SOUTH ASIA POLICY PERSPECTIVES #05 SEPTEMBER 2025

Climate-Smart Agriculture Technologies in Bangladesh

Adoption, Policy Barriers, and Way Forward

Introduction

This discussion brief is part of the knowledge management and capacity building component of the Consortium for Scaling-up Climate-Smart Agriculture in South Asia (C-SUCSeS) project. C-SUCSeS is a joint initiative between the SAARC[1] Agriculture Centre (SAC), International Fund for Agriculture Development (IFAD) and International Food Policy Research Institute (IFPRI). It aims to promote bottom-up applied research on climate-smart agriculture (CSA) technologies through active participation of smallholder farmers based on the participatory research experiences in the region.

As part of the knowledge management and capacity building component, the project partners were required to develop a community of practice in the target countries including Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. In line with this mandate, IFPRI organized a series of regional forums that aimed to provide a collaborative platform for researchers, extension officials, private sector organizations, entrepreneurs, and practitioners. These forums involved webinars and discussions that allowed various stakeholders to exchange knowledge, share practical experiences, and update each other on the latest CSA technologies and innovations from their respective countries. Furthermore, they facilitated mutual learning, enabling participants to explore diverse challenges and discuss specific technical, social, and policy-related issues surrounding CSA implementation.

The first forum on CSA in Bangladesh was organized on December 13, 2022, featuring a presentation by Dr. Md. Ayub Hossain, Chief Scientific Officer, farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute (BARI), Gazipur. The session was moderated by Dr. Md. Baktear Hossain, Director, SAC. Dr. Ayub Hossain's presentation provided an overview of agriculture in Bangladesh, highlighted the vulnerability of the sector to climate change impacts, and discussed current levels of adoption for CSA technologies. He emphasized that CSA aims to enhance agricultural productivity, improve resilience to climate impacts, and reduce greenhouse gas emissions. Given Bangladesh's high vulnerability to climate-induced stresses like flooding, drought, and salinity intrusion, adopting CSA practices has become critical. CSA also aligns with Bangladesh's commitments

[1] South Asian Association for Regional Cooperation (SAARC) is the regional intergovernmental organization and geopolitical union of the countries in South Asia - Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

under the Nationally Determined Contributions (NDCs), particularly targets related to climate adaptation and sustainable agriculture. The webinar also examined existing barriers to adopting these technologies and explored actionable steps to overcome these constraints.

Agriculture Sector in Bangladesh

Features: Bangladesh, a relatively small country in South Asia, is one of the most densely populated countries in the world and is home to approximately 165 million people. This demographic pressure places immense demand on its agricultural systems. The country exhibits high cropping intensity, with farmers practicing single, double, and even triple cropping in a year to meet the food requirements of its growing population. Agriculture occupies 70% of the total land area, and rice alone accounts for nearly 76% of the cultivated land. The remaining area is used for a diverse range of crops including wheat, maize, potatoes, pulses, oilseeds, sugarcane, jute, and tea. Despite being a small country, Bangladesh has a diverse physical geography, and the country is divided into 30 agroecological zones (AEZs) and 88 agroecological sub-regions, based on topography, flooding patterns, and soil types.

Challenges: The agriculture sector in Bangladesh faces several critical challenges.

1. The foremost is ensuring food security for a growing population, which represents 2.1% of the global total. The difficulty of providing food from limited land is exacerbated by the fact that Bangladesh loses about 8,000 hectares of cultivable land annually due to urban expansion, infrastructure development, human settlement, and riverbank erosion. In 2022 alone, river erosion led to the loss of 2,270 hectares of land and displaced an estimated 64,000 people and destabilized their livelihoods.

2. Soil fertility is also under severe stress. While farmers are increasingly pushing for higher yields—often cultivating two to three crops annually—there is limited evidence of returning organic matter or crop residues to the soil, resulting in nutrient depletion. Currently, around 11.07 million hectares of land is categorized as nutrient-deficient in Bangladesh.

3. Another pressing concern is the declining groundwater table, particularly in drought-prone regions. Groundwater extraction has long exceeded natural recharge rates, leading to a significant and persistent drop in water levels.

4. The increased frequency and intensity of extreme weather events caused due to climate change has further exacerbated some of these challenges. Farmers are experiencing longer and hotter summers, warmer winters, and more erratic monsoons. These shifts have led to flash floods, droughts, and unpredictable rainfall patterns—causing serious disruptions to traditional cropping cycles, particularly sowing of the rice crop. Salinity intrusion in coastal areas is expanding rapidly due to rising sea levels and seawater encroachment.

The Government of Bangladesh has identified six major agricultural hotspots that are especially vulnerable to climate change. These include:

- Salinity-affected areas (1.06 million ha),
- Drought-prone regions (3.5 million ha),
- Waterlogged lands (2.6 million ha),
- Charland (0.82 million ha),
- Haor areas (standing water zones, 0.86 million ha), and
- Hilly regions (1.81 million ha).

Together, these hotspot areas constitute about 60% of the total arable land in the country and present increased challenges to the farmers in these regions.

Intersection of climate change and agriculture in Bangladesh: Between 2000 and 2019, Bangladesh experienced 185 extreme weather events—including cyclones and flash floods—leading to an estimated economic loss of $3.72 billion. The lower elevation in the coastal regions of the country (only around 9m above mean sea level) makes it particularly vulnerable to sea-level rise, which has been occurring at a rate of 9–21 mm per year over the past 30 years. This has led to a sharp increase in salinity-affected areas in Bangladesh, which have grown from 83.3 million hectares in 1973 to 105.6 million hectares in 2009 and continue to expand.

Despite the high vulnerability of the agriculture sector to climate change, it is also a contributor to greenhouse gas (GHG) emissions. In Bangladesh, 33% of agricultural GHG emissions come from rice cultivation, the country's principal crop. To address these interlinked challenges, the country must strengthen efforts to conserve soil, water, and biodiversity. There is also a pressing need to enhance resource efficiency and promote sustainable practices that improve soil health and long-term productivity. Moreover, investment in mechanization and digital technologies is essential to modernize the sector, and in this context, climate-smart interventions provide huge opportunities to tackle the most pressing challenges in the agriculture sector in Bangladesh.

Strategies for Agriculture, Food, and Nutrition Security

To ensure sustainable agriculture, food, and nutrition security, the Government of Bangladesh is promoting a range of strategies aimed at building resilience in agricultural systems. These include diversifying crop portfolios to align with changing climate conditions and encouraging a shift from subsistence to commercial farming. The use of nanotechnology-based fertilizers is also being explored to reduce overall fertilizer consumption while maintaining soil health and productivity.

Bangladesh's cropping intensity—currently around 198%—offers further potential for increasing land productivity. The Bangladesh Agricultural Research Institute (BARI) is actively working to enhance cropping intensity by optimizing temporary cropping systems. In parallel, innovative approaches such as vertical farming, rooftop gardening, hydroponics, and floating agriculture are being promoted as alternative methods to increase food production in limited spaces.

CSA Technologies in Bangladesh

Climate-smart agriculture (CSA) technologies are increasingly emerging as a solution to tackle existing difficulties and prepare farmers for the future challenges. The three pillars of CSA—sustainably increasing productivity and incomes, strengthening resilience, and reducing greenhouse gas emissions—guide these efforts. Several CSA technologies, some of which are listed below, are practiced across different agroecological zones in Bangladesh.

5. ***Conservation Agriculture:*** Zero tillage and strip planting, both categorized as conservation agriculture, are increasingly becoming popular in Bangladesh. Under this technology, relay planting of lentils is done 10 days prior to rice harvest, while leaving a 20 cm straw layer. It helps retain soil moisture and reduces input costs. Similarly, strip tillage, where only parts of the land where the seeds are sown, are tilled, is another example of conservation agriculture. It not only enhances efficiency and reduces carbon emissions but also lead to increase in productivity.

6. ***Bed planter technology:*** Developed by BARI, this mechanized implement forms raised soil beds and simultaneously sows seeds (e.g., wheat, maize). It improves yields by 10–15%, reduces pest incidence (e.g., rats in wheat), and enhances irrigation efficiency by retaining soil moisture longer. It also reduces CO_2 emissions by up to 44% compared to traditional tillage.

7. ***Water-Smart Irrigation Technologies:*** Solar-powered and axial flow pumps: Solar irrigation pumps are increasingly used to replace diesel-based systems, cutting down greenhouse gas emissions. The axial flow pump, also developed by BARI, is more fuel-efficient (30% less than centrifugal pumps) and provides high water discharge at low heads (3–5 meters), making it suitable for surface water irrigation.

8. ***Zero tillage with mulching for garlic:*** This long-practiced method leverages residual moisture from the previous rice crop, reducing water demand and enhancing garlic yield and bulb size. It is considered a successful CSA practice in water-scarce areas.

9. ***Conjunctive use of saline and freshwater:*** In saline-prone areas, farmers are adopting irrigation systems that combine mildly saline water with freshwater. Saline water is applied during mid-to-late crop stages. This approach results in only a 5–6% reduction in yield, offering a viable option where freshwater is scarce.

10. ***Alternate furrow irrigation:*** For row crops, this technique involves irrigating alternate furrows while leaving the adjacent ones dry. In the next cycle, the process is reversed. This method reduces water use by 35–40% without sacrificing yield.

11. ***Promotion of drought-tolerant crop varieties:*** In drought-prone regions, low water-requirement crops such as chickpea, lentil, mustard, white grain maize, and barley are being encouraged. These crops provide stable yields even under moisture stress conditions.

In addition to the above, Bangladesh also has some area-specific CSA innovations:

12. ***Sorjan farming system:*** In waterlogged and flood-prone regions like southern Bangladesh and the haor areas, the sorjan system—raised floating beds for upland crops—has become an effective adaptation strategy, enabling year-round cultivation in otherwise unproductive lands.

13. ***Char land agriculture:*** Char land are sandy, low-organic matter landmasses formed through river sedimentation. Bangladesh has nearly 0.8 million hectares of such land, much of which is cultivable. Through the use of improved crop varieties and site-specific management practices, yields—especially for horticultural crops—have seen notable improvement in these areas.

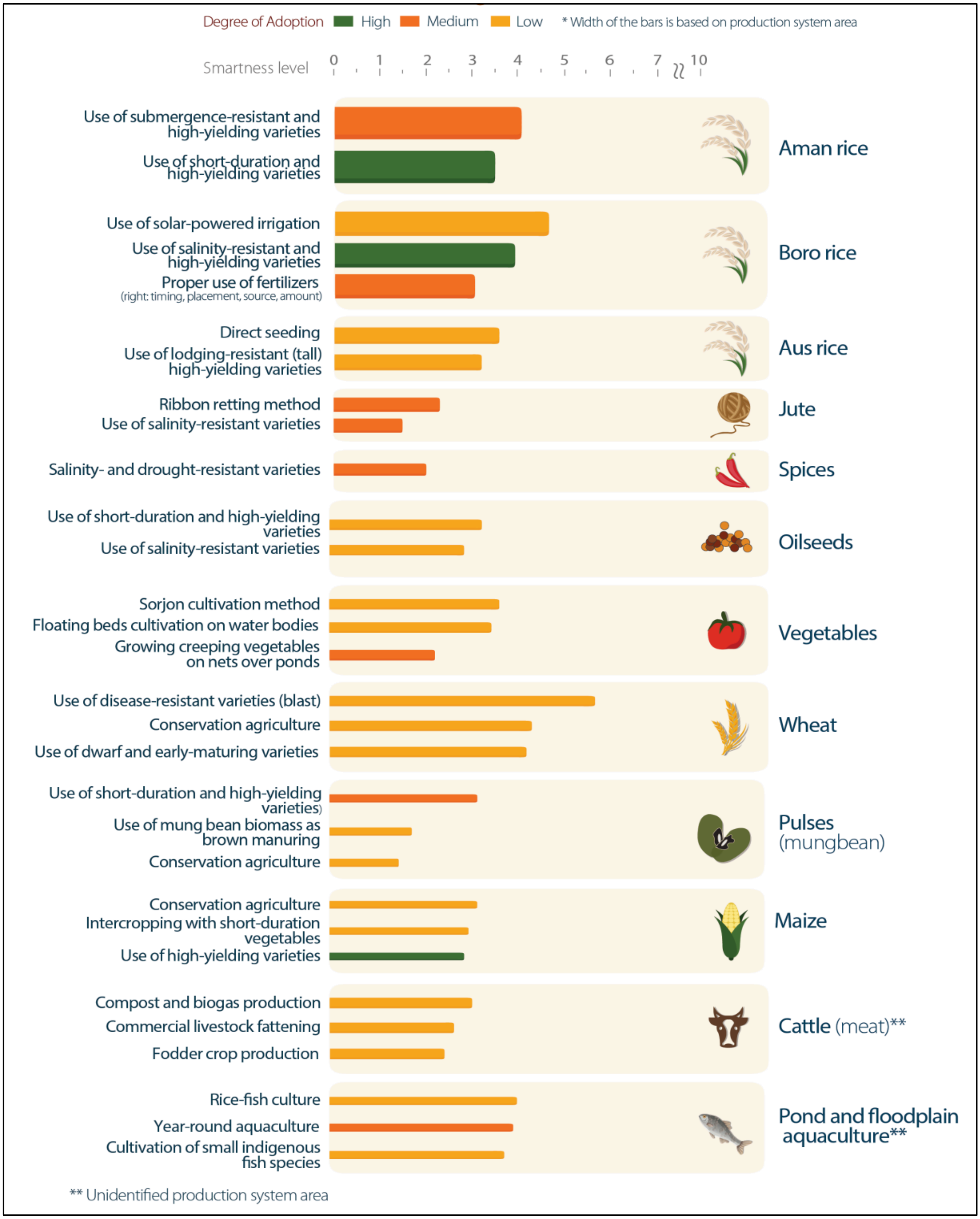
Extent of CSA Adoption and Barriers

A wide range of CSA technologies have been adopted, even if to a limited extent, in Bangladesh across different crop categories, including Aman rice, Boro rice, spices, oilseeds, vegetables, and wheat. The adoption levels of these technologies vary—ranging from low to high—depending on factors such as suitability, awareness, and economic feasibility. Recent assessments have also evaluated the relative "smartness" of these technologies, illustrating their effectiveness in achieving the core objectives of CSA: productivity, resilience, and emissions reduction. Figure 1 provides a snapshot of the extent of adoption.

While the barriers to CSA adoption are largely technology-specific, there are several overarching constraints. These include limited awareness and understanding of CSA practices, insufficient farmer training, and a lack of robust research to generate evidence supporting the effectiveness and scalability of these technologies. The absence of location-specific CSA solutions and the lack of long-term, sustained research further weaken the technology pipeline.

The lack of a cohesive policy framework and institutional arrangements to promote CSA also hinders scaling up. Additionally, the operational and infrastructural constraints specific to Bangladesh prove to be antithetical to the requirements of CSA. These include fragmented land holdings that complicate the use of mechanized equipment, lack of road access to fields, and physical barriers such as narrow field embankments that restrict the movement of heavy machinery and transport vehicles. Other barriers include insufficient training on the use and maintenance of CSA machinery, and the unavailability of spare parts in remote areas.

Figure 1: Selected CSA practices & technologies for agricultural systems in Bangladesh



Source: Climate-smart agriculture in Bangladesh, World Bank, 2019

Highlights From the Discussion

The forum concluded with a lively discussion on issues related to CSA in the respective countries of the participants. The discussion revealed both practical and policy-level considerations crucial for scaling CSA technologies in Bangladesh.

- ***Persistent Adoption Barriers:*** Despite the availability of a range of CSA technologies, adoption remains uneven. In addition to the constraints listed earlier, there are other issues that prevent scaling-up. For instance, stress-tolerant crop varieties are often not adopted due to yield trade-offs and insufficient dissemination of agronomic information such as the level of saline tolerance or heat tolerance. Similarly, mechanization-based CSA interventions face challenges related to the availability of spare parts, maintenance services, and technical capacity at the local level.

- ***Need for Policy Coherence and Institutional Mechanisms:*** While Bangladesh has a number of sectoral policies related to agriculture and climate change, there is no dedicated policy framework for CSA. Participants emphasized the need for CSA-specific support mechanisms, including financial incentives and low-interest loans tailored to climate-resilient technologies. A dedicated institutional body was also proposed to oversee coordination and implementation across the diverse landscape of CSA interventions.

- ***Importance of Location-Specific Approaches:*** The discussions highlighted the heterogeneity of Bangladesh's agroecological zones and the need for site-specific solutions. For instance, haor regions face excess water challenges, while southern coastal areas deal with salinity intrusion. Developing and disseminating CSA technologies that are responsive to local environmental conditions is critical in scaling up.

- ***Smallholder-Centric Technology Design:*** Most farmers in Bangladesh are small to medium-scale, and technologies must be suited to their economic realities. Practices that deliver quick, visible benefits—such as small solar pumps or CSA techniques for high-value crops—are more likely to be adopted. Financing instruments like microcredit and targeted subsidies were identified as essential tools to support smallholders in managing risk and investing in CSA.

Way Forward for expanding CSA in Bangladesh

Several key recommendations emerged from the forum to facilitate the scaling up of CSA technologies in Bangladesh. First, there is a need to prioritize location- and crop-specific technologies that are developed through adaptive, context-driven research. Such innovations must respond to the agroecological diversity and specific needs of farming systems across the country. Second, there is a need to provide targeted incentives to farmers and early adopters to encourage adoption until these technologies cross the threshold of economic viability. Incentive mechanisms can help reduce the perceived risk of transition and promote greater farmer engagement. Third, women and youth offer untapped potential for scaling CSA technologies. Their participation must be actively supported through inclusive design, targeted outreach, and capacity-building programs tailored to their needs and constraints.

Alongside technology dissemination and extension, financing, continuous monitoring and evaluation of CSA technologies is critical. Systematic evidence on their costs, benefits, and long-term impacts will build trust and inform policy and investment decisions. Further, networking remains a frequently overlooked but essential component of successful CSA adoption. Strong linkages among researchers, extension services, farmer organizations, private sector actors, and policymakers are needed to foster collaboration, knowledge exchange, and joint problem-solving in the promotion and management of climate-smart solutions. Lastly, the integration of digital technologies, including climate information services, early warning systems, and mobile-based advisory tools, can further empower farmers to make timely and informed decisions under changing climate conditions.

Bangladesh has made important strides in piloting and adapting CSA technologies suited to its unique agroecological challenges. To build on this momentum, coordinated efforts across research, policy, and local-level institutions will be essential in achieving a climate-resilient and food-secure future for the country.

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ACKNOWLEDGMENTS

This publication has been prepared as an output of the project Consortium for Scaling-Up Climate-Smart Agriculture in South Asia (C-SUCSeS), jointly implemented by the SAARC Agriculture Centre (SAC), the International Food Policy Research Institute (IFPRI), the International Fund for Agricultural Development (IFAD), and the SAARC Development Fund (SDF). The project is funded by IFAD and SDF. The project team sincerely thanks Dr. Ayub Hossain, the SAC and BARI teams, especially the national focal points from Bangladesh for their vital contributions toward the success of this regional forum. Special appreciation goes to Ms. Anisha Mohan, communications & knowledge management lead from IFPRI, for organizing and managing the CSA regional forum series and associated outputs. We also extend our heartfelt gratitude to the entire C-SUCSeS project team and the broader community of practice – including NARES representatives, CSA experts, researchers, and practitioners from across South Asia – for their active participation and for enriching the forum discussions.

Funding for this work was provided by IFAD and SDF. This publication has been prepared as an output of C-SUCSeS project and has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI or partnering organizations.

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