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Climate-Smart Agriculture Technologies in Nepal

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. Following the first webinar on Bangladesh, the second session focused on Nepal and was held with the participation of stakeholders from across the region.

The keynote presentation was delivered by Dr. Tika Bahadur Karki, Chief of the National Agronomy Research Center (NARC) under the Nepal Agricultural Research Council (NARC). Dr. Karki holds an MSc in Agronomy from the Indian Agricultural Research Institute and a PhD from Tribhuvan University. He is widely published in national and international journals, a contributor

[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.

to several book chapters, and currently serves as the President of the Agronomy Society of Nepal. His research interests include conservation agriculture, climate-smart agriculture technologies, and integrated farming systems.

Dr. Karki presented on behalf of the National Agriculture Environment Research Center (NAERC), which is the lead implementing partner for the C-SUCSeS project in Nepal. His presentation focused on the status, challenges, and opportunities related to climate-smart technologies in Nepal. The presentation was followed by a moderated discussion and Q&A session involving participants from across South Asia.

Agriculture Sector in Nepal

Agroecological Context: Nepal, based on its diverse topography, is divided into five major physiographic regions: the Tarai, Shivalik, Middle Mountains, High Mountains, and High Himalayas. These are commonly grouped into three agroecological zones based on elevation and climatic characteristics: the Mountain zone (35% of land area, subalpine climate), the Hill zone (42%, cool temperate climate), and the Tarai zone (23%, subtropical climate). Climatic variation across Nepal is largely driven by altitude, with conditions ranging from warm subtropical lowlands to cool and cold mountainous areas. Approximately 80% of annual rainfall occurs during the monsoon season, from June to September, with areas like Pokhara in Gandaki Province receiving over 1,900 mm annually.

In terms of land use, Nepal has six major land types: cultivated land (21%), uncultivated land (7%), forests (40%), grassland and pasture (12%), water bodies (3%), and other land—including snow-covered and rocky terrain (17%). The total cultivated area is approximately 2.6 million hectares. The livestock sector contributes 13% to national GDP and 27% to agricultural GDP. Despite its agrarian economy, food insecurity persists, affecting 29% of urban and 38% of rural households. Nepal is rich in agrobiodiversity, with over 1,026 crop species, 35 livestock species, 250 aquatic animal species, 17 aquatic plant species, and more than 3,500 insect species. However, only 28% of agricultural land is under irrigation.

Challenges: The agriculture sector in Nepal grapples with a range of challenges. These include:

1. Decline in soil fertility, low levels of mechanization, and the use of low-yielding crop genotypes and livestock breeds. Climate change further exacerbates these challenges, with increased incidence of droughts, floods, and erratic rainfall patterns affecting sowing schedules, crop maturity, and yields. In this context, climate-smart agriculture (CSA) technologies offer a promise to a sustained agricultural growth scenario, particularly with their all-round benefits.

2. The development and dissemination of these technologies, however, remains limited in Nepal, with most technologies still at early stages of research and on-farm validation. The country’s exposure to climate shocks is becoming increasingly evident. For example, off-

season heavy rainfall in 2021 led to floods and landslides that destroyed paddy crops valued at approximately USD 50 million. The economic cost of climate change to the agriculture sector was estimated at around 1.5–2% of GDP in 2020, along with an estimated 40% loss in biodiversity.

3. Long-term climate trends show a clear shift in temperature and rainfall patterns. Extreme climate events are increasing, particularly in the northwestern districts of Karnali Province and parts of central Gandaki and Lumbini Provinces. Consecutive dry days are decreasing, while warm days and warm nights are rising significantly across the country. Cool days are on the decline, and cold spell durations are increasing only in far western districts. These shifts underline the urgency of climate-adaptive strategies across Nepal's diverse farming systems.

Policy Initiatives and CSA Interventions in Nepal

Nepal has undertaken several sectoral initiatives to address the growing impacts of climate change. These include both government-led policies and programs supported by international partners. Key strategic documents shaping the national response to climate change include:

- National Climate Change Policy (2019)
- Local Adaptation Plan of Action (LAPA) Framework (2012)
- Climate Change Budget Code (2013)
- Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy (2016)
- Nationally Determined Contributions (NDCs, 2016 and updated versions)
- National Adaptation Plan (currently under development)
- Agriculture Development Strategy (ADS) 2015–2025
- Measures under the Fourteenth and Fifteenth Five-Year Plans

These frameworks illustrate Nepal's efforts towards an integrated approach to climate action. In alignment with the three pillars of CSA, Nepal has begun to prioritize CSA technologies in the Terai and hill regions. The selection of CSA interventions is guided by both agroecological context and vulnerability assessments.

CSA Technologies in the Terai Region: The Terai region, characterized by subtropical climate and relatively flat terrain, has seen the introduction of a wide range of CSA technologies, including:

- System of Rice Intensification (SRI) using alternate wetting and drying (AWD) techniques
- Efficient irrigation systems, including gravitational and pressurized irrigation
- Laser land leveling to improve water-use efficiency
- Relay cropping with pulses and oilseeds
- Zero tillage for wheat and direct seeding of rice (DSR)

- Precision nutrient management, including judicious use of chemical fertilizers, farmyard manure, green manure, and crop residue mulching
- Increased adoption of stress-tolerant varieties, particularly drought- and flood-tolerant strains
- Varietal improvement of niche crops such as mustard, soybean, and aromatic rice

CSA Technologies in the Hill Region: In the hill region, where terrain is steeper and rainfall patterns are more erratic, CSA technologies focus on soil conservation, water harvesting, and integrated farming. Practices include:

- Rainwater and snow harvesting and use of solar-powered and drip irrigation
- Soil organic matter enhancement for improved soil and water retention
- Laser land leveling adapted for terraced fields to reduce erosion
- Sloping Agricultural Land Technology (SALT) integrating cereals, legumes, and cover crops
- Mulching to suppress weeds and reduce evapotranspiration
- Bioengineering techniques for flood and erosion control—such as tree sapling and forage transplantation, stream bank stabilization using gabion wires, and check dams
- Drought-tolerant and deep-rooted crop species to enhance resilience in water-stressed areas

These region-specific interventions are helping build the foundation for a more resilient and sustainable agricultural sector in Nepal.

Institutional arrangements for CSA development in Nepal:

Although still limited in scope, Nepal is in the process of setting up several institutional arrangements towards the advancement of climate-smart agriculture (CSA) in Nepal.

- The Ministry of Agriculture and Livestock Development (MoALD) is the primary government body responsible for agricultural policy, implementation, and oversight. One of its flagship programs, the Prime Minister Agriculture Modernization Project (PMAMP), focuses on formulating and implementing CSA-related policies, as well as monitoring and evaluation mechanisms across various sectors.

- The Nepal Agricultural Research Council (NARC) serves as the country's principal agricultural research institution. It has been engaged in several CSA-relevant initiatives, including the Pilot Program for Climate Resilience (PPCR) and the Asian Food and Agriculture Cooperation Initiative (AFACI). NARC also collaborates with CGIAR institutions such as the International Rice Research Institute (IRRI) and CIMMYT on diverse areas, including:
  - Agro-meteorological advisory services
  - Organic and traditional crop diversification
  - Gender-sensitive and climate-adaptive technologies
  - Mechanization in rice-lentil systems
  - Climate-resilient varieties of maize, wheat, and rice

- At the subnational level, the Agriculture Ministries of Lumbini and Gandaki Provinces have initiated the development of Climate Smart Villages (CSVs). Selected villages in these provinces are piloting various CSA technologies and practices tailored to their local agroecological contexts.

- The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), though based in New Delhi, has also supported CSA initiatives in Nepal through regional partnerships and knowledge sharing.

- Among non-governmental actors, LI-BIRD (Local Initiatives for Biodiversity, Research, and Development) plays a key role in promoting CSA. Through its Modern CSA Project, LI-BIRD identifies and documents best practices and local CSA champions across different agroecological zones.

- Practical Action is another important organization involved in promoting CSA through private sector engagement, particularly in industrial and commercial crops.

- Other contributing organizations include ICIMOD and CEAPRED, both of which are involved in piloting the Resilient Mountain Villages (RMV) concept, which integrates CSA principles into hill and mountain farming systems.

Finally, the Developing Climate Resilient Livelihoods (DCRL) project, funded by UNDP, is focused on climate-resilient water resource conservation and sustainable agricultural practices in the drought-affected eastern districts of Okhaldhunga and Khotang. This initiative emphasizes conservation agriculture and watershed-based CSA strategies.

Other CSA Technologies and Practices in Nepal

In addition to the technologies mentioned above, Nepal also practices, to a limited extent, a range of CSA technologies tailored to its diverse agroecological zones. These include:

1. ***Climate-Resilient Crop Varieties:*** The Nepal Agricultural Research Council (NARC), in collaboration with CGIAR centers and development partners, has developed and released several crop varieties resilient to heat, drought, cold, and submergence:
    - ***a.*** Drought-tolerant rice: Sukhadhan 1–6, So Karan 2–6, Ghaiya-3
    - ***b.*** Flood- and drought-tolerant rice: Bahuguni Dhan 1, Swarna Sub-1
    - ***c.*** Cold-tolerant hill rice: Lekali Dhan 1 & 3, Chandannath 1 & 3, Muchhapuchhre 3
    - ***d.*** Heat-tolerant wheat: Gautam, Vijaya, Bhrikuti, Bandganga, Borlaug 2020
    - ***e.*** Heat-tolerant maize: Rampur Hybrids 8, 10, 12; RML 12/32; Sitala
    - ***f.*** Drought-tolerant lentils: Sagun, PRP 3, 5, 6, 8, 1313 L.3, 2335.4, 3940-7-7.15, 3940-3-4.65
    - ***g.*** Resilient local landraces: Proso millet, foxtail millet, finger millet, Jamie, Marshi (rice)

h. Climate-resilient fruit crops: Walnut, almond, pomegranate, grapes, lime (Sun Kagati 1 & 2), and dragon fruit
i. Over 18,000 agro-genetic accessions are currently conserved at the NARC gene bank.

2. ***Water- and Energy-Smart Practices:*** Efficient use of water and energy is promoted through technologies such as laser land leveling, drip and sprinkler irrigation systems, rainwater and greywater harvesting ponds, solar-powered lifting irrigation systems, especially in the Terai, sloping Agriculture Land Technology (SALT) for water conservation in hills, zero tillage for wheat, lentil, maize, and garlic—especially garlic after rice residue, with no soil disturbance.

3. ***Nutrient- and Carbon-Smart Practices:*** To promote soil fertility and reduce emissions, farmers are increasingly adopting interventions, including site-specific nutrient management, improved composting and farmyard manure management, biochar, liquid manure, and green manuring, agroforestry models integrating cereals, fruit trees, and fodder species, fodder management and concentrate livestock feeding for methane reduction.

4. ***Knowledge-Smart and Integrated Systems:*** A variety of CSA practices focus on improving farmer decision-making and system resilience, including weather-based crop insurance, protected cultivation of vegetables, climate-smart livestock housing, sowing and planting time adjustment, integrated farming systems, such as rice–duck farming and integrated fish farming.

5. ***Native Livestock Breeds Resilient to Climate Stress:*** Nepal maintains a wide variety of stress-tolerant indigenous livestock breeds well-adapted to local environments. These include:
   - Cattle: Lulu, Siri, Achhami, Pahadi, Terai, Khaila, Yak
   - Buffalo: Lime, Gaddi, Parkote, Terai
   - Goats: Terai, Khari, Sinhal, Chyangra
   - Sheep: Lampuchhre, Kage, Baruwal, Bhyanglung
   - Pigs: Chwanche, Hurrah, Bampudke, Bandel
   - Chickens: Sakini, Ghanti khuile, Pwanka ulte

6. ***Agro-Meteorological Advisory Services:*** The Agro-Met Advisory Bulletin System (ABIS) provides climate-smart advisories to farmers. A multidisciplinary team integrates data from meteorological stations, farmer call centers, and feedback loops to develop region-specific recommendations. Advisories are disseminated electronically and in print across Village Development Committees and agricultural zones, helping farmers make informed decisions on planting, irrigation, pest management, and harvesting.

Challenges and Barriers to CSA in Nepal

The widespread adoption and scaling up of CSA in Nepal continue to face several systemic and structural challenges. Nepal's complex biophysical and socioeconomic condition calls for greater investment in agricultural research which is more tailored to the country's landscape. Currently, the extent of such research is limited due to the fragmented and piecemeal efforts related to data collection and organization, limited on-station trials, and a lack of impact assessment frameworks. There is no national database on CSA technology adoption, and the scale and scope of on-farm implementation, such as acreage coverage and farmer adoption rates.

In terms of policy, CSA is yet to be systematically integrated into Nepal's agriculture and climate frameworks. Existing policies are not fully CSA-aligned, despite the recent efforts to develop CSA-friendly policies. Institutional and human resource capacity at all levels—federal, provincial, and local—remains a bottleneck. Weak coordination among stakeholders, including the public and private sectors, research institutions, and extension agents, hampers effective knowledge transfer and scaling. Finally, access to finance is a persistent and one of the primary constraints to scale up CSA in Nepal. Both technology development and implementation suffer from inadequate investment.

Highlights From the Discussion

The webinar concluded with an engaging discussion, reflecting the diverse perspectives of researchers, practitioners, and regional partners on the status and challenges of CSA in Nepal. The participants also spoke about technologies that have been practiced in their countries and to share similarity and differences in their implementation. The excerpt from the discussion is provided below:

- ***Data and Evidence Gaps:*** Participants highlighted a significant lack of data on CSA technology adoption in Nepal. Despite the growing list of promoted technologies, reliable information on land area covered, number of adopters, and region-wise uptake remains unavailable. Projects like C-SUCSeS and KISAN II are currently working to fill this gap through mapping and monitoring of CSA practices such as zero tillage and direct-seeded rice (DSR).

- ***Mechanization and Terrain Constraints:*** Mechanization was identified as both an opportunity and a challenge. While technologies like zero till maize and Jap planters are gaining traction in the Terai region due to flatter terrain, adoption remains difficult in the hills due to small landholdings, sloping topography, and poor accessibility. NARC is developing smallholder-friendly tools to address this gap, particularly for cereal-legume systems.

- ***CSA Classification and Crop Establishment:*** The classification of CSA technologies (e.g., zero tillage as weather-, carbon-, and energy-smart) was discussed, with emphasis on the need for multi-dimensional evaluation of technologies. In rice–wheat and rice–

maize systems, farmers are increasingly adopting dry DSR followed by zero till wheat, often using happy seeders to manage crop residues. While yield differences between CSA and conventional systems are minimal, economic benefits from reduced input costs are significant.

- ***Weed Management in Zero-Till Systems:*** Participants raised concerns over weed control without herbicides in zero-till systems. Current practices involve crop residue management and plastic mulching, though applicability varies by crop. The need for non-chemical and crop-specific weed control strategies remains a key area for innovation.

- ***Status of SRI Adoption:*** The System of Rice Intensification (SRI) is practiced in some areas with 10–15-day-old seedlings and spacing of 25–30 cm. However, expansion has been limited, and the technology remains confined to pockets of farmer experimentation rather than widespread use.

- ***Solar-Powered Irrigation Initiatives:*** Subsidized solar-powered irrigation systems are gaining popularity, especially in drought-prone districts like Okhaldhunga and Khotang, supported by provincial governments and donor agencies. In some areas, farmers incur zero installation costs, resulting in increased adoption and improved access to irrigation during dry seasons.

- ***Adoption Barriers and Policy Challenges:*** Participants discussed barriers to scaling CSA, including non-aligned government policies, lack of conviction among extension agents, and absence of local service providers for machinery repair and maintenance. These issues contribute to the limited promotion and uptake of CSA technologies despite their potential.

- ***Biochar Application:*** Biochar was cited as a promising soil amendment, but its optimal dosage remains uncertain. Preliminary field applications range from 30–40 metric tons per hectare, though more research is needed to tailor recommendations based on soil type, ecology, and cropping system.

Way Forward

In consultation with the C-SUCSeS team in Nepal, the following actions are recommended to accelerate CSA development and adoption:

- Invest in robust, evidence-based research, including long-term on-station and on-farm trials, to generate context-specific CSA technologies and document their performance.

- Strengthen enabling policy frameworks by mainstreaming CSA across agricultural and environmental policies, with coordinated action across federal, provincial, and local governments.

- Build capacity across all levels—including policymakers, researchers, extension workers, technicians, and farmer organizations—to enhance CSA planning, delivery, and outreach.

- Enhance collaboration with CGIAR centers, regional programs, and global CSA initiatives to leverage knowledge and resources.
- Mobilize financing through public investment and incentivize private sector engagement in CSA promotion and technology delivery.
- Foster public-private partnerships to improve last-mile delivery of CSA inputs, services, and innovations.

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.

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