SOUTH ASIA POLICY PERSPECTIVES #06 SEPTEMBER 2025

Climate-Smart Agriculture for Sustainable Agriculture in Bhutan

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 webinar on Bhutan focused on CSA activities and challenges in the country's eastern region and was delivered by Mr. Domang, Programme Director at the Agriculture Research and Development Centre (ARDC), Wengkhar, under the Department of Agriculture, Royal Government of Bhutan. His presentation covered the status of Bhutanese agriculture, agro-ecological diversity, climate change impacts, CSA practices, implementation challenges, and future opportunities.

[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.

Overview of Bhutanese Agriculture

Features: Agriculture remains a central pillar of Bhutan's economy and rural livelihoods. Approximately 57% of Bhutan's population (and 49% of the labor force) is directly dependent on agriculture, which contributes 19.2% to the national GDP. Despite its importance, only 2.93% of Bhutan's land area—about 172,551 hectares—is arable, encompassing wetlands, drylands, and orchards.

Major food and horticultural crops grown in Bhutan include rice, maize, wheat, buckwheat, potato, chili, and vegetables. The country also has significant production of spices and fruits, particularly in the eastern region, which has favorable agroclimatic conditions. Bhutan is ecologically diverse, with six distinct agroecological zones (AEZs) based on altitude and climate:

- Wet subtropical (100–600 m)
- Humid subtropical (600–1,200 m)
- Dry subtropical (1,200–1,800 m)
- Warm temperate (1,800–2,600 m)
- Cool temperate (2,600–3,600 m)
- Alpine (3,600–7,500 m)

The country experiences four seasons: spring (March–May), summer (June–August), autumn (September–November), and winter (December–February).

Climate Change and its Impact on Agriculture

Bhutan's agriculture sector is increasingly vulnerable to the impacts of climate change. Key challenges include:

- Rising average temperatures
- Changing precipitation patterns
- Flash floods causing erosion and crop damage
- Increased frequency of droughts and heat stress
- Incidence of wind and hailstorms
- Growing outbreaks of pests and plant diseases

These climatic disruptions pose a direct threat to agricultural productivity, food security, and rural livelihoods, particularly in ecologically fragile areas such as Bhutan's eastern and mountain regions. Over

the past three decades, Bhutan has experienced a range of extreme weather events directly affecting agriculture. The table below highlights notable climate-related events and their consequences:

Year	Extreme Weather Event	Impact
1994	Glacial lake outburst flood (GLOF)	Damaged 965 acres of agricultural land
1996	Rice blast epidemic	80–90% crop loss in high-altitude areas
2004	High-intensity monsoon rain (nationwide)	Damaged 39 irrigation channels
2007	Northern corn blight	Over 50% crop loss in high-altitude areas
2008	Unusual windstorm	Damaged maize crops of 320 households in Eastern Bhutan
2009	Cyclone Aila / flash flood	Washed away over 100 acres of land
2010	Flash floods and landslides	Affected 809 acres of land; damaged irrigation channels
2012	Hailstorm in Punakha	Damaged 30–40% of rice crop
2013	High-intensity rain and windstorm	Damaged over 100 acres of maize crop; erosion; damaged irrigation
2015	Hailstorm and flash flood	Damaged over 100 acres of rice crop
2016	High-intensity rain	Damaged over 100 acres of rice crop

Localized Impacts and the Climate Smart Village (CSV) approach

Farmers in Bhutan are increasingly witnessing the tangible effects of climate change on agriculture. Flash floods and windstorms frequently damage infrastructure and standing crops, while pest and disease outbreaks—driven by shifting climate patterns—are becoming more common. Heat stress and drought events are particularly damaging during sensitive crop stages such as paddy nursery establishment and transplantation, especially in areas lacking irrigation infrastructure. Maize crops are also adversely affected during tasseling and silking stages, reducing yields and increasing vulnerability.

In response to these challenges, Bhutan has adopted the Climate-Smart Villages (CSV) model—an integrated, community-based adaptation approach. Rather than targeting individual farmers, the CSV

model identifies clusters of households in climate-vulnerable areas and introduces a range of CSA technologies and practices to build resilience at the village level. A total of 12 CSVs have been established in eastern Bhutan till now, serving as pilot sites for scaling CSA interventions.

CSA Technologies in Bhutan

To enhance resilience against climate risks and improve productivity, Bhutan has identified 28 climate-smart agriculture (CSA) technologies spanning crop improvement, water and nutrient efficiency, energy management, and knowledge-based practices. These technologies are categorized based on the type of "smartness" they target—weather, water, nutrient, carbon, knowledge, or combinations thereof. Some notable CSA technologies currently being promoted in Bhutan include:

- Weather-smart: Protected cultivation, upland and spring paddy, heat-tolerant maize and vegetables, quinoa, sunken greenhouse, and tissue culture
- Water-smart: Drip irrigation, hydroponics, aeroponics, low-cost water harvesting ponds
- Nutrient-smart: Mulching, composting, vermicomposting, bio-inputs (biopesticide and biofertilizer), intercropping, crop rotation, and rice bran bokashi
- Carbon-smart: Sustainable land management, bio-pesticides, smart electric fencing
- Knowledge-smart: Integrated pest management, rain shelters for vegetables, smart fencing (dual benefit)
- Integrated practices such as aeroponics, arecanut-based multi-tier cropping, and ultra-high-density fruit plantations (apple and mango) combine multiple smartness dimensions—weather, water, and nutrient—offering high potential for adaptation and productivity gains.

These CSA technologies are being tested, demonstrated, and adapted through Bhutan's Climate-Smart Village (CSV) initiative, which enables context-specific application and farmer-led innovation. While Bhutan has identified 28 climate-smart agriculture (CSA) technologies, a subset is actively being piloted and adopted in the eastern region. These technologies are tailored to the agroecological and climatic conditions of the high hills and valleys, where farmers face both low temperatures and erratic rainfall.

- ***Protected Agriculture:*** Protected cultivation using polyhouses allows farmers—especially in high-altitude areas—to grow high-value, short-duration horticultural crops under controlled environments. This technology is crucial in regions where low winter temperatures traditionally restrict year-round production.
- ***Upland Paddy (Drought-Tolerant):*** To cope with increasing water stress, Bhutan has released five upland paddy varieties suitable for altitudes ranging from 1,800 to 3,000 meters above mean sea level (msl). These varieties yield up to 1,900 kg per acre, providing a reliable staple crop under drought-prone conditions.

- ***Spring Paddy Cultivation:*** spring paddy offers farmers an opportunity to grow rice between February and July, particularly in regions between 650 to 1,100 msl. This cropping window complements the traditional summer paddy season (July to November), enabling farmers to increase their gross cropped area and enhance rice self-sufficiency.
- ***Quinoa:*** Quinoa cultivation is gaining popularity due to its nutritional value and income-generating potential. It is well-suited for altitudes ranging from 650 to 3,000 msl. In higher elevations, it is grown between May and Oct, while in mid and low altitudes, planting is done from August to December.
- ***Heat-Tolerant Vegetable Varieties:*** To address rising temperatures, heat-tolerant varieties of cabbage and cauliflower have been introduced. Notable varieties include Cabbage (Bengal King and Asha varieties) and Cauliflower (White Express 50 and Pragati varieties). These varieties allow farmers to successfully cultivate vegetables during peak summer months, previously unsuitable for production.

Soil Health-Enhancing Practices

- ***Bokashi***: A fermented organic fertilizer made from organic waste, Bokashi enhances soil fertility, recycles on-farm biomass, and helps control soilborne diseases.
- ***Composting:*** A traditional method of converting organic waste into natural fertilizer, composting is seeing renewed emphasis in Bhutan's sustainable farming programs for its role in improving soil structure and long-term productivity.
- ***Drip Irrigation:*** Drip irrigation is increasingly adopted in commercial vegetable and high-value crop farms. It offers dual benefits: efficient water use and increased productivity, especially critical in water-scarce and slope-sensitive landscapes.

Challenges and Constraints in CSA Adoption in Bhutan

Despite the growing momentum around climate-smart agriculture (CSA), several barriers continue to limit its widespread adoption in Bhutan:

- Lack of awareness and education: Many farmers are unfamiliar with CSA technologies and their potential benefits, especially in remote and high-altitude areas.
- Limited access to finance: Smallholder farmers often face challenges in accessing credit, subsidies, or other financial resources needed to adopt new technologies.
- Climate variability and risk: Frequent and unpredictable weather events make it difficult for farmers to plan and invest in new practices with confidence.
- Limited domestic research and development: There is a shortage of locally adapted CSA technologies, with research efforts still at an early stage.
- Behavioral and cultural constraints: Traditional beliefs and risk-averse attitudes can slow the adoption of modern practices.

- Challenging terrain: Bhutan's mountainous and uneven topography complicates mechanization, access to markets, and technology deployment.

Highlights From the Discussion

The discussion session surfaced rich insights into the implementation, challenges, and cross-learning potential of climate-smart agriculture (CSA) in Bhutan. Several recurring themes emerged:

- ***Policy influences and gaps:*** The discussion also explored the influence of public policy in shaping CSA adoption. While supportive subsidies have accelerated uptake of technologies like polyhouses, mismatches between policy priorities and farmer needs (e.g., technical knowledge gaps, narrow subsidy portfolios) remain. Participants emphasized the need for policy frameworks that enable—not just fund—CSA adoption, including provisions for research, extension, training, and market development.

- ***Forest-agriculture linkages:*** Participants highlighted opportunities to better integrate Bhutan's vast forest resources into CSA. Bhutan follows a model of community-managed forests, allowing farmers to collect leaf litter for composting, while also preserving water catchments that feed agricultural irrigation. These forest-agriculture synergies are already embedded in Bhutan's farming systems and could be further formalized as part of CSA strategies.

- ***Quinoa cultivation as a CSA intervention:*** Quinoa was discussed as a notable CSA crop due to its low water and nutrient requirements, suitability for poor soils, and high-altitude adaptability. Its adoption is particularly important in areas where traditional crops are no longer viable due to climate stress, offering both resilience and diversification for farmers.

Way Forward for expanding CSA in Bhutan

Climate-smart agriculture (CSA) presents a powerful pathway for Bhutan to build a more resilient and sustainable agricultural future. To unlock its full potential, efforts must now focus on expanding the reach of CSA technologies and tailoring them to Bhutan's diverse agroecological regions. Strengthening the link between research and on-farm application is critical, particularly in high-risk and high-altitude areas where traditional practices are no longer sufficient to withstand climatic stress.

CSA offers multiple benefits that should guide future interventions. It enhances productivity while improving farmers' ability to cope with extreme weather events. By supporting practices that are both adaptive and resource-efficient, CSA enables better economic returns through reduced input costs, yield stability, and increased cropping opportunities. Importantly, CSA also supports Bhutan's environmental goals by promoting the sustainable use of water, nutrients, and soil, while minimizing agriculture's ecological footprint.

Moving forward, it is essential that agricultural researchers, development institutions, and policymakers work collaboratively to mainstream CSA into national agricultural programs, ensure access to finance and extension services, and strengthen community-level capacity. With the right investments and enabling policies, CSA can serve as a foundation for Bhutan's agricultural transformation—ensuring food security, rural prosperity, and environmental stewardship in a changing climate.

ABOUT THE AUTHOR

This publication has been prepared by Mr. Himanshu Pathak based on the audio-visual documentation and materials from the forum. Mr. Pathak is a PhD student and graduate research assistant at the Institute for Resources, Environment and Sustainability, University of British Columbia.

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 Mr. Domang, the ARDC and Dept. of Agriculture teams, especially the national focal points from Bhutan 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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IFPRI is a CGIAR Research Center

NASC Complex, Dev Prakash Shastri Road, Pusa, New Delhi 110012, India | T: +91-011-42244545 | F: +91-011-42244549
Email: IFPRI-NewDelhi@cgiar.org | https://southasia.ifpri.info