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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 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 answer 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 ● CSA prioritization manuscript for peer reviewed journal co-authored by all collaborators ● Cost benefit analysis of climate smart agriculture manuscript for peer reviewed journal co-authored by all collaborators	● Four CSA practices were prioritized for each country under study. ● Cost and benefits of the adopted CSA practices in Nepal, Bangladesh and India were evaluated. ● Expert consultation workshop was held. ● Externalities associated with CSA practices were valuated and the values were incorporated in the	Through this project, we were able to prioritize climate smart agricultural practices adopted in Bangladesh, India and Nepal and assess the profitability of the prioritized practices. In addition to the private profitability to the adopter farmers, the externalities associated with the CSA practices were also identified and analysed. The

● Templates for expert consultation workshop ● Externalities evaluation method for CSA ● Potential value chain in the region identified ● Project website ● Media release for awareness on economies of CSA.	analysis of costs and benefits of CSA practices. ● Increased awareness on economies of CSA technologies.	project outcomes are expected to enhance climate change resilience in Ganges Brahmaputra river basin. Further, the availability of evidence based knowledge materials supports development of country-specific climate smart agriculture policy for Bangladesh, India and Nepal and contribute to the development of an enabling environment for improving policy and practice that addresses 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' workshop 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 climate smart 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 coverages of the project work.

5. Publications

List all publications in APA6 Format (published and under review, with DOI if available) and attach them to the present report, where possible, for dissemination on the APN website. Please be sure to check the data sharing and management policy in your contract.

- Poudel, S., Thapa, R. and 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. Agriculture System
- 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 Prospect on Nature-based Solution in South Asia. PLOS Climate. https://doi.org/10.1371/journal.pclm.0000289
- Poudel, S., Mishra, B., Ghimire, S., Luintel, N., Thapa, P., and Sapkota, R. (2023). Climate change and agroecosystem: impacts, adaption, 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 from 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

1. Featured by Online Khabar "50 Influential Women of Nepal" and our work in Ganges Brahmaputra River basin on 8th March 2024: https://english.onlinekhabar.com/influential-women-nepal.html
2. Featured by Nepal Britain "10 Inspiring Nepali Women from Aboard" and our work on climate smart agriculture on 8th March 2024: https://nepalbritain.com/?p=144799
3. Featured by Community Information Network (online media) on 11th January, 2024: https://www.cinkhabar.com/detail/4348?fbclid=IwZXh0bgNhZW0CMTEAAR3hAEz9UL1Yeq8_PZKKQugHUpACx0OdIOpYn6NVSnbNcuxUZqdG96UK4-I_aem_AaxOuuNXcQR8HPo3gyk9tE32UUM8nI927sxTVvup9TuRJlB2YHZb1BzHWuSOkLbniBWb0phNXShS03ahuo7zdDpZ
4. Featured by Shilapatra, On the occasion of International Women Day 2023: https://shilapatra.com/detail/107274?fbclid=IwAR3CQSU6kKAcuBVqeCz7gTsxELC4CoCIY1bRQkkB9_RjQVQbjcWH2OL7PEs on 8th March 2023).
5. Featured by Kantipur National Daily on 12th February, 2023: https://ekantipur.com/opinion/2023/02/12/167616754804788075.html?fbclid=IwZXh0bgNhZW0CMTEAAR0Dvk3sQUVPD8dm7FsLPj6C4vhZ8TBG5qKybHlGQ-uo5E4Jwsk0ZiOtRjA_aem_AazsYH0t2Dbe_fq9EdZSl-UMSfqp7-QGfFqyQt1n4zcYUNWhgcPTWRcRvhCiZMoRB7HdynE2SzsP0hDtXl_oHqkB
6. Featured by Nepal Times. Sky is the limit for Nepal's women scientists on 11th February 2022: https://nepalitimes.com/here-now/sky-is-the-limit-for-nepal-s-women-scientists
7. Featured by Himal Khabar, The Avenues shown by Scientist Shobha in Agriculture on February 11, 2022: https://www.himalkhabar.com/news/128261
8. Featured by Kantipur National Daily on 19th February 2022: https://ekantipur.com/opinion/2022/02/19/164524838808579138.html?fbclid=IwZXh0bgNhZW0CMTEAAR2JJOR9JtJhoZoF8dfl70vLFTJ53oOi_xAXLmK3tl0FqE9O

Hvty-paKMjE_aem_AazWx15lRIoMvNZGy2MWdCNn0UvHtUt5X8t3tbLRXB7m3xtArEMeOcJGfMBF3QXmbKnqGBakaEe2gNeU1snhddhY

9. Featured on Himal Khabar Patrika for our work on climate smart agriculture in Nepal February 12, 2022: https://www.himalkhabar.com/news/128268?fbclid=
10. Featured on Arniko Television on Climate Change and disasters impact on food security on 22 October, 2021. https://www.facebook.com/AranikoNewsChannel/videos/690811648557780/

7. Pull quotes

Include up to three quotes from individuals (the head of your organisation, the project leader, a member of the research team, a local trainee, etc.) to demonstrate your project's impacts

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

Provide a list of all appendices and attach them as separate files to the report.

Appendix 1: APN Planning Meeting:

Date: 2021/12/18

Place: Remote in Teams

APN planning meeting report

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.


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Science Hub
RIKA
Agriculture and Forestry University
Organizer: Science Hub
Partners: AFU, RIKA, BAU
Farmers' workshop on Assessing the Profitability of Climate-Smart Agriculture in the Ganges-Brahmaputra River Basin of South Asia
Date: 2022-07-16
Venue: Kavrepalanchwok, Nepal

Appendix 3: Stakeholders' workshop in Rajashahi, Bangladesh:

Date: 20 -21 August 2022

Venue: Upazilla Agriculture Training Room, Godagari, Rajshahi

Bangladesh is experiencing climate uncertainties and extremes, which are disproportionately affecting agriculture, the state of food security, and livelihoods of small-scale farmers. Godagari upazilla in Rajshahi district under Ganges Brahmaputra (GB) river basin of South Asia is one of the climatic hotspots of Bangladesh.

Climate-Smart Agriculture (CSA) is undoubtedly important to deal with these challenges by increasing productivity, adapting to the extreme climate conditions, and mitigate greenhouse gas 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. The proposed study aims 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. 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 agricultural policies and programs.

Addressing climate change impacts on agriculture is special challenge. There are number of factors that influence the extent to which farmers in a particular location adopt CSA technologies. Many agricultural practices and technologies such as minimum tillage, different methods of crop establishment, nutrient and irrigation management and residue incorporation can improve crop yields, water and nutrient use efficiency and reduce Greenhouse Gas (GHG) emissions from agricultural activities (Branca et al., 2011; Jat et al., 2014; Sapkota et al., 2015). Similarly, rainwater harvesting, use of improved seeds, ICT based agro-advisories and crop/livestock insurances can also help farmers to reduce the impact of climate change and variability (Mittal, 2012; Altieri and Nicholls, 2013). Despite the various benefits of CSA technologies, the current rate of adoption by farmers is fairly low (Palanisami et al., 2015). The identification, prioritization and promotion of available CSA technologies considering local climatic risks and demand for technology are major challenges for scaling out CSA in diverse agro-ecological zones. Basically, the identification and prioritization of CSA technologies support climate change adaptation planning in agriculture by designing an investment portfolio across various agro-ecological zones. When designing CSA implementation strategies at the farm level, one must consider adaptation options that are well evaluated and prioritized by local farmers in relation to prominent climatic risks in that location (FAO, 2012).

This study used a stated preference method to analyse farmers' choice of CSA technologies in adverse climatic conditions. In the stated preference method, respondents are asked about their preferences in a list of technologies. Whereas in the revealed preference method, actual adoption of technology or related technology reveals farmers' preferences and the market value is available for that technology. The revealed preference methods can be an appropriate tool to assess farmer's preferences. There are several prioritization approaches such as the use of simulation models, expert judgement, household and key informant surveys, participatory appraisal and hybrid methods. This research study applied a participatory assessment method of farmers' preferences and willingness-to-pay for CSA technologies to help policy makers to make plan at the farmers level based on the CSA priority.

The main objective of this workshop was

- to find out the CSA practices followed to address the extreme climatic events in the study area.
- to develop the CSA prioritization framework.

A farmers’ workshop was conducted on the 20 August 2022 in the Upazilla Agriculture Training Room, Godagari, Rajshahi to find out the CSA practices followed by the farmers of Godagari Upazilla in Rajshahi (Fig. 1). The workshop started with the recitation of the Holy Quran. Then the participants were introduced to each other. A total of 50 participants attended the workshop. The UAO, Godagari, was the chief guest. Shova Paudel, Bhogendra Mishra and Prashed Thapa from Nepal attended the workshop. All the SAAO of the upazillas attended the workshop. The Director of Rural Development Academy (RDA) were also present in the workshop. The project team (PI, CoPIs, researchers) conducted the workshop.

At the beginning of the workshop, Professor Dr. Md. Anwarul Abedin, Co-PI of the project, gave a brief presentation on the project idea followed by discussion on CSA practices that farmers practiced at climatic hotspots Godagari, Rajshahi. In the open discussion, all the participants were very enthusiastic to express their understanding of the theme of the project, its future usefulness of the CSA practices and how it going to be a change-maker in the agriculture sector. The farmers' took part in the discussion very willingly and prioritized the CSA practices with consultation with each other. Firstly, they told the practices they follow in the field to cope with the adverse climatic conditions. Then, an auction was conducted to know the how much the farmers want to pay for the CSA practices they follow. The scores and bidding amount was noted down for ranking of the CSA practices. After the open discussion, the UAO talked about different CSA practices that were being practiced at Godagari upazila. They expressed their willingness to help with necessary upazilla level data for the development of climate resilient CSA practices. Professor Dr. Anwarul Abedin wrapped up the open discussion. Finally, Professor Dr. Md. Anwarul Abedin wrapped up the workshop thanking all the percipients for their time and active participation.

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

Farmers' workshop on assessing the profitability of climate smart agriculture in the Ganges-Brahmaputra river basin of South-Asia

The workshop consists of heterogeneous group of people such as UAO, AEO, SAAOs, farmers, RDA Director, BAU representatives, and academia. During the discussion among the participants a set of CSA practices came out which are summarized as follows:

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

There are good number of CSA practices were found out from the open discussion at Godagari upazilla. Among the CSA practices, the farmers prioritized 12 practices (Table 1) based on different extreme climatic events such as drought, flood, very high temperature during summer, very low temperature during winter, soil fertility decline, etc. The prioritization ranking was done by multiplying the CSA pillars total with the bidding amount. The most preferred technologies by local farmers were the use of short duration and high-yielding varieties, improved water management techniques, use of drought tolerant and high yielding varieties, high land to high value-crops, alternative crops, proper use of fertilizers, organic amendments, mulching, changing planting dates, crop rotation, intercropping with short duration vegetables, and the use of submergence tolerance and high-yielding varieties. The use of short duration and high-yielding varieties was ranked 1st followed by improved irrigation techniques. Short duration and high yielding varieties help the farmers to escape adverse climatic conditions. The least prioritized CSA practice was the use of submergence tolerance and high yielding varieties. This might be related to the less amount of low land areas which face inundation problems during the rainy season.

The workshop was successfully completed with a belief that this prioritization of CSA practices would help the policy makers to take necessary actions and provide facilities for sustainable agricultural production and betterment of the livelihood of the farmers in the climatic hotspots Godagari Upazilla. The results also indicate that farmers' preferences and willingness to pay are influenced by technologies and their cost of implementation. This study showed the potential for using a participatory CSA prioritization approach to provide information on climate change adaptation planning at the local level.

A stakeholder workshop was conducted on the 21 August 2022 at the Training Hall, DD office, DAE, Rajshahi to verify, make policy recommendations on the implementation of the CSA practices followed by the farmers of Godagari Upazilla in Rajshahi (Fig. 1). The workshop started with the recitation of the Holy Quran. Then the participants were introduced to each other. A total of 50 participants attended the workshop. The District Training Officer (DD), Rajshahi, was the chief guest. Shobha Poudel, Bhogendra Mishra and Prashed Thapa from Nepal attended the workshop. UAO, ADD and DTO attended the workshop. The Director of Rural Development Academy (RDA), Bangladesh Agricultural Research Institute (BARI) Representative, Professors from Rajshahi University and Bangladesh Agricultural University, representatives from national NGOs, were also present in the workshop. The project team (PI, CoPIs, researchers) conducted the workshop.

At the beginning of the workshop, Professor Dr. Md. Anwarul Abedin, and Dr. ShobhaPoudel, PI of the project, gave a brief orientation on the project idea followed by discussion to verify the CSA practices that farmers practiced at climatic hotspots Godagari, Rajshahi. In the open discussion, all the participants were very enthusiastic to express their understanding of the theme of the project, its future usefulness of the CSA practices and how it going to be a change-maker in the agriculture sector. The stakeholders took part in the discussion very willingly and verified the prioritized CSA practices with consultation with each other. The external effects of each CSA practices were identified by the stakeholders. Then, they told the ways of the effective implementation of the prioritized CSA practices at farmers level. After the open discussion, the UAO talked about the policies that can make the CSA practices more effective at farmers level in the climatic hotspots like Rajshahi. The PI of the project Shobha Poudel also thanked the stakeholders for their warm hospitality and fruitful discussion. They expressed their willingness to help with necessary upazilla level data for the development of the policies on climate resilient CSA practices. Finally, Professor Dr. Md. Anwarul Abedin wrapped up the workshop thanking all the percipients for their time and active participation.

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

The workshop consists of heterogeneous group of people such as DTO, UAO, RDA Director, BARI, RU and BAU, NGOs representatives, and academia. During the discussion among the participants verified the CSA practices and identified the external effects (positive effects).

The CSA practices at farmers level which are being followed at Godagari Upazila were verified from the stakeholders open discussion. The external effects of the CSA practices were identified by the stakeholders. The most preferred technologies by local farmers were verified i.e. use of short duration and high yielding varieties, improved water management techniques, use of drought tolerant and high yielding varieties, high land to high value crops, alternative crops, proper use of fertilizers, organic amendments, mulching, changing planting dates, crop rotation, intercrop with short duration vegetables, and use of submergence tolerance and high yielding varieties. The positive effects indicate that all the CSA practices are effective in considering different context and situation such as the seasons, soil fertility, crop requirement, financial benefit, etc. Now, it's the time for the policy makers to think on the effective implementation framework of the prioritized CSA practices at local level.

The workshop successfully completed with a belief that the verified CSA practices would help the policy makers to take necessary actions to bring that in a frame and effectively implement providing facilities for sustainable agricultural production. These micro-level policies would help in betterment of the livelihood of the farmers in the climatic hotspots Godagari Upazilla by climate change adaptation planning at local level.

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

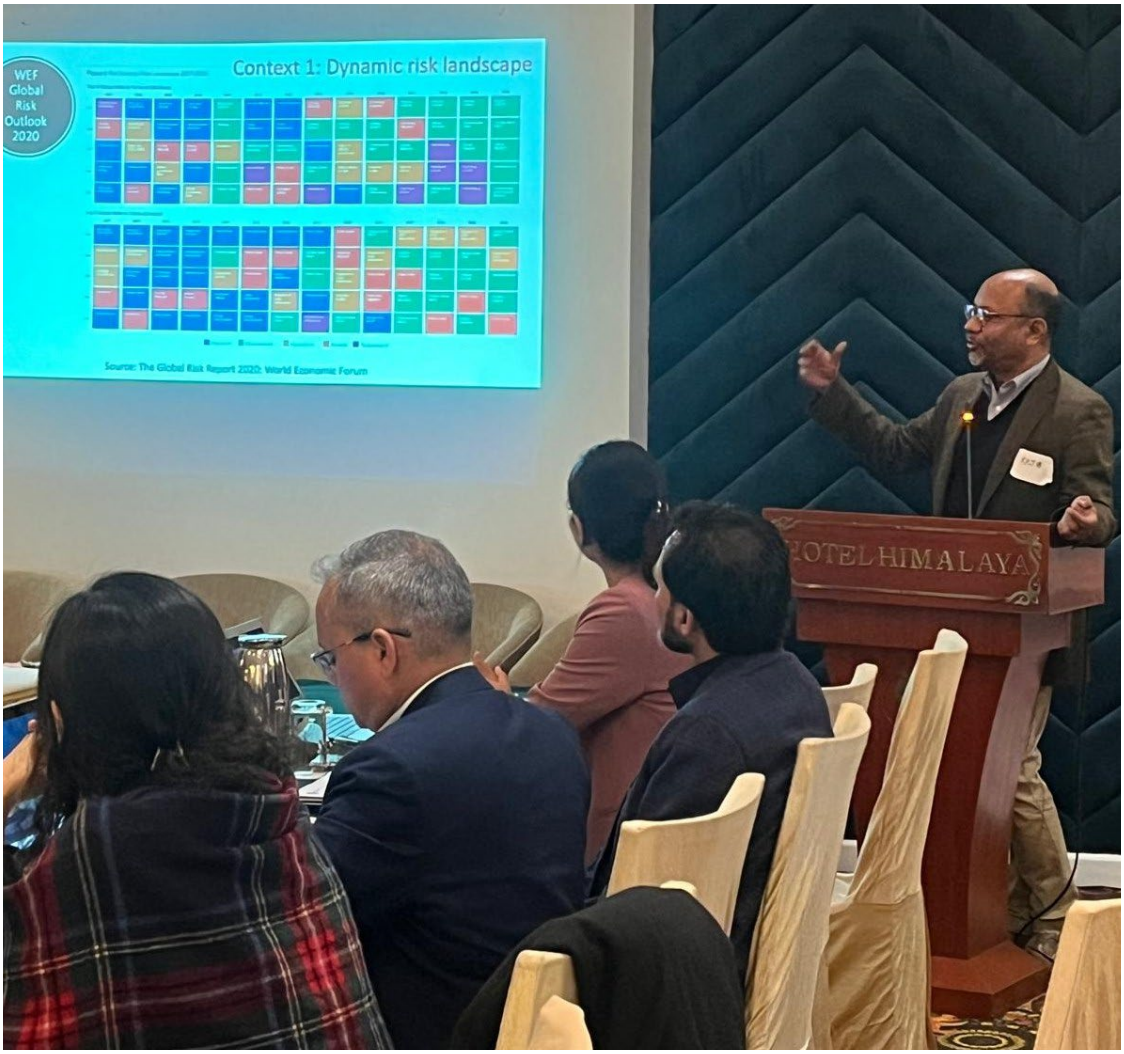
Date: 21-23, February 2024
Venue: Hotel Himalaya, Nepal

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 group.

The major objectives 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
HOTEL HIMALAYA


WEF Global Risk Outlook 2020
Context 1: Dynamic risk landscape
Source: The Global Risk Report 2020: World Economic Forum
HOTEL HIMALAYA


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

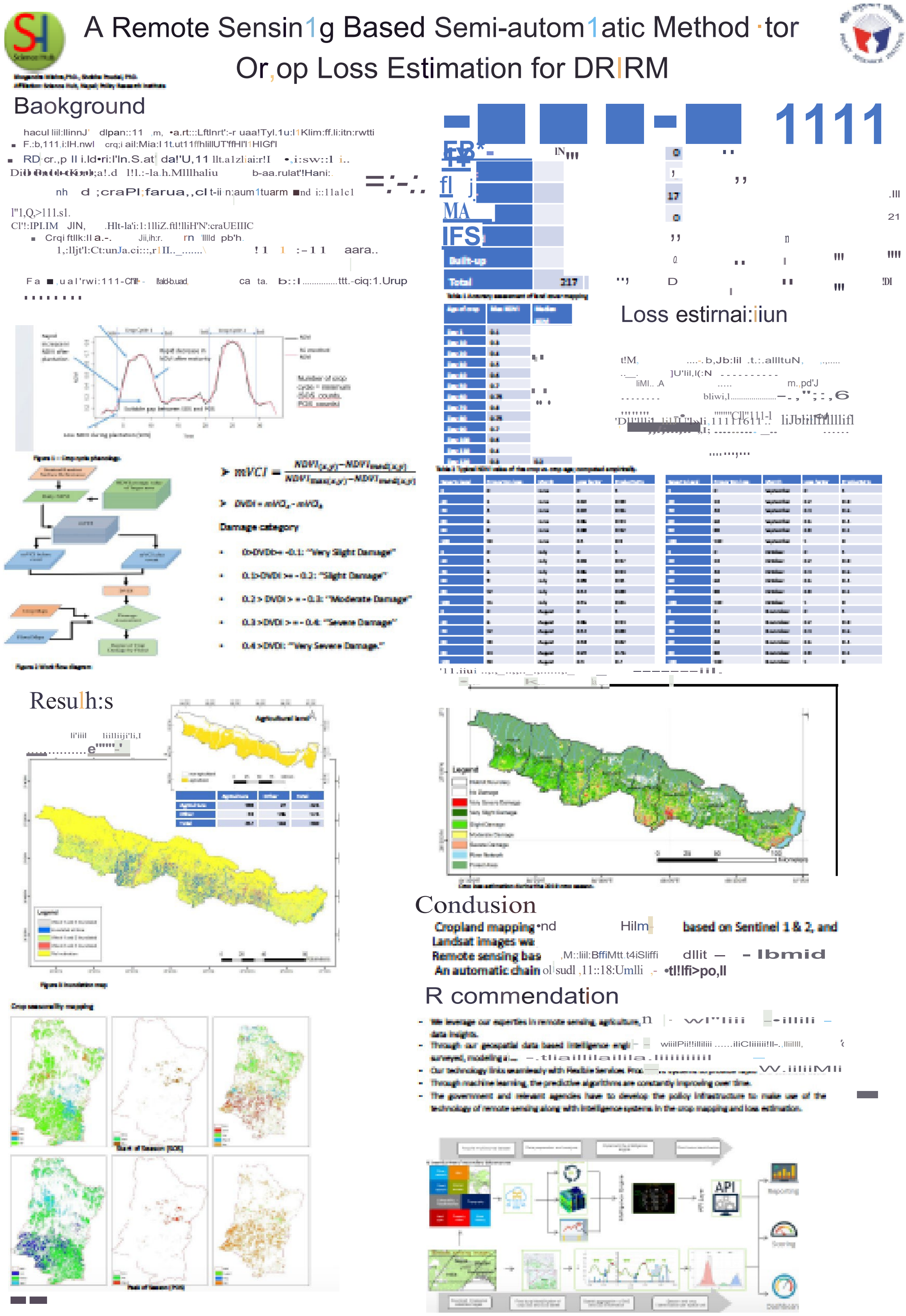


Figure 9 Poster presented at Asia Pacific Ministerial Conference on Disaster Risk Reduction, 19-22 September, Brisbane, Australia.

Shobha Poudel

Climate Smart Agriculture: Agriculture Technologies and Practices for Disaster Risk Reduction

Background

Changes in global surface temperature:

- Global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011–2020 than 1850–1900.
- Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades.

Climate induced disasters impact on food security hindering to meet Sustainable Development Goals.

IPCC 2022

Climate Smart Agriculture (CSA):

Agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals- (FAO).

South Asia

- Hot extremes are increasing
- More intense and more frequent Heavy precipitation is increasing
- Increases in monsoon precipitation

Climate Change Impacts in Nepal

- More frequent and extreme climatic events -heatwaves, floods and violent storms
- Glacial retreat
- Depletion of water resources
- Deforestation
- Biodiversity losses, species translocations, invasions and pest/insects outbreak
- Increased risk of vector-borne diseases
- Loss in agricultural production- threat to food security

Sendai Framework for Disaster Risk Reduction in the context of agriculture

- Priority 1: Understanding disaster risk
- Priority 2: Strengthening disaster risk governance to manage disaster risk
- Priority 3: 3 Investing in disaster reduction for resilience
- Priority 4: Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

Study Area

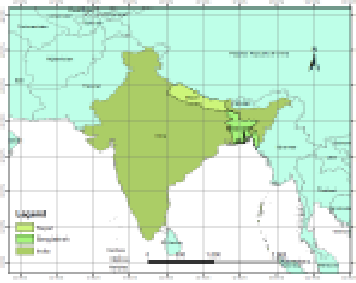


Fig. 1, Map of the study area (Bangladesh-[illegible], India-[illegible], and Nepal-[illegible])

Methods

- Stated Preference Method
- Farmers and experts workshops
- Identification of all CSA practices
- Prioritization of high interest CSA practices
- Scoring and bidding of the selected CSA practices
- Ranking of the most preferred CSA practices

Results and Discussion

Prioritized CSA technologies and practices

Category	Adaptation Practices	Specifications
Energy smart (Improve energy use efficiency)	Jab planter	Zero GHG emission
	Zero tillage	No tillage and soil conservation
Water Smart	Drip irrigation	Efficient use of water – drip irrigation, sprinkles
	Laser land levelling	Leveling field ensure ensures uniform distribution of water in the field and reduces water loss.
	Cover crops Methods	Reduces evaporation loss of soil water (also adds nutrients into the soil)
	Drainage Management	Removal of excess water (flood) through water control structure
Knowledge smart (Use of combination of science and local knowledge)	Bio pesticides	Use of bio pesticides for controlling the pests
	Improved seeds	Sowing of improved seeds of rice, maize and wheat
Nutrient smart (Improve the nutrient use efficiency)	Organic fertilizers	Use of organic fertilizers like Farm Yard Manure (FYM), Compost as a means of fertilizer
	Green Manuring	Improves nitrogen supply and soil quality
Carbon Smart	Agroforestry	Promote carbon sequestration including sustainable land use management
	Integrated Pest Management	Reduces use of chemicals

CSA Practices and Technology for DRR

- Low carbon emission technology- Jab planter, solar irrigation
- Disaster resilient technology:
  - Introduction of new varieties of crop such as flood resilient rice varieties
  - Drought tolerant Wheat
  - Laser land leveling
  - Agroforestry

Policy Recommendation

- Identifying the synergies and tradeoffs between food security, adaptation and mitigation that may arise in transforming.
- Conduct Vulnerability and Gender analysis within all Agricultural programs and policies to assess the implications and benefits of CSA technology and practices on the people involved.
- Transformational changes in agriculture take time, so important to plan coherent and long term program aligned with policies.

Shobha Poudel, PhD
Bhogendra Mishra, PhD

Affiliation :Science Hub Nepal
:Policy Research Institute

Supported by: APN Asia-Pacific Network for Global Change Research

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

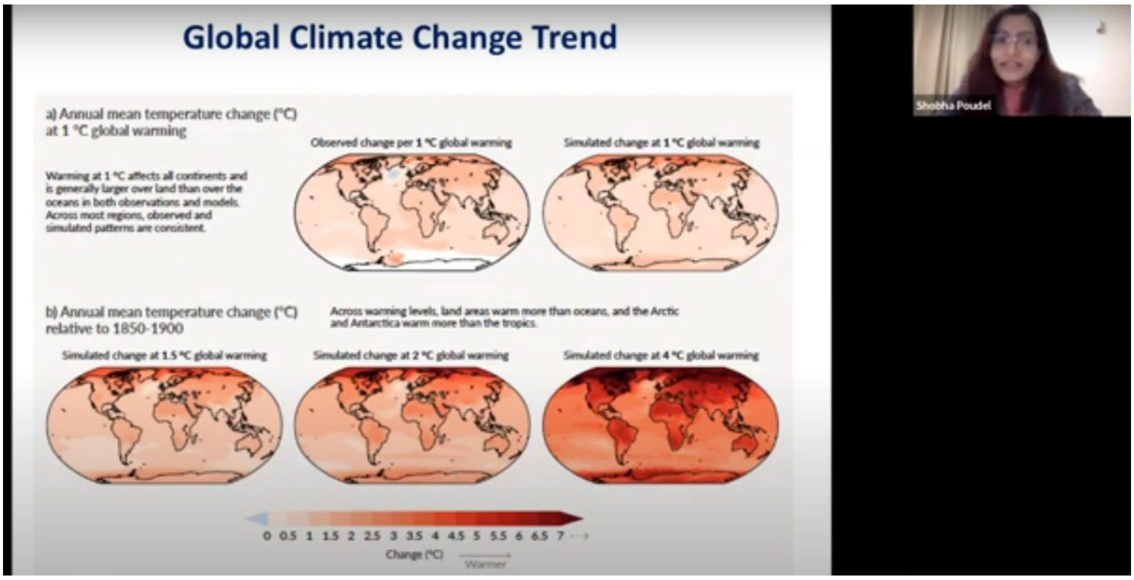


Figure 11 Illustration of virtual presentation.

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