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Institutional Innovations for Climate Smart Agriculture: Assessment of Climate-Smart Village Approach in Nepal

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Institutions have a crucial role in communicating climate science into meaningful forms and to develop context specific adaptation options. Led by multiple institutions, Climate Smart Village (CSV) in Nepal is an organized approach to designing location specific package of interventions in response to climatic and other ongoing changes in the agricultural system. While addressing the impending risk of climate change and promoting food security objectives in smallholder settings, the CSV approach aims to increase the adoption of Climate Smart Agricultural (CSA) technologies at the local levels. One of the challenges, however, has been to sustain and scale the CSA technologies and practices. Based on the in-depth review of policy documents, field observations, and interviews with stakeholders involved in the implementation of pilot programs, this study evaluates the institutional framework of the CSV approach in the Gandaki region, Nepal. Our analysis proposes a revised conceptual model of innovation in the agricultural system that contributes to an increase in knowledge, attitude, and skills of multiple stakeholders for agricultural adaptation and the scaling of appropriate options. Our case demonstrates that while the scaling of the CSV approach is a concern, the institutional innovation around CSV has been instrumental in making farmers aware of CSA technologies. This has been done largely through collaboration among public, private, civil society organizations, and communities. This collaborative effort illustrates the possibilities for scaling the CSV approaches in the future and highlights their contribution to climate and development goals.

Keywords: climate smart agriculture, climate smart village, innovation, adaptation, institutions

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INTRODUCTION

The issues of institutional innovation remain a critical dimension of agricultural adaptation to climate variability and change. Following Agrawal (2008), we argue that if the welfare of smallholder farmers is to be addressed effectively by technological innovation on demand, institutions play a significant role in enhancing the climate adaptation practices. Institutional dimensions of climate adaptation, according to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), include strategic integration of climatic information into technological innovation, planning, decision-making, and implementation (Pachauri et al., 2014). Humanly created formal

(e.g., extension services, sectoral offices, and ministries) and informal (such as local clubs, saving groups, farmers organizations, and local natural resource users' committees), institutions shape social and individual expectations, interactions, and behavior. Institutions also play a critical role in interpreting highly science-centric and abstract attributes of climate change science to usable forms (O'Riordan and Jordan, 1999) and provide critical input to drive location-specific agricultural innovations (Chhetri et al., 2012). For institutions to operate effectively, there is a need for interactions between public (administrative units), private firms (business), and civic (NGOs) institutions (Agrawal, 2008) as well as a meaningful collective action among those that have heterogeneity in terms of scale and operational contexts (Adger et al., 2003).

Effective climate change adaptation requires utilizing knowledge, skills, and best practices (Regmi and Bhandari, 2013) as well as technological, institutional, and relational innovation (Rodima-Taylor et al., 2012), highlighting the undisputable relationship between adaptation, innovation, and institutions. It also calls for a stronger collaboration between formal research institutions, extension systems as well as informal community-based organizations, and private sectors to facilitate the practice of climate adaptation technologies at the local levels (Bhatta et al., 2017). Because of their centrality to climate adaptation, institutional context determines the extent to which new technological innovations result in wider adoption (Agrawal, 2010; Chhetri and Easterling, 2010). Five major characteristics that determine the rate of adoption of innovation are: (a) attributions of innovation, (b) type of innovation decision, (c) communication channel, (d) nature of social systems, and (e) the extent of promotion by agents (Rogers, 2010). A number of them relate to institutional aspects of innovation.

Despite the importance accorded to the role of institutions in facilitating adaptation to changing climate, there is a dearth of research on how the challenges of responding to emerging climatic threats in agriculture induce new forms of institutional arrangement. Stakeholders working on adaptation policies and practices need to recognize the crucial role of institutions in determining the adoption of best technologies and practices. In this paper, we analyze the role of institutions, operating at multiple levels, in shaping the outcomes of Nepal's Climate Smart Village (CSV). Strategically designed to generate evidence on the application of climate-smart agriculture (CSA) technologies, CSV programs are designed to build resilient agricultural systems in Nepal. In the CSV approach, participating farmers are piloting innovations that are Nutrient Smart, Water Smart, Crop Smart, Information Smart, Energy Smart, and Future Smart involving a range of actors, interactions, and processes within them. Using the case of CSV, this paper illustrates how the institutional context has influenced the wider adoption of CSA technologies and practices in Nepal, a country highly vulnerable to climate variability and change.

Climate change impacts are evident in the Nepalese agriculture sector that contributes to about one-third of the GDP while providing employment to nearly three-quarters of the population (CIAT et al., 2017). Given the strategic importance of Nepal's agriculture to the nation's economy, potential impacts of climate variability and change on national food security are causes for concern. According to the Demographic and Health Survey 2016, 4.2 million people of Nepal's 28.6 million population are food insecure (USAID, 2019). The traditional agricultural development approaches have not been adequate in responding to impending threats emanating from the rapidly changing climate. In Nepal and other 19 countries around the world, the CSV approach has been recognized as a potential pathway to generating policy support for building resilient and viable agricultural production systems (Aggarwal et al., 2018; Xu et al., 2019), however, the institutional aspects necessary to scale are not studied adequately. The policies and plans designed to implement the CSV approach in Nepal by engaging multiple stakeholders provides a strong basis for institutional innovation. In this context, the objectives of this paper are to, (a) evaluate an institutional framework for scaling the CSA with the CSV approach, (b) assess the role of the new institutional design in enhancing collaboration to promote climate adaptation, (c) assess the scope for scaling CSA technologies at a wider level, and (d) understand the relationship between Nepal's CSV approach to that of global policies, particularly, Nationally Determined Contributions (NDC) under the Paris Agreements and Sustainable Development Goals (SDGs).

The remainder of the paper is organized as follows. The following section provides a brief introduction to the CSA intervention, the scaling of CSA through the CSV approach, and the analytical framework of institutional innovation. The subsequent section presents the description of the study area and the CSA initiative in Nepal. The results and discussion section presents the finding of our study, a revised conceptual model, and the impact of the new institutional model. Finally, the concluding section provides the summary of our paper.

SCALING CSA THROUGH CSV APPROACH

Climate change along with the surge in frequency and severity of extreme events are major challenges for the agricultural system worldwide. According to the World Health Organization, about 700 million people globally were undernourished and two billion people experienced some kind of hunger in 2019 and a large proportion of the food-insecure people live in developing regions of Asia and Africa (WHO, 2020). Climate change along with unsettling social and political conditions are expected to destabilize global food security. On the other hand, the global food system is one of the largest sources of greenhouse gas emissions that contributed an average of 25–30 % of total anthropogenic emissions during the 2007–2016 period that includes emissions from agriculture, land use, and beyond farm gate activities (Mbow et al., 2019). All these realities have made the agricultural sector a center for inquiries for both climate change adaptation and mitigation.

CSA Interventions

Launched by the United Nations Food and Agricultural Organization (FAO) in 2010, the CSA is attributed as climate compatible intervention (Lipper et al., 2014). Designed to also address food security and livelihoods concerns, the CSA

is gaining currency, especially among smallholder settings. It goes beyond technologies to include enabling policies and institutions as well as identification of financing mechanisms. Recognized for its synergies and trade-offs among food security, adaptation, and mitigation, the CSA is reorienting agricultural policy to support multiple social goals (Scherr et al., 2012). Agricultural technologies and practices can be considered as CSA if they: improve productivity or increases the efficiency of the use of scarce resources (**Food security goal**); reduce exposure, sensitivity, or vulnerability to climate variability or change (**Resilience goal**); and sequester carbon from the atmosphere or reduces agricultural emissions wherever possible (**Mitigation goal**) (Neufeldt et al., 2013). While these three goals are equally important, in developing countries the food security and resilience building goals have a greater urgency whereas the mitigation is generally regarded as a co-benefit. The CSA is composed of a variety of practices drawn from our collective learnings in ecological agriculture, soil conservation, agroforestry, and conservation agriculture (Chandra et al., 2018), its larger purpose, however, is to manage climatic risk and enhance resilience in the context of agriculture development (Neate, 2013).

The CSA is gaining currency as a set of interventions that embraces intellectual openness to blending science and technology with local knowledge and practices. Some of the CSA technologies implemented in different parts of the world have identified several promising practices such as agricultural insurance, weather based agro-advisories, nutrient and water management, and contingent crop planning (Khatri-Chhetri et al., 2017, 2019). Many of these CSA practices are being implemented throughout the world, such as modern weather services and agricultural helplines in Ghana, climate and crop modeling approach in India and Mali (ICRISAT, 2016), the use of biopesticides (*jholmal*) in Nepal (Subedi et al., 2019), and solar pump irrigation systems in Nepal and India. Some of the other low cost CSA practices gaining momentum in Nepal are: adoption of organic compost, use of water harvesting technologies, watershed management, utilization of early maturing crop varieties, and use of cultural and management practices such as mulching. With some exceptions, most of the CSA activities are being implemented as pilot projects at a smaller scale by NGOs and sub-national governments. For CSA technologies to build resilient agricultural production systems, they need to be applied at a larger scale involving a large number of farmers. And if the adaptation needs of smallholder farmers are to be addressed by innovation, a broader understanding of institutions operating at the community level to one that works at the supranational level is required.

Scaling of CSA Technologies Through CSV Approach

With the aim of increasing the adoption of CSA technologies and practices through appropriate technological and institutional interventions, policymakers and practitioners have developed a new approach to CSV which has also been embraced by farmers and their supporting institutions. According to the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), the CSV approach is a key part of agriculture research-for-development (AR4D) and climate adaptation (CCAFS, 2016). This approach prioritizes testing and piloting technological innovations while simultaneously devising institutional and policy innovation. The overarching vision is to generate evidence of best practices through partnership and technical guidance and knowledge for the design, implementation, and evaluation of the CSV approach. Scaling of CSV sustainably requires an active engagement of institutions. With its focus on the co-development of CSA technologies at the community level, the CSV approach is also expected to empower local communities and their supporting institutions (Bayala, 2021).

With the leadership of CCAFS, the CSV approach has been implemented in more than 20 countries in Asia, Africa, and South America (Aggarwal et al., 2018). This includes multiple sites in the three South Asian countries: Andhra Pradesh, Maharashtra, Madhya Pradesh, Bihar, Punjab, and Haryana states of India, six districts of Nepal, and Barisal, Khulna, and Sylhet divisions of Southern Bangladesh. Results from initial studies indicated that the CSV program is promising in setting a framework for scaling up adaptation options in agriculture for farmers and their supporting institutions (Bayala, 2021).

Some programs have demonstrated the initial success in the extension of CSA and CSV programs through horizontal and vertical scaling (Aggarwal et al., 2018)—two broad mechanisms for scaling of CSV. In horizontal scaling (also called-scaling out) the CSV sites serve as demonstration sites whereby promising agricultural technologies and practices are fostered through farmer-to-farmer learning. By organizing exposure visits and/or other interactions, farmers and their supporting institutions learn about successful CSA technologies and promote them through local policies, programs, and grassroots institutions. For example, in Senegal, a pilot CSA program that focuses on climate forecast and farm advisories, first implemented in the Kaffrine region, has now extended to other parts of the country through a partnership between institutions operating at multiple levels (CCAFS, 2016).

In vertical scaling (also called-scaling up) the success of the CSV program influences policymakers, funding agencies, and implementing organizations so that changes in policy instruments, institutions, or investments are made for the promotion of promising technologies and practices. For example, in the state of Haryana in India, having worked in CSV programs promoted by other organizations, the state government has made policy changes to promote promising CSA practices. At present, through the participatory process, the government of the Indian state of Haryana is implementing the program in more than a hundred climate smart villages with the commitment to expand it to 500 villages (Aryal et al., 2020). The range of strategies for scaling climate smart technologies and practices exhibit different characteristics, and all have considerable potential and limitations to scale CSA intervention (Westermann et al., 2018). Both vertical and horizontal scaling demonstrates the need of understanding institutional aspects that can scale or impede CSA interventions. However, the role of institutional innovation in scaling adaptation options has received less scholarly attention.

It is important to note that the institutional environment has serious implications for providing incentives and the ability of the farmers to invest in CSA technologies.

The collaborative efforts from multiple stakeholders, particularly government, private sector, development organizations, and grassroots institutions are crucial to contribute to the scaling of climate smart technologies, practices, and services appropriate for a particular location or a farming community. The public sector can promote promising technologies and practices through plans, policies, and programs. The private sector can contribute by delivering climate smart services and technologies including the development of new seeds and breeds, the innovation of promising agricultural machinery, development of agro-advisory, and development of sensors for water and nutrient management (Khatri-Chhetri et al., 2019). Finally, the community-based organizations, cooperatives, and farmers groups have a major role in the scaling of CSA in communities.

Analytical Framework for the Study of Institutional Innovation

For analyzing the issue of institutional innovation for the scaling of CSA interventions our study draws insights from the conceptual model that integrates institutional and technological innovation in agriculture proposed by Chhetri et al. (2012) (**Figure 1**). The framework suggests that climate change will manifest through changes in resource endowment (e.g., changes in crop growing seasons, change in soil moisture, increase in pest infestation, etc.) which will then provide signals to farmers and their supporting institutions that trigger reactions in anticipation of the potential climate change impacts. In the process, farmers and their supporting institutions can make adjustments in their agricultural operation such as changes in crop types that better suit the new environment or investment in irrigation infrastructure should drier conditions be created due to changes in rainfall patterns. This might then also induce institutional arrangements that may give rise to the innovation of technology and/or approach to doing agriculture in a changing condition, including communication of complex climate change science to simple and easily understandable forms so that farmers can use this for making everyday decisions.

Climate adaptation is also a local process whereby the community-based organizations (e.g., farmers groups) exert influence in institutional innovation. Climate adaptation is also mediated by local social and ecological context, making cultural dimensions of climate change an important part of the conversation. According to Chhetri et al. (2012), Nepal has transformed the traditional top-down bureaucratic approach to a more participatory and collaborative approach which has contributed to agricultural research and development in the country. This transition fostered the development of location-specific technology in vulnerable places while simultaneously contributing to the formation of a pragmatic institutional mechanism. Recent studies on farmers' adaptation and technology development in Nepal have highlighted the need for including farmers and their situated knowledge and skills in the adaptation planning process to enhance the benefits of policies (Khanal et al., 2018).

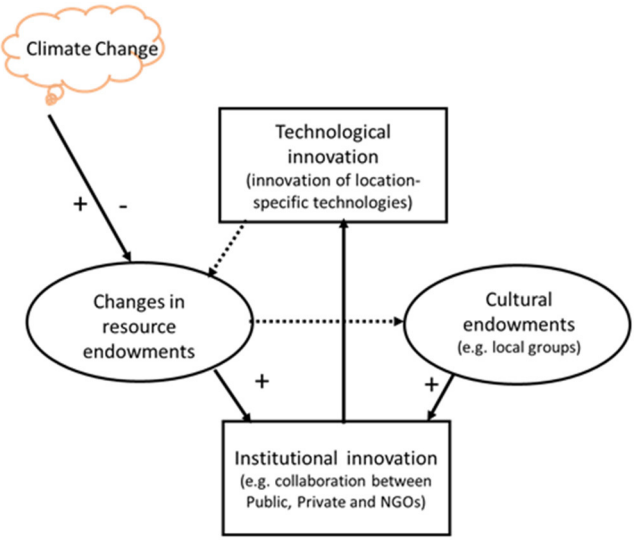

FIGURE 1 | A conceptual model illustrating the integration between institutional, cultural, and technological innovation (source: Chhetri et al., 2012).

STUDY AREA AND THE CSV APPROACH IN NEPAL

In this paper, we present the experience of Nepal's farmers and their supporting institutions to implement CSV pilot programs. Nepal makes an ideal case for the study of the role of institutions for a number of reasons. First, Nepal is an agriculture dependent country and about 83% of Nepal's population lived in rural areas (CBS, 2012). Enhancing their livelihoods and income through the smallholder production system is crucial for reducing poverty and achieving food security. Projections indicate that agricultural production will need to double by 2050 to meet increased demand due to the rise in population, and most of this will need to come from increased productivity (Ray et al., 2013).

Second, Nepal ranks as one of the most vulnerable countries to climate variabilities and changes due to its climate-sensitive ecosystems, and low adaptive capacity (MoE, 2010). Increases in the frequency and intensity of extreme events such as drought, heavy rainfall, flooding, and high maximum temperatures are already occurring and are expected to accelerate in many regions (Xu et al., 2019). Average and seasonal maximum temperatures are projected to continue rising (Thakuri et al., 2019), with higher and untimely rainfall in many parts of the country (Wester et al., 2019). Studies have also shown the likelihood of the surge in various climate-induced events such as dry spells, erratic and intense rainfall, flash floods, landslides, forest fires, and glacial lake outbursts (Xu et al., 2019). Some other studies in the hilly regions of Nepal have revealed an increase in invasive weeds

coverage, increased infestations of crops by insects, and livestock diseases (Gentle et al., 2014, 2018).

Third, Nepal's agriculture is largely rainfed and heavily dependent on monsoon rainfall. Any departure from the expected "normal monsoon" poses serious threats to the long-term sustainability of food production in the country (Chhetri et al., 2012). Climatic events such as erratic rainfall, prolonged drought, and seasonal variability can have significant impacts on agricultural productivity and water availability (Chhetri and Easterling, 2010; Dhungana et al., 2020). These impacts add to a host of challenges to Nepal's agricultural systems. Lack of agricultural technology, limited access to irrigation facilities, and timely supply of inputs make it even harder for farmers to cope with the vagaries of climate. This is further compounded by the migration of youth and the agricultural labor force to urban centers and abroad (Parajuli et al., 2021).

Finally, Nepal makes an interesting case in the governance of climate change adaptation where the agricultural sector has been a prime focus. In addition to the enactment of enabling policies such as the National Adaptation Program for Action (NAPA) 2010 and Climate Change Policy 2011 (now replaced by Climate Change Policy 2019) at the central level, the Government of Nepal (GON) has set a model for promoting grassroots level adaptation initiatives through programs such as Local Adaptation Plans of Action (LAPA) and Community Level Adaptation Plan (CAPA). One initiative that connects grassroots and national level institutions and aspirations is the promotion of CSA interventions through the CSV approach.

The CSA in Nepal has garnered special attention from the development organization. With the aim of boosting food security in the nation while also adapting to the deleterious effects of changing climate, more than a dozen NGOs have mainstreamed CSA activities in their programs (Xu et al., 2019). In the process of implementing CSA activities, the NGOs also work closely with the government and other funding organizations such as the Nepal Agriculture Research Council (NARC), the Ministry of Population and Environment, and research and development organizations such as CCAFS, International Center for Integrated Mountain Development (ICIMOD), USAID, and the World Bank. Some of the early works on CSV include the one implemented by ICIMOD, Center for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED), and partner organizations in Kavrepalanchowk district (also known as resilient mountain village), the CSA program by SNV and other organizations in Western Nepal, as well as the pilot program by Local Initiatives for Biodiversity Research and Development (LI-BIRD) and CCAFS in the Gandaki region.

Following the initial success, Nepal's agricultural development policies and plans began incorporating CSV as one of their climate adaptation policy objectives. For example, with its focus on increasing the resilience of Nepal's farmers, the 2014 Agricultural Development Strategy (ADS) has a strong focus on promoting CSA. In its fiscal year 2016/17 program, the GON stated its plan to implement the CSV concept as a part of its efforts to adapt to climate change. Consequently, the Department of Environment (DOE), Ministry of Population and Environment, GON, initiated a pilot CSV program in 2016 with the target of establishing 170 climate smart villages throughout the country (Pudasaini et al., 2019). Currently, three provinces, namely, Gandaki, Lumbini, and Sudurpaschim, are actively implementing the CSV approach as one of the agricultural development programs, and together they have implemented the idea in more than 200 villages.

METHODOLOGY

This study focuses on two pilot CSV programs in the Gandaki River Basin of Nepal: the development of the CSV portfolio in Nepal initiated by one of Nepal's national NGOs LI-BIRD and the recent works by Gandaki Province that has extended the idea to all eleven districts and 36 provincial constituencies (**Figure 2**).

One of the major undertakings on CSA activities in Nepal was initiated by LI-BIRD in partnership with CCAFS, The Climate and Development Knowledge Network (CDKN), and the GON in 2015–16. This initiative began with an extensive national-level study on the identification, prioritization, and scaling up of CSA technologies. With a focus on increasing productivity and enhancing resilience through the utilization of local resources, in 2018, the Gandaki Province initiated and prioritized the CSV approach as a part of their development plan. Named as "*The Chief Minister Environment Friendly Model Agricultural Village*" and led by the Ministry of Soil Conservation, Agriculture, and Cooperative along with institutions operating at the local levels, this program soon reached all 36 provincial constituencies and created a mutual learning environment. With these interventions, Nepal's Gandaki Province is seen as a pioneer in building the knowledge and capacity to implement CSV programs. Besides having promising initiatives in promoting the CSV approach in Nepal, the Gandaki region is endowed with large arable land and abundant water resources that make it a hub for agricultural research and development. Using the CSV approach implemented in the Gandaki region as a case, this paper assesses the institutional dimension of the CSA. We employ both qualitative and exploratory methods to understand the potential for scaling CSA activities beyond Gandaki Province. The evaluation includes prioritization of CSA options for local context, generation of evidence by piloting the technologies in farmers' fields across different ecological gradients of the province, collaboration, and engagement of a range of CSA stakeholders (farmers and their communities, local government officials, agriculture departments, NGOs, private sector), and overall adoption of CSA through CSV approach by the farmers.

The data collection for this research followed three stages. First, the preparatory works for this paper began with a visit by the first author from November 2017 to January 2018 that included field observation and consultations with key stakeholders involved in CSA programs in Nepal. At this stage, the first author visited climate smart villages in Kavrepalanchowk, Sarlahi, Ramechhap, and Bhaktapur districts and consulted with researchers working on CSA related projects in DOE, ICIMOD, LI-BIRD, and CEAPRED.

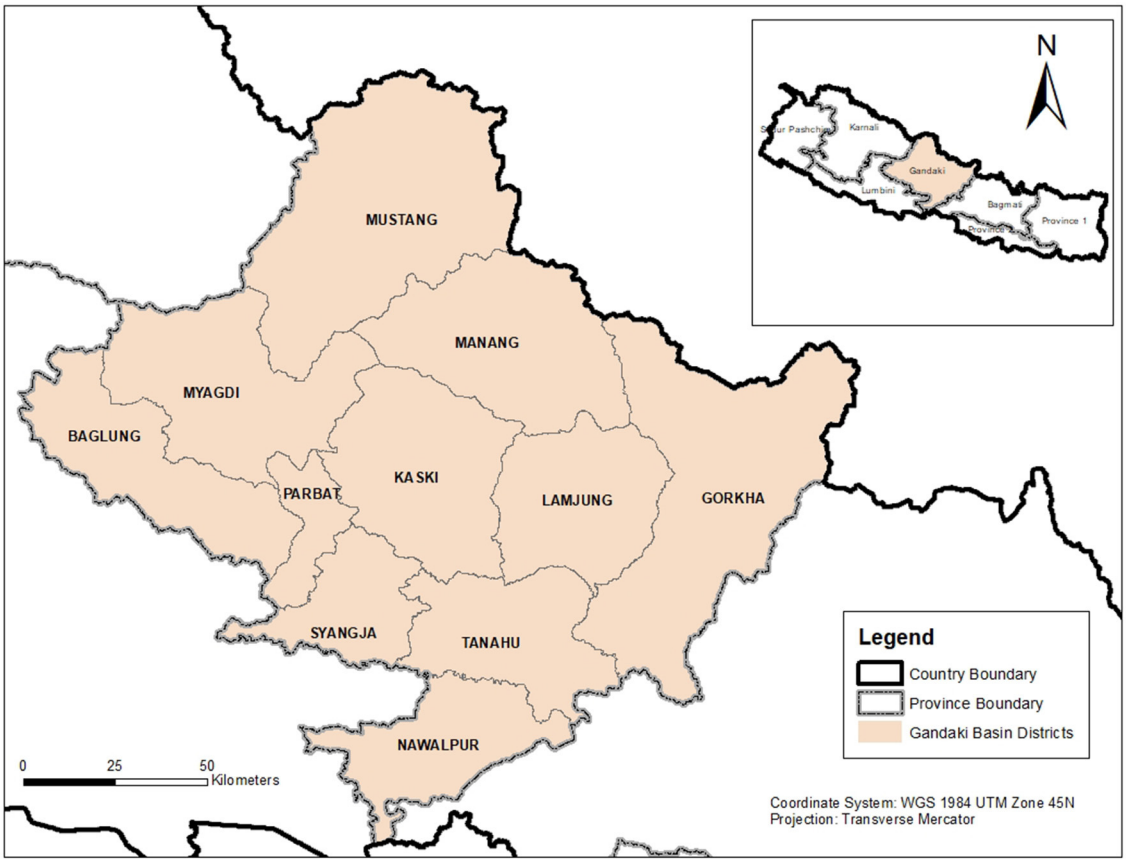

FIGURE 2 | Map of Nepal showing Gandaki province.

The second stage includes the extensive review of policy documents, annual progress reports, and other general publications on CSA activities in Nepal. The documents we reviewed are reports on scaling CSA in Nepal project, CSV training manual, project implementation manuals, and publications related to projects implemented by DOE, ICIMOD, SNV, and the provincial government of the Gandaki province.

Finally, using a snowball sampling method the first author conducted fifteen semi-structured qualitative interviews from September 2020 to January 2021. The research subject included key experts from academia and think tanks, government and non-governmental organizations, funding agencies, and media houses working in adaptation governance in Nepal, including officials involved in implementing these CSV in the Gandaki region. All interviews were conducted via zoom due to the travel restrictions caused by the COVID-19 pandemic. Despite challenges in recruiting women respondents for our interview due to their reluctance and added responsibilities due to the pandemic, it required extra effort to ensure the participation of women in our research. We made sure that at least one-third of the respondents are women—a representative proportion deemed necessary in multiple formal and informal provisions in Nepal. Since the purpose of these interviews was to triangulate the findings of the document review conducted using secondary data and to learn how policy objectives were linked with the local level activities, our focus was to conduct fewer but in-depth interviews. During the field visit and interviews, approval was taken from the Institutional Review Board of the first author's institution and other relevant institutions in Nepal. The transcripts from open-ended interviews with central and regional level stakeholders were analyzed qualitatively using the RQDA computer program, R package for qualitative data analysis.

RESULTS AND DISCUSSION

This section explains the results from the CSA initiative in the Gandaki region and presents a revised conceptual model of institutional innovation while outlining the impacts of the new institutional approach. Both the reviews of the recent literature and our interviews reveal that Nepal has experienced changes in temperature and precipitation at a faster rate than the global average (Xu et al., 2019). Manifested in the forms of droughts, unseasonable rain, extreme temperature and flooding, impacts of climate change are visible in Nepal's food production systems. Lack of access to irrigation, non-existence of weather forecasting systems, and lack of location specific technological innovation make the farmers of the Gandaki region vulnerable to climate change. According to Nepal's NAPA, local communities have

reported that the change in climate has caused a decrease in agricultural and livestock production and productivity (MoE, 2010). Increased incidence of pests and diseases infestation, presence of invasive species, exodus of labor force from rural areas to urban centers, and market volatility has posed serious concerns in the agricultural systems in the region.

Although it is too early to see the actual impacts, the Gandaki Province's CSV can be seen as a noble approach to revitalize the overall agrarian economy of the region. Most importantly, its focus on strengthening local institutions and integrating the existing efforts of various institutions for agricultural adaptation bode well for its effort to scale the CSV approach to national level. First initiated by LI-BIRD and other organizations in the region, our finding reveals that the CSV approach was quickly adopted by the government of Gandaki Province. By involving multiple stakeholders in the implementation of CSA activities and using their own financial resources, the Gandaki Province shows its commitment to scaling as well. Interestingly, investment in the preparation of CSV training materials and simultaneous focus on strengthening collaborative capacity among institutions shows how CSV's focus on increasing productivity and enhancing resilience has galvanized the policymakers and institutions in the region. This study also reveals that the collaborative approach, a signature of the CSV in Gandaki Provence, has enhanced the capacity of the public sector while also making them more accountable to farmers' requests. According to one of the key stakeholders:

> "We have prepared training manuals and flyers of certain technologies in simple Nepali language so that extension staff and the community members can understand them properly. We are trying to integrate this with the government training practice to sustain the capacity building. We are working closely for knowledge-based support for the capacity building of communities."

In addition to the strong public sector engagement, the leadership of the civil sector serves as a boundary object to connect public, private and NGOs operating in the province. For example, LI-BIRD has been engaging a range of actors working in the CSV approach. For accessing scientific knowledge and financial resources they closely collaborate with international organizations such as CCAFS. To increase the capacity of farmers' organizations at the local level, they organize a series of capacity building workshops and trainings. To coordinate CSV activities across the region, in collaboration with the Provincial government, LI-BIRD also organizes periodic workshops and seminars. We also find that the private sector is also playing a crucial role. By bringing them to the calculus of CSV, farmers are able to access credits, agro-vet services, and ICT development relatively easily. The private sector has also been instrumental in enhancing access to markets for farm products. Overall, our study reveals that the CSV approach in the Gandaki region provides a good example of vertical scaling of promising CSA technologies through collaboration, iterative interactions, and mutual learning across public and private institutions operating at multiple levels.

The scaling of CSA in the Gandaki region has a strong focus on the engagement and empowerment of local farmers groups. For example, the CSV's provision of mobilizing local resources has promoted strong and continuous engagement of agricultural staff and local farmers groups. By bringing agricultural experts and multiple institutions closer to the farmers and farming communities this initiative has enhanced the knowledge and experience of farmers and community organizations. In addition to science and technology, the CSV's explicit attention to empowering local-level organizations and local communities, with minimum financial support from the partner organizations, shows potential for continuity beyond the pilot phase of the program. Consequently, this approach has been geared toward changing the knowledge, attitude, and skills of farmers and community organizations that are critical for the success of any program. For example, by working with farmers' cooperatives at the local level, the CSV approach created a pathway to reach the most vulnerable communities in the region. This would not have been possible in the absence of engagement with the Provincial government. By actively engaging with local communities and empowering them to take control of their own CSA activities, providing local agricultural technicians for each village, and gradually reducing subsidies for CSA technologies the CSV offers a more inclusive and bottom-up approach to local development. Frequent interaction between farmers and their supporting institutions also has the potential to build the capacity of local farmers and farming communities in the long run. As one key informant pointed out:

> "In the Gandaki region, we have been working in different aspects at a village level such as local capacity building, institutional strengthening, skill development, technology screening and promoting, marketing, ICT, and integration of all these at the local level to prepare a package. We believe in demonstration and screening of those technologies, to convince local people by having some work in the ground as a demonstration site."

While several other programs in the province and across the country still follow a traditional technology transfer approach for climate adaptation, the CSV approach in the Gandaki region has been active in blending traditional knowledge with new science-based insights for adaptation. A range of location-specific adaptation options developed, piloted, and recommended by the CSV program in the region illustrate the potential for scaling the CSV approaches beyond Gandaki Province. The program, first initiated by an NGO in early 2010, has now been widely included in government policy. While the government of Gandaki Province should be credited for creating a pathway to CSV to pilot, it was possible due to a rigorous process of coming up with a host of location-specific CSA technologies and location-based services (microfinancing)—all geared toward building resilient and viable agricultural production systems in the face of climate and other ongoing changes. The collaborative effort to develop the CSV portfolio is a good example to illustrate this. First, through consultation with government organizations, local development agencies, and farmers, the identification of a pool of 147 CSA technologies is a remarkable achievement.

Second, based on four criteria of appropriateness (technical considerations, farmers' acceptance, climate sensitivity, and scalability) a portfolio of CSA technologies and practices was prepared. Third, CSA technologies were piloted in farmers' fields in three districts of the Gandaki Province (Nawalparasi, Kaski, and Lamjung) for field verification (Paudel et al., 2017). Fourth, based on the learning from the farmer field, a portfolio of promising CSA options was prepared using two cross-cutting themes: (a) three pillars of CSA (food security, adaptation, and mitigation); and (b) gender and social inclusion (GESI). Based on the consultation of agricultural experts and farmers, each of these criteria was given a different weightage. Food security being a major national concern received 40% of the total weightage. The mitigation that is generally considered as a co-benefit for a country having a low carbon footprint received 10 percent of the total weightage. Climate adaptation and GESI were given 30 and 20 percent of the total weightage, respectively.

Based on piloting, testing, and validation of promising technologies, the program ultimately came up with 17 technologies which formed the basis for the scaling of the CSV approach in the region with the re-packaging, co-development, testing and piloting of multiple promising CSA options at village levels. LI-BIRD subsequently added a solar irrigation system as a part of CSA to areas chronically hit hard by prolonged drought and lack of other irrigation facilities. This was necessary to buffer the rising threats of climate variability and change in the region. To date, the Gandaki Province has added a number of new CSA technologies to provide more options for farmers. With further engagement of the National Agricultural Research Council (NARC), Agriculture Knowledge Center, and Livestock Service Center, the CVS is poised to bring additional CSA technologies in the future. Overall, by working closely with the local communities, the CSV program in the Gandaki region has been prioritizing location-specific technologies rather than embracing universal solutions for responding to climate change impacts ill suited to the local needs of the farmers. One of the key stakeholders working in LI-BIRD, illustrated this as:

> "In the Gandaki region, we conducted research in high altitude, middle hills, and the Terai region. Rather than coming up with new technologies, we tried to make a framework to screen available adaptation practices. We also worked on pathways to scale these technologies and practices. Together with CCAFS, we worked on the idea of a climate smart village, to bring this concept forward by understanding context-specific options."

Revised Conceptual Model of Institutional Innovation and the CSV Intervention

Based on our research findings and following the conceptual model by Chhetri et al. (2012), we have developed a new conceptual framework to scale CSA technologies so that it provides a resilient and viable agricultural production system in the face of climate and other ongoing changes. The revised framework (**Figure 3**) recognizes a strong link between the cultural endowment with institutional and technological innovation. This framework emphasizes the integration between biophysical and social, cultural, and relational aspects of climate adaptation (Rodima-Taylor et al., 2012). This is in contrast to adaptation programs that are largely implemented by external agencies without regard to location-specific needs of agricultural systems (Nightingale, 2014). We recognize that the framework provided by Chhetri et al. (2012) is an improvement on the earlier framework that focused more on climate change and technology interaction (Chhetri and Easterling, 2010) and believe that the close coupling between cultural endowment and institutional innovation requires a further extension.

We argue that farmers' decision to adapt to climate change is mediated by social and cultural context. It is embedded in the way farmers organize their agricultural activities and their lifestyles, giving rise to a social organization at the local level. These local social and institutional contexts may hinder and/or facilitate practice of CSA at the farm level. For this reason, local social and cultural context is no less central to scaling CSA technologies. It is also important to note that local social-cultural contexts are also not static. They are in turn shaped by the narrative of the science of climate change. Hence social and cultural context, and its analysis, is central to scaling CSV approach. Similarly, the recognition of the cultural endowment will foster community participation and enhance knowledge, attitude, and skills of farmers and community organizations. This may foster a horizontal or farmer to farmer scaling of CSA technologies. It is in this context, we argue that the proposed framework is more encompassing and offers an integrated model of community, government, and private sector involvement, along with the integration of global and local knowledge.

Impact of the New Institutional Approach—CSV in Nepal

The CSV approach in Nepal has proposed a new model of agricultural adaptation that can be seen as a form of institutional and technological innovation with changes in the financial model, collaboration, capacity building, and the integration of global and local knowledge. Through the case study of Gandaki Province, this section presents pathways through which CSV can contribute to the triple win of increased productivity, enhanced resilience, and reduced emissions.

Enhancing Collaboration

The case of the CSV initiative in Nepal's Gandaki region demonstrates a mechanism for strong cooperation between civil, public, and private sectors in implementing CSA in the country. The initiative taken by provincial and local governments without active financial support from donor agencies provides a clear message of the public sector commitment. This research and deployment of CSA technologies through a collaboration between international and national NGOs, think tanks, local government, and farmers organizations illustrate an example of how different institutions operating at multiple levels can work together in operationalizing CSA technologies. The involvement of the private sector to provide access to insurance, ICT-based agro-advisories, agro-vet establishment, and the development of market mechanisms also demonstrate we need more than the public sector to meet climate adaptation policy objectives. Emerging collaboration with research institutions

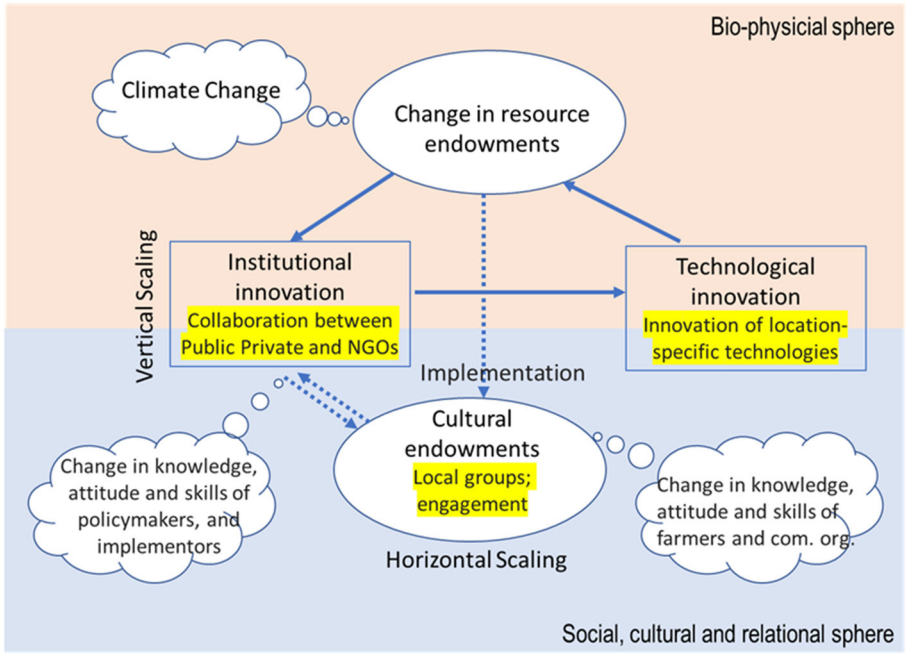

FIGURE 3 | Revised conceptual model illustrating interactions between institutional, cultural, and technological innovation in agriculture.

(e.g., NARC) and universities also signals the beginning of the understanding of the role of science based knowledge in CSV in the future.

Broadly these approaches fall under three models for scaling of CSA: (a) knowledge transfer model, (b) commercial business model and (c) policy incidence model (Khatri-Chhetri et al., 2017). First, the knowledge transfer model focuses on the strong engagement of local institutions, civil society organizations, and I/NGOs in increasing the adoption of promising technologies through training, exposure visits, and demonstrations to farmers. Second, the commercial business model focuses more on the private sector and is suitable for CSA options that require more input or private sector involvement. Finally, the policy incidence model calls for increased support from the government in the form of subsidies and agricultural extension programs. The initiative in Nepal recognizes that different institutions might take leadership in each of the three models, each of them calls for strong collaboration between multiple actors. In general, the knowledge transfer model is conceptually closer to horizontal scaling, the policy incidence model builds on the idea of vertical scaling, and the commercial business model lies somehow in between these. This suggests that, while bringing multiple institutions together, the CSV approach also supports horizontal and vertical models for scaling of promising CSA options. For the scaling of CSA one size may not fit all, as these options differ based on their characteristics, methods of application, and the contextual factors of a given place. Often the scaling of CSA options also requires a combination of approaches rather than having one best approach (Khatri-Chhetri et al., 2017).

Integrating Local and Global Knowledge for Climate Action

Although introduced by the UN agency, the CSV resonated with Nepal's local level actors. The initial success of the CSV is credited to its strong link to local-specific need for responding to climate and other ongoing challenges. This was further strengthened by vibrant grassroots organizations and the rich history of community-based natural resource management (e.g., Community Forestry). While most Least Developed Countries (LDCs) did not mention local institutions as having a role in actively engaging in climate adaptation policy objectives (Agarwal et al., 2012), Nepal demonstrated its commitment through their NAPA such as by preparing LAPA and committed to investing 80% of the climate change budget at the local level, leaving only 20% coordination at central levels (MoE, 2010).

The integration of local and global knowledge for climate action has produced context-appropriate technologies and practices. Although several CSA practices are not new, they have been integrated into the CSV model. For example, communities have been practicing mixed crop-livestock farming for generations. By engaging farmers and their supporting institutions, the advocates of CSV have, with some modification, included a large number of locally practiced knowledge into the overall package. In doing so this initiative demonstrates that the divide between indigenous and scientific knowledge is misleading as both can be science-based, and the scientific knowledge is deeply intertwined with the social sphere (Agrawal, 1995; Ghimire and Chhetri, 2021). Moreover, while coming up with separate sets of adaptation options suited for different ecological regions, new initiatives such as the CSV recognizes

that there is a large difference in climatic impacts and available adaptation options within and among the Mountain, Hills, and Terai region (Chhetri, 2011).

The CSV approach has been helpful in strengthening the capacity of actors at the local levels by changing their knowledge, attitude, and skills about climate change and adaptation. By engaging with local government units, established after the enactment of the Constitution of Nepal 2015, this initiative was able to forge new alliances and enhance the capacity of all institutions working on agricultural adaptation. The leadership of the provincial government, in association with NGOs and other civil society actors has been very helpful to advance the idea of locally led adaptation as a signature approach of CSV. This is in contrast to contemporary practices on adaptation driven by international and national agendas, where the voices of local communities struggle to reach the decision-makers. Capacity strengthening is an important part of agricultural adaptation and there should be a value proposition or incentive for all stakeholders to contribute to adaptation.

Addressing National and Global Climate Policies

By linking with the triple goal of increasing productivity, enhancing resiliency and simultaneously reducing agriculture's greenhouse gas emission, the CSV provides environmental co-benefits and aligns with domestic and international commitments such as Paris Agreements, NDC, and SDGs. Although the agriculture sector in developing countries has a small carbon footprint and the focus has been more on the adaptation of the agriculture sector against climate change impact, the commitment toward mitigation as a co-benefit means a lot. Among 17 SDGs proposed by the United Nations (2015), the CSV approach contributes to multiple SDGs. Directly it supports three goals (SDGs #2 zero hunger, #13 climate action, and #15 partnerships for the goals) and indirectly contributes to multiple other goals. The CSA initiative in developing countries in general and more specifically the CSV approach has focused on food security more seriously. For example, the food security goal was given the highest weightage (40% of total) for evaluating CSA options. Through its focus on local and contextual knowledge, CSV also contributes to enhancing agrobiodiversity. Likewise, the CSV program also has a strong focus on climate action as it provides mitigation co-benefits for achieving country specific mitigation goals. The role of CSV in collaboration between the multiple institutions and the indirect link to multiple SDGs illustrate its contribution to building partnerships for the achievement of SDGs.

The institutional and technical innovation promoted by this initiative indirectly benefits SDGs #1 No poverty, #3 good health and wellbeing, #5 gender equality, #6 clean water and sanitation #7 affordable and clean energy #15 life on land, and #17 peace, justice, and strong institutions. With the increase in productivity, the CSV approach can reduce poverty and increase income for marginalized smallholder farmers. In fact, increasing productivity and farmers' income is one of the pillars of the CSA intervention. Since the focus on CSV approach has been on practices such as mixed farming, homestead garden, reducing pesticide use, and encouraging biopesticide and biofertilizers these all can contribute to providing balanced nutrition, good health, and wellbeing. The commitment of the CSV approach to gender equality is evident from the fact that GESI is one of the pillars for prioritizing CSA options. In addition, there is a strong involvement of women and women's groups during the implementation of this initiative. The CSV programs have categorized CSA options as water-smart and many such programs are geared toward providing clean water and sanitation at the household and community levels. Similar to providing water security, the CSA options promoted through CSV programs provide alternative energy sources such as improved cooking stoves, solar pump irrigation systems, small hand devices, etc. Strongly contributing to the forest and biodiversity, another benefit of these practices can be on flora and fauna living on land. Finally, institutional innovation through the CSV initiative has promoted the strengthening of institutional capacity while fostering partnership and collaboration between multiple actors. The findings from this study also aligns with Newell et al. (2019). Conducted in four Eastern African countries they reveal that CSV has a greater potential of building more climate resilient food and agricultural systems while contributing to achieving multiple SDGs.

The CSV programs being implemented in Nepal are not immune to challenges. Aryal et al. (2020) suggest climate change is adding yet another stress to the local resource base as it has been used indiscriminately. The CSV's ambition is to reach out to a large number of communities in a short period of time may be unrealistic. Most research and publications on CSA have focused their attention on CSV operated by NGOs, whereas the government program despite being imperative in scaling up CSV is relatively less discussed. While we acknowledge that the NGOs role in making the CSV approach widely available is commendable, it is hard for them to make a long-term impact through their programs because of the short-term and project-based nature of their activities. It is also imperative to understand the dynamic nature of socioeconomic, institutional, and technological factors that shape the development and scaling of CSA options (Waaswa et al., 2021). With the analysis of government policies and related documents of Nepal, Paudyal et al. (2019) have argued that CSA interventions are largely gender-responsive, its continuity will hinge on developing gender-responsive technologies and practices. Likewise, other scholars have urged on reducing gender gaps and enhancing mainstreaming in CSA technology development and adoption (Khoza et al., 2019; Khatri-Chhetri et al., 2020). Finally, it is imperative to extend the number of villages benefiting from the CSV initiative as prior studies have demonstrated that farmers from a CSV are more aware of climate variability and likely to adopt adaptation options compared to farmers from a village that has not implemented the CSV program (Tetteh et al., 2020).

CONCLUSION

This paper has explained how the CSV approach promoted through collaborative approaches in Nepal makes a strong case for scaling CSA activities. By proposing a modified institutional

framework this study also reveals possibilities for scaling CSA technologies beyond their test sites. We also found that, since the start, the CSV program promoted collaboration among public, private, and development sector organizations to design, implement, monitor, and evaluate climate actions at the local level. By building the capacity of community-based organizations, the CSV approach has a strong potential for scaling both vertically and horizontally. With the involvement of provincial and local governments, CSV programs are deploying already tested and evaluated climate smart technologies, practices, and services to the farmers and their communities. This approach is also helping to combine local and global knowledge while serving as a hub for active learning and innovation for climate action in agriculture and allied sectors. This initiative promises to provide environmental benefits including contributing to domestic and international commitments such as Nationally Determined Contributions (NDC) under the Paris Agreements and Sustainable Development Goals (SDGs).

This study reveals the importance of building collaboration among multiple institutions—local to international and between private, public, and civil society for scaling up/out of climate smart agricultural technologies, practices, and services. This collaboration catalyzes innovation in climate change adaptation and enhances farmers' participation and adoption of CSA. This is also crucial to cultivate an ideal partnership with local government, community-based organizations, development organizations (NGOs), and the private sector. Local institutions (i.e., farmer groups) and intermediaries (i.e., non-governmental organizations) can play a leading role in institutional innovation and integration of local and global knowledge for effective design, management, and monitoring of the CSV approach of scaling the CSA.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

RG conceptualized the paper, prepared a draft manuscript, and performed analysis. AK-C edited the manuscript and contributed to the revision of the paper. NC wrote and edited the manuscript and contributed to the modified framework as well as the revision of the paper. All authors contributed to the article and approved the submitted version.

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The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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