising from 3.59 million MT in 2020-21 to 4.12 million MT in 2022-23. The growth in these high-value sectors indicates a successful diversification away from an exclusive focus on rice, which enhances income security and potentially builds resilience against climate shocks that specifically affect cereals.

Drugs and Narcotics

The regression analysis for drugs and narcotics crops showed varying relationships between cultivated area and production. Betel Leaves exhibited a very strong positive linear relationship ($R^2 \approx 0.91$), while Tobacco also showed a good fit ($R^2 \approx 0.89$). However, Tea showed only a moderate correlation ($R^2 \approx 0.53$), and Betelnut a very poor one ($R^2 \approx 0.03$), the latter likely due to a dramatic reported drop in area in 2022-23 not matched by a proportional drop in production. This anomaly could indicate significant yield improvements or a data reporting issue. The overall slight decline in total area for this sector suggests other land-use pressures or shifting economic priorities.

Synthesis and Interpretation

The results collectively paint a picture of an agricultural sector under severe stress but actively adapting. The highly significant Chi-square results confirm that farmer behavior, reflected in crop variety choice and area allocation, is responsive to changing conditions. The widespread decline in local varieties in favor of HYVs is a rational response to the dual pressures of ensuring food security and adapting to climate change, given the superior yield potential of HYVs.

The projections and recorded data on salinity, sea-level rise, and extreme weather events provide the "why" behind these shifts. The gradual loss of arable land and the increasing fallow area are direct consequences of these environmental pressures. However, the resilience of the sector is evidenced by the steady cereal production despite land loss, and the robust growth in oilseeds and spices. This aligns with the literature review, which highlighted climate-resilient crop varieties and diversified farming systems as key adaptation measures.

The core of the discussion lies in interpreting the regression results on seed demand and supply. The widening gap is a stark warning. It symbolizes the growing disconnect between the escalating needs of the population and the capacity of a climate-stressed agricultural system to meet them. This analysis strongly supports the claim that under a business-as-usual scenario, the country faces significant agricultural losses, potentially up to USD 7.7 billion annually, with rice production falling by 33% in the next two decades.

In conclusion, the results confirm a statistically significant link between environmental stressors and agricultural performance in Bangladesh. The adoption of HYVs and diversification into resilient crops are positive signs of adaptation. However, the relentless pressures of salinity, extreme weather, and land degradation, compounded by a systemic gap between seed demand and supply, threaten to overwhelm these efforts. This underscores the critical need for accelerated investment in climate-smart agriculture, as outlined in the literature review, to bridge this gap and secure the future of agriculture in Bangladesh.

4. Conclusion & Recommendations:

Climate change poses significant challenges to agriculture in Bangladesh, a country heavily reliant on farming, due to increased frequency and intensity of extreme weather events like floods and droughts. These events can severely impact crop yields, leading to food insecurity. However, Bangladesh is also actively pursuing climate-resilient and green agriculture practices to mitigate these effects and enhance food production.

Bangladesh's agriculturally based economy is under increasing stress due to environmental changes, but proactive adaptation strategies, particularly green agriculture, show promising results. The government and development partners should further scale up support for climate-resilient practices, improve farmer access to climate information and technology, and invest in infrastructure for water conservation and saline-resilient crop varieties. These efforts are essential for safeguarding food security and promoting sustainable agricultural development in the face of a changing climate.

5. References

Ahmed, A., Bakhtiar, M. M., Hoddinott, J., & Roy, S. (2024). *Does nutrition-sensitive social protection build longer-term resilience? Experimental evidence from Bangladesh* (No. 2282). International Food Policy Research Institute (IFPRI). <https://doi.org/10.55158/DEEPWP25>

- Akter, M. M., & Nasher, N. R. (2025). Climate change impact on food security: Household-level adaptation barriers to Charland community in Bangladesh. *World Development Perspectives*, 37, 100656. <https://doi.org/10.1016/j.wdp.2025.100656>.
- Alotaibi, M. (2023). Climate change, its impact on crop production, challenges, and possible solutions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 51(1), 13020-13020. [10.15835/nbha51113020](https://doi.org/10.15835/nbha51113020)
- Ashrafuzzaman, M., Artemi, C., Santos, F. D., & Schmidt, L. (2022). Current and future salinity intrusion in the south-western coastal region of Bangladesh. *Spanish Journal of Soil Science*, 12, 10017. <https://doi.org/10.3389/sjss.2022.10017>.
- Bhuyan, M. I., Supit, I., Kumar, U., Mia, S., & Ludwig, F. (2024). The significance of farmers' climate change and salinity perceptions for on-farm adaptation strategies in the south-central coast of Bangladesh. *Journal of Agriculture and Food Research*, 16, 101097. <https://doi.org/10.1016/j.jafr.2024.101097>
- Bhuyan, M. S., & Raju, V. (2018). Post-Harvest losses and marketing technologies of agricultural products in Bangladesh. *International Journal of Marketing & Human Resource Management*, 9(1), 18-30. DOI: [10.34218/IJMHRM.9.1.2018.002](https://doi.org/10.34218/IJMHRM.9.1.2018.002)
- Chapagain, T. R., Karki, T. B., Shah, P., Acharya, G. D., Gyeltshen, K., Islam, M. R., & Hossain, M. B. (2023). Climate-smart agriculture technologies and practices in Nepal. *SAARC Agriculture Centre, SAARC, Dhaka, Bangladesh*, 82p. ISBN Number: 978-984-35-4878-8
- Chowdhury, M. M. I., Rahman, S. M., Al Amran, M. I. U., Malik, K., Abubakar, I. R., Aina, Y. A., & Hasan, M. A. (2022). Climate change impacts on food system security and sustainability in Bangladesh. <https://doi.org/10.21203/rs.3.rs-1673139/v1>.
- Chowhan, S., Sultana, R., Md, A. R., & Islam, M. (2023). Contribution of agriculture sector in the GDP growth of Bangladesh. *Food and Agri Economics Review*, 3(2), 51-54. doi: <http://doi.org/10.26480/faer.02.2023.51.54>
- Debsharma, S. K., Rahman, M. A., Khatun, M., Disha, R. F., Jahan, N., Quddus, M. R., & Kabir, M. S. (2024). Developing climate-resilient rice varieties (BRRI dhan97 and BRRI dhan99) suitable for salt-stress environments in Bangladesh. *Plos one*, 19(1), e0294573. <https://doi.org/10.1371/journal.pone.0294573>
- Feist, S. E., Hoque, M. A., Islam, M. A., Dewan, A., & Fowler, M. (2025). Sea-level rise drives changes in salinisation patterns in low-lying Bangladesh. *Ecological Indicators*, 176, 113543. <https://doi.org/10.1016/j.ecolind.2025.113543>.

- Ferdushi, K. F., Ismail, M. T., & Kamil, A. A. (2019). Perceptions, knowledge and adaptation about climate change: A Study on farmers of Haor areas after a flash flood in Bangladesh. *Climate*, 7(7), 85. <https://doi.org/10.3390/cli7070085>
- Habib, M. A., Babur, K. A. R., Islam, M. M., Akter, N., Bari, M. S., Bashir, M. A., & Ali, M. M. (2025). Climate Change Dynamics and Their Effects on Bangladeshi Agriculture: A Systemic Review. *Nature-Based Solutions*, 100275. <https://doi.org/10.1016/j.nbsj.2025.100275>
- Hasan, M. K., Desiere, S., D'Haese, M., & Kumar, L. (2018). Impact of climate-smart agriculture adoption on the food security of coastal farmers in Bangladesh. *Food Security*, 10(4), 1073-1088. <https://doi.org/10.1007/s12571-018-0824-1>
- Hossain, M. S., Dearing, J. A., Rahman, M. M., & Salehin, M. (2016). Recent changes in ecosystem services and human well-being in the Bangladesh coastal zone. *Regional Environmental Change*, 16(2), 429-443. [DOI 10.1007/s10113-014-0748-z](https://doi.org/10.1007/s10113-014-0748-z)
- IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Working Group II contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/?utm>
- Islam, M. D., & Eusuf, M. A. (2025). Analysing the National Plans of Bangladesh for Their Effectiveness in Mitigating Socio-economic and Environmental Vulnerabilities in Char Areas. *Asia-Pacific Journal of Rural Development*, 35(1), 112-131. <https://doi.org/10.1177/10185291251343346>
- Khan, M. Z., & Shoumik, B. A. (2022). Land degradation neutrality concerns in Bangladesh. *Soil Security*, 9, 100075. <https://doi.org/10.1016/j.soisec.2022.100075>
- Kibria, G., Pavel, H. R., Miah, M. R., & Islam, M. R. (2022). Impacts of climate change in Bangladesh and its consequences on public health. *Journal of Sustainability and Environmental Management*, 1(3), 359-370. Available online at <https://www.nepjol.info/index.php/josem>
- Majumder, M. K., Rahman, M., Mondal, R. K., & Akter, M. (2024). Climate-smart agriculture and food security in climate-vulnerable coastal areas of Bangladesh. *Heliyon*, 10(22). <https://doi.org/10.1016/j.heliyon.2024.e39885>
- Miah, M. Y., Kamal, M. Z. U., Salam, M. A., & Islam, M. S. (2020). Impact of salinity intrusion on agriculture of Southwest Bangladesh-A review. *International Journal of Agricultural Policy and Research*. <https://doi.org/10.15739/IJAPR.20.005>
- Nandi, R., Krupnik, T. J., & Kabir, W. (2024). Crop diversification in Bangladesh: Public policy provisions, practices, and insights for future initiatives. *Journal of Agriculture and Food Research*, 18, 101486. <https://doi.org/10.1016/j.jafr.2024.101486>
- Pathak, H., Pal, B. D., & Joshi, P. K. (2018). Climate change induced salinity intrusion and its implications for agriculture. <https://cgspace.cgiar.org/server/api/core/bitstreams/3ae25eea-b6e4-4238-a930-261d5921843b/content>
- Pervez, M., Ahmed, Z., Uddin, M. S., & Rahman, M. M. (2024). Agricultural Output and Economic Growth Nexus: A VECM Approach on Bangladesh. *Journal of Agricultural Sciences*, 30(4), 644-657. [doi: 10.15832/ankutbd.1388810](https://doi.org/10.15832/ankutbd.1388810)
- Quddus, A., & Kropp, J. D. (2020). Constraints to agricultural production and marketing in the lagging regions of Bangladesh. *Sustainability*, 12(10), 3956. <https://doi.org/10.3390/su12103956>
- Rahman, M. S., & Rahman, M. A. (2019). Impacts of climate change on crop production in Bangladesh: a review. *Journal of Agriculture and Crops*, 5(1), 6-14. [doi: https://doi.org/10.32861/jac.51.6.14](https://doi.org/10.32861/jac.51.6.14)
- Rahman, J., Foissal, M. Z. U., Mohajan, B., & Islam, S. (2022). Nexus between agriculture, economy, energy use, and ecological footprint toward sustainable development in Bangladesh. *Journal of environmental and energy economics*, 1(2), 18-31. [DOI: 10.56946/JEEE.V1I2.486](https://doi.org/10.56946/JEEE.V1I2.486)
- Rahman, M. M., Chowdhury, M. M. I., Al Amran, M. I. U., Malik, K., Abubakar, I. R., Aina, Y. A., & Rahman, S. M. (2024). Impacts of climate change on food system security and sustainability in Bangladesh. *Journal of Water and Climate Change*, 15(5), 2162-2187. [doi: 10.2166/wcc.2024.631](https://doi.org/10.2166/wcc.2024.631)
- Rayhan, S. J., Rahman, M. S., & Lyu, K. (2023). The role of rural credit in agricultural technology adoption: The case of Boro rice farming in Bangladesh. *Agriculture*, 13(12), 2179. <https://doi.org/10.3390/agriculture13122179>
- Ruba, U. B., Talucder, M. S. A., Zaman, M. N., Montaha, S., Tumpa, M. F. A., Duel, M. A. K., & Triza, A. H. (2024). The status of implemented climate smart agriculture practices preferred by farmers of haor area as a climate resilient approach. *Heliyon*, 10(4).
- Saleem, A., Anwar, S., Nawaz, T., Fahad, S., Saud, S., Ur Rahman, T., & Nawaz, T. (2025). Securing a sustainable future: the climate change threat to agriculture, food security, and sustainable development goals. *Journal of Umm Al-Qura University for Applied Sciences*, 11(3), 595-611. <https://doi.org/10.1007/s43994-024-00177-3>
- Sheikh, M. M., & Pervez, A. K. M. K. (2025). Climate change and agriculture in Bangladesh: impacts and adaptation

- strategies: Climate Change and Agricultural Adaptation in Bangladesh. *Bangladesh Journal of Agriculture*, 50(1), 132-148. Tasnim, I., Iqbal, M. A., Begum, I. A., Alam, M. J., Graversgaard, M., Sarma, P. K., & Manevski, K. (2025). Household resilience and its role in sustaining food security in rural Bangladesh. *PLoS One*, 20(9), e0332868. <https://doi.org/10.1371/journal.pone.0332868>
- Uddin, M. M., & Hoque, M. A. (2025). Climate Change Trends and Vulnerabilities in Bangladesh's Crop Sector: A Review of Crop Production Challenges and Resilience Strategies. *Turkish Journal of Agriculture-Food Science and Technology*, 13(2), 258-272. DOI: <https://doi.org/10.24925/turjaf.v13i2.258-272.6923>
- World Bank. (2024). *Bangladesh Climate-Smart Agriculture and Water Management Project: Supporting farmers with technology for increased productivity and climate resilience* (Project document). World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099055401032414144?>