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FINAL REPORT

Assessing the Profitability of Climate Smart Agriculture in the Ganges-Brahmaputra River Basin of South Asia.

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1. Summary
Ganges Brahmaputra (GB) River Basin of South Asia is experiencing climate uncertainties and extremes which are disproportionately affecting agriculture, state of food security and livelihoods of small-scale farmers. Climate-Smart Agriculture (CSA) is undoubtedly important to deal with these challenges by increasing productivity, adaptation to the extreme climate conditions and mitigate greenhouse gases (GHGs) emission. Currently, CSA has been highly adopted to reduce the climate change effects on the agricultural sector and enhance the resilience of small-scale farmers. Assessing the profitability of these practices is imperative to decide whether to continue or drop the adopted practices. This study aimed to assess the profitability of CSA practices through cost and benefit analysis adopted by small-scale farmers in Ganges Brahmaputra River basin of South Asia particularly in Bangladesh, India and Nepal. A thorough understanding of the costs and benefits of CSA options is urgently needed to identify the best adaptation options for both short and long-term interventions in the agriculture sector amid climatic uncertainties. The outcomes of the research would support the farmers to make decisions on the most profitable option and for policymakers to formulate effective climate change linked to agricultural policies and programs. Thus, this research fosters links between science, practice and policy linkages for sustainable food security and small-scale farmers’ resilience to climate change.

2. Objectives
The broad objective of the project is to assess the profitability of CSA practices through cost and benefit analysis adopted by small-scale farmers in Ganges Brahmaputra River basin of South Asia particularly in Bangladesh, India and Nepal (BIN).

The specific objectives of the project are:

1. To develop the CSA prioritization framework;
2. To evaluate the major costs and benefits associated with implementing the selected CSA practices in Bangladesh, India and Nepal.
3. To assess the value of externalities associated with CSA practices and to incorporate the estimated value of externalities in the cost and benefit analysis of the CSA practices;
4. To develop an open access web-based platform (CSAFarm) for information sharing and data archive system of CSA and small-scale farmers.

The objectives will seek answers to the following questions:

1. What are the highly adopted/high interest CSA technologies in BIN?
2. What are the major costs and benefits associated with implementing the selected CSA practices?
3. What are the externalities and their value associated with implementing the CSA practices?

3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
• Workshop reports • Survey reports • Manuscript on CSA prioritization for a peer-reviewed journal, co-authored by all collaborators • Manuscript on the cost-benefit analysis of climate-smart agriculture for a peer-reviewed journal, co-authored by all collaborators • Templates for expert consultation workshops • Methodology for evaluating externalities of CSA practices • Identification of potential value chains in the region • Project website • Media release to raise awareness on the economic benefits of CSA practices	• Four climate-smart agriculture (CSA) practices were prioritized for each country under study. • The costs and benefits of the adopted CSA practices in Nepal, Bangladesh, and India were evaluated. • An expert consultation workshop was conducted. • Externalities associated with CSA practices were evaluated and incorporated into the analysis. • Analysis report on costs and benefits of CSA practices • Increased awareness of the economic benefits of CSA technologies	This project enabled the prioritization of climate-smart agricultural practices in Bangladesh, India, and Nepal and assessed the profitability of these prioritized practices. Beyond private profitability for adopting farmers, the externalities associated with the CSA practices were identified and analyzed. The project outcomes are expected to enhance climate change resilience in the Ganges-Brahmaputra River basin. Additionally, the availability of evidence-based knowledge materials supports the development of country-specific climate-smart agriculture policies for Bangladesh, India, and Nepal. This contributes to an enabling environment that improves policies and practices addressing the strategic needs of small-scale farmers.

4. Key facts/figures

- A total of 300 farm households were surveyed: 100 from each Bangladesh, Nepal and India.
- 3 Farmers' workshops and 3 stakeholders' workshops were held, one in each study area.
- One final workshop was held in Kathmandu, Nepal.
- A project website has been developed (https://www.krishiangan.com/) for data archive system and information sharing. Four smart climate agricultural practices were prioritized for rice, maize and vegetable farming system in each of the study area.
- Among the prioritized practices, the use of crop specific lure in maize farming system was found to be most profitable practice in Nepal. Mixed cropping of potato was found to be the most profitable practice in India and the use of improved manure in cabbage farming system was found to be the most profitable practice in Bangladesh.
- Media coverage of the project work.

5. Publications

- Poudel, S., Thapa, R., & Mishra, B. (2024). Cost-benefit Analysis of Climate Smart Agriculture in the Gandaki River Basin of Nepal. Under revision, Regional Sustainability, Elsevier.

- Poudel, S., Mishra, B., Anwarul, A., & Shaw, R. Is Climate Smart Agriculture Profitable in the Ganges-Brahmaputra River Basin? Under review, Agricultural Systems.

- Poudel, S., Wickramasinghe, D., Mukherjee, M., Chowdhooree, I., Chimi, C., Mishra, B., Abhinay, K., Mitra, S., & Shaw, R. (2023). Science, Policy, and Practice: The Status and Prospects of Nature-Based Solutions in South Asia. PLOS Climate. https://doi.org/10.1371/journal.pclm.0000289

- Poudel, S., Mishra, B., Ghimire, S., Luintel, N., Thapa, P., & Sapkota, R. (2023). Climate Change and Agroecosystems: Impacts, Adaptation, and Mitigation in South Asia. In Climate Change, Community Response, and Resilience, Elsevier. https://doi.org/10.1016/B978-0-443-18707-0.00017-5

- Mukherjee, M., Wickramasinghe, D., Chowdhooree, I., Chimi, C., Poudel, S., Mishra, B., Faruqui Ali, Z., & Shaw, R. (2022). Nature-Based Resilience: Experiences of Five Cities in South Asia. International Journal of Environmental Research and Public Health, 19(19), 11846. https://doi.org/10.3390/ijerph191911846

- Mishra, B., Panthi, S., Ghimire, B. R., Poudel, S., Maharjan, B., & Mishra, Y. (2023). Gridded Precipitation Products on the Hindu Kush-Himalaya: Performance and Accuracy of Seven Precipitation Products. PLOS Water, 2(8), e0000145. https://doi.org/10.1371/journal.pwat.0000145

6. Media reports, videos and other digital content

- Featured by Online Khabar: "50 Influential Women of Nepal" and work in the Ganges-Brahmaputra River Basin. March 8, 2024. Link: https://english.onlinekhabar.com/influential-women-nepal.html
- Featured by Nepal Britain: "10 Inspiring Nepali Women from Abroad" highlighting work on climate-smart agriculture. March 8, 2024. Link: https://nepalbritain.com/?p=144799
- Featured by Community Information Network: Report on January 11, 2024. Link: https://www.cinkhabar.com/detail/4348
- Featured by Shilapatra: On International Women’s Day 2023, March 8, 2023. Link: https://shilapatra.com/detail/107274
- Featured by Kantipur National Daily: Opinion feature, February 12, 2023. Link: https://ekantipur.com/opinion/2023/02/12/167616754804788075.html
- Featured by Nepal Times: "Sky is the Limit for Nepal’s Women Scientists", February 11, 2022. Link: https://nepalitimes.com/here-now/sky-is-the-limit-for-nepal-s-women-scientists
- Featured by Himal Khabar: "The Avenues Shown by Scientist Shobha in Agriculture", February 11, 2022. Link: https://www.himalkhabar.com/news/128261
- Featured by Kantipur National Daily: Opinion piece, February 19, 2022. Link: https://ekantipur.com/opinion/2022/02/19/164524838808579138.html

- Featured by Himal Khabar Patrika: Coverage on CSA work in Nepal, February 12, 2022. Link: https://www.himalkhabar.com/news/128268
- Featured by Arniko Television: "Climate Change and Disaster Impacts on Food Security", October 22, 2021. Link: https://www.facebook.com/AranikoNewsChannel/videos/690811648557780/

7. Pull quotes

The workshop brought together a diverse group of stakeholders from government, academic and civil society, and research institutes. With specific deliberations from Nepal, India and Bangladesh, the workshop exemplified the importance of climate smart agriculture (CSA) with specific focus on its cost effectiveness. The panel discussion at the end expanded the key challenges and potentials with specific examples from different countries- Prof. Rajib Shaw, Keio University, Japan.

Climate Smart Agriculture (CSA) is not a luxury, it is essential to tackle climate variability using weather smart, water smart, energy/carbon/nutrient smart, institution/market smart and finally seed and breed smart approaches. It's my great honour to work as a collaborator of this project. The key focus of the project was to analyse profitability of CSA practices in the Ganges Brahmaputra River Basin, which is time demanding for the farmers of this region. Our Bangladesh team is very much keen to work on in-depth analysis of CSA practices and its true implication in global south. Nevertheless, we strongly believe that our research findings have a positive impact of our end users like farmers and policy makers. Definitely, our team are ready to work together as new beginning of research in the field of CSA in the forth coming days- Prof. Md. Anwarul Abedin, Department of Soil Science, Bangladesh Agricultural University, Bangladesh.

I have participated the project closing workshop on "Assessing the profitability of climate smart agriculture practices in the Ganges Brahmaputra River Basin" and found it very interesting. I would like to appreciate the team for the exploration of new dimension in agriculture. I am very much sure that the results of the project will be useful to the farmers and also to the policy makers- Dr. Biva Aryal, Amrit Science Campus, Tribhuvan University

It was a wonderful workshop with experience and expertise from Japan, Bangladesh and other countries. Presentations and experience sharing by the dignitaries was real ground based and would be useful for all participants. It was widely covered by participants from academia, policy makers from the Government of Nepal and farmers from the project sites. There was a wide range of active participants. Last but not the least, this program was really useful for my professional as well as practical life. I am very much grateful to organisers for their excellent technical as well as logistic management- Dr. Pradyumna Pandey, Senior Agriculture Economist, Ministry of Agriculture and Livestock Development

8. Acknowledgments

We extend our heartfelt appreciation to the Asia Pacific Network for Climate Change Research (APN) for granting us the opportunity to undertake this project in the Ganges Brahmaputra River basin covering three countries. Gratitude is also owed to all our collaborators for their unwavering support and understanding, particularly during the challenging times of COVID-19. Our immense thanks go out to the entire project team, including research assistants, program managers, field data collectors, technical supervisors, and the advisor we consulted. We feel fortunate to have had such a dedicated and capable team; their contributions were indispensable in maintaining the quality of our work.

9. Appendices

Appendix 1: APN Planning Meeting:

Date: 2021/12/18

Place: Remote in Teams

<u>APN planning meeting report</u>

The planning meeting of the Asia-Pacific Network for Global Change Research (APN) took place on December 12, 2021, remotely. Distinguished guests in attendance included Prof. Shinya Funakawa from Kyoto University, Japan, and Dr. Bhogendra Mishra from Science Hub, Nepal, Mr. Praseed Thapa from Agriculture and Forestry University, Nepal, Prof. Dr. Anwarul Abedin from Bangladesh Agricultural University, Bangladesh and Dr. Ranit Charterjee from Resilience Innovation Knowledge Academy (RIKA), India and Dr. Shobha Poudel from Science Hub, Nepal hosted a meeting. Unfortunately, our esteemed advisor Prof. Rajib Shaw from Keio University Japan was unable to attend due to his busy schedule.

The primary purpose of the meeting was to kick off the planning phase of the project "Assessing the Profitability of Climate Smart Agriculture in the Ganges-Brahmaputra River Basin of South Asia." Dr. Poudel opened the meeting with a presentation outlining the agenda of the meeting followed by project goals, objectives and expected results as well as roles and responsibilities among the collaborators. All the collaborators and advisor committed for the successful completion of the project.

Appendix 2: Stakeholders' Workshop in Kavre Nepal:

Date: July 16, 2022

Venue: Apris Bhojanalay and Khaja Ghar, Kavre, Nepal

According to the objective of the project we had stakeholders meeting in Kavre to identify and prioritize the CSA practices in the study area. The workshop aimed to gather farmers, policy makers, related stakeholders and government official to understand the CSA practices implementing CSA on the study site. The program started with welcoming remarks by the Research Assistant of the project Mr. Saurya Karmacharya from Science Hub, Nepal. Chairman of the Science Hub, Dr. Bhogendra Mishra delivered the opening remarks.

The main objective of this workshop was to find out the CSA practices followed to address the extreme climatic events in the study area.

1. To develop the CSA prioritization framework


Appendix 3: Stakeholders' workshop in Rajashahi, Bangladesh:

Date: 20 -21 August 2022
Venue: Upazilla Agriculture Training Room, Godagari, Rajshahi

Bangladesh faces climate uncertainties and extreme weather conditions that disproportionately impact agriculture, food security, and the livelihoods of small-scale farmers. Godagari Upazila, located in the Rajshahi district within the Ganges-Brahmaputra river basin of South Asia, is one of the climate hotspots in Bangladesh.

Background

Climate-Smart Agriculture (CSA) plays a crucial role in addressing these challenges by increasing productivity, adapting to extreme climate conditions, and mitigating greenhouse gas emissions. CSA practices have been widely adopted to reduce the effects of climate change on agriculture and improve the resilience of small-scale farmers. Assessing the profitability of these practices is essential to determine whether they should be continued or modified.

This study aims to evaluate the profitability of CSA practices through a cost-benefit analysis, focusing on small-scale farmers in the Ganges-Brahmaputra River basin, specifically in Bangladesh. A comprehensive understanding of the costs and benefits of CSA options is urgently needed to identify the best adaptation strategies for both short-term and long-term interventions in the agriculture sector. The findings of this research will assist farmers in selecting the most profitable options and will aid policymakers in formulating effective, climate-linked agricultural policies and programs.

Challenges

Addressing climate change impacts on agriculture presents unique challenges. Several factors influence the extent to which farmers in a specific area adopt CSA technologies. Practices such as minimum tillage, various crop establishment methods, nutrient and irrigation management, and residue incorporation can enhance crop yields, improve water and nutrient efficiency, and reduce greenhouse gas emissions (Branca et al., 2011; Jat et al., 2014; Sapkota et al., 2015). Similarly, rainwater harvesting, improved seeds, ICT-based agro-advisories, and crop/livestock insurance can help mitigate the impacts of climate change (Mittal, 2012; Altieri and Nicholls, 2013). Despite these benefits, the adoption rate of CSA technologies remains relatively low (Palanisami et al., 2015). Identifying, prioritizing, and promoting CSA technologies that address local climate risks and meet farmers' demands are essential steps in scaling CSA across diverse agro-ecological zones.

The identification and prioritization of CSA technologies contribute to climate change adaptation planning by guiding investments across various zones. CSA implementation strategies should consider adaptation options that local farmers have evaluated and prioritized in response to local climatic risks (FAO, 2012).

Methodology

This study used a stated preference method to analyze farmers' choices of CSA technologies under adverse climatic conditions. In this method, respondents were asked to choose from a list of technologies, while the revealed preference method assesses preferences based on actual adoption and market values. Multiple prioritization approaches were applied, including simulation models, expert judgment, household surveys, key informant interviews, participatory appraisals, and hybrid methods. This research employed a participatory assessment to gauge farmers' preferences and willingness to pay for CSA technologies, assisting policymakers in developing plans that reflect local CSA priorities.

Workshop Objectives

- To identify CSA practices used to address extreme climatic events in the study area.
- To develop a CSA prioritization framework.

Workshop Overview

The farmers' workshop was held on 20 August 2022 at the Upazila Agriculture Training Room in Godagari, Rajshahi (see Fig. 1). The workshop began with a recitation of the Holy Quran, followed by participant introductions. A total of 50 participants attended, including the UAO of Godagari as the chief guest, and representatives Shova Paudel, Bhogendra Mishra, and Prashed Thapa from Nepal. All SAAOs of the upazilas and the Director of the Rural Development Academy (RDA) were also present. The project team (PI, Co-PIs, and researchers) conducted the workshop.

Professor Dr. Md. Anwarul Abedin, Co-PI of the project, opened the session with a presentation on the project objectives, followed by a discussion on CSA practices used by farmers in Godagari, a climate hotspot in Rajshahi. Participants actively engaged, sharing insights on the project theme, the benefits of CSA practices, and their potential as change-makers in agriculture. Farmers openly discussed the CSA practices they use to cope with adverse climatic conditions, and their willingness to invest in these practices was gauged through an auction-style exercise, with scores and bidding amounts recorded for prioritization.

The UAO shared insights on CSA practices used in Godagari Upazila, expressing willingness to provide necessary data for developing climate-resilient CSA strategies. Professor Dr. Anwarul Abedin concluded the discussion and thanked all participants for their active engagement.

Farmers' Workshop on Assessing the Profitability of Climate-Smart Agriculture in the Ganges-Brahmaputra River Basin, South Asia

The workshop brought together a diverse group of participants, including the UAO, AEO, SAAOs, farmers, the Director of the Rural Development Academy (RDA), representatives from BAU, and members of academia. Through discussions, a set of climate-smart agriculture (CSA) practices was identified and prioritized based on extreme climate events, such as drought, flooding, high summer temperatures, low winter temperatures, and soil fertility decline.

Among the CSA practices, farmers prioritized 12 techniques (Table 1), ranking them by multiplying the CSA pillar totals with the bidding amounts. The top practices included using short-duration, high-yielding varieties, improved water management, drought-tolerant varieties, converting highlands for high-value crops, alternative cropping, proper fertilizer use, organic amendments, mulching, adjusted planting dates, crop rotation, intercropping with short-duration vegetables, and submergence-tolerant varieties. Notably, short-duration, high-yielding varieties ranked first, helping farmers avoid adverse climate conditions, while submergence-tolerant varieties ranked lowest, likely due to the limited lowland areas facing inundation during the rainy season.

The workshop concluded successfully with a shared belief that prioritizing these CSA practices will guide policymakers in developing supportive actions and resources for sustainable agriculture and improved farmer livelihoods in climate-sensitive areas like Godagari Upazila. The findings also indicate that farmers' preferences and willingness to pay are influenced by the costs and benefits of the technologies.

Stakeholder WorkshopA stakeholder workshop was conducted on 21 August 2022 at the Training Hall, DD Office, DAE, Rajshahi, to validate and provide policy recommendations on implementing CSA practices followed by farmers in Godagari Upazila, Rajshahi (Fig. 1). The workshop opened with a recitation of the Holy Quran, followed by introductions. A total of 50 participants attended, including the District Training Officer (DD), UAO, ADD, and DTO. Additional attendees included representatives from the Bangladesh Agricultural Research Institute (BARI), Rural Development Academy (RDA), Rajshahi University (RU), Bangladesh Agricultural University (BAU), and national NGOs. The project team (PI, Co-PIs, and researchers) facilitated the workshop.

Professor Dr. Md. Anwarul Abedin and Dr. Shobha Poudel, the PI of the project, provided a brief overview, followed by discussions to verify the CSA practices implemented by farmers in climate-sensitive areas of Godagari, Rajshahi. Participants enthusiastically shared their insights on the project's relevance, potential impact, and its role as a catalyst in transforming the agriculture sector. Stakeholders actively validated the prioritized CSA practices, identifying the positive externalities of each and suggesting methods for effective local implementation.

After the discussion, the UAO addressed policies that could enhance the effectiveness of CSA practices in areas like Rajshahi. Dr. Shobha Poudel thanked stakeholders for their hospitality and fruitful discussions, expressing commitment to collaborate on necessary upazila-level data for developing climate-resilient CSA policies. Professor Dr. Md. Anwarul Abedin concluded the workshop by thanking all participants for their time and engagement.

Verified CSA Practices and External Effects

During the workshop, stakeholders verified the CSA practices adopted by farmers in Godagari Upazila and identified positive external effects. Preferred practices included using short-duration, high-yielding varieties, improved water management, drought-resistant varieties, high-value cropping on highlands, alternative crops, appropriate fertilizer use, organic amendments, mulching, altered planting dates, crop rotation, intercropping with short-duration vegetables, and submergence-tolerant varieties. The positive effects indicate that these practices are effective when considering factors like seasonal variations, soil fertility, crop requirements, and financial benefits.

Conclusion

The workshop successfully concluded with confidence that the verified CSA practices would support policymakers in developing a structured framework for implementing prioritized practices at the local level. Such micro-level policies could enhance sustainable agricultural production and improve the livelihoods of farmers in climate-sensitive areas like Godagari Upazila, contributing to climate change adaptation at the local level.

Figure 3 Photograph taken during the Stakeholders' workshop in Rajashahi, Bangladesh.

Figure 4 Photograph taken during the Stakeholders' workshop – government officers in Rajshahi, Bangladesh.

Table 1: CSA practices followed by farmers and prioritization ranking at Godagari upazilla, Rajshahi

CSA Practices	CSA Pillars				Bid	Obtained Score	Prioritization Ranking
Names	**Productivity**	**Adaptation**	**Mitigation**	**Total**	**(Amount of money)**	**(CSA Pillars Total X Bidding amount)**	**Highest value gets higher priority**
Use of short duration and high yielding varieties	4	3	3	10	100.00	1,000.00	1
Improved irrigation Deep Tubewell, AWD, Use of River Water)	3	3	3	9	100.00	900.00	2
Use of drought tolerance and high yielding varieties (Feb, March April) drought arises	3	4	2	9	80.00	720.00	3
High land to high value crops	3	3	2	8	80.00	640.00	4
Alternative crops	2	3	3	8	70.00	560.00	5
Proper use of fertilizers	1	1	3	5	100.00	500.00	6
Use of organic fertilizers	2	2	2	6	80.00	480.00	7
Mulching (Tomato, watermelon, chilli, cucumber)	3	3	3	9	50.00	450.00	8
Changing planting dates	3	2	2	7	60.00	420.00	9
Crop rotation	2	2	1	5	80.00	400.00	10
Intercropping with short duration vegetables	2	1	1	4	80.00	320.00	11
Use of submergence tolerance and high yielding varieties	2	2	1	5	50.00	250.00	12

Appendix 4: Stakeholders' workshop in Samastipur, India:

Date: 8-9 September 2022

Venue: Kisan Vigyan Kendra, Birauli and Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur

For the prioritisation of climate-smart agriculture (CSA) practices in the Ganges-Brahmaputra River Basin of South Asia, a workshop was conducted with the farmers on September 08, 2022, at Chako Bhindi village of Nikaspur panchayat of Morwa block of Samastipur district in Bihar. A total of 43 stakeholders participated in the workshop, including 31 farmers, and eight experts from the Agriculture Department, Samastipur and Kisan Vigyan Kendra, Birauli.

Food and Agriculture Organisation of the United Nations define climate-smart agriculture (CSA) "as an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices". Bihar state in India is located on the rich fertile land of the Ganga basin and has a high potential for adaptation of the CSA practices. The state is dominated by agriculture as its 77 percent population is engaged in the sector. State also enjoys favourable weather conditions that support a variety of crops. Parallelly, the state is also suffering erratic rainfalls leading to floods and droughts and affecting cropping patterns.

The government of Bihar is working towards the promotion of climate-smart agriculture practices in the state. As a pilot project, CSA practices have been introduced in the five villages, namely Chako Bhindi, Chak Pahar, Gurai Basti, Harpur Bhindi and Rampur of the Samastipur district and are being supported by the Krishi Vigyan Kendra for its implementation. CSA practices have been introduced in these villages recently and are piloted on the crops such as paddy.

The objective of the workshop was

- to identify the CSA practices applied in Samastipur
- to select and prioritization of the CSA practices
- to identify the externalities generated by CSA practices

Prioritisation of CSA Practices

After the discussion with farmers, it was found that the following key practices were introduced in the area.

1. Zero Tillage
2. Direct Seeded Rice (DSR)
3. Raised Bed Planting
4. Intercropping
5. Sprinkle Irrigation
6. Kitchen Gardening
7. Residue management/ mulching
8. Laser land levelling

The zero-tillage technique was piloted in the village as a CSA practice for rice, maise and wheat last year. In this practice, seeds are sown through drillers without disturbing the soil where previous crop stubbles are present. The farmers could not get the desired results as the area suffered severe flooding and suffering drought conditions in the current season. Direct Seeding of Rice (DSR) is also piloted in the fields, and as per the farmers, in some fields where enough irrigation is provided, their growth is good as compared to others.

The group of women who participated in the workshop are members of the Bihar Rural Livelihoods Project (BRLP), locally known as JEEViKA and got trained in kitchen gardening through natural farming practices. They make eco fertilisers and pest management solutions at home. It involves the usage of locally available natural materials such as cow dung and cow urine to prepare the natural fertiliser and neem leaves, garlic, chilli etc., to control pests. This method is used to reduce the cost of cultivation without affecting productivity as farmers use indigenous inputs made from crop residuals and other home-grown materials.

The farmers were asked to prioritise these practices based on the three criteria.

Sr. No.	CSA Practice	Productivity	Adaptation	Mitigation
1	Zero Tillage			
2	Direct Seeded Rice (DSR)			
3	Raised Bed Planting			
4	Intercropping			
5	Sprinkle Irrigation			
6	Kitchen Gardening			
7	Residue management/ mulching			
8	Laser land levelling			

Figure 6 Stakeholder discussion at Dr.Rajendra Prasad Central Agricultural University, Bihar.

The stakeholder discussions were held with the group of experts of Kisan Vigyan Kendra, Birauli and Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, to understand the externalities associated with the CSA practices. Based on the discussion with farmers and experts, the following key aspects were discussed and noted.

Zero Tillage

Zero-till or no-till farming is a way of growing crops without disturbing the soil through tillage using a zero-till planter/drill. It increases the amount of water that infiltrates into the soil and increases organic matter retention and nutrient cycling. Zero-tillage improves soil properties, making it more resilient. It helps reduce crop duration and cost and effectively utilises residual moisture.

However, its adaptability over the traditional practices is low as it has limited impact on yields in the short-term and weed management becomes very important. As shared by the participants during the workshop, the last two years remained highly unpredictable in terms of rainfall, last year's access rainfall resulted in a flood and this year, it is a drought condition, which has a negative impact on the overall productivity of the crops.

Figure 7 Interaction with Scientists at Krishi Vigyan Kendra, Birauli (Left) and iinteraction with experts at Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Right).

Direct Seeded Rice (DSR)

Traditional rice cultivation involves sprouting rice in a nursery or a separate field and then transplanting the seeding into an intensively tilled field with standing water. With direct seeded rice, the rice seeds are sown directly in a dry seedbed just like any other upland crop using a multi-crop zero till planter. DSR eliminates the laborious process of manually transplanting seeding. It significantly reduces the crop's water requirement and improves the soil's physical condition. In delayed/uneven distribution of rainfall conditions, the direct seeded rice suffers less than transplanted rice.

It requires compulsory laser land levelling and timely sowing, which again remains a challenge based on the availability of a tractor and levelling machine. It also requires comparatively higher seeds than the traditional method.

Raised Bed Planting

It is the process of planting crops (wheat, maise and horticultural crops) in row geometry and on raised beds with furrow irrigation arrangements using a multi-crop raised bed planter. It mainly helps save irrigation water by 30-40%; furrows act as drainage channels in case of heavy rains and hence save crops from excess moisture. This provides an excellent opportunity for inter-culture operations and crop diversification. Beds can be used for a longer time as permanent beds without any tillage, saving on cost and energy, increasing income and improving soil health. It also extends the planting season and reduces weed growth.

Intercropping

It is an agriculture practice in which two or more crops are grown in proximity. It is usually practised to get a higher yield on a given land by using resources that would otherwise not be utilised by a single crop. Crops are sometimes grown in a row or mixed. Weed management and the use of machinery become an issue when crops are fully grown.

Sprinkle Irrigation

Sprinkle irrigation has been introduced by a few farmers only in the area owing to its cost and maintenance. It helps in water management, higher yields, and greater land use intensity. It requires the initial investment for purchasing the system and a safe place and space for storing it.

Kitchen Gardening

Kitchen gardening is the way of cultivating organic vegetables in backyards or small farmland. Women are growing vegetables through natural farming practices using locally available natural materials such as cow dung and cow urine to prepare the natural fertiliser and neem leaves, garlic, chilli etc., to control pests.

The current practice of kitchen gardening is for self-consumption mode and is not being produced for the market.

Residue management/mulching

Crop residue mulching maintains a protective cover of vegetative residues and stubble on the soil surface. It adds to soil organic matter, which improves the seedbed's quality and increases the soil's water infiltration and retention capacity. Retention of the rice residue on soil surface acts as mulch and crops can be directly drilled without tillage while residue on surface using innovative planting machinery like Turbo Happy Seeder/Zero tillage.

Usually, farmers having livestock usually do not prefer mulching as they need to do potential trade-off with the use of crop residue as animal feed.

Laser land levelling:

A laser-leveller is a tractor-towed, laser-controlled device that achieves an exceptionally flat surface. Levelling the field ensures equitable reach and distribution of water and increases crop productivity. It also increases energy efficiency as less water means less need to run diesel pumps which leads to less GHGs.

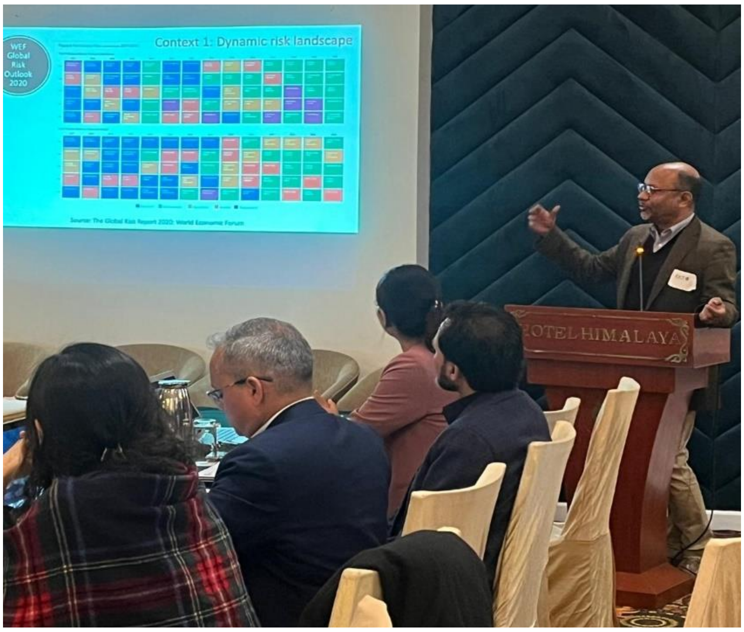
Appendix 7: Project Closing workshop in Kathmandu, Nepal

Date: 21-23, February 2024
Venue: Hotel Himalaya, Nepal

Regional workshop to disseminate the findings and to get the feedback from the stakeholders was held from 21-23 February was organised in Kathmandu, Nepal. The program was inaugurated by two CSA farmers, 1 male and 1 female as the main objective of this workshop was to share the findings of CSA in the Ganges Brahmaputra River Basin. There was a wide range of participants from universities, government institutes, research institutes, media to farmers groups.

The major objective of this regional workshop was to

- disseminate the research outcomes
- share an open access website and data archive system of CSA and small- scale farmers developed from this project




Workshop


Closing
ICAS
慶應義塾
Keio University


Closing
ICAS


Closing Workshop
APN
ICAS

Figure 8 Illustration at Project Closing workshop in Kathmandu, Nepal.

Appendix 8: Presentation in Conferences:

1. Asia Pacific Ministerial Conference on Disaster Risk Reduction, 19-22 September, Brisbane, Australia

Title: A Remote Sensing Based Semi-automatic Method for Crop Loss Estimation for DRRM

Bhogendra Mishra

Date: September 19-22, 2022

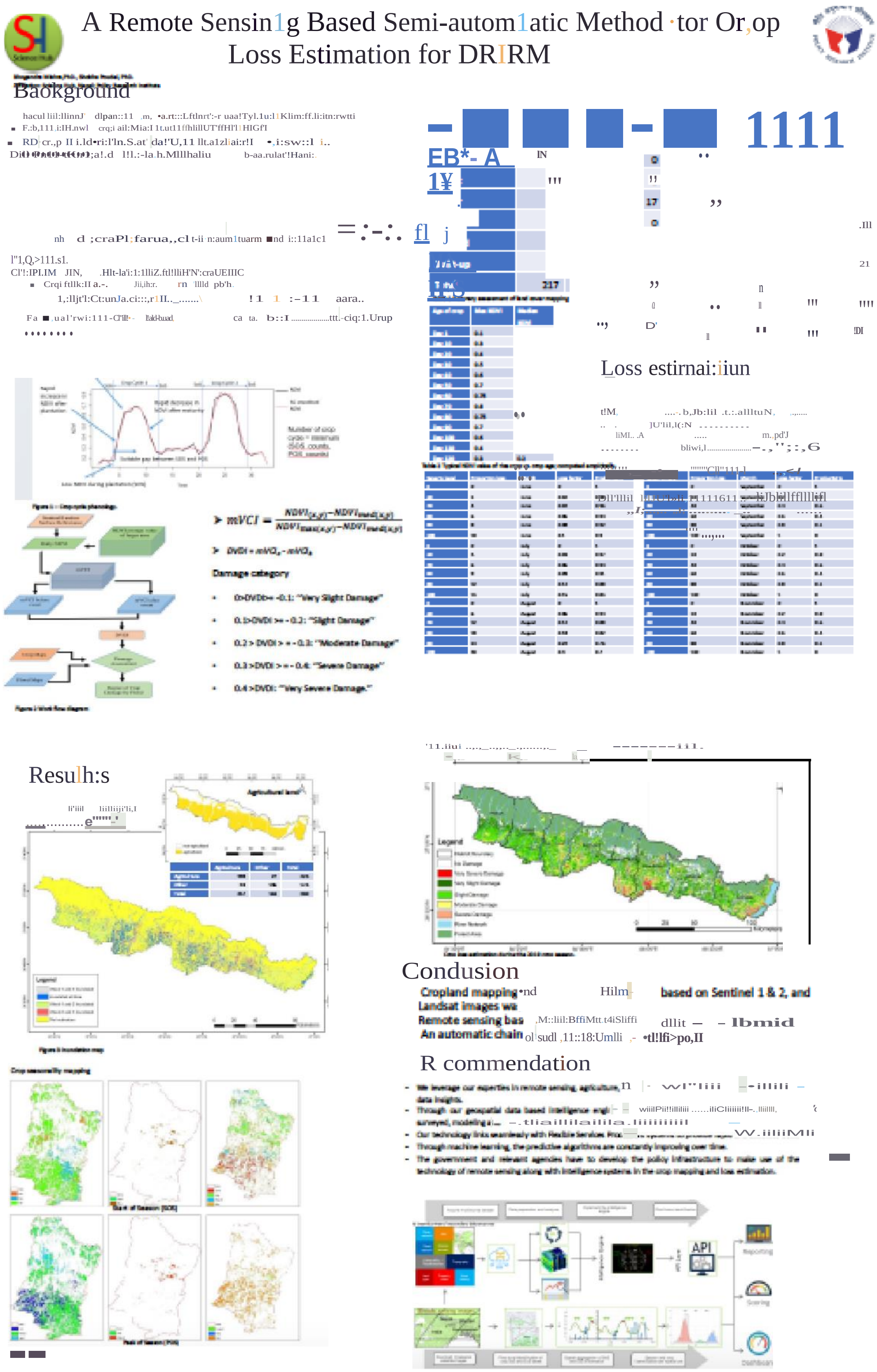
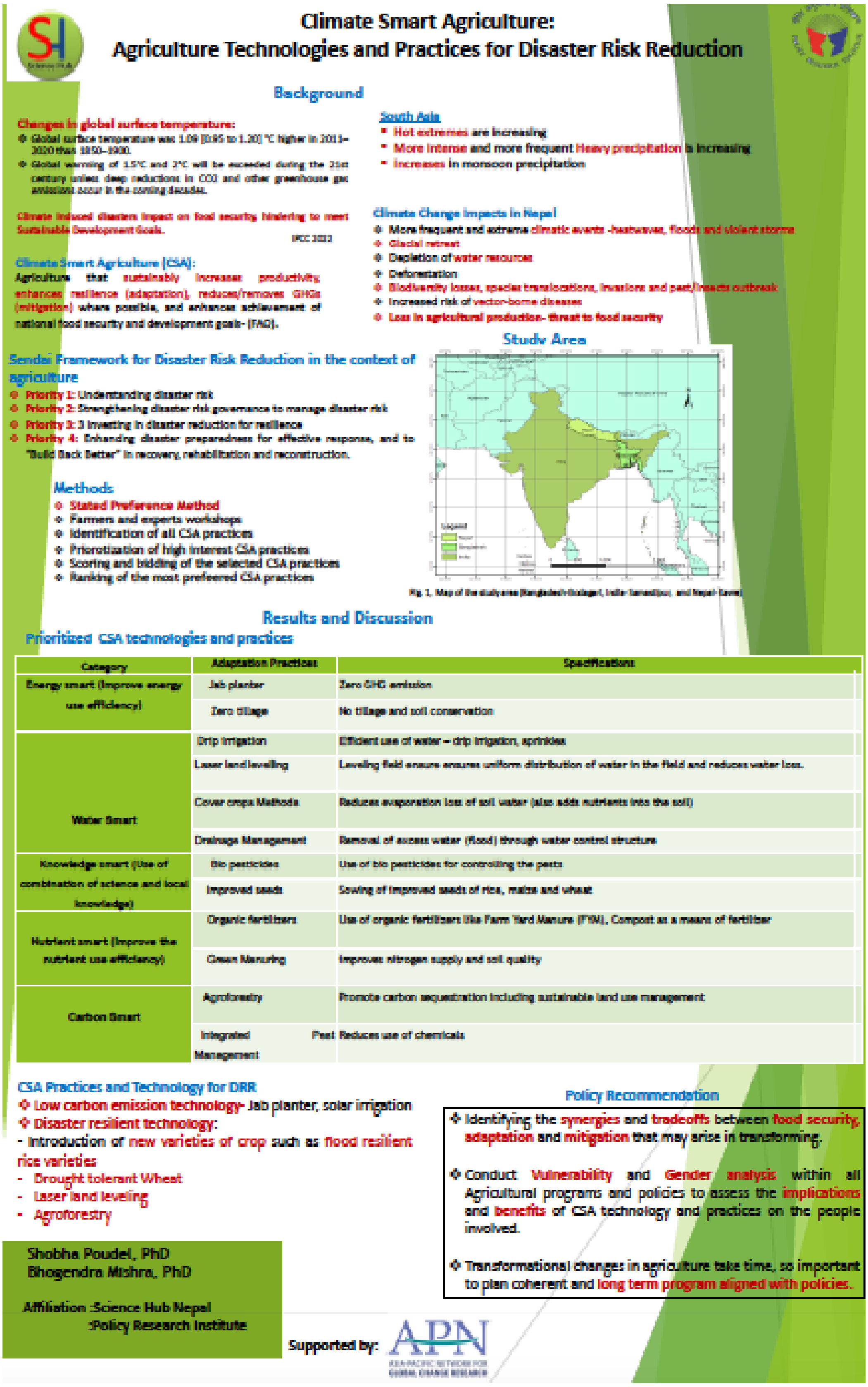


Figure 9 Poster presented at Asia Pacific Ministerial Conference on Disaster Risk Reduction, 19-22 September, Brisbane, Australia.

Shobha Poudel



Title: Climate Smart Agriculture: Agriculture Technologies and Practices for Disaster Risk Reduction
Date: September 19-22, 2022

Appendix 9: Presentation in Webinar

IIDS Webinar Series on Politics, Economy and Public Policy

Cost Benefit Analysis of Climate Smart Agriculture in the Agro-Ecological Zones of the Gandaki River Basin of Nepal

Date: February 7, 2022; Monday

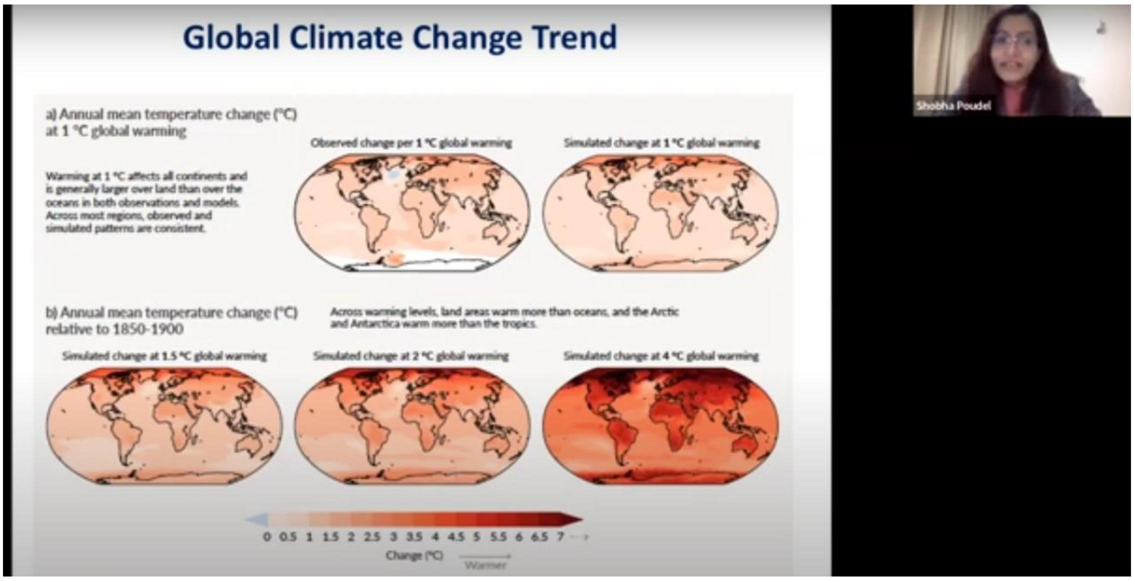


Figure 11 Illustration of virtual presentation.

Link: https://www.youtube.com/watch?v=ZE-wK3uO0cI&t=2864s