CSRD
CLIMATE SERVICES FOR RESILIENT DEVELOPMENT

CLIMATE SERVICES FOR RESILIENT DEVELOPMENT IN SOUTH ASIA

Mid-Term Report
January to June 2018

Strategic alignment

CGIAR Research Program on Climate Change, Agriculture and Food Security — CCAFS

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Acronyms and Abbreviations

ADB	Asian Development Bank
AWS	Automated Weather Station
BACS	Bangladesh Academy for Climate Services
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agriculture Research Institute
BAU	Bihar Agricultural University
BIADP	Barind Integrated Area Development Project
BMD	Bangladesh Meteorological Department
BMDA	Barind Multipurpose Development Authority
CABI	Centre for Agriculture and Biosciences International
CCAFS	Climate Change Agriculture and Food Security
CIMMYT	International Maize and Wheat Improvement Center
CSISA	Cereal Systems Initiative for South Asia
CPT	Climate Predictability Tool
CSRD	Climate Services for Resilient Development
DAE	Department of Agricultural Extension
DFID	Department for International Development
DST	Decision Support Tool
EWS	Early Warning System
FGD	Focus Group Discussion
GIS	Geographic Information Systems
HKH	Hindu Kush Himalaya
ICCCAD	International Center for Climate Change and Development
ICIMOD	International Center for Integrated Mountain Development
IRI	International Research Institute for Climate and Society
IRRI	International Rice Research Institute
IUB	Independent University of Bangladesh
LDAS	Land Data Assimilation System
MoT	*Magnaporthe Oryzae Triticum*
NARC	Nepal Agricultural Research Council
NARES	National Agriculture Research and Extension System
NASA	National Aeronautics and Space Administration
NMME	North American Multi Model Ensemble
PANI	Program for Advanced Numerical Irrigation
PICSA	Participatory Integrated Climate Services for Agriculture
S2S	Seasonal to Sub-Seasonal
SAAO	Sub-Assistant Agricultural Officer

SALDAS	South Asia Land Data Assimilation System
SB	*Stemphylium* blight
SOW	Scope of Work
SOP	Standard Operating Procedure
SSAOs	Sub Assistant Agricultural Officers
SB	*Stemphylium* blight
SMCI	Soil Moisture Condition Index
USAID	United States Agency for International Development
UPF	*Universidade de Passo Fundo*
UR	University of Reading
URI	University of Rhode Island
WaterApps	Water Information Services for Peri-urban Agriculture
WRF	Weather Research and Forecasting Model
WUR	Wageningen University and Research

Executive Summary

Aligned with the Global Framework for Climate Services, Climate Services for Resilient Development (CSRD) is a global partnership that works to link climate science, data streams, decision support tools, and training with decision-makers in developing countries. CSRD is led by the United States Government and is supported by the UK Government Department for International Development (DFID), UK Meteorological Office, ESRI, Google, the Inter-American Development Bank, the Asian Development Bank, and the American Red Cross. Led by the International Maize and Wheat Improvement Center (CIMMYT), the CSRD initiative in South Asia implements applied research and facilitates an expanding network of partners assure that actionable climate information and crop management advisories can be generated, refined, and delivered to smallholder farmers.

This report details activities of the CSRD project in South Asia during the first six months of 2018. Key highlights include the following:

- CSRD has linked the Bangladesh Meteorological Department (BMD) and Department of Agricultural Extension (DAE) to the University of Reading to University of Reading (UoR), United Kingdom to adapt and pilot 'Participatory Integrated Climate Services for Agriculture' (PICSA) methods for communicating climate services with 20+ farmers' clubs in Bangladesh in the 2nd half of 2018. CIMMYT, UoR, DAE, and BMD staff spent two weeks in the field together visiting farmers and DAE staff in Khulna, Barisal, Patuakhali, and Dinajpur districts. Field visits resulted in the CSRD team organizing schedules and curricula for master trainer and training of trainer programs. These activities will serve as the foundation for further PICSA engagement as part of this pilot program.

- A two-week science and training exchange was hosted by IRI at Columbia University, located at the Lamont-Doherty Earth Observatory campus in New York, in April 2018. The group included four senior staff from BMD and DAE, totaling eight visitors including the Director of BMD, Mr. Shamsuddin Ahmed. The visit to IRI offered new opportunities for rich exchange between CSRD partners, enhanced hands-on training in climate prediction tools, climate science, and participatory climate services and agricultural extension methods. At the conclusion of the learning exchange, BMD and DAE made a joint presentation on what they had learned during their time at IRI, as well as how they planned to collaboratively implement their newly developed and climate science communication skills upon return to Bangladesh.

- Working in partnership with BMD, CSRD has made significant progress in improving the quality and skill of meteorological forecasts for Bangladesh's farmers, including the use of historical climate information. These activities, which include systematic literature review to identify thermal stress thresholds for key cereal crop species, mapping of 1) historical and forecasted dry spells, 2) seasonal monsoon onset and progression, and 3) heavy rain events. Using the outputs of the systematic literature review, extended range forecast maps of crop species-specific probabilities of encountering thermal stress are expected

to be completed before the end of 2018. The CSRD team is also making solid progress in developing improved seasonal forecasts and climatic stress maps in partnership with IRI. These activities move CSRD further towards meeting its objectives of (1) provision of GIS maps displaying climatic stresses, (2) forecasts for integrated irrigation management services, and (3) development of "impact based agro forecast" systems. These systems incorporate improved forecast and vulnerability to identify impacts, with emphasis on the development of crop specific pest and disease models.

CSRD in action. Left: Farmers in Bhagia Ghata draw resource flow maps of their farms to identify what parts of their farming systems are most affected by climate variability. This activity was conducted is in preparation for implementing 'Participatory Integrated Climate Services for Agriculture' training approaches in 20 farming communities across Bangladesh in the second half of 2018, in collaboration with the University of Reading, Wageningen University's WaterApps project, and the Bangladesh Meteorological Department (BMD) and Department of Agricultural Extension (DAE; Photo by Timothy J. Krupnik). Upper right: Mr. Abdul Mannan and Dr. Md. Shahab Uddin from the BMD and DAE, respectively, discuss their partnership and planned activities in CSRD while visiting the International Research Institute for Climate and Society (IRI) at Columbia University in April-May of 2018. Lower right: Mrs. Mélody Braun from IRI discusses the development of the Bangladesh Academy for Climate Services, which has developed out of CSRD's partnership with IRI, BMD, and the Independent University of Bangladesh (both right side photos by Elizabeth Gawthrop).

- CSRD successfully completed the first season's evaluation of PANI, which means 'water' in Bangla, in partnership with the Bangladesh Agricultural Research Institute (BARI). This is an irrigation scheduling app that estimates crop water use and the amount of plant available soil moisture on a daily basis. Based on forecasted weather data, PANI generates an alert that can be used by extension agents or farmers as to whether a particular crop field needs to be irrigated in the next seven days. Field trials were completed in Barisal,

Rajshahi and Dinajpur districts, with data now being analyzed. CSRD also completed business model studies to identify where and under what irrigation pricing circumstances the app could be most useful to smallholder farmers. A second season of field trials to validate and recalibrate the model will be initiated in November of 2018.

- CSRD's scientists also completed the first season of validation of its spatially explicit and meteorologically driven wheat blast (*Magnaporthe oryzae Triticum*, MoT) disease risk decision support tool. Disease incidence and severity were observed by DAE staff in 800 fields from across Bangladesh. Data are being analyzed at the time of writing and will be used to refine the model for additional validation in the 2018-19 wheat season. CSRD also facilitated visits by wheat pathology modelers from Brazil who are collaborating in the development of the beta version of the numerical weather model driven blast advisory.

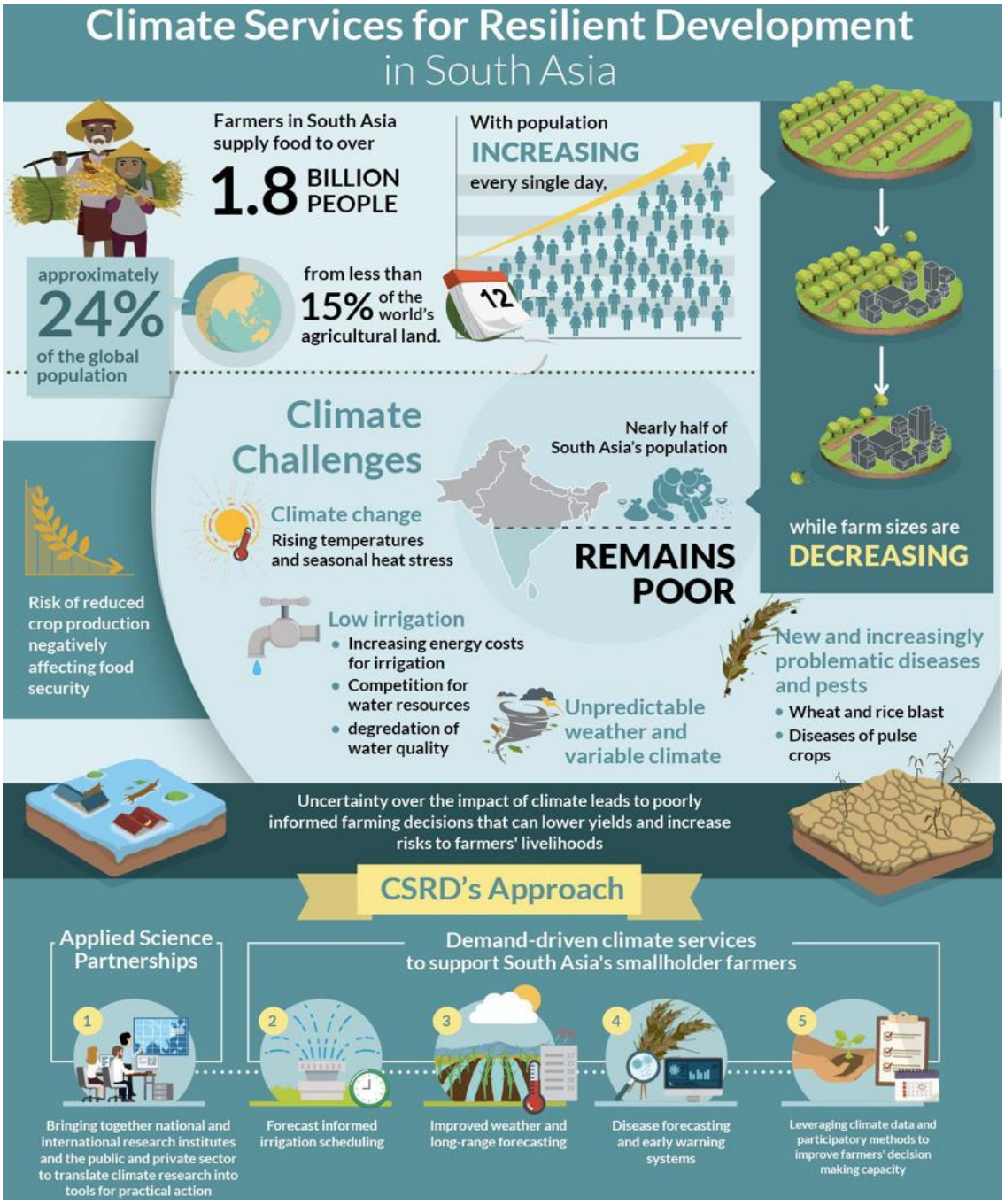
- In collaboration with ICIMOD, CSRD has completed the installation of SALDAS, a data assimilation and forecasting platform that captures soil hydrological extremes on short to seasonal timescales, at the Bangladesh Agricultural Research Council (BARC). The SALDAS system is also being put into operation in Nepal, Pakistan, and Afghanistan, rounding out CSRD's regional work. A Tethys platform for SALDAS data visualization has also been completed. The beta version of the application was presented in the Regional Stakeholder Workshop on SERVIR Hindu Kush Himalaya Applied Science Projects held during 23–24 April 2018 in Dhaka, Bangladesh.

- Stemphylium blight, which is caused by *Stemphylium botryosum*, is a serious threat the resilience of smallholder farmers' livelihoods in Bangladesh, India and Nepal. The severity of the disease is conditioned by cloudy weather, relative humidity, and temperature and precipitation regimes. To address this issue, the 'Stempedia' model was developed by scientists working with CSRD to assess the regional and seasonal risks of the disease within South Asia, and to rationalize the use of foliar fungicide application to achieve financial gain while limiting environmental impact. Partnering with the Bihar Agricultural University and Nepal Agricultural Research Council, the former associated with the USAID and Bill and Melinda Gates Funded Cereal Systems Initiative for South Asia, 480 farmers' fields were monitored in Bangladesh, India, and Nepal. Data were collected from farmers' fields, each of which were located near automatic and synoptic weather stations in each country. Preliminary results validating the model are presented in this report. CSRD scientists will work to improve the model's predictive performance in each country prior to the second season of field testing beginning in November of 2018. At the same time, CSRD is working to educate partners in each country to develop awareness of the model so that a rapid alert system can be put into place to warn farmers of disease risks.

CSRD has continued to foster strong collaboration, including deepening links with the World Bank funded Bangladesh Weather and Climate Services Regional Project. This 'sister' project aims to strengthen Bangladesh's capacity to deliver reliable weather, water, and climate information services and improve access to such services by priority sectors, and provides strong opportunity to scale-out and scale–up the results of CSRD's work. Further details on the development of this strategic partnership will be discussed in the 2018 end of year report.

Introduction

Smallholder farmers make myriad decisions regarding what crop species and varieties to plant, where, when, and on how much land to plant it, how to fertilize and irrigate, how to manage pests and diseases, and how harvest and store produce. Similar decisions apply to livestock and aquaculture. Farm productivity is in turn influenced by temperature, relative humidity, and precipitation, among other variables. Where quality climate information can be translated into understandable and actionable advisories, smallholders can be empowered to make livelihood decisions that are based on tangible data and thus more improving resilience.



Climate Services for Resilient Development (CSRD) is a global partnership that connects climate science, data streams, decision support tools, and training to decision-makers in developing countries. CSRD responds to the challenges faced by smallholder farmers identified above. The partnership is led by the United States Government and is supported by the UK Government Department for International Development (DFID), UK Meteorological Office, ESRI, Google, the Inter-American Development Bank, the Asian Development Bank, and the American Red Cross. In South Asia, CSRD is led by the International Maize and Wheat Improvement Center (CIMMYT), with funding from USAID. The partnership aims to increase resilience to climate change in South Asia by creating and providing timely and useful climate data, information, tools, and services. These activities aligned with the Global Framework for Climate Services and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

In South Asia, CSRD implements applied research and facilitates an expanding network of partners to assure that actionable climate information and crop management advisories can be generated, refined, and delivered to smallholder farmers. CSRD works towards achieving three main objectives. The first includes the development 'Impact-based and national-scale decision tools to support the agro-meteorology track of the Bangladesh Meteorological Department's (BMD)'. The second Objective, 'collaborative development and refinement of South Asian regional-scale agro-climate decision support tools, services' focusses on Bangladesh, India, and Nepal, but also supports the work of CSRD partners in Afghanistan and Pakistan. The third and final CSRD Objective establishes CSRD's service role in support of climate information services in agriculture.

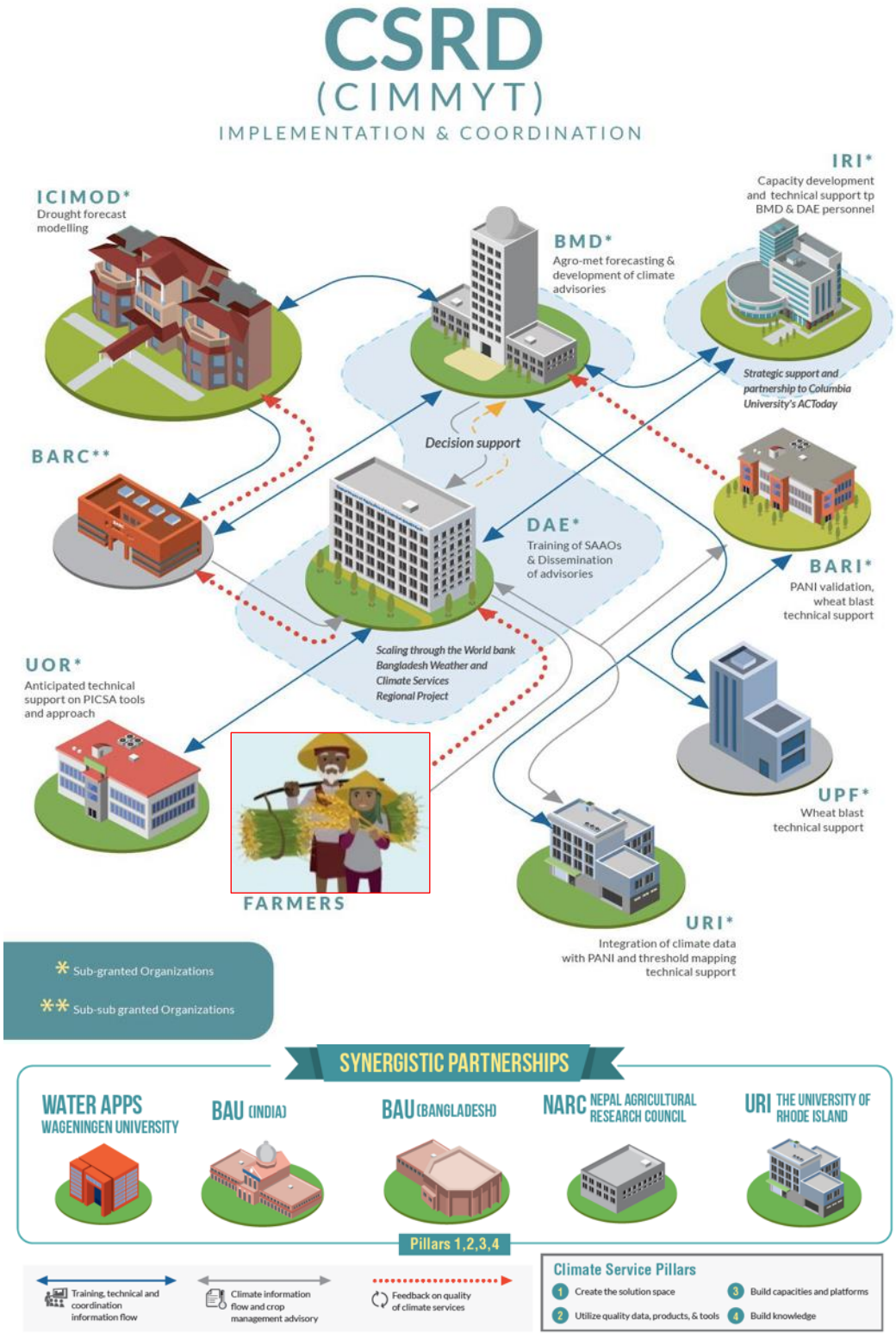
The CSRD consortium in South Asia

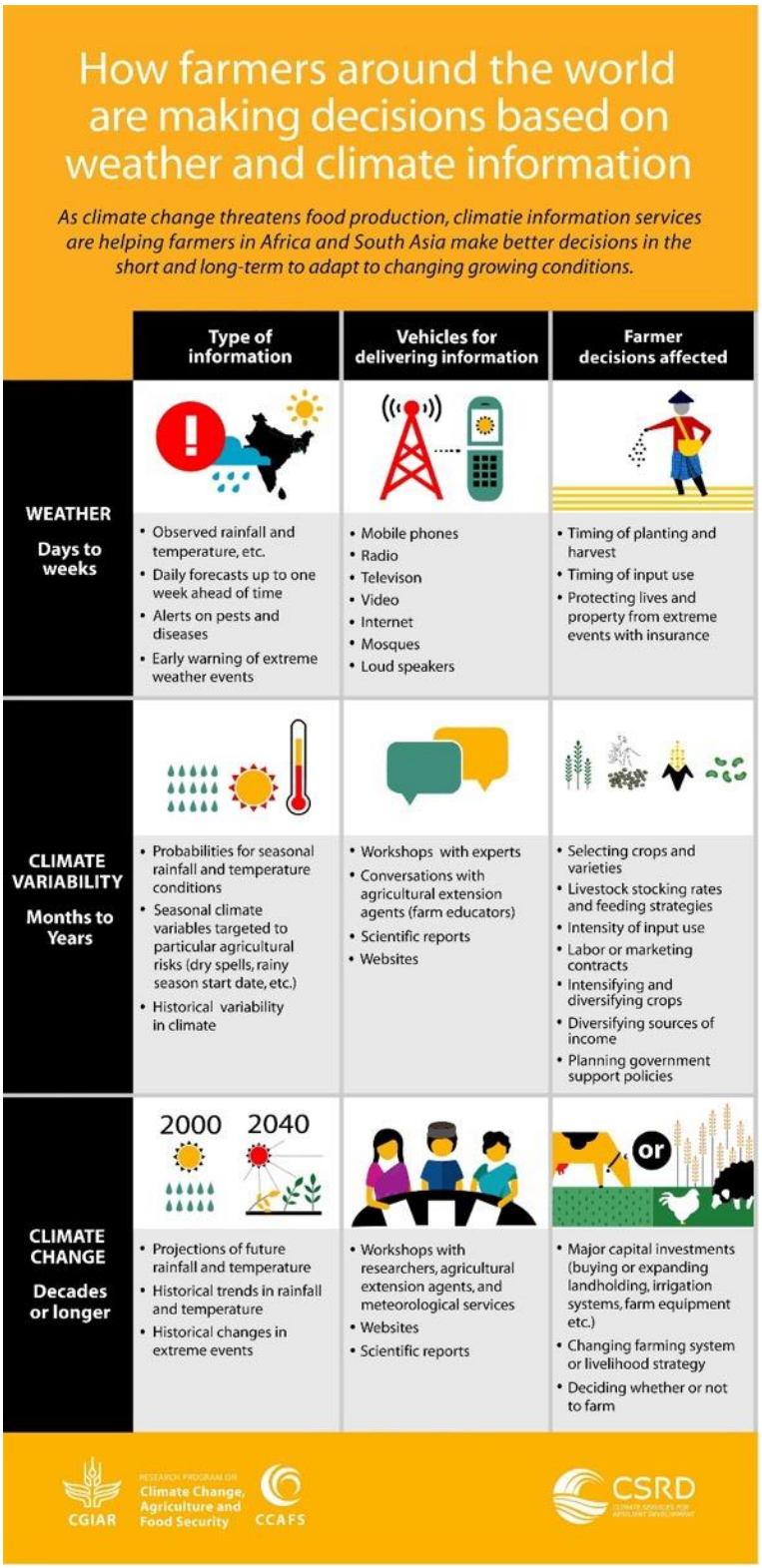
Under the leadership of CIMMYT, the CSRD project in South Asia receives guidance from the United States Agency for International Development's (USAID's) Global Climate Change Office (Bureau for Economic Growth, Education and Environment) in addition to the CSRD Steering Committee. CIMMYT is the facilitating organization for agricultural climate services in the region, and works to facilitate research, training, and coordination linkages between the CSRD partners across South Asia.

CSRD in Bangladesh

Although CSRD is a regional effort in South Asia, much of the focus of the consortium's efforts focus on Bangladesh (See Objective 1). CSRD works with the Bangladesh Meteorological Department (BMD) and Bangladesh's Department of Agricultural Extension (DAE). CSRD works with both agencies to develop decision support tools (DSTs) and climate-smart crop management advisories. CSRD also collaborates with BMD and DAE staff involved in the World Bank funded Bangladesh Weather and Climate Services Regional Project. This 'sister' project aims to strengthen Bangladesh's capacity to deliver reliable weather, water, and climate information services and improve access to such services by priority sectors. In addition, the Bangladesh Agricultural Research Institute (BARI) is another CSRD partner that participates by evaluating irrigation scheduling decision support tools developed by CIMMYT

that make use of weather forecasts provided by BMD. BARI is also a core collaborator in the development and implementation of a wheat blast (*Magnaporthe oryzae* pathotype *Triticum*) disease risk early warning system for farmers, both nationally (Objective 1) and regionally (Objective 2).





CSRD is aligned with the CGIAR Research Program 'Climate Change, Agriculture and Food Security (CCAFS)'. The CCAFS info-graphics above has been adapted to more accurately reflect climate data and their relevance to South Asian smallholder agriculture.

South Asia regional collaborations

ICIMOD, the International Center for Integrated Mountain Development, is one of CSRD's core South Asian regional partners. Working with ICIMOD, CSRD supports ongoing efforts to develop a drought monitoring and forecasting system for South Asia using earth observation data, in alignment with the USAID-supported SERVIR-Hindu Kush Himalaya (HKH) program (see Objective 2). This effort spans Afghanistan, Pakistan, Nepal, and Bangladesh.

The Bangladesh Agricultural Research Council (BARC) is also affiliated with CSRD and is sub-contracted by ICIMOD implement a national center for drought monitoring and forecasting center using the results of CSRD's work in Bangladesh. Several additional regional partnerships have developed on an informal and synergistic basis since the last CSRD report was completed on 31st December 2018. These include Bihar Agriculture University (BAU) in India, and the Nepal Agricultural Research Council (NARC, specifically the Council's Grain Legume Research Division), both of which are involved in climate services for lentil disease prediction using weather-based models in South Asia. The Bangladesh

Agricultural University, is also cooperating in the laboratory confirmation of lentil diseases.

Women near Khulna in south-western Bangladesh participate in planning visits to develop PICSA activities with the assistance of the University of Reading. CSRD is also collaborating with Wageningen University's 'WaeterApps' project on this activity. PICSA aims to empower farmers to understand climate data and to use climate information to make better-informed farm and livelihood decisions. In this photo, women identify what parts of their farming systems are most sensitive to climate. (Photo: Timothy J. Krupnik)

International collaborations

International Center for Climate Change and Development (ICCCAD) at the Independent University of Bangladesh (IUB) are also now in the process of linking to CSRD and CIMMYT. Combined with BMD, these partners are now working to implement a *Bangladesh Climate Services Academy* to develop curricula and teaching in cross-sectoral climate services in Bangladesh, including but not limited to agriculture (See Objective 3).

CIMMYT is also in the final stages of signing an agreement with the University of Reading (UoR) to pilot the PICSA (Participatory Integrated Climate Services for Agriculture) approach across Bangladesh in the second and third quarters of 2018. CSRD's work in PICSA has garnered an additional new partnership with Wageningen University's Water Information Services for Peri-urban Agriculture (WaterApps) project, which is also supporting the expansion of PICSA pilot sites in southwestern Bangladesh on an in-kind basis. Details of the

primary scientists involved in implementing CSRD in South Asia and Bangladesh can be found in Annex 1. CSRD's subcontractors and partners can be found in Annex 2.

CSRD's theory of change and strategic pillars in South Asia

Details of CSRD's theory of change is discussed in detail in the 2016-17 CSRD in South Asia Annual Report. The contributions of each activity to the CSRD Pillars 1-4 are described in each section and summarized in the info-graphic below.

Demand-driven and actionable climate services to support smallholder farmers

Pillar 1

Create the solution space

Establish a problem-focus, engage key stakeholders, and create a platform for sustained communication and collaboration. Build synergies among relevant programs.

Pillar 2

Use quality data, products, and tools

Provide decision-maker access to useful and available information and technology. Develop tailored products and services responsive to specific needs.

Pillar 3

Build capacities and platforms

Support the use of targeted products and services.

Promote sustainability, scalability, and replicability.

Pillar 4

Build knowledge

Identify and promote good practices among the global climate services community. Support research efforts and innovation that increase the effectiveness of climate services.

Objective 1: Impact-based national-scale decision tool platforms to support the Bangladesh Meteorological Department's (BMD) Sector 3 agro-meteorology track

Sub-Objective 1.1. Agricultural climactic information framework improved

Activity 1.1.1 Updating agro-meteorological information for major food and income staples in Bangladesh using farmer decision making frameworks

Background

CSRD Activity 1.1.1 focusses on applied and actionable research to understand how farmers in South Asia conceptualize of and plan their livelihoods using climate and weather information. Activities also make use of this information to improve the ways in which climate and agricultural science-based advisories can be translated, tailored, and extended to farmers on a timely basis. Further work under this activity emphasizes participatory processes and capacity development efforts focused on Bangladesh's Department of Agricultural Extension and partners on how they can better partner with farmers to improve the strategic decisions they make regarding their livelihoods and farm management, detailed below.

Product 1. Crop-specific farmer decision making frameworks and extension training to improve the quality and usefulness of agro-meteorological forecasts

Before farmers can make use of climate services, they need to be positioned to better understand how climate affects their livelihoods. They also need to be inspired to make climate-smart farm and livelihood management decisions. To meet this objective, the CSRD initiative in South Asia is initiating a partnership with the University of Reading in the United Kingdom. To adapt and pilot the 'Participatory Integrated Climate Services for Agriculture' (PICSA) approach with 20+ farmers' clubs in Bangladesh in the second half of 2018.

PICSA, is a ground-up and participatory approach to changing the way that extension services interact with farmers on climate services and livelihood improvement options. Professor Peter Doward, who has been working to expand use of the PICSA approach since its beginnings in climate services activities in Africa in 2012, explains that "*PICSA is not a tool to convince the people to do something, but an honest decision-making process to help people to plan*". Within CSRD, the PICSA process is being led by DAE. They coordinated field visits in Bangladesh by Professor Dorward, who visited in April-May of 2018 to discuss the adaptation of PICSA so that it is appropriate for Bangladeshi smallholder farmers and their diverse livelihood systems.

During these field trips, which were also attended by CIMMYT and BMD, PICSA pilot sites in Khulna, Barisal, Patuakhali, Rajshahi, and Dinajpur districts were collaboratively identified. At least three farmer's clubs in each location will participate in the piloting of PICSA in the second half of 2018. Wageningen University's WaterApps project, funded by Netherlands Organization for Scientific Research (NWO), is also adding value through in-kind collaboration to this effort to foster improved agricultural climate services (see Annex 6). The

goal of the PICSA piloting is to enhance farmers' resilience to climate-related livelihood challenges. A cadre of 15 PICSA facilitators from the DAE will be trained to deploy the approach in early July of 2018. They will then train at least 30 additional extension agents to implement PICSA in the pilot locations that have been identified.

Through a series of engagements, the extension agents will assemble farmer groups to analyze and discuss historical climate data in graphical form. Looking at the data and discussing its implications, farmers learn the same way scientists do. Facilitators of the PICSA process will also work with farmers to identify what options they have, including crops, livestock, and other income generating activities, to respond to the implications of climate variability and increase livelihood resilience. PICSA will introduce decision-making tools such as participatory budgets and scenario analysis to help farmers make informed decisions about what options work best for them in their own context. In sum, the approach encourages data-informed and climate-smart decision making.

The view from above: Farmers and university student staff from CSRD's partnering WaterApps project (which is affiliated with Wageningen University) discussing and drawing a farm resource allocation map in Khulna, Bangladesh. This is a participatory tool that enables farmers to understand the household's main uses and production of resources and how these may be affected by weather and climate. Participatory farm mapping is one of the key steps in implementing the PICSA process with farmers. (Photo: Timothy J. Krupnik)

CSRD aims to scale-out use of this training approach. DAE maintains a strong interest in utilizing the PICSA approach piloted through CSRD in the World Bank funded Agro-Meteorological Information Services project, in addition to incorporating this in ongoing DAE supported farmer field school programs. If CSRD's pilots are successful, these efforts could be scaled out to hundreds of thousands of farmers across Bangladesh by institutionalizing the PICSA approach within DAE's ongoing programs.

Planned activities in Quarters 3 and 4 of 2018:

As indicated above, PICSA will be piloted with at least 20 farmers' clubs in five districts across Bangladesh. A training of master PICSA trainers from the DAE and partner organizations (including the NGO, Practical Action, as a potential CSRD partner), will take place in early June. These master trainers will train at least 30 more DAE staff to administer and implement PICSA in each of the 20+ farmers' clubs. They will convene at least six climate services learning engagements with farmers' clubs prior to the advent of the 2018-19 dry season in Bangladesh. Farmers' use of climate information and advisories will be subsequently monitored throughout the season, and in a follow-up evaluation exercise, ideally scheduled for June 2019. (see the section 'Implementation Challenges' in the end of this report for information on a proposed no-cost extension to permit completion PICSA and other ongoing activities).

Contribution of Activity 1.1.1 to CSRD's Action and Learning Framework:

Pillar 1, Indicators 1.1 and 1.2, Pillar 2, Indicators 2.1 and 2.2, Pillar 3, Indicators 3.1, and 3.2, and Pillar 4, Indicator 4.1 (see Annex 3).

Sub-Objective 1.2. Climate services capacity development

Activity 1.2.1. Climate services capacity development in partnership with the International Research Institute for Climate and Society

Product 1. BMD agricultural Forecast skills assessment

With the assistance of IRI, CSRD completed a climate and meteorological services capacity and skills assessment of BMD in the third quarter of 2017. This assessment is detailed in Annex 4 of the 2016-17 CSRD in South Asia Annual Report. Based on the assessment, CSRD is working with BMD to implement a number of recommendations which were also identified as being priorities for the development of improved agricultural climate services, and are discussed in turn below:

Summary of Recommendations and Action Taken

Recommendation from the skills assessment	Actions taken or underway
• Improve the BMD Ag-Met. Bulletin by including an online tool with a clickable map of Bangladesh	• CIMMYT and BMD are collaborating to develop a clickable map as a new addition to BMD's website. The map will provide location-specific weather forecasts with associated crop management advisories. The target audience are DAE extension staff, who are being consulted to improve map design.

Recommendation from the skills assessment	Actions taken or underway
• Include digital elevation and other fixed physical aspects of the geography of Bangladesh in forecasting efforts	• Ongoing work to refine and improve forecasting for precipitation in Bangladesh now considers digital elevation, which is being leveraged through spatial interpolation to develop more skillful forecasts.
• Develop and provide maps on the ag. meteorological bulletin that indicate the progression of the monsoon, rather than providing tabular data on precipitation for the previous week	• Using advice on coding from CIMMYT's climatologist, BMD's meteorologists have developed a series of maps (detailed below using 2017 data to develop the maps) that show monsoon progression and cumulative precipitation. The maps will be included in the revised version of the BMD ag. meteorological bulletin (completed by the end of 2018)
• Provide Information on historical temperature extremes and distributions, compare current with historical data	• CSRD's partners are pursuing this work which is now under way. .
• Simplify the text of the ag. meteorological bulletin and provide new designs.	• Work is underway to provide new design and simplified, actionable text for the ag, meteorological bulletin. Where technical language is used in the bulletin, BMD has agreed to provide a glossary so that less experienced and non-technical readers can understand the document.
• Include products from work in CSRD in the Bangladesh Climate Atlas (published by BMD)	• The CSRD partners have agreed that products from work conducted in 2018 – particularly maps – will be included in the Climate Atlas
• Improve data quality control, missing value estimation, homogenization and statistics tools to summarize data	• CSRD is working to develop algorithms that can be used by BMD to regularly check for missing or outlying weather data before it is archived. BMD is exploring options to make use of the IRI's Climate Data Tool (Product 2).
• Fortran, Matlab and R programming, together with Linux Shell scripting skills for data processing and automation of routine tasks, such as data reformatting and database updates.	• Dr. Carlo Montes, Agricultural Climatologist at CIMMYT, will convene a multi-day training with BMD on the use of Matlab (and with some emphasis on R) to automate routine data quality control tasks and update BMD's database
• Climate database management training.	• BMD is in active discussions with Genesis Computer Consultants and similar consultancy firms to implement a training program on the CLISYS data management tool. A BMD-wide training is anticipated in late 2018 with CSRD support.
• Improve BMD's awareness of agriculture and what climate	• This objective was accomplished through collaborative sessions and joint homework and

Recommendation from the skills assessment	Actions taken or underway
information is relevant for agricultural decision making. Conversely, improve DAE's understanding of the complexities of climate science and limitations of forecasting.	presentation assignments completed by BMD and DAE while at IRI (see Product 2 below). In addition, BMD and DAE core staff identified in Annex 1 traveled for a 10-day period together in April of 2018, visiting with farmers in 12 villages in four locations. Such intensive travel provided ample time for discussion, collaboration, sharing, and team building to meet this objective.
• Deepen research to identify the most useful climate models for seasonal prediction.	• CIMMYT and BMD are actively engaging with IRI scientists to identify appropriate climate models for seasonal prediction (>1 month), and at the sub-seasonal scale, forecast for <1 month. Progress has been made on improving precipitation forecasts. With CSRD support, BMD is also exploring the potential to move from statistical to dynamic (North American Multi-Model Ensemble) models (see Product 2).

Product 2. National scientist training, exchange, and CSRD planning with IRI

In April 2018, a two-week science and training exchange was hosted by IRI at Columbia University, located at the Lamont-Doherty Earth Observatory campus in New York, USA. The first week was dedicated to the training to CSRD team members from BMD on improved use of the climate predictability tool (CPT). This group consisted of four professionals, including BMD's Director, Mr. Shamsuddin Ahmed. Other activities included joint discussions and practical work to specify the agriculturally relevant climate information generated so far by BMD under CSRD, in addition to the challenges identified as part of ongoing research work, and opportunities for future improvements.

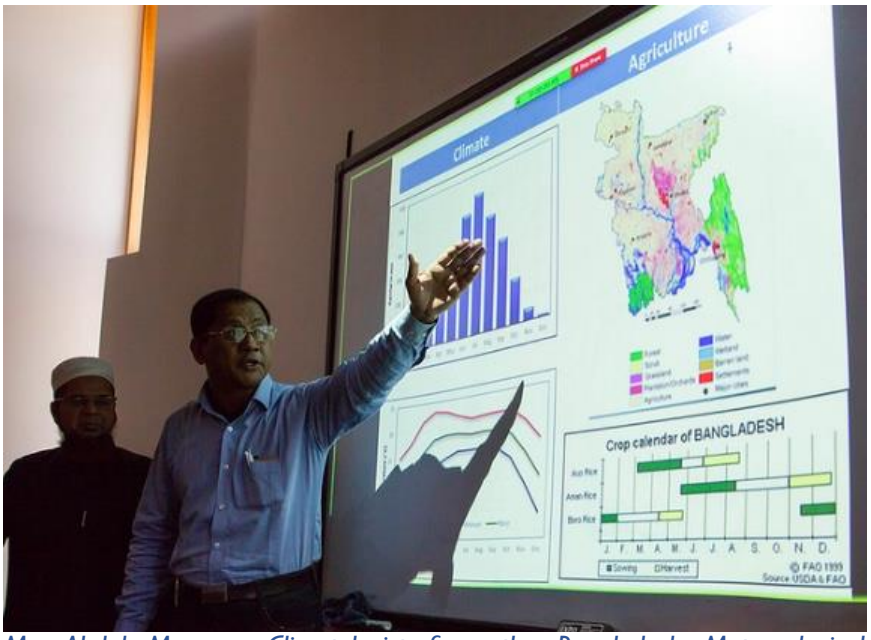
Considerable time went into discussing the quality of monitoring information being generated by BMD for the Agro-meteorological bulletin, and the verification and calibration of BMD's weather forecasting. Other activities included the presentation of information tools developed by IRI which are relevant to the work of BMD. The latter included the introduction to the IRI data library. Participants were familiarized with this data repository, its structure and organization, and were walked through ways to access available datasets. IRI also organized a presentation and discussion on meteorological data quality control and database management. This underscored the importance of considering data quality protocols in the design and implementation of weather station networks. BMD participants were also introduced to the use of IRI's Climate Data Tool, an R language-based tool that can be used for data quality checking and gridded product generation. Participants were introduced to IRI research in a number of non-agricultural climate services sectors including public health, index insurance, and forecast-based financing.

CSRD team members from CIMMYT, BMD and IRI converged for a two-week collaborative learning exchange held at Columbia University during in April-May of 2018 (Photo: Elizabeth Gawthrop)

In addition to the above topics, the first week of BMD – CIMMYT – IRI exchanges at Columbia University focused on the improvement of the seasonal and sub-seasonal forecasting skills and abilities of BMD professionals. Following presentations and discussion on the challenges of seasonal climate predictability for Bangladesh, practical and discussion-based activities focused on identification of relevant predictors and models for seasonal range forecasts using IRI's Climate Predictability Tool (CPT), and how to implement an automated procedure to generate forecasts using the CPT "batch" version. The latter process will save BMD's meteorologists considerable time each month when developing seasonal forecasts. Other activities focused on exploring outputs from different dynamical models that can be used to generate input data for CPT and research to identify large-scale physical drivers of climate in Bangladesh. Lessons from these activities are now being used by IRI scientists to identify or modify forecasting variables necessary to generate improved sub-seasonal to seasonal-scale outlooks for BMD.

Scientists and stakeholders discuss progress towards developing agricultural climate services in Bangladesh during the two-week learning exchange held at IRI (Photo: Elizabeth Gawthrop)

During the second week of the IRI exchange, participants from the DAE and Bangladesh's Ministry of Defense (under which BMD is housed) arrived and joined the group. The exchange's topical focus shifted to emphasize cross-learning between BMD and DAE, and to train participants from the latter in fundamental climate science principles. Both groups also engaged in facilitated discussions on agricultural climate services and lessons from different global regions, as well as being introduced to climate risk management in smallholder agriculture in developing nations, focusing on vulnerabilities, uncertainties, technologies, and policies. Examples of the successful use of seasonal forecasting in agricultural extension were provided in discussion-based presentations with visiting IRI experts working in Latin America and Sub-Saharan Africa, in addition to South East Asia. Technical training was also given on the management of automatic weather stations (AWSs), synoptic weather stations, and data maintenance.



Mr. Abdul Mannan, Climatologist from the Bangladesh Meteorological Department (BMD), presents progress on research progress towards improved forecasting achieved during the two-week visit to IRI.

This exercise led into discussions and strategy development on how to translate and disseminate to agricultural climate advisories through DAE channels to farmers. At the conclusion of the learning exchange, BMD and DAE made a joint presentation on what they had learned during their time at IRI, as well as how they planned to collaboratively implement their newly developed and climate science communication skills upon return to Bangladesh.

Planned activities in Quarters 3 and 4 of 2018:

All activities for this CSRD Product are described in the Product 1 table above.

Contribution of Activity 1.2.1 to CSRD's Action and Learning Framework:

Pillar 1, Indicator 1.1and Pillar 4, Indicator 4.1 (see Annex 3).

Sub-Objective 1.3: Development of forecast products, impact assessments, and decision support tools for agriculture, fisheries and/or livestock

Activity 1.3.1: Iterative development and refinement of decision support platforms with improved agro-meteorological services visualization and communications tools

Background

Under previous collaborations, BMD discussed technical concerns on 12th July 2016, which is the basis of Activity 1.3.1Sector 3 Agro-meteorology track for the broader CSRD investment portfolio. The technical areas highlighted by BMD for technical support and collaboration included (1) provision of GIS maps which would display climatic stresses; (2) forecasts for integrated irrigation management services; and (3) development of "impact based agro forecast" systems incorporating improved forecast and vulnerability to identify impacts, with emphasis on the development of crop specific pest and disease models. These products form the backbone of Activity 1.3.1. topics and include (a) agriculturally short- and extended-range forecasts graphically depicted as climactic stress risk maps for major cereals, (b) an ITC platform for meteorologically integrated irrigation management services, and (c) spatially explicit and meteorologically driven wheat blast *(Magnaporthe oryzae Triticum*, MoT) disease risk assessments for Bangladesh.

Product 1. Agriculturally relevant climatological analysis and improved extended-range forecasts and outlooks[1]

Looking towards historical climate data to inform the present and future

Deriving actionable climate information for crop planning from historical data

A key activity in CSRD that leverages historical data to provide climate service advisories is the analysis of temperature data to map crop species-specific potential of encountering thermal stress that can reduce yields. Where farmers are likely to encounter heat stress during the season, extension services can advise the use of more heat or drought tolerant varieties (as heat and drought are often associated). Farmers in regions more likely to encounter terminal heat stress towards the end of the season can also be advised to consider smartly timed irrigation to lower the canopy (leaf) temperature of the crop, which has been demonstrated to have some potential to limit yield loss.

[1] The initial SOW developed by USAID based on the 12 July of 2016 consultation with BMD suggested focusing on the development of 'Seven-day rainfall forecasts with 15-day accumulative rainfall outlooks' (Task i. ii.). Upon commencement of the project, CSRD staff found that BMD is already generating seven-day rainfall forecasts using WRF model outputs. 15 cumulative rainfall outlooks are however relevant in the context of several other forecasting parameters that were identified during the BMD skills assessment. Importantly, these topics are more agriculturally relevant for farmers than generic seven-day or 15-day accumulative rainfall outlooks. With the endorsement of BMD, CSRD has therefore begun focusing on these forecasting needs under this activity product now renamed 'Agriculturally relevant climatological analysis and improved extended-range forecasts and outlooks'.

CSRD has completed the development of R code that can analyze historical temperature data and generate maps of Bangladesh showing the probabilistic risks of exceeding temperature thresholds (both high and low). Preliminary maps for wheat, maize, and rice have been generated using expert informed and estimated threshold values. These thresholds are being refined through a systematic review of peer-reviewed literature that quantify the species-specific low and high thermal stress thresholds for each of these crops. Examining available studies from the Web of Science, Agricola, CABI and Scopus databases, more than 24,000 papers were initially retrieved. These were screened down to approximately 350 papers that used appropriate methods for determining species thermal stress thresholds that can reduce yield. These papers were scrutinized in detail, from which data analyzed is presented in the table below.

CSRD's collaborators at URI also plan to develop the R code packages that generate these maps into an open-source product that will be made available online for agricultural scientists or climatologists conducting similar research in different countries and regions. Similarly, the database and bibliography of papers used in our systematic literature review will be made available at the conclusion of the CSRD project on CIMMYT's dataverse website.

	Seeding stage		***Vegetative stage***		***Flowering stage***		***Grain filling stage***	
Maize	—	—	7.5±1.5(2)	35±1.7(3)	10±0(1)	34.8±0.2(15)	15±0(2)	33±1(2)
Wheat	—	—	—	35±1(24)	17±1(16)	35±.04(45)	12±0(5)	33±0.1(9)
Rice	3±.5(2)	35±0(1)	—	30±0(1)	6±1(4)	31±0.2(41)	9±0.05(2)	33±0.4(18)

Note: '—' indicates no suitable data were found. ± data are standard errors. Data in parentheses indicate number of observations.

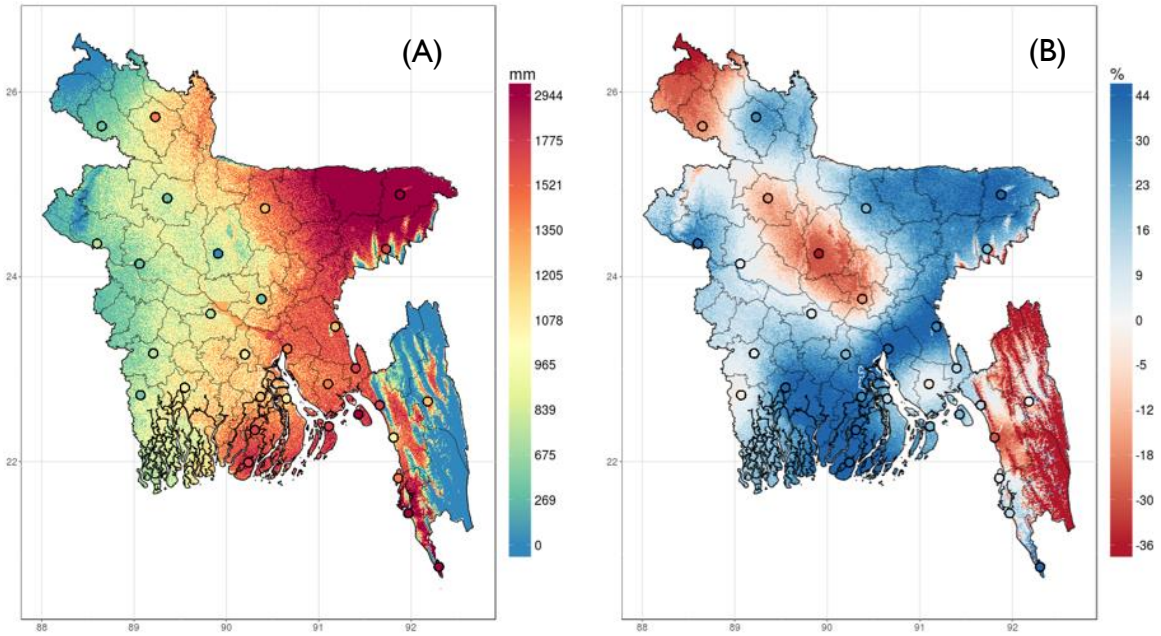
Mapping of the seasonal progression of the monsoon and deviation from historical normal

Using geographical covariates and statistical mapping, the progression of accumulated rainfall during the monsoon is being mapped by BMD and CIMMYT. This mapping will be useful for extension agents and agricultural planners to monitor rainfall progression and make data-based decisions regarding management of monsoon season transplanted *aman* rice, which is Bangladesh's most widely grown crop.

The maps and data will be are also useful in the development of yield forecasts at a national and sub-national scale. These maps are based on the R code, and as such are open-access and easy to use. They show the spatial pattern of the actual rainy season, together with any observed anomalies from historical data. The following maps show the products developed by the CSRD team, which are now in the process of being merged into BMD's website and agro-meteorological bulletin.

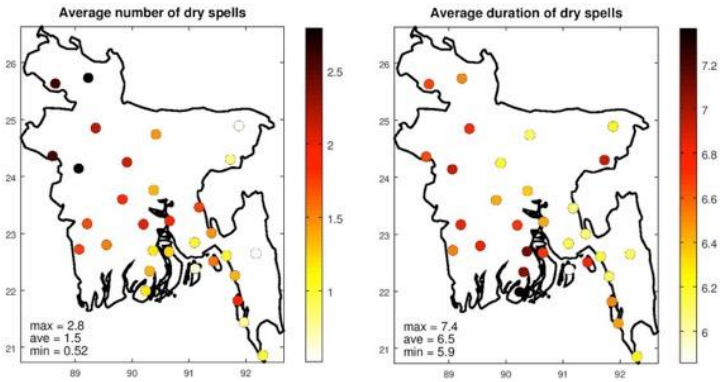
The CSRD science team is generating relevant climate data products from time-series observations from specific BMD weather stations. These graphs show the cumulative amount of precipitation during the 2016 monsoon. This year has been chosen to develop preliminary maps; future maps will be updated daily as precipitation data are received from automatic weather stations. The data show how precipitation in 2016 is less than the historical average, caused by the late onset data of the monsoon.

Information products such as these were requested by BMD and DAE, and enable agricultural planners to target specific areas of Bangladesh for additional extension support. Data such as these are also useful in national and sub-national yield forecasting. CSRD is in discussion with its partners as to how best to make use of these information products; they are likely to be incorporated into the revised and improved BMD agro-meteorological bulletin.



Left: Map of the seasonal progression of precipitation during the 2018 monsoon (mm). Right: Deviation of the 2018 season from the long-term average (%).

Historical mapping of monsoon dry spells (consecutive 5 days with < 1 mm, monsoon seasonal scale)



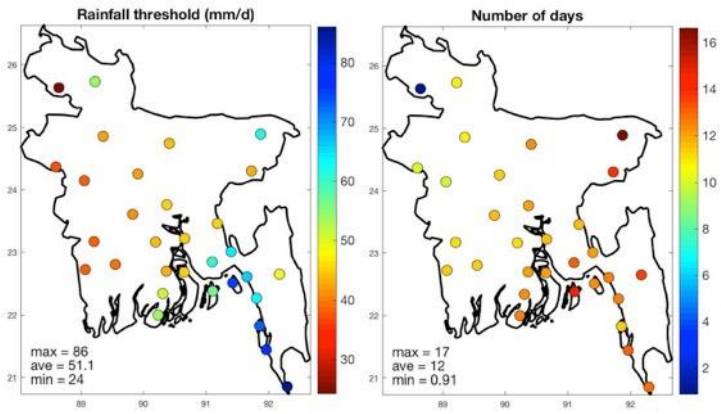
Climatology of number (left) and duration (right) of dry spells measured as consecutive 5 days with < 1 mm of precipitation during the monsoon season in Bangladesh.

The CSRD team has actively collected necessary data from local weather stations and gridded products to quantify and statistically characterize the occurrence of dry spell events over the last four decades for different regions within Bangladesh. This data has also been shared at knowledge at the regional level for broader use across South Asia. Historical mapping of monsoon dry spells is important in the generation of relevant agricultural climate services aimed at developing and early warning products based on weather forecasts according to the probability dry spell occurrence and existing crops in a country or region above figures shows a climatology of dry spells in

Bangladesh during the monsoon season in terms of number and duration in days. A spatial pattern is evident from these metrics, which indicates the need to focus on collection and analysis of data and information on dry spells so as to be included as information in climate services.

Historical mapping of heavy rain events (moderately heavy and greater in February to March)

Given that the occurrence and magnitude of extreme rainfall events vary from place to place depending on a location's precipitation regime, their statistical characterization for each specific place corresponds to the first step in defining an extreme rainfall event. Maps generated by CIMMYT and BMD climatologists. The maps are based on historical information collected by BMD, which show the climatology of the precipitation amount from February to April, indicating it to be an extreme event, when considering this value as the 90% percentile of daily precipitation. The average number of extreme events for each station is also presented. Similar to the case of dry spells, a spatial pattern in terms of amount and number of events is evident, and this indicates differential processing of the information provided by a weather forecast, as well as differences in the potential impact of these events in Bangladesh.



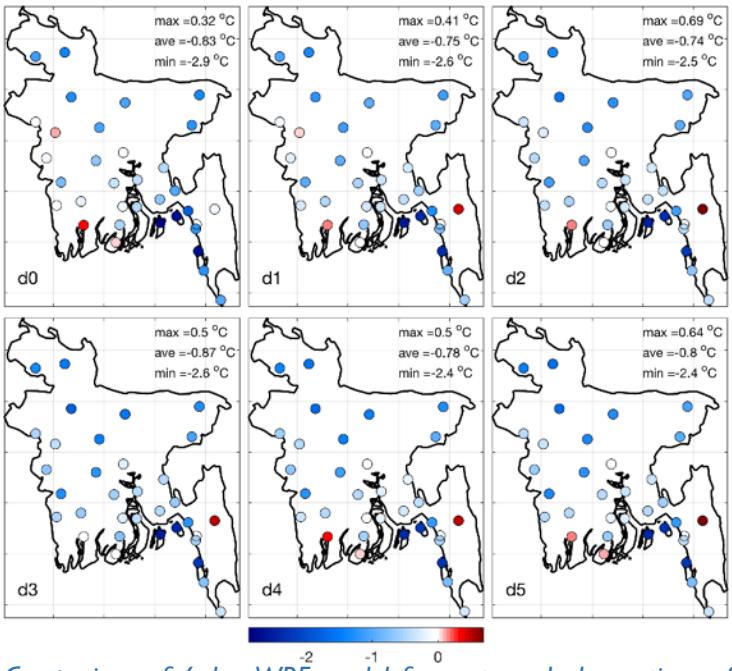
Climatology of rainfall amount in mm per day (left) considered as an extreme rainfall event and the duration (right) of these events in Bangladesh.

Forecasting to improve climate information and services in Bangladesh

Quantitative assessment and improvement of BMD forecasting skill

Ongoing work to quantitatively assess and improve BMD's weather scale forecast skill has helped identify possible systematic biases in the forecast generated by the Weather Research and Forecasting (WRF) model under its current configuration for Bangladesh. This work has only begun with under the CSRD project because BMD did not use to regularly save WRF model outputs for calibration with observed data. CSRD skills assessment facilitated by IRI, helped to identify this gap in BMD's activities and identified the regular saving and re-analysis of data as a key priority. It is important to note that initial results are *very* preliminary and will be completed in the coming months once a representative time series of WRF model outputs are generated.

Below figure shows an example of comparison of the results of the WRF model and the observations obtained by BMD stations for November and December of 2017. The figures highlight the difference between predicted and observed daily maximum temperatures for a six-day period. A negative bias (underestimation, blue colors) can be clearly seen throughout the country. The reverse is however observed in some coastal or higher altitude stations (in red). Results such as these will be used to apply statistical correction to the WRF model outputs, once all the necessary data are available, and enhance the skill of BMD's weather forecasts. Further work will assess other weather forecast variables such as precipitation and relative humidity.



Comparison of 6-day WRF model forecasts and observations of maximum temperatures in Bangladesh. Color bars are in °C.

Extended range forecast mapping of crop species-specific probabilities of encountering thermal stress

Corrections made to WRF model outputs and weather forecasting will be used to generate products for the BMD website and the weekly agro-meteorological bulletin, including the clickable maps depicting site-specific agricultural advisories for locations within Bangladesh. Improved WRF outputs will be combined with the data described in the sub-product under Product of Activity 1.3.1 i.e. 'Deriving actionable climate information for crop planning from historical data' as described above', and used to generate maps which advise on the risk of exceeding thermal stress thresholds. Such products are important and in demand by DAE, and are therefore a priority for CSRD.

Planned activities in Quarters 3 and 4 of 2018:

The CSRD team is currently preparing final maps obtained through statistical techniques to improve representation of dry spells and heavy rainfall events. These maps will be used by BMD as part of their website, and for training DAE staff to better understand the climate history of the areas they work in across Bangladesh. Next steps to improve the skill of BMD's weather forecasts will involve the comparison of longer time series of temperature data, currently being generated, and the identification of systematic biases for different seasons and other weather variables. Following this, statistical methods will be applied to generate an improved weather forecasting. These improved forecasts will provide the basis for crop-species thermal risk mapping and the generation of advisories through interactive, web-based

forecast maps which will be placed on the BMD website before the conclusion of the CSRD project.

Product 2. Weather forecast based irrigation scheduling with PANI (Program for Advanced Numerical Irrigation)

PANI, which means 'water' in Bangla, is an irrigation scheduling app that estimates crop water use and the amount of plant available soil moisture on a daily basis. Based on forecasted weather data, PANI generates an alert that can be used by extension agents or farmers as to whether a particular crop field needs to be irrigated in the next seven days. The alert is sent out on a weekly basis to farmers and irrigation service providers indicating if it is necessary to irrigate, or not. This simple but effective climate service is designed to save farmers money, while eliminating unnecessary fuel or electricity consumption for irrigation of wheat and maize.

CSRD's PANI related activities focuses on three regions within Bangladesh, including Barisal, Rajshahi and Dinajpur. In each of these country divisional and agro-ecological regions, the Bangladesh Agricultural Research Institute (BARI), is working in collaboration with CIMMYT to conduct experiments to calibrate and validate PANI. The CSRD team also implemented a series of farmer and pump owner Focus Group Discussions (FGDs) in each of the regions, in order to determine the interest of farmers in using PANI. This latter activity is an important step in the development of viable business models to support the use of PANI in locations where farmers can financially benefit from irrigation water savings – both through reduced costs and higher yields.

The three agro-ecological regions of Bangladesh chosen for the PANI tests and the FGDs are contrasting, with different climates, soil types, and irrigation pricing structures. By conducting research in each location, the project aims to determine how broad the envelope might be for PANI's use.

- ***Barisal District:*** This coastal region has heavy clay soils, geographically variable soil salinity, and shallow groundwater tables. Most crop production is not irrigated. Farmers predominantly grow legume crops, such a mungbean, lentil and grasspea during the dry winter '*rabi*' season months. These crops are sown without any irrigation and draw on soil moisture stored within the root profile from the previous monsoon season. Capillary rise is another important source of water supply to these crops. Crop establishment is often poor and irregular, due to lack of moisture. Only *boro* rice and vegetable and wheat are irrigated on a limited land area. A considerable portion of the land in Barisal District is left fallow and used for grazing. Weeds that grow on these fallow lands and that are used as grazing have a low productivity and poor feed quality. As such, there is considerable potential to intensify crop production in this region with irrigation.

- ***Rajshahi District***: In this part of eastern Bangladesh, irrigation during the winter months is widely practiced. *Boro* rice, maize and wheat are the main crops, in addition to mango orchards. Groundwater is the main source of irrigation. This region is generally free from floodwater during the monsoon, and experiences no soil salinity. Since the rate of dry season water abstraction for irrigation is however faster than of replenishment during

the monsoon, the water table is declining. This means that the energy cost for irrigation is increasing and sometimes, towards the end of the *rabi* season, not enough water can be accessed for irrigation from the shallow tube wells. The area is therefore considered drought-prone, and is geographically linked to the 'High Barind Tract" of Bangladesh (a higher-elevation area with distinctly coarser soil textures) where ground water levels are being depleted in some wells at a rate up to 40 cm per year (1981-2014) (Dey et al., 2017)[2]. Large scale irrigation started in the late 1990's, first under the Barind Integrated Area Development Project (BIADP), now called the Barind Multipurpose Development Authority (BMDA) project.

- ***Dinajpur District:*** This district is located at the northern end of the Barind Tract. Circumstances in Dinajpur are similar to those in Rajshahi, although water tables are generally closer to the surface for much of the calendar year. This district is the main wheat and maize production zone of Bangladesh, though *boro* rice cultivation is also widely practiced. Despite the wide cultivation of *boro* rice in the dry winter season with irrigation, groundwater extraction is not considered to be severe. Farmers however frequently voice concerns regarding the high cost of irrigation, especially where diesel pumps are used to bring water to the surface.

Preliminary findings from FGDs on PANI:

In order to determine farmers' interest in PANI and in advice for irrigation scheduling, focus group discussions were conducted in Barisal, Dinajpur and Rajshahi Districts in the first half of 2018. FGDs were carried out at the village level, and involved both farmers and irrigation pump owners. Based on recommendations from local DAE officers, three villages were selected from each District for the FGDs. The main objectives were:

- To identify village level information regarding irrigation contract systems and water payment modality
- To pinpoint problems related to irrigation and its associated costs
- To introduce farmers and pump owners to PANI
- Develop an initial business model from FGDs findings in order to identify where extension efforts promoting use of PANI should be concentrated

[2] Dey, N. C., Bala, S. K., Islam, A. K. M. S., Rashid, M. A., & Hossain, M. (2013). Sustainability of groundwater use for irrigation in northwest Bangladesh. *Policy Report prepared under the National Food Policy Capacity Strengthening Programme (NFPCSP). Dhaka, Bangladesh*, *89*.

Farmers' opinions and interest in the use of an irrigation scheduling app

Location	Farmers' opinions and concerns	Irrigation service providers' (pump owners) opinion and concerns
Barisal (hourly service charge for irrigation)	Farmers anticipate benefiting from PANI for the following reasons: • Potential cost savings if the number of irrigations can be reduced while maintaining crop yield • Crops will perform better if farmers are able to avoid over-watering • PANI would help farmers them to plan their work a few days ahead of time • Information on upcoming heavy rains will allow them to prepare within field drainage	Pump owners assessment of PANI was positive for the following reasons: • Pumps will require less running time, which saves time and money (fuel or electricity reductions) • Service providers can plan their work schedule and possibly free-up time for other business activities when irrigation is not needed • Irrigation pumps will last longer with less depreciation (presumably because pumps will be run for less time)

Rajshahi (pre-paid card system for electric tube-wells)	Limited benefits of PANI were found in electric tube-well systems managed by the Barind Multipurpose Development Authority (BMDA) for the following reasons:
	• Irrigation is subsidized under the current BMDA system
	• No cost savings can be accrued if farmers irrigate less
	• The present BMDA contract system is established and is not likely to change in the near future
	• The only major benefits suggested by farmers included:
	  ○ Reduced risk of over-watering
	  ○ Schedule allows farmers to plan their work ahead of time
		Service providers thought they were not likely to benefit, from PANI because:
		• They are likely to receive less commission and reimbursement for labor costs associated with irrigation. The commission depends on the number of hours of irrigation work under the current BMDA system.

Rajshahi (hourly contract)	Farmers anticipate benefiting from PANI for the following reasons: • Reduced irrigation costs • Irrigation can be applied according to the needs of the crop • Farmer can plan her/his work more effectively ○ Reduced cost because the risk of over-watering is reduced	Pump owners' assessment of PANI was positive for the following reasons: • Service providers can plan other work in advance of the day in which irrigation is normally applied • Irrigation pumps will last longer with less depreciation • More timely irrigation and the ability to plan irrigation in advance of when it is needed could assist pump owners in increasing their efficiency and irrigating more fields than they currently do, which could generate more profits
Dinajpur (multiple water payment structures, but no card system)	In Dinajpur, farmers also hoped to benefit from an app like PANI because of the following reasons • Reduced irrigation costs • Optimum irrigation possible, • Save crop from over water or irrigation, • Plan for other work	Service providers also expect to have positive benefits from a service like PANI: • PANI would enable more effective irrigation planning and the application of water in advance of when it is needed. This reduces the stress and difficulty of managing irrigation and having unhappy farmer clients with dry fields.

In brief, farmers and service providers see potential in the use of PANI, particularly in Barisal and in Dinajpur, because it could allow them to plan in advance, reduce the number of irrigations, and achieve cost savings. PANI could also help limit the negative effects of over-irrigation, for example waterlogging or leaching of nutrients that reduce crop yields. At one site in Rajshahi district, farmers and pump owners were more skeptical, because irrigation is heavily subsidized by the government through the BMDA system and so PANI might cause some income loss for irrigation service providers, and farmers struggled to see benefits from the system. These results highlight the need for appropriate planning in the future extension of PANI, in order to avoid locations and irrigation water payment systems that are unlikely to result in benefits from a weather-informed irrigation scheduling app.

Calibration and Validation of the PANI algorithm:

In order to test the capability of PANI to provide accurate advice on irrigation scheduling, CSRD worked with BARI to conduct irrigation experiments for maize and wheat near the same locations where the focus group discussions were held in Dinajpur, Rajshahi, and Barisal. PANI was initially developed in southern Bangladesh where rainfall tends to be more frequent and reliable, and where soil moisture conditions are usually optimum for most days of the calendar year. It is therefore, necessary to test the applicability of PANI in other parts of Bangladesh. BARI conducted irrigation scheduling experiments in each of their regional research facilities to evaluate PANI. The following treatments were planned: (1) 'Dry' (reduced number of irrigations in wheat and maize), (2) BARI (irrigation according to standard BARI recommendations) and (3) PANI (irrigations according to recommendations from the PANI algorithm). BARI staff collected all the necessary data for the calibration and validation of PANI. Unfortunately, the integration of PANI with other data sources took more than initially planned and the app was fully ready to guide the PANI treatment in the 2017/18 wheat and maize season. However, the data gathered will still be used to test the sensitivity of the underlying PANI algorithm in order to improve it in anticipation of repeating experiments in the 2018/19 *rabi* season.

Planned activities in Quarters 3 and 4 of 2018:

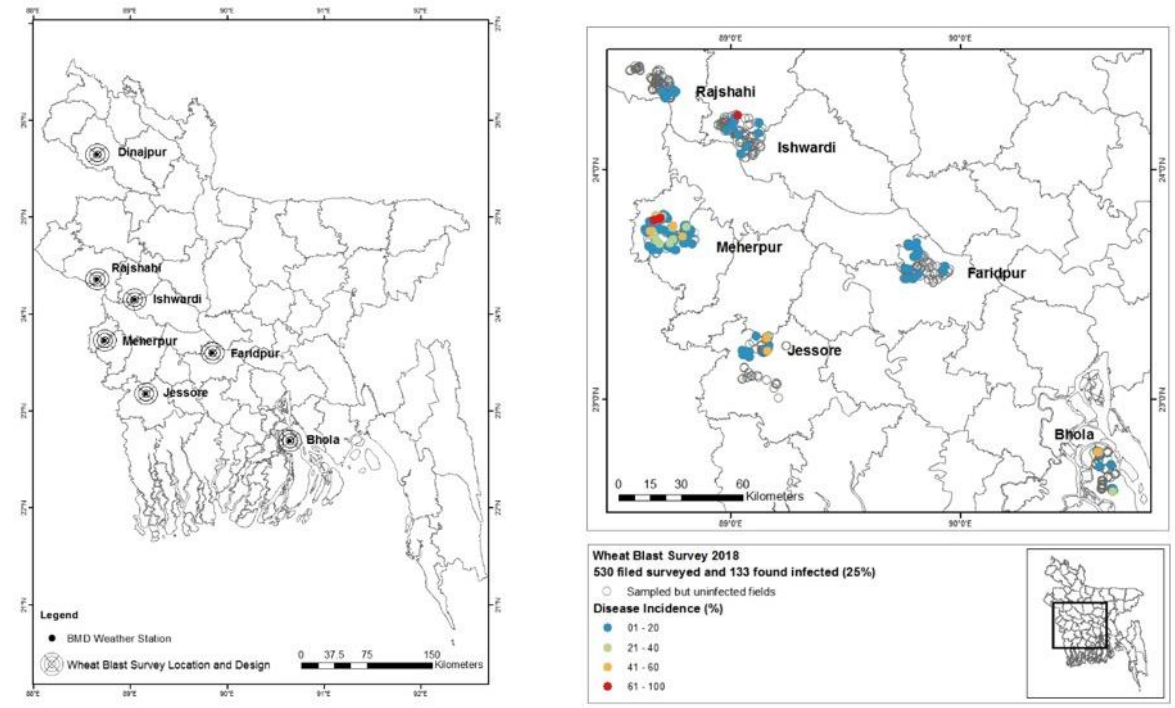
In the next three months of 2018 s, the CSRD South Asia team will carry out activities focused on the analysis and review of the data collected by BARI. Based on the results, the research plan for the 2018/19 season will be adjusted in collaboration with BARI. This will be completed by the end of the 3rd quarter of 2018. In the last quarter, BARI will be supported to carry out planned experiments and also collaborate with DAE to prepare the tests of the PANI app by extension agents and farmers in the coming winter season.

Product 3. Spatially explicit and meteorologically driven wheat blast (Magnaporthe oryzae Triticum, MoT) disease risk assessments for Bangladesh

Though it is the second most important crop globally, sustained wheat production in the tropics and sub-tropics is challenged by highly problematic diseases. Wheat blast, which is caused by the fungus *Magnaporthe oryzae* pathotype *Triticum,* is now a key concern in South

Asia. First discovered in Brazil in 1985, wheat blast spread to Bolivia, Paraguay, and Argentina. In 2016, it suddenly appeared outside South America in Bangladesh, and again in 2017 and 2018 with news reports of further spread to India. Late-season fungicides are only partly reliable. Seven million hectares are at risk of reoccurring infection in South Asia, with losses to smallholders of up to 1.77 MT worth $264 million year^{-1} with light infections of just 10%.

CSRD has responded to this problem by partnering with scientists at the University of Passo Fundo (UPF) in Brazil, who developed a numerical weather forecast based disease forecasting model in 2017. The model functions by integrating temperature, precipitation, and relative humidity forecasts to predict the development of inoculum and a spore cloud favoring low-, medium-, or high-outbreak risks. CSRD's partnership with UPF is strategic and crucial, as Bangladesh's Ministry of Agriculture requested CIMMYT in late 2016 to urgently develop a wheat blast early warning system that can be used by the Department of Agricultural Extension to aid farmers in integrated crop and disease management. CSRD's work therefore directly responds to this request by working to develop practical and action oriented agricultural climate services in the form of a wheat blast disease early warning system.



Left: Wheat Blast surveillance locations centered around BMD weather stations in early 2018. Right: Wheat Blast disease incidence as observed in the fields near BMD weather stations.

This system, which is programmed using R and R Shiny, is now fully developed and available online in beta version. Yet in order to validate and adapt this model to the climatic conditions found in South Asia, the CSRD team collected a large amount of data from over 800 wheat farmers' fields in early 2018. Disease incidence and severity information was collected at least twice from each field, along with variety, crop management and phenological information. Although disease levels were low in 2018, data are now being analyzed to confirm how accurately the model can predict infection. Where large deviation from observed data and the

model are found, the model's parameters will be modified to improve prediction. The same process will be repeated in the 2018-2019 wheat growing season.

Planned activities in Quarters 3 and 4 of 2018:

Data from the 2017-2018 wheat season are currently being analyzed. More details will be presented in the 2018 end of year report. In the interim period, CSRD will be working with the Ministry of Agriculture – and specifically the DAE – to position them to use the model as a practical early warning system. Interactions with the CSRD partners are ongoing to achieve this aim (see Objective 3), with expectations that the DAE will make use of the blast model in the context of the World Bank Climate Services project and as a general extension tool to assist farmers.

Contribution of Activity 1.3.1 to CSRD's Action and Learning Framework:

Pillar 2, Indicators 2.2 and 2.3, Pillar 3, Indicator 3.1 and Pillar 4, Indicator 4.1 (see Annex 3).

Activity 1.3.2: Agro-meteorological forecast services applications and systems for crops, fisheries and/or livestock developed and refined for medium term decision making co-developed and refined

Background

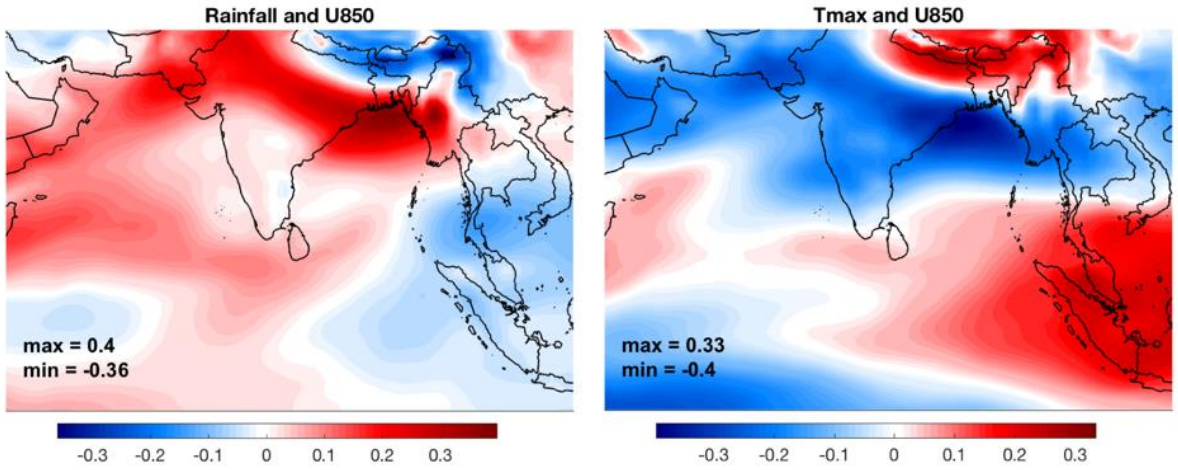
Similar to the topics addressed in Activity 1.3.1, CSRD's Activity 1.3.2 also responds to the result of USAID's consultation for the Sector 3 Agro-meteorology track in 2016. Activity 1.3.2 focusses on seasonal and sub-seasonal forecasts that are of benefit for both agricultural climate services as well as a number of other sectors. The outputs from this activity are already being primed for inclusion into BMD's website and it is expected to be used in complementarity with the World Bank funded Agro-Meteorological Systems Development project, among other applications.

Product 1. Improved seasonal forecasts and climatic stress maps developed and refined

Activity 1.3.2 Product 1 has been supported by ongoing interactions between IRI, BMD, and CIMMYT between 2017 and the April 2018 learning exchange at IRI in Columbia University. A large portion of this exchange was devoted to generating climate forecasting in the seasonal range for Bangladesh using IRI's Climate Predictability Tool (CPT). This work was crucial in understanding and identifying the challenges associated with climate predictability in South Asia and Bangladesh in relation to other mid-latitude regions. Research conducted on Bangladesh during this period has revealed the complexity of finding adequate skill for climate predictability in Bangladesh that can be statistically explained by large-scale climate drivers including sea surface temperature and atmospheric circulation.

CSRD's forecasting skill analysis indicated that monthly rainfall and temperature predictability for different seasons and using multiple input variables and outputs from general circulation models can be generated with some degree of confidence for Bangladesh. This is especially in

the case of air temperature, the results for which were generally better than for precipitation. Scientists from IRI, BMD and CIMMYT are currently looking into the appropriate skill for forecasting delivered by the North American Multi-Model Ensemble dynamical models that can be applied to different areas of Bangladesh.

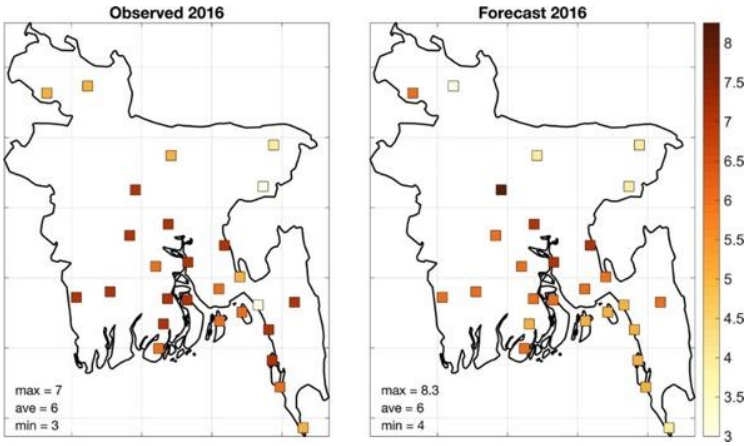


The correlation between monthly anomalies zonal wind (850 hPa) and monthly rainfall and maximum temperature (Tmax) in South Asia using the Era Interim reanalysis of the European Center for Medium-Range Weather Forecasts (ECMWF).

In the context of a seasonal forecasting assessment, different climate predictors can have a different weights, depending on factors such as the proximal location of the forecast point of interest to the sea or to mountains. To exemplify this, the maps in figure below display the correlation between monthly anomalies of the zonal wind magnitude at 850 hPa, rainfall, and maximum temperatures.

The results from these maps show an opposing relationship between the north and south part of the Bangladesh. Consequently, the predictability of atmospheric circulation factors are expected to vary between the north and south, a situation which may in turn require different forecasting systems for each part of the country. The skill of the seasonal and sub-seasonal forecasting for Bangladesh is being explored for different regions and metrics (seasonal precipitation, extreme events) separately, which might improve the results. This issue is being further explored at the time of reporting.

At present, work focusses on the study of the monsoon onset definition for Bangladesh and South Asia along with its potential seasonal predictability. This topic was identified as a core research need during the BMD skills assessment, and was also highlighted by farmers in focus group discussions conducted under Activity 1.1.1 due to its importance for planning land preparation and transplanting of monsoon season aman rice in Bangladesh. As a preliminary result, below figure shows the monsoon onset Julian pentad (5-day periods) using different threshold precipitation amounts together with field onset dates provided by farmers through surveys and ethnographic studies. These maps indicate that monsoon onset can be highly sensitive to the rainfall amount used as a threshold, and that a high spatial variability exists, with a clear pattern represented by an East-West gradient.



Example of results obtained by using CPT to predict the onset of the monsoon season in Bangladesh. Data shown are the number of weeks after April 1.

Previous work on the timing of the monsoon is being extended by assessing the statistical predictability of the onset of the rainy season. We initially explored the skill of CPT forecasting of monsoon onset. The following map shows an example of the performance of CPT as a tool applied to the bi-weekly scale in predicting monsoon onset. The CSRD team is now comparing local definitions of monsoon onset provided by farmers, and high-skill predictability combining sub-seasonal forecasting in ensemble dynamical models.

Planned activities in Quarters 3 and 4 of 2018:

CSRD scientists have started conducting a skills assessment study for seasonal and sub-seasonal climate forecasting provided by the North American Multi-Model Ensemble (NMME) Dynamical forecast system, analyzing different variables and models available. The seasonal amount of total precipitation and sub-seasonal metrics (dry spells, extreme events) together with the ability of forecasting the monsoon onset at the sub-seasonal scale (15 days, 1 month) are being analyzed. Results will be reported on in the end of year CSRD report.

Contribution of Activity 1.3.2 to CSRD's Action and Learning Framework:

Pillar 2, Indicators 2.2 and 2.3, Pillar 3, Indicator 3.1 and Pillar 4, Indicator 4.1 (see Annex 3).

Objective 2: Collaborative development and refinement of South Asian regional-scale agro-climate decision support tools, services, and products

Sub–Objective 2.1: Support to facilitate the development and refinement of regional decision support decision support tools, services, and products

Activity 2.1.1: Coordination support for the International Centre for Integrated Mountain Development (ICIMOD) and partners in drought forecasting

Background

This activity focusses on establishing the capacity, infrastructure, partnerships and strategy necessary to establish an agricultural drought monitoring and forecast system for Bangladesh

using earth observation data and methods. This CSRD activity makes use of its partnership with ICIMOD to add three research locations in Bangladesh to ICIMOD's regional efforts in drought monitoring under the SERVIR Hindu Kush Himalayan (KHK) project. These locations complement remote-sensing based drought monitoring and forecasting activities in Nepal, Pakistan, and in Afghanistan. The following passages detail achievements in this work stream in the first six months of 2018.

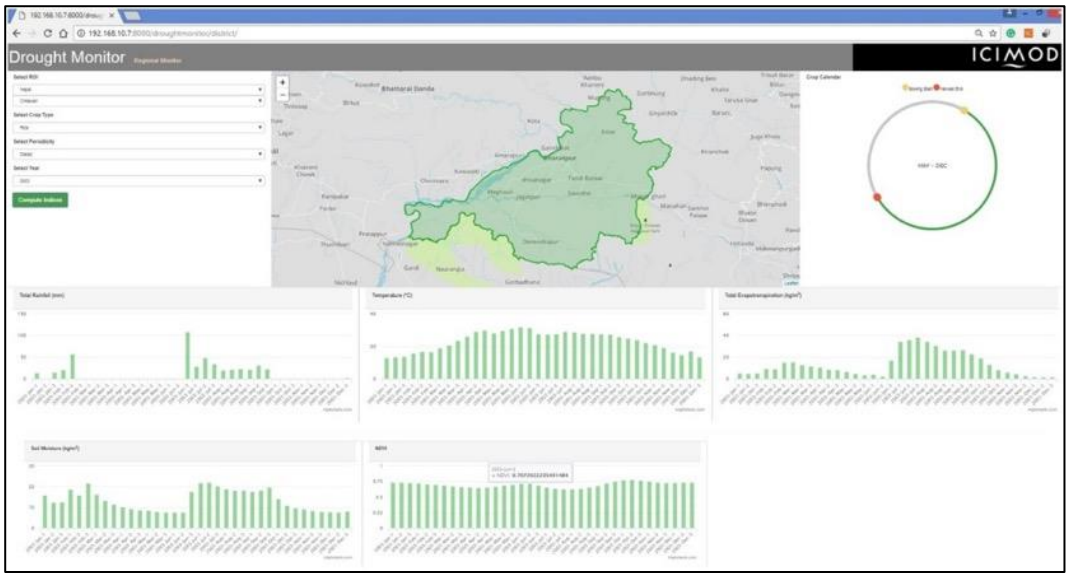
Product 1. Ongoing support for ICIMOD and partners

Further development of the sub-seasonal to seasonal (S2S) South Asia Land Data Assimilation System (SALDAS)

The seasonal (S2S) South Asia Land Data Assimilation System (SALDAS*) has* been developed by ICIMOD with CSRD's support and has been installed at both ICIMOD, in Kathmandu and the Bangladesh Agricultural Research Council (BARC) in Dhaka. SALDAS is a data assimilation and forecasting platform that captures soil hydrological extremes on short to seasonal timescales. SALDAS has also been upgraded to include a rapid workflow system at ICIMOD. This was achieved with support from NASA-SERVIR AST team from John Hopkins University. As part of this work, ICIMOD scientists working with CSRD are developing a function for extracting temporal and spatial subsets of data at the dekadal (10 day), monthly, and three monthly (running aggregation) intervals. These data are converted into GIS workable format by the function currently under development.

Drought data analysis and visualization made easy: Development of an online data exploration system

In addition to physical infrastructure and capacity development in Bangladesh, Product 1 places emphasis on the development of a web-based information system to disseminate Regional operational drought monitoring products in South Asia. Activities undertaken in the last six months include installation of a Tethys platform and development of prototype of Tethys application for SALDAS data visualization.



Screenshot of the preliminary user interface for district level crop data and drought monitoring visualization.

Tethys is free and open-source software that is designed to represent environmental and water management data, and develop online decision support tools. The system has been used to develop an application programming interface for extracting and representing summary data from processed remotely sensed and GIS data. Users of the programming interface can easily request data within any time period (up to one year). Making use of a number of relevant drought indices, a beta version of the programming interface for data visualization has been completed at a district level in Bangladesh. The beta version of the application was presented in the Regional Stakeholder Workshop on SERVIR Hindu Kush Himalaya Applied Science Projects held during 23–24 April 2018 in Dhaka, Bangladesh. User feedback was systematically collected and the system is now being refined based on requests for improved user ease.

Planned activities in Quarters 3 and 4 of 2018

In the spring of 2018 SALDAS was combined with pre-existing SERVIR-HKH data acquisition and analysis systems to provide operational real-time monitoring of drought conditions in operational countries of South Asia. SALDAS also provides a platform for sub-seasonal to seasonal (S2S) hydrological forecasts. These forecasts were scheduled to go online for the 2018 monsoon season. Unfortunately, technical delays and the need to capture additional ground truth precipitation data (an activity led by CIMMYT staff in Bangladesh) have deferred operationalization of the forecast system by 3 months. The system is now expected to be complete and ready for implementation sometime between August and October of 2018. At that point CSRD will begin detailed forecast validation (and down-scaling analysis). The project also plans to disseminate sample forecast products to BMD, BARC, BARI and DAE for end-user feedback. Despite these setbacks, the preliminary system is still on track for full development, refinement, and full operational condition by 2019. As per this revised schedule, team members Yifan Zhou and Wanshu Nie from John Hopkins University will be visiting ICIMOD headquarters with the support of CSRD during July 26 – 5 August 2018 to deploy preliminary forecast modules.

Contribution of Activity 2.1.1 to CSRD's Action and Learning Framework:

Pillar 1, Indicator 1.1, Pillar 2, Indicator 2.2, and Pillar 4, Indicator 4.1 (see Annex 3).

Activity 2.1.2. Regional learning platform for climactically refined decision support tools to support precision nutrient management (PNM) by smallholders

Product 1. STEMPEDIA: Lentil Stemphylium blight disease forecasting systems in Bangladesh, Nepal, and India[3]

Background

The production of lentil (*Lens culinaris*), an integral part of many nutrition-sensitive farming systems in South Asia, is significantly affected by diseases. Among the diseases, Stemphylium

[3] Note that this work stream replaces 'Precision Nutrient Management' as described in the original CSRD SOW for South Asia. The change to the current work stream was agreed with USAID in Q3 of 2017, and was chosen because of the potential for rapid model validation and impact in the context of integrated disease management across Nepal, India, and Bangladesh.

blight (SB), which is caused by *Stemphylium botryosum*, is a serious threat to the resilience of smallholder farmers' livelihoods in Bangladesh, India and Nepal. The severity of the disease is conditioned by cloudy weather, relative humidity, and temperature and precipitation regimes, and varies between locations within a growing season and also between seasons within a location. These conditions make it difficult for farmers to properly formulate financially-viable fungicide-based disease control measures. As a consequence, farmers either apply too much fungicide when it is not needed, which can lower their profits and increase environmental externalities, or not at all. Although the latter limits environmental consequences, it also lowers yield and contributes to rural poverty traps. Addressing this issue, the 'Stempedia' model was developed by scientists working with CSRD to assess the regional and seasonal risks of the disease within South Asia, and to rationalize the use of foliar fungicide application to achieve financial gain while limiting environmental impact.

Since the last reporting period, 'Stempedia' was tested in limited scale across field locations in Bangladesh, India, and Nepal. Data from the latter countries are under analysis and will be reported on at the end of year report. The information below pertains to preliminary results for Bangladesh.

Field staff together in a lentil field in Jessore, Bangladesh prior to the start of field-to-field disease monitoring (Photo: Jahangir Alam)

Hands-on training session on lentil diseases and early warning systems development attended among other by Additional Director Mr. K. Chandra Das (Photo: M. Arafat)

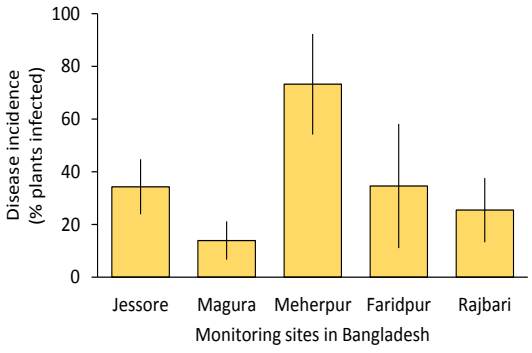
Developing models and climate services to support early warning systems for Stemphylium disease in lentil in South Asia

In order to validate and re-calibrate the Stempedia model, 480 farmers' fields, 160 each in Bangladesh, India and Nepal were monitored. The fields were located in five sites (Jessore, Magura, Meherpur, Faridpur and Rajbari) in Bangladesh, five sites (Barh, Mokama, Barhaiya, Masaurhi and Paliganj) in the State of Bihar, India, and in four sites (Kanchanpur, Kailali, Bardiya and Banke) in Nepal. Locations in India were monitored through synergistic and in-kind support from the USAID and Bill and Melinda Gates Funded Cereal Systems Initiative for South Asia, or CSISA, with additional in-kind backing from Bihar Agricultural University that worked to confirm *S. botryosum* presence through laboratory analysis. Activities in Nepal were supported directly by the CSRD project in partnership with the Nepal Agricultural Research Council's National Grain Legume Research Program, the latter through in-kind support for laboratory analysis. Similar field arrangements were made in Bangladesh, with cooperation

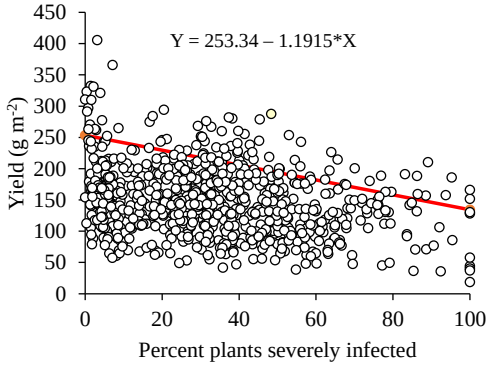
provided by the DAE and Bangladesh Agricultural University (also for laboratory analysis and disease species confirmation).

Fields were chosen to represent a gradient of climatic variables (differing in precipitation, temperature, and relative humidity generally, as described in the 2016-17 CSRD in South Asia Annual Report. By doing so, these applied research efforts provide a more stringent evaluation of the model's performance in differing environments while generating a high-quality dataset for model re-calibration. In order to implement field monitoring of diseases using the protocol provided in the Annexure of the 2016-17 CSRD in South Asia Annual Report, partner and CIMMYT scientific staff were trained in the three countries. Training included understanding the purpose of the study, the protocol, hands-on methodologies for data collection and identification of *Stemphylium* and other diseases in lentil fields. Trainings were conducted from 2-4 January in Jessore in Bangladesh, 7-10 January in Bihar in India, and 11-13 January in Nepalgunj in Nepal. In addition, two 2-day long training sessions was arranged for senior (Deputy Director and Upazila Agriculture Office) and grass-root (Sub-Assistant Agriculture Officer) level DAE officers in Jessore region on 7-8 February 2018 and in Faridpur region on 10-11 February 2018. These training sessions oriented DAE officials on agricultural climate services, disease forecasting, and applied research in CSRD.

Data were collected from farmers' fields, each of which were located near automatic and synoptic weather stations in each country. The CSRD team measured the status of Stemphylium blight and other diseases three times before harvest, during which yield was also assessed. Samples of visually recognized Stemphylium blight plants were collected for pathology verification in BAU (Bangladesh), BAU (Bihar), and NARC laboratories. Given the size of the dataset, only preliminary analysis from Bangladesh was possible at the time of reporting. Stemphylium blight was recorded in all the five monitoring sites within Bangladesh, though with a high degree of variability between the sites. The figure below shows the incidence of the disease, at the crop maturity stage, was the highest (73.2±19.1%, ± is standard deviation) in Meherpur and the lowest (13.9±7.3%) in Magura.



Incidence of Stemphylium blight in lentil (alone or in association with other diseases) recorded at maturity in five sites in Bangladesh in early 2018. Vertical bars represent the standard deviation for 32 fields in each site.



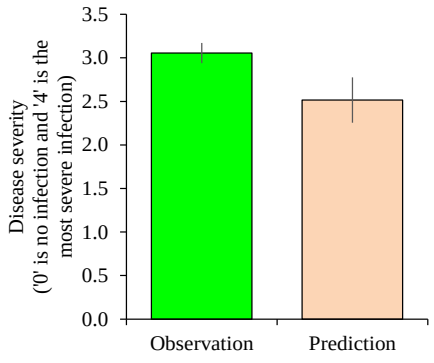
The yield-reducing relationship between yield and level of high-severity of Stemphylium blight infection in lentil at the 95th probability percentile. Data were recorded from 5 quadrats in each of the 32 fields across five sites in Bangladesh.

Blight occurred both alone and in combination with other diseases, which included a diversity of root and other fungal diseases. Accounting for all the diseases, the highest incidence of 87.0±18.6% was in Meherpur, followed by 58.3±10.3% in Jessore, 55.0±19.6% in Faridpur, 51.1±12.9% in Rajbari and the lowest (39.9±11.2%) in Magura. Root diseases usually occurred when the crop was young, whereas Stemphylium blight became a more significant problem after flowering.

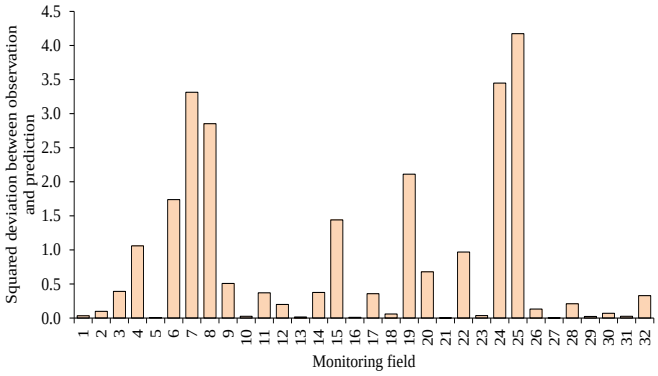
Analyzing yield of 800 data-points (5 quadrats × 32 fields × 5 sites) for yield across Bangladesh, yield appears to have been influenced by two variables – plant population density and the disease status. The 95th percentile of the data showed a linear reduction in yield at approximately 12 kg ha^{-2} with each percentage increase in Stemphylium blight infection. This preliminary analysis indicates that Stemphylium blight can cause significant yield loss in lentil when less than half the plants in a field experience infection.

Weather-based stemphylium model validation and performance

Due to late availability of field and weather data, the latter due the predominance of synoptic weather stations in each of the countries in which research was carried out, the Stempedia model can at the time of writing be subjected only to limited validation. the project's preliminary validation utilized 32 fields in the Faridpur site within Bangladesh. Model results indicate that on average, the Stempedia model predicted slightly less disease severity (2.52±0.26, ± is 95% confidence interval) compared to visually observed severity (3.06±0.12). The root mean squared deviation, which quantifies the differences between values, in this case disease severity, predicted by the Stempedia model and observed data, was 0.88. This deviation occurred due to large discrepancies in 9 out of 32 monitoring fields. These preliminary results are encouraging. Although the data are highly variable and the Stempedia model appears to under-estimate severity when driven by weather data supplied by BMD, further research will allow the CSRD team to adjust the model's underlying equations to improve performance.



Comparison of observed and predicted severity of Stemphylium blight of lentil in Faridpur, Bangladesh in 32 farmers' fields in early 2018. Bars are the 95% confidence interval.



Deviation between observed and predicted severity of Stemphylium blight of lentil from 32 farmers' fields in Faridpur in southern Bangladesh in early 2018. Although highly variable, these and subsequent analysis will permit the CSRD team to re-calibrate and improve model performance.

Planned activities in Quarters 3 and 4 of 2018:

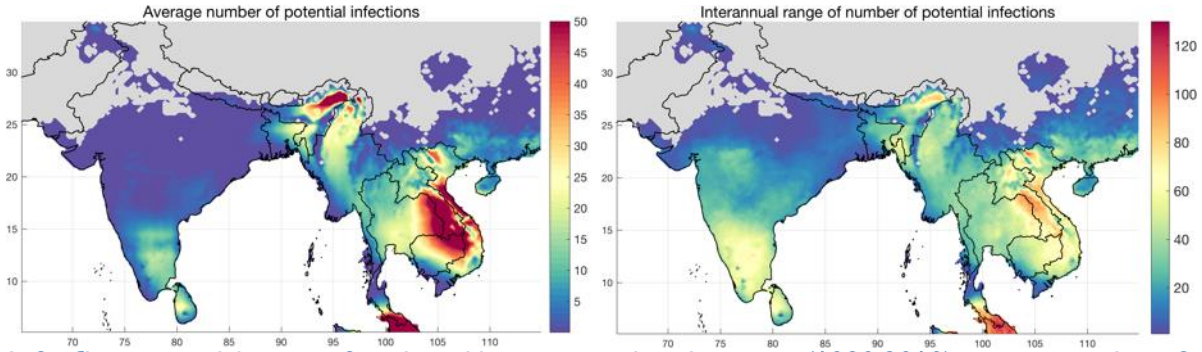
The following activities will be completed in the last two quarters of 2018, and reported in the end of year report (1) The current version of the Stempedia model will be completely coded into R analytical software, permitting increased ease of re-calibration and forming the basis of further disease early warning system to development. (2) All data (including field observations, weather observations, and model performance) will be completed for the 2017-18 lentil production season. (3) Stempedia will be fully validated and re-calibrated with 2017-18 data for the three countries as required (July-August 2018). (4) A preliminary presentation of results will be delivered to stakeholders in Bangladesh, India and Nepal (September-October 2018). Finally, (5) The second season of field data collection and training will commence for the 2018-19 lentil production season in Bangladesh, India, and Nepal (through to December 2018 end).

Contribution of Activity 2.1.2 to CSRD's Action and Learning Framework:
These efforts contribute to Pillar 2, Indicator 2.1, and Pillar 4, Indicator 4.1(see Annex 3).

Activity 2.1.3. Application of historical, near-term, and future climate data applied to develop spatially explicit wheat blast (*Magnaporthe oryzae* Triticum) disease risk assessments for South Asia

Product 1: Climatically driven regional disease risk assessment for wheat blast (Magnaporthe oryzae Triticum)

Although wheat blast has only been officially reported in Bangladesh, media reports indicate it has spread to neighboring India. Nepal and countries throughout South Asia that are large wheat producers remain concerned that the disease could spread and cause large yield losses. Using data fusion approaches combining historical climate information derived from multiple models and products with biological models of wheat blast disease development, CSRD aims to provide a broad assessment the regional spatial and temporal variability in climate-related suitable conditions for wheat blast outbreaks.



Left: Climate suitability map for wheat blast expressed as long-term (1980-2010) average number of potential infections during winter. Right: inter-annual range (1980-2010) of number of potential infections.

Ongoing analysis shown in the figure below maps the average number of potential wheat blast infections during the winter season across the whole of South and South-East Asia. The inter-

annual range of measurements are based on daily data for the period 1980-2010. A generic infection model for fungal plant pathogens was applied. The maps therefore depict key infection periods. The generic model applied has been reported as appropriate for use in forecasting pathogens that do not have an extensive epidemiological literature. This model extends work described in Objective 1 and is applied at the regional scale. The model makes use of estimates of cardinal temperatures and wheat leaf wetness duration requirements. By integrating this data, the model provides information on the climatic suitability for potential wheat blast infection events.

This preliminary analysis shows that a large area in South and South East Asia can be categorized as potentially under risk of wheat blast infection, including Bangladesh, where a northeastward-increasing pattern exists (confirming model results from Activity 1.2.1). Portions of India also appear to be at risk, including 'bread basket' region in India and Nepal's western Indo-Gangetic plains, although at a low number of average potential infections. Parts of Myanmar, Thailand, and southern China are at risk at higher infection levels. Inter-annual variability (shown in the map on the right) indicates that, infection risks can fluctuate in a range of around 20 potential events during the winter season during which wheat is grown, which, certainly, is associated with inter-annual climate variability that should be characterized and related to the results of the present model. These results have to be updated by incorporating location-specific crop calendars for winter wheat, and regions of wheat cultivation.

Planned activities in Quarters 3 and 4 of 2018:

During the following months, results obtained by applying this model will to be refined by evaluating specific parameters for wheat blast. The project expects to modify the generic disease model to account for evidence from Brazil of the minimum temperature threshold after which wheat blast develops. An additional application of this analysis will be the assessment of the potential economic value of a regional disease early warning and forecasting system. The value of the model in terms of delivering an agricultural climate service will therefore be evaluated in terms its potential to alleviate yield and income losses and the necessary investments required for disease control.

Contribution of Activity 2.1.3 to CSRD's Action and Learning Framework:

Pillar 2, Indicator 2.2, Pillar 4, Indicator 4.1 (see Annex 3).

Objective 3: Coordination with CSRD partners in-country to ensure progress on the work streams under the CSRD South Asia and Bangladesh working group

Sub-Objective 3.1. Coordination of Bangladesh CSRD partners

Background

One of the key objectives of the CSRD initiative in South Asia is the support of partners in Nepal, Bangladesh, and India interested in agricultural climate services. The below passages

summarize CSRD's efforts in the first half of 2018 to interact with and coordinate institutions working in climate services in each country.

Participation in the 4th Gobeshona Annual Conference for Research on Climate Change in Bangladesh

The 4th Gobeshona Annual Conference for Research on Climate Change in Bangladesh was held during January 8-11, 2018 organized by the International Center for Climate Change Adaptation (ICCCAD) at the Independent University of Bangladesh in Dhaka. On January 10, 2018 as a parallel session of the Conference, CSRD collaboratively organized a Symposium with IRI, BMD, and ICCCAD on Climate Services in Bangladesh. The session was attended by 51 participants from a variety of organizations. Dr. Timothy J. Krupnik of CSRD presented on the need for improved climate services and an academy to train young and mid-career professionals. This was followed by panel discussion by Dr. Saleemul Huq (ICCCAD), Mr. Shamsuddin Ahmed (Director of BMD), Dr. Mazharul Aziz (DAE and Project Leader for the Agro-Meteorology project supported by the World Bank), Dr. Wais Kabir, Executive Chairman of the Krishi Gobeshona Foundation (KGF), and Dr. John Furlow (Deputy Director of IRI) and Ms. Melody Braun (IRI). Following the conference, participants agreed to establish a Bangladesh Academy for Climate Services in association with to provide curricula and teaching support at educational institutions throughout Bangladesh. Further detail on the workshop and its outcomes can be found online in the Proceedings of the 4th Gobeshona Annual Conference on Climate Change Research in Bangladesh.

Partnership in the Design Workshop for the Bangladesh Academy for Climate Services (BACS)

As a follow-up from the 4th Gobeshona Annual Conference, the CSRD team took a leadership role along with IRI, BMD, and ICCAD in a Design Workshop for the Bangladesh Academy for Climate Services (BACS), which was held on March 21, 2018 at BMD. The objective of the workshop was to solicit the ideas of participants and exchange crosstalk on jointly establishing a climate services academy to provide relevant training for young and mid-career professionals and students in cross-sector climate services. Such an academy is also expected to serve as a dynamic platform that would consolidate and co-ordinate the endeavors on climate services and bring together several actors and sectors who possess different levels of knowledge on climate information. The design workshop encouraged the active networking of the participants, problem and solution identification exercises, and discussions on how the academy would effectively support the educational and capacity building related

Participants in the March 21-22 workshop held at BMD to generate ideas and stakeholder input on the creation of a Bangladesh Academy for Climate Services (see Annex 5).

initiatives through the implementation of a masters programs to graduate students and training programs to professionals. A total of 54 (37 male and 17 female) participants attended the workshop. Further details of the workshop can be found in Annex 5, which was written by CSRD collaborators working at ICCCAD.

Seminar on climate services for wheat blast prediction and modeling held at BMD

A seminar on *climate services for wheat blast prediction and modeling* presented by Dr. Jose Mauricio Fernandes from Universidade de Passo Fundo in Brazil was organized by CSRD in the BMD conference room in Dhaka on February 28 of 2018. Participants included key climatologists from BMD, extension staff from DAE, and visiting staff from BARC. Dr. Mauricio explained the wheat blast modeling framework being adapted from Brazil to Bangladesh through CSRD. The model is being validated and calibrated with Bangladesh weather data from the 2017-18 wheat production season in Bangladesh. The Seminar was attended by 34 (26 male and 8 female) participants from four CSRD partner organizations.

Left and Right: Dr. Jose Mauricio Cunha Fernandes of the University of Passo Fundo (Brazil) presents to the Bangladesh Meteorological Department and Department of Agricultural extension in a joint meeting convened by CSRD to discuss progress on adapting the weather based wheat blast forecast model from Brazil to agro-climatological conditions in Bangladesh (Photo: Timothy Krupnik)

Planned activities in Quarters 3 and 4 of 2018:

CSRD will continue to convene and participate in climate services oriented events in Bangladesh in the second half of 2018. Key planned events include an official launch for the CSRD associated Bangladesh Academy for Climate Services (BACS), organized collaboratively with BMD, IRI and ICCCAD, in early August. A cross-sectoral one-week introduction to cross-sectoral climate services is planned as part of BACS for October of 2018.

Contribution of Sub-Objective 3.1 to CSRD's Action and Learning Framework:

Pillar 2, Indicator 2.2 (see Annex 3).

Sub-Objective 3.2. Policy maker, agro-metrological services, extension, and farmer awareness of agro-meteorological forecasts and decision support tool platforms for agriculture increased

Background

This section highlights key activities undertaken to support CSRD's aims to support general capacity development of national and regional partners in agricultural climate services.

On-the job training on application of GIS and Remote Sensing for agriculture and drought monitoring

To build the capacity of young and mid-career climate services and research professionals, a two-week on-the-job training took place during 12-23 March 2018 on the application of remote sensing technologies and tools in drought monitoring and crop mapping. . The training was organized with CSRD's support in alignment with the SERVIR HKK program and conducted at the ICIMOD headquarters Kathmandu. The training introduced newly developed science tools to participants from BARC, Bangladesh's apex agricultural research body, and also participants from BARI. The training strengthened the remote sensing capabilities of visiting scientists. Participants were also exposed to a number of remote sensing and GIS tools including SPIRITS, QGIS, ArcMap, GeoCLIM, as well as a foundation course on use of Google Earth Engine.

Left to right: Dr. Suraya Parvin, Senior Scientific Officer from BARC, Birendra Bajracharya Programme Manager, SERVIR HKH, ICIMOD, Bhoj Raj Ghimiri GIS Analyst with ICIMOD, and Mr. Kowshik Kumar Sah, a Scientific Officer FMP Engineering Division of BARI.

Google Earth Engine

Visiting scientists from Bangladesh gained foundational knowledge in the use of Google Earth Engine to support processing of geospatial and drought monitoring data.

The learning exchange took important initial steps in building national capacity of Bangladeshi scientists in the analysis of agricultural drought risks in parts of north-western Bangladesh where farmers may lack access to irrigation, or where they are unable to afford consistent water pumping due to high diesel or energy costs. This situation leads to bottlenecks in crop productivity and can impair the livelihoods of smallholder farmers otherwise reliant on variable and unpredictable precipitation. Once translated into easy to understand and actionable advisories, to quality drought monitoring and forecasts could assist farmers in adapting to these climactic risks. As such, meteorological and agricultural research institutions play a crucial role in providing improved information flow and drought risks advisories to farmers.

National Training Workshop on the use of satellite data products for drought monitoring

Visiting scientists from ICIMOD collaborated with CSRD to organize a 5-day workshop on the use of satellite data products for drought Monitoring at BMD headquarters in Dhaka during 15-19 April, 2018. Twenty four people representing different government organizations and universities in Bangladesh were trained in the use of satellite data products for drought monitoring and early warning.

Participants learned about gridded rainfall data products produced by the climate hazard group for hydrology and agro-metrology. The training was successful in strengthening the remote sensing capabilities of the participants for drought application. Hands on exercises and

activities on remote sensing and GIS tools including SPIRITS, QGIS, R, and GeoCLIM, SALDAS (Tethys) were learning subjects.

Satellite data products for drought monitoring training participants at BMD in Dhaka.

The training was conducted in a well-equipped lab of BMD. The participants were of course from different level of exposure to remote sensing and GIS. Renowned experts representing leading organizations in the respective domain were called for interaction, lab exercise and presentation to provide latest update on the research and application domain of remote sensing data products for drought monitoring. The participants remained highly active and interactive throughout the training program. 20 (16 male and 4 female) participants from BARC, BMD, BARI, BRRI, DAE, CIMMYT, ICIMOD, selected NGOs and private sector partners attended the workshop, which was facilitated by resource persons from BARC, BMD, CIMMYT, ICIMOD, NASA-SERVIR, and John Hopkins University.

Contribution of Sub-Objective 3.2 to CSRD's Action and Learning Framework: Pillar 3, Indicator 3.1(see Annex 3).

Implementation challenges

No significant implementation challenges were experienced during the first two quarters of 2018. Very solid progress is being made in CSRD, although the project still suffers from the delays experienced in gaining approval from Government of Bangladesh and Ministry of Defense for formal collaboration with BMD, which is the keystone organization involved in CSRD. Full details of the challenges faced in 2017 and the consequent delays in project implementation and delivery can be found in the 2016-17 CSRD in South Asia Annual Report. Given the formidable delays experienced – which set back the project in over 10 months – CSRD is now in discussion and planning with Dr. Pete Epachin, Climate Adaptation Specialist at the Bureau for Economic Growth, Education and Environment, to develop a no-cost extension for the project to either the end of the 2019 fiscal or calendar year. Full details on this topic will be provided in the 2018 end-of-year report.

Annexes

Annex 1. Key Staff and Core Partner Designations

Name	Role	Institution	Address	Phone	Email	Comments
CIMMYT – BANGLADESH						
Dr. Timothy J. Krupnik	Systems Agronomist and CSRD Project Leader	CIMMYT	Dhaka, Bangladesh	+88-0175-556-8938	t.krupnik@cgiar.org	55% FTE
Dr. Urs Christoph Schulthess	Senior Scientist Remote Sensing	CIMMYT	Dhaka, Bangladesh	+88-0178-766- 9073	U.Schulthess@cgiar.org	15% FTE In-Kind contribution
Dr. Carlo Montes	Agricultural Climatologist	CIMMYT	Dhaka, Bangladesh		c.motes@cgiar.org	100% FTE
Dr. Ghulam Hussain	Senior Consultant: Project coordination and partner liaison	CIMMYT	Dhaka, Bangladesh	+880- 0171-5885608	sghussain.bd@gmail.com	100% FTE
Dr. Moin Salam	Senior Consultant: Lentil *Stemphylium* modeling and forecasting	CIMMYT	Dhaka, Bangladesh	+880 1855871938	moinsalam1@gmail.com	50% FTE on consultancy basis
Mr. Ansar A Siddiquee Iqbal	Project Manager	CIMMYT	Dhaka, Bangladesh	+880-171-3044764	a.siddiquee@cgiar.org	25% FTE
Dr. Shafiq Islam	Jessore Hub Coordinator	CIMMYT	Jessore, Bangladesh	+880 17 1145 1064	Shafiqul.Islam@cgiar.org	In-kind contributions to lentil disease model validation in Bangladesh through CSISA
Dr. Dinabandhu Pandit	Senior Technical Coordinator (CSISA)	CIMMYT	Faridpur, Bangladesh	+880 17 1213 0599	d.pandit@cgiar.org	In-kind contributions to lentil disease model validation in Bangladesh through CSISA
Mr. Khaled Hossain	Research Associate	CIMMYT	Dhaka, Bangladesh	+880-171-7765505	m.k.hossain@cgiar.org	100% FTE
Mr. Azahar Ali Miah	Research Associate	CIMMYT	Dhaka, Bangladesh	+880-171-1904766	a.miah@cgiar.org	100% FTE
Mr. Mustafa Kamal	Research Associate	CIMMYT	Dhaka, Bangladesh	+880-171-7425006	m.kamal@cgiar.org	100% FTE
Mr. Md. Motasim Billah	Data Specialist	CIMMYT	Dhaka, Bangladesh	+880-182-4367257	--	100% FTE
Mr. Shahidul Haque	Communication	CIMMYT	Dhaka, Bangladesh	+880-171-3330981	msh.khan@cgiar.org	25% FTE

Name	Role	Institution	Address	Phone	Email	Comments
Khan	Specialist					
Ms. Fahmida Khanam	Program Assistant	CIMMYT	Dhaka, Bangladesh	+880-171-3409446	Fahmida309@gmail.com	100% FTE
Mr. ASM Alanuzzaman Kurishi	Research Associate	CIMMYT	Dinajpur, Bangladesh	+880-171-5803856	a.kurishi@cgiar.org	75% FTE
Mr. Mani Krishna Adhikary	Agricultural Development Officer	CIMMYT	Dinajpur, Bangladesh	+880-171-2544706	m.adhikary@cgiar.org	100% FTE
Mr. Anarul Haque	Extension Agronomist	CIMMYT	Rajshahi, Bangladesh	+880-171-9546672	an.haque@cgiar.org	100% FTE
Mr. Md. Ashraful Alam	Technical Officer	CIMMYT	Dhaka, Bangladesh	+880-172-7022007	a.alam@cgiar.org	30% FTE
Mr. Golam Morshed Rokon	Agricultural Development Officer	CIMMYT	Barisal, Bangladesh	+880-171-9408321	g.rokon@cgiar.org	In-Kind contribution in 2017 through the Dutch Funded "Groundcover' app project; 100% FTE from January 2018
CIMMYT - NEPAL						
Dr. Andrew McDonald	Systems Agronomist	CIMMYT	Kathmandu, Nepal	+977 9808757832	a.mcdonald@cgiar.org	In-kind strategy guidance and contributions
Dr. Mina Devkota	System Agronomist	CIMMYT	Patna, India	+ 009779851197994	m.devkota@cgiar.org	In-kind contributions to lentil disease model validation in Nepal
CIMMYT - India						
Dr. R.K. Malik	System Agronomist and CSISA India Country Coordinator	CIMMYT	Patna, India	+977 9745060768	m.devkota@cgiar.org	In-kind contributions to lentil disease model validation in India through CSISA
Dr. Poonia SP	CSISA India Research Platform Coordinator		Patna, India	+91 8292525557	S.Poonia@cgiar.org	In-kind contributions to lentil disease model validation in India through CSISA

Name	Role	Institution	Address	Phone	Email	Comments
Dr. Tek Sapkota	Agricultural Systems and Climate Change	CIMMYT	New Delhi, India	--	T.Sapkota@cgiar.org	15% FTE, 10% in-kind CCAFS contribution
CIMMYT - GLOBAL						
Dr. Clare Maeve Stirling	CIMMYT CCAFS Representative	CIMMYT	El Batan, Mexico	+44(0) 756340907	C.Stirling@cgiar.org	15% FTE
Dr. Bruno Gérard	Sustainable Intensification Program Director	CIMMYT	El Batan, Mexico	+52 (55) 5804 2004 ext. 2123	b.gerard@cgiar.org	3% FTE strategy and guidance
REGIONAL AND INTERNATIONAL PARTNERS						
International Center for Integrated Mountain Development (ICIMOD)						
Dr. Mir Abdul Matin	Theme Leader, Geospatial Solutions, Science and Data Lead (SERVIR-Hindukush Himalaya)	ICIMOD	Kathmandu, Nepal	+977-984-377-5633	mir.matin@icimod.org	ICIMOD focal point for CSRD in South Asia.
Mr. Faisal Mueen Qamar	Remote Sensing Specialist Geospatial Solutions	ICIMOD	Kathmandu, Nepal	---	faisal.qamer@icimod.org	Lead analyst for CSRD in South Asia activities.
International Research Institute for Climate and Society (IRI, Columbia University)						
Dr. Simon J. Mason	Chief climate scientist	IRI	Palisades, NY, USA	+1-845-680-4514	simon@iri.columbia.edu	IRI focal point for CSRD in South Asia. 10.5% FTE
Dr. James Hansen	Senior Research Scientist CCAFS Theme Leader	IRI	Palisades, NY, USA	+1 (845) 680-4410	jhansen@iri.columbia.edu	5% FTE
Mr. John Furlow	Deputy Director for Humanitarian and International Development	IRI	Palisades, NY, USA	+1 (845) 680-4466	jfurlow@iri.columbia.edu	In-kind contribution through the Columbia World program and ACToday
Dr. Eunjin Han	Associate Research Scientist: Crop modeling	IRI	Palisades, NY, USA	--	eunjin@iri.columbia.edu	8% FTE
Dr. Nachiketa	Post Doctorial Research	IRI	Palisades, NY, USA	--	nachiketa@iri/columbia.ed	15% FTE

Name	Role	Institution	Address	Phone	Email	Comments
Acharya	Scientist: Sub-seasonal forecasts				u	
Dr. Colin Kelly	Associate Research Scientist: Temperature forecasting	IRI	Palisades, NY, USA	+1 (845) 680-4463	ckelly@iri.columbia.edu	8% FTE
Ms. Mélody Braun	Staff Associate	IRI	Palisades, NY, USA	--	m.braun@iri.columbia.edu	13% FTE
Mrs. Ashley Curtis	Senior Staff Associate	IRI	Palisades, NY, USA	--	acurtis@iri.columbia.edu	13% FTE
Mrs. Elizabeth Gawthrop	Science Communication Specialist	IRI	Palisades, NY, USA	--	gawthrop@iri.columbia.edu	4% FTE
Bangladesh Meteorological Department (BMD)						
Mr. Shamsuddin Ahmed	Director	BMD	Agargaon, Dhaka, Bangladesh	+ 880 2 891 4576	info@bmd.gov.bd	20% FTE
Mr. Md. Abdul Mannan	Meteorologist, Storm Warning Center	BMD	Agargaon, Dhaka, Bangladesh	+880 29135742	mannan_u2003@yahoo.co.in	20% FTE
Mr. S.M Quamrul Hassan	Meteorologist, Storm Warning Center	BMD	Agargaon, Dhaka, Bangladesh	+88 019162255449 +880 2 9135742	smquamrul77@yahoo.com	20% FTE
Mr. Md. Bazlur Rashid	Meteorologist, Storm Warning Center	BMD	Agargaon, Dhaka, Bangladesh	+880 2 9135742	bazlur_rashid76@yahoo.com	20% FTE
Department of Agricultural Extension (DAE)						
Dr. Aziz Mazharul	Additional Deputy Director and Project Director, Agro-Meteorological Information Services (DAE part)	DAE	Farmgate, Dhaka, Bangladesh	+880 2 9130928	azizdae@gmail.com	In-kind contribution through the World Bank funded Agro-Meteorological Information Services project
Dr. M. Shahabuddin	Additional Director Planning & ICT management	DAE	Khamarbari, Farmgate, Dhaka, Bangladesh	+880 01742601461	shahabipm@gmail.com	20% FTE
Mrs. Rahana Sultana	Upazila Agriculture officer	DAE	Khamarbari, Farmgate, Dhaka, Bangladesh	+880 01715551091	rahanaplp@yahoo.com	20% FTE

Name	Role	Institution	Address	Phone	Email	Comments
Mr. Md Saiful Islam	Additional Deputy Director, Crop Wing	DAE	Khamarbari, Farmgate, Dhaka, Bangladesh	+880 01715332319	anntara2008@yahoo.com	20% FTE
Md. Fazlul Hoque	District Training Officer	DAE	Khamarbari, Barisal, Bangladesh	+880-172-8251836	f.hoq1542@gmail.com	In-kind contribution to administering district based training work
Md. Monzurul Haque	District Training Officer	DAE	Khamarbari, Rajshahi, Bangladesh	+880-171-1224280	monzurul.aeo@gmail.com	In-kind contribution to administering district based training work
Nikhil Chandra Biswas	District Training Officer	DAE	Khamarbari, Dinajpur, Bangladesh	+880-193-8826855	ncbiswasdae@gmail.com	In-kind contribution to administering district based training work
Bangladesh Agricultural Research Institute (BARI)						
Md. Shariful Bin Akram	Scientific Officer	BARI	Wheat Research Centre, Dinajpur, Bangladesh	+88 01717-545797	sariful.santo@gmail.com	Time in-kind; sub-grant costs for experiments only
Md. Jakir Hossain	Scientific Officer	BARI	Regional Wheat Research Station, Shampur, Rajshahi, Bangladesh	+88 01710-375943	zakzubari@gmail.com	Time in-kind; sub-grant costs for experiments only
Shiek Shamsul Alam Kamar	Scientific Officer	BARI	Regional Agricultural Research Station, Rahmatpur, Barisal, Bangladesh	+88 01724-461414	alamkamar91@gmail.com	Time in-kind; sub-grant costs for experiments only
***Universidade de Passo Fundo* (UPF)**[1]						
Dr. José Maurício Cunha Fernandes	Senior Scientist – Plant Epidemiology	UPF	Passo Fundo, RS, Brazil	--	mauricio.fernandes@embrapa.br	Time in-kind for scientific coordination
Mr. Felipe de Vargas	Computer scientist	UPF	Passo Fundo, RS, Brazil	--	119685@upf.br	100% FTE (wheat blast computer model coding)
University of Reading (UR)						
Dr. Peter Dorward	Professor, School of Agriculture, Policy and Development	UR	Reading, UK.	+44 (0) 118 378 8492	p.t.dorward@reading.ac.uk	Currently being determined

Name	Role	Institution	Address	Phone	Email	Comments
Dr. Samuel Poskitt	Post-Doctoral Scholar	UR	Reading, UK	--	samuel.poskitt@reading.ac.uk	Currently being determined
Dr Graham Clarkson	Senior Research Fellow, School of Agriculture, Policy and Development	UR	Reading, UK	+44 (0) 118 378 5036	g.clarkson@reading.ac.uk	Currently being determined
Bihar Agricultural University (BAU)						
Dr. Abhijeet Ghatak	Assistant Professor of Plant Pathology	BAU	Sabour, Bihar, India	--	ghatak11@gmail.com	In-kind contribution to lentil disease monitoring activities
Bangladesh Agricultural University (BAU)						
Dr. M.A. Farukh	Professor, Department of Environmental Science	BAU	Mymensingh-2202, Bangladesh	+880-1712-106603/	BAU	Mymensingh-2202, Bangladesh
Wageningen University: WaterApps project						
Dr. Saskia Werners	Assistant Professor of Adaptive Water Management	WUR	Wageningen University & Research Teams WSG - CALM (Water Systems and Global Change) PO Box 47, 6700 AA Wageningen, the Netherlands	+31 317 486442	saskia.werners@wur.nl	In-kind contribution to PICSA work
Mr. Uthpal Kumar	PhD Student	WUR	Wageningen University & Research Teams WSG - CALM (Water Systems and Global Change) PO Box 47, 6700 AA Wageningen, the Netherlands	--	uthpal.kumar@wur.nl	In-kind contribution to PICSA work
Nepal Agricultural Research Council (NARC)						

Name	Role	Institution	Address	Phone	Email	Comments
Dr. Rajendra Darai	Senior Scientist and Coordinator, Grain Legumes Research Program	BAU	Khajura, Banke, Nepal	--	Nglrp_khajura@narc.cov.np	In-kind contribution to lentil disease monitoring activities

Annex 2. Project subcontractors and key partners

Partner	Partnership Objective	Strategic Alignment	Leveraging Opportunity	Anticipated or committed funding (USD)	Objective and activity contributions (Core activity contributions)	Status of Partnership
Bangladesh Meteorological Department (BMD)	Integrative CSRD partner to produce and control the quality of climate information and forecasts. Iterative development of climate services frameworks and decision support tools.	Pillars 1, 2, 3, and 4	BMD is Bangladesh's lead agency for meteorological forecasting in Bangladesh and is interested to improve the quality of their ag-meteorological forecasts. Improvement of short-term and seasonal forecasts and integration of the resulting information as crop specific climate service advisories will be deployed through CSRD partners.	$195,598	Sub-Objective 1.1., Activity 1.11., Sub-Objective 1.2, Activity 1.2.1., Sub-Objective 1.3: Activity 1.3.1 (all three sub-activities), Activity 1.3.2, Sub–Objective 2.1, Activity 2.1.1, Objective 3, Sub-Objective 3.1.	The sub-grant agreement between CIMMYT and BMD has been signed on 29 August 2017 (Dated June 15, 2017) with full approval of the Ministry of Defense. Sub-grant copies are available for review upon request.
Department of Agricultural Extension (DAE)	Iterative development of climate services frameworks and communication strategies. Extension and dissemination of agriculturally relevant	Pillars 1, 2, 3, and 4	DAE has over 14,000 field extension agents operating throughout Bangladesh. DAE also has capabilities in ICT tools for extension purposes.	$100,000	Sub-Objective 1.1., Activity 1.11., Sub-Objective 1.2, Activity 1.2.1., Sub-Objective 1.3: Activity 1.3.1 (all three sub-activities), Activity 1.3.2, Sub–Objective 2.1, Activity 2.1.1,	The Sub-grant agreement between CIMMYT and DAE has been signed on 16 October 2017. CIMMYT maintains a formal partnership MoU with the DAE, collaboration in CSRD has been initiated and is ongoing, although a formal
Bangladesh Agricultural Research Institute (BARI)	Validation and improvement of irrigation scheduling decision support tools (PANI). Collaborative research to develop and improve wheat blast forecasts and	Pillars 1, 2, 3, and 4	BARI is Bangladesh's lead institute for research in non-rice crops, with significant technical capacity in irrigation and wheat related research.	$30,000	Sub-Objective 1.3: Activity 1.3.1 (PANI and wheat blast activities)	The sub-grant agreement between CIMMYT and BMD has been signed on 8 August 2017 and is now under way. Sub-grant copies are available for review upon request. Please see report sections on PANI for more details.

Partner	Partnership Objective	Strategic Alignment	Leveraging Opportunity	Anticipated or committed funding (USD)	Objective and activity contributions (Core activity contributions)	Status of Partnership
	decision support systems.					Sub-grant copies are available for review upon request.
International Research Institute for Climate and Society (IRI)	Skills assessments and advanced forecasting and agriculturally relevant climate services training for BMD and DAE, consistent technical backstopping and support.	Pillars 1, 2, 3, 4	Scientists at IRI have been collaborating with BMD for over four years. CSRD is leveraging this partnership provide consistent technical support and backstopping to BMD, and to develop improved climate services communications and extension strategies with DAE through IRI's contributions to *CCAFS's Research Theme on Adaptation through Managing Climate Risk.*	$300,000	Sub-Objective 1.1., Activity 1.11., Sub-Objective 1.2, Activity 1.2.1., Sub-Objective 1.3: Activity 1.3.1 (all three sub-activities), Activity 1.3.2, Objective 3, Sub-Objective 3.1.	The sub-grant agreement has been signed between IRI and CIMMYT on 31 August 2017. Sub-grant in near final stages of development, signatures and formalization expected by approximately the third week of May, 2017. Sub-grant copies are available for review upon request.
International Centre for Integrated Mountain Development (ICIMOD)	Collaborative development and refinement of South Asian regional-scale decision support tools, services, and products with emphasis on seasonal to sub-seasonal drought forecasts and integration with BARC[1].	Pillars 1 and 4	Drought modeling downscaling at different resolutions and development of seasonal to sub-seasonal forecast of drought aligned with ongoing work in the SERVIR-Hindu Kush Himalaya (HKH) program	$195,000	Sub-Objective 1.1., Activity 1.11., Sub-Objective 1.2, Activity 1.2.1., Sub-Objective 1.3: Activity 1.3.1 (all three sub-activities), Activity 1.3.2, Objective 3, Sub-Objective 3.1.	The sub-contract agreement between CIMMYT and ICIMOD has been signed and completed on 1 May 2017. Sub-grant copies are available for review upon request.

Partner	Partnership Objective	Strategic Alignment	Leveraging Opportunity	Anticipated or committed funding (USD)	Objective and activity contributions (Core activity contributions)	Status of Partnership
Universidade de Passo Fundo (UPF)	Collaborative development and refinement of disease forecasting model and decision support system for wheat blast early warnings, supporting BARI	Pillars 2, 4	• Establish a web-based application and decision support tool (DST) for in-season 5 and 10-day lead time forecasts to present the probabilistic risk of wheat blast infection • Adapt a surveillance smartphone application to Bangladesh. • Engage with CIMMYT's partners in Bangladesh to incorporate input and feedback on performance of the application DST detailed in Objective 1, and to assist in training and advising partners on use of the application DST	$15,000	Objective 1, Sub-Objective 1.3, Activity 1.3.1: (MoT forecasting) Objective 2, Sub–Objective 2., Activity 2.1.3.	A consultancy has been awarded to Mr. Felipe de Vargas of UPF for 11 months (total value of the consultancy is $15,000). Total duration of the consultancy will be June 2017-May 2018, with potential for renewal based on performance. de Vargas is supervised by Dr. José Maurício Cunha Fernandes, Senior Scientist – Plant Epidemiology at UPF, and developer of the preliminary wheat blast forecasting model. The terms of reference for de Vargas are available upon request
University of Reading	Embed PICSA into DAE programming	Pillars 2, 3	• Identify the key opportunities for a locally adapted form of PICSA to enable farmers to make effective plans and decisions in the context of (a) existing farming and livelihood systems and (b) climate and related challenges • Provide technical support and training for the piloting	Under negotiation (likely $47,419)	Objective 1, Sub-Objective 1.3, Activity 1.3.2, Objective 3, Sub-Objective 3.2	The sub-contract agreement between CIMMYT and University of Reading has been drafted. Now it's being scrutinized for legal matters. It is likely to be signed soon. However, the scoping visit for PICSA implementation was conducted during 5-13 May 2018.

Partner	Partnership Objective	Strategic Alignment	Leveraging Opportunity	Anticipated or committed funding (USD)	Objective and activity contributions (Core activity contributions)	Status of Partnership
			of PICSA with DAE and other stakeholders • Develop recommendations for the wider roll out of PICSA in Bangladesh by DAE			

Annex 3. Monitoring, Evaluation and Learning Plan

Cumulative action and Learning Framework Report for November 2016 – July 2018
Climate Services for Resilient Development (CSRD)

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
Pillar 1: Create the solution space	**1.1.** Number of collaborative climate services development processes (e.g., working groups) established with identified problem focus and participation of key stakeholders.	• Collaboration among the CIMMYT-CSRD partners in an integrated way, including Bangladesh Meteorological Department (BMD), International Centre for Integrated Mountain Development (ICIMOD), Department of Agricultural Extension (DAE), International Research Institute for Climate and Society (IRI), the Bangladesh Agricultural Research Institute (BARI), Universidade de Passo Fundo (UPF), University of Rhode Island (URI), and University of Reading (UoR)	• Number of formal climate services working groups that have a clearly defined problem focus and participation of approved and designated stakeholders	**Achieved:** • CSRD working group in Bangladesh established: The Director General (DG) DAE has nominated three focal persons and Director BMD nominated three focal persons to work with CSRD on a consistent basis. Fortnightly coordination meetings are underway since August of 2017 • Climate Services Academy established: BMD together with the International Center for Climate Change and Development (ICCCAD), the Independent University of Bangladesh (IUB), CIMMYT, and the International Research Institute for Climate and Society (IRI) at Columbia University, which leads the Adapting Agriculture to Climate Today for Tomorrow (ACToday) project focusing on climate challenges to food systems in six developing countries are jointly establishing a Climate Services Academy in Bangladesh. The Climate Services Academy will be established in association with the Bangladesh Gobeshona umbrella, and as such it will be hosted at the Independent University of Bangladesh with curricula and teaching provided by the partners listed above and other qualified institutions. Monthly meetings of participating stakeholders are envisioned to improve direction and governance of the Climate Services Academy. • Five climate services thematic meetings were held with Dr. Hamidur Rahman, Former DG-DAE; Mr. Manzurul Hannan, Current DG-DAE; Mr. Golam Maruf, Former DAE-DG (DAE has changed DGs several times in the last year, necessitating repeat meetings). • One meeting with Mr. Golam Maruf, Former DAE-DG and Mr. Shahmsuddin (Director, BMD) was held in July of 2017 to shore-up collaboration on CSRD.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				• IRI scientists have visited Bangladesh on three occasions to collaborate with CSRD partners (BMD and DAE). • Seven one-on-one meetings were held with BMD's Director to steer and discuss progress on CSRD. • Focal points for CSRD have been assigned by the ICIMOD-DG. Six consultations have been held, including a large-scale partner workshop on drought monitoring hosted by ICIMOD at BARC (for details, click here). CIMMYT is assisting ICIMOD in coordination with BARC. After signing of ICIMOD sub-grant, ICIMOD has joined the formal CSRD working group with national research and extension partners (NARES) in Bangladesh. As per contract with BARC, CSRD has supplied the requisite hardware and software to BARC to permit national drought monitoring. • With support of USAID, CSRD and the USAID SERVIR and Climate Services Support Activity hosted an international 'Participatory and Institutional Approaches to Agricultural Climate Services Development: A South and Southeast Asia Regional Technical & Learning Exchange' between September 17-19, 2017 in Dhaka, Bangladesh. Participants were from eleven countries, mainly in South and South East Asia. This created unprecedented opportunities for South-South linkages in agricultural climate services. • Four consultation meetings have been held with focal points from BARI's Irrigation Management Division, for a sub-contracting mechanism. The sub-grant has been signed and BARI is now conducting field experiments for validation of PANI for wheat and maize in three locations across Bangladesh. Regular discussions are being held with BARI to assure proper implementation of PANI experiment. • CSRD and UPF scientists hold skype calls on at least a weekly basis to coordinate modeling and forecasting efforts on wheat blast. • A webinar took place on 11 October at 8:30 AM in the CIMMYT office. Dr. Jose Mauricio Fernandes from UPF made a presentation on wheat blast model that they have developed. The meeting was attended by focal points from DAE and BMD, the Director, WRC and other relevant scientists • Dr. Jose Mauricio Fernandes from UPF visited Bangladesh in early 2018.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				• UoR was invited to the CSRD Technical Exchange in September of 2017 to present on PICSA. This led to considerable interest by DAE in PICSA. Ongoing discussions between CSRD and UoR have focused on their inclusion in the CSRD project to achieve the aims detailed in Annex 2. • The 4th Gobeshona Annual Conference for Research on Climate Change in Bangladesh was held during January 8-11, 2018 organized by ICCCAD at the Independent University Bangladesh, Dhaka. On January 10, 2018 a parallel session of the Conference CSRD-CIMMYT organized a Symposium on Climate Services in Bangladesh which was attended by 51 participants. • On January 11, 2018 a coordination meeting with IRI, BMD and CIMMYT was held at the CSRD office at BMD. Besides participants from BMD and CIMMYT, Drs. John Furlow, Melody Braun and Nachiketa Acharya from IRI attended the meeting. Discussions were held on the planning for next steps to build a platform for Bangladesh Climate services Academy, review the assignments of BMD scientists given by Dr. Simon (IRI) and Planning for IRI visit in March 2018 and agenda for the workshop at IRI. • Five CSRD coordination meetings were held at the CSRD office, BMD and DAE
		• Sub-grants awarded to CSRD partners awarded	• Signed documentation of sub-grant agreements or consultancies with eight CSRD partners (BMD, DAE, ICIMOD, IRI and BARI, UPF, URI). Sub-granting to UoR is expected in early 2018	**Achieved:** • After significant effort to clarify CSRD's purpose to the Ministry of Defense, which houses BMD in Bangladesh, CSRD was successful in securing approval for collaboration with the BMD by the Prime Minister's office of Bangladesh. The BMD sub-grant of USD 195,598 was signed on August 29, 2017. See Annex 2 for more details. • The DG of DAE approved sub-granting from CIMMYT to DAE using an existing Memorandum of Understanding (MoU) between the organizations. Due to the delay in sub-granting to BMD, the DAE sub-granting was also delayed. After assuring that both organizations agree on their key points of collaboration the sub-grant to DAE of $100,000 was finally signed on October 16, 2017. See Annex 2 for more details • The BARI sub-grant of USD 30,000 to the Irrigation Management Division was signed on June 15, 2017. See Annex 2 for more details.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				• The IRI sub-grant of USD 300,000 was signed on August 18, 2017. See Annex 2 for more details. • The ICIMOD sub-grant (USD 195,000) was signed on May 1, 2017. • The URI sub-grant of USD 20,000 was signed on June 14, 2017. See Annex 2 for more details. • UPF entered into partnership with CSRD on July 19, 2017 through a consultancy agreement to F. de Vargas (see Annex 2 for details) **In Progress:** • UoR sub-grant to contextualize the potential of PICSA and pilot the approach in three pilot locations for a sustainable roll out in Bangladesh is under negotiation and expected to be completed in Q2 of 2018
		• National scientist training, exchange, between CSRD partners and IRI	• Completion of at least 10 days of exchange training with DAE and BMD focal points at IRI at Columbia University.	**Achieved** • Curricula for training has been development with IRI and formalized as part of the IRI sub-grant (available upon request). • Problems with gaining clearance of the Ministry of Defense and endorsement of the BMD sub-grant under CSRD, which were resolved on August 29, 2017 with approval of the Prime Minister's office, prevented the planned summer 2017 visit of BMD and DAE officials to IRI. • In response, CSRD organized two training visits by IRI scientists to Bangladesh to complete BMD skill assessment and forecast skill and science communication training on July 9-18 and 4-12 November, 2017. • These events however have not dashed plans for CSRD's in-depth training visit to IRI: BMD scientists are expected now to visit IRI in March-April, 2018, pending Ministry of Defense travel approval, which has already been requested and is now in process. See Objective 1, Sub-Objective 1.2, Activity 1.2.1 for details.
		• BMD and DAE knowledge and technical skill gaps identified	• Completion of BMD forecast and communication skill, and DAE communication skills completed	**Achieved** • The skills assessment of BMD and DAE by IRI and CIMMYT has been formalized as part of the IRI sub-grant. Dr. Simon J. Mason from IRI, The Earth Institute of Columbia University conducted an agriculturally-relevant weather and climate services skills assessment during July 9 – 17, 2017.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				• Dr. Jim Hansen and Melody Braun IRI visited Bangladesh and conducted a day-long assessment with CIMMYT and DAE focal persons on September 15, 2017. • The results of these efforts can be reviewed in Annex 4. • During March 26 - April 06, 2018 the Climate Services for Resilient Development Workshop cum Retreat was held at the International Research Institute, Columbia University, New York. Dr. Timothy J. Krupnik and Dr. Carlo Montes from CIMMYT, Mr. Md. Abdul Mannan, Mr. SM Quamrul Hasan Mr. Md. Bazlur Rashid from BMD participated in the workshop from March 26 to April 06, 2018. In the second week (from April 02-06, 2018) Dr. M Shahab Uddin, Dr. Mazharul Aziz, Mrs. Rahana Sultana and Mr.Md Saiful Islam of DAE; Mr. Shamsuddin Ahmed Director (BMD) and Dr. Sk. Ghulam Hussain from CIMMYT joined the workshop.
		• BMD, DAE, BARC, BARI, ICIMOD, IRI and other secondary partners' involvement in CSRD (supply of in-kind human resources, facilities, logistics)	• Letters of support from CSRD collaborating organizations clarifying in-kind partnerships and support	**Achieved** • CSRD has achieved in-kind staff time contributions to support agricultural climate services work from the following organizations: CIMMYT-Bangladesh, CIMMYT-India, CIMMYT-Nepal (all through the CSISA program), IRI through Columbia University's ACToday project, the Department of Agricultural Extension in Bangladesh, the Bangladesh Agricultural Research Institute, and the Universidade de Passo Fundo, Bihar Agricultural University, the Nepal Agricultural Research Council (See Annex 1 for further details) • BMD has approved office-space to CSRD staff in their headquarters in Dhaka, Bangladesh. The office has been furnished and officially opened in January of 2018 as a facility to support CSRD researchers and the above-mentioned Climate Services Academy. A signage has been installed at the entrance of the room. BMD is also providing venue and logistics for holding workshops and training. A Training workshop on Use of Satellite Data Products for Drought Monitoring was held during April 15 -19, 2018 at the brand new training facility of BMD. The training was organized by ICIMOD. A total of 20 (16 male and 4 female) participants from BARC, BMD, BARI, BRRI, DAE, CIMMYT,ICIMOD, Selected NGO and private sector partners attended the workshop and

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				was facilitated by resource persons from BARC, BMD, CIMMYT, ICIMOD, NASA-SERVIR SCO, and John Hopkins University. • CSRD is currently seeking formal letters of support from the above partners clarifying in-kind support. These will be shared in the next Annual Report. • In-kind support letters from BMD and BARC have been issued in favor of CSRD project.
Pillar 2: Utilize quality data, products, and tools	**2.1.** Number of and type of information and technology resources identified and offered, or brokered, by CSRD to meet problem needs and support targeted climate services.	• Crop specific forecasting maps + management advisories refined and made publically available with ongoing refinement following user feedback	• Support to CSRD partners in developing regional drought monitoring and forecasting products and interfaces • Report on planning sessions to develop crop specific forecasting maps + management advisories • Prototype crop specific forecasting maps + management advisories • Public launch of crop specific forecasting maps + management advisories • Refinements made in crop specific forecasting maps + management advisories	**Achieved** • Through CSRD's partnership, work on the South Asia Land Data Assimilation System (SALDAS) has been expanded to Bangladesh to include drought monitoring and forecasting (see Objective 2, Sub-Objective 2.1, Activity 2.1.1, Product 1). **In Progress:** • R code (which is being developed into an R code package for public download and use, in collaboration with URI) and a preliminary method for determining cereal crop thermal stresses in Bangladesh has been developed and is currently under refinement (see Sub-Objective 1.3, Activity 1.31.1, Product 1. Improved seasonal forecasts and climatic stress maps developed and refined. Completion is anticipated on schedule by Q2 of 2018. • Three planning sessions on the development of crop-specific forecasting maps + management advisories have been held with BMD and DAE. Further progress in actual dissemination of crop specific forecasting maps + management advisories area has been delayed because of the delay gaining formal agreement with BMD through the Ministry of Defense. • Planning sessions have been initially fruitful in generating many ideas for improvement in crop specific forecasting maps + management advisories. Refinement of these ideas is expected to take place in Q2 of 2018 as part of the training exchange with IRI at Columbia University. • Refinements in the crop specific forecasting maps + management advisories will continue throughout the project period.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
	2.2. Number of tailored products developed to support specific decisions	• Establishment of Program for Advanced Numerical Irrigation (PANI) prototype, subsequent field calibration experiments incorporating precipitation forecasts implemented with BARI	• Availability of PANI prototype application • Protocols for field experiments, and upload of resulting datasets to publically available databases • Revised PANI prototype following CSRD partner and farmer evaluation.	**Achieved**: • A PANI prototype irrigation DST app has been completed and is under refinement based on experimental trials initiated in November of 2017. Validation trails are being conducted by BARI Irrigation Management Division at three locations (Rajshahi, Barisal and Dinajpur). • Protocols for field experiments have been completed in partnership with BARI (see Annexes 9 and 10. **In Progress:** • Discussions are underway with BARI, BMD, and DAE regarding the feasibility of different public platform (portal and/or application DSTs) for the longer-term housing of PANI. • Refinement of PANI will take place in 2018/19.
		• Agriculturally relevant climatology, extended-range and outlooks articulated as climactic stress risk maps generated	• Prototype availability of agriculturally relevant climatology, extended-range forecasts and outlooks articulated as climactic stress risk maps • Refinement of agriculturally relevant climatology, extended-range forecasts and outlooks articulated as climactic stress risk maps based on CSRD partner and farmer feedback • Formal establishment of agriculturally relevant climatology,	**Modifications:** • Initial USAID consultation with BMD in 2016 revealed an interest in developing seven-day precipitation forecasts with 15-day accumulative rainfall outlooks. Subsequent consultations with CSRD during the skills assessment and IRI trainings however resulted in new priorities being set that better reflect and respond to management decisions made by farmers and agricultural decision makers in the DAE and other relevant organizations. As such, the Product from these activities has been renamed 'agriculturally relevant climatology, extended-range forecasts and outlooks'. These changes are detailed below and are under research and therefore in progress, with completion anticipated before Q2 of 2018. **In Progress:** • Five meetings have been held between CIMMYT, DAE, IRI and BMD on the development agriculturally relevant climatology, extended-range forecasts and outlooks. • Key sub-products resulting from this work will include the following, which have been agreed on by CSRD partners: **Historical Monitoring** • Crop-specific thermal stress risk mapping

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
			extended-range forecasts and outlooks articulated as climactic stress risk maps on BMD website, with links from other CSRD partner websites	• Monsoon progression: Seasonal accumulation • Monsoon progression: Deviation from the norm • Pseudo-monsoon onset • Monsoon dry spells (consecutive 5 d < 1 mm, monsoon seasonal scale) • Heavy rain events (moderately heavy and above, February-March) • Improved language, text, format for agricultural meteorological bulletin produced by BMD • *Historical and projected variability in monsoon onset and withdrawal over South Asia using NASA-NEX Ensemble* Forecasts **Forecasts** • Crop-specific thermal stress risk mapping (extended range, < 14 day periods) • Heavy rain events (moderately heavy and above, 0-15 day forecasts in Feb-March) • Further details on progress are provided in Objective 1, Sub-Objective 1.3, Activity 1.3., Product 1.
		• Spatially explicit and meteorologically driven *Stemphylium* disease risk assessments model for South Asia (Replacement for previous Precision Nutrient Management work stream as agreed on with USAID)	• Preliminary model availability • Field protocols for model calibration in India, Bangladesh, and Nepal • Model converted to R code for integration into a formal DST • Refinement and improvement of model to improve suitability in India,	**Achieved** • A preliminary model for lentil crop *Stemphylium* disease risk assessments has been developed based on Salam et al. (2016), see Objective 2, Sub-Objective 2.2, Activity 2.1.2, Product 2 'STEMPEDIA: Lentil *Stemphylium* blight disease forecasting systems in Bangladesh, Nepal, and India' for details • The protocol for data collection for validating and calibrating the prediction of onset and severity of Stemphylium disease of lentil using 'Stempedia' model in India, Bangladesh, Nepal (Rabi season 2017/18) has been developed and is currently being implemented (see Annex 15) • Site selection (India (Bihar), Nepal (Terrai), Bangladesh (Jessore, Faridpur) has been completed. • Model converted to R code for integration into a formal DST has been completed **In Progress:**

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
			Bangladesh, and Nepal	• Data are being collected following the protocol in Annex 15 from over 400 farmers' fields in Bangladesh, India and Nepal to validate the model. • Combined with weather data from each country, the model will be refined and improved to increase suitability in India, Bangladesh, and Nepal • Where adequate model fit is achieved, CSRD will explore opportunities for developing a Lentil *Stemphylium* blight disease forecasting and early warning system in South Asia
		Spatially explicit and meteorologically driven wheat blast (MoT) disease risk assessments model for Bangladesh and South Asia	• Coding for preliminary back-casting and forecasting models for MoT disease risk competed • Prototype of MoT forecasting DST completed Refinement and public availability of MoT forecasting DST	**Achieved** • In partnership with UPF, initial modelling and preliminary back-casting and forecasting models for MoT disease risk completed for Bangladesh and the South and South-East Asian region. Coding (available on GitHub) and a prototype of MoT forecasting DST (web-based portal) for Bangladesh has been completed, more than six months ahead of schedule. • CIMMYT has established regular communications with the Wheat Research Centre of BARI's pathologists to leverage intellectual support on this work stream. • A webinar took place on 11 October at 8:30 AM in the CIMMYT office. Dr. Jose Mauricio Fernandes from UPF made a presentation on wheat blast model that they have developed. The meeting was attended by focal points from DAE and BMD, the Director, WRC and other relevant scientists. • MoT forecasting in Bangladesh DST is reliant upon regular access to BMD WRF model outputs. CSRD has achieved installation of a server to access BMD WRF model outputs as inputs to the MoT forecasting model (for details on the server, please see Objective 1, Sub-Objective 1.3, Activity 1.3., Product 1) **In Progress:** • Based on models developed by Cruz et al. (2016), preliminary code and maps have been generated using ECMWF climatologies for the South and South-East Asian region to determine land area that may be at risk of wheat blast infection. This work is in progress and can potentially be incorporated into a forecasting model, although further effort is needed to refine the current climatological model. For further details, see Objective 2, Activity 2.1.3, Product 1.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				• Efforts to implement regional forecasting efforts in South Asia remain heavily dependent on the Government of India and Nepal's directives in mitigating risks of wheat blast. Through CIMMYT, CSRD is well positioned to interact with the relevant Indian and Nepali research and meteorological agencies. Next step decisions will be taken depending on how each Government chooses to respond to the risk of wheat blast.
		• Contributions to climate services products developed by other CSRD partners to support specific decisions	• Number of climate services products developed by other CSRD partners that the CSRD South Asia and Bangladesh group contributed to	**Achieved:** • CSRD is actively supporting ESRI that has developed a preliminary portal and repository of shapefiles and datasets that can be publically accessed to support climate services decision making. Eight spatial datasets have been shared so far. • CSRD in South Asia's Project Leader has met with the World Bank delegation responsible for administering the large-scale Agro-Meteorological Information Services project in Bangladesh in which BMD, DAE, and the BWDB collaborate. The Agro-Meteorological Information Services project was approved by the Government of Bangladesh only in late 2016 and as such the project – which focusses mainly on the procurement of equipment and infrastructure – has only just begun activities. Verbal agreement was achieve to continue communications and support Agro-Meteorological Information Services project partners in Bangladesh and the region on a technical advisory basis. • DAE has agreed to incorporate the tools and products developed through CSRD into the Agro-Meteorological Information Services project, as stipulated in the CSRD sub-grant for CSRD. • Both BMD and DAE have invited CSRD and CIMMYT to participate as an external partner and technical advisory participant for the Agro-Meteorological Information Services project leadership committee (whose monthly coordination meetings are expected to begin in the first quarter of 2018). • CSRD has reached agreement with Columbia University's ACToday project, led by IRI, and the International Center for Climate Change and Development's (ICCCAD, housed at the Independent University of Bangladesh (IUB)) Gobeshona platform to implement a *Climate Services Academy* in Bangladesh (see Objective 3, Sub-Objective 3.2 for details).

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
				Progress: • CSRD and CIMMYT remain available to support ADB on CSRD related efforts in South Asia. ADB however has not been overly pro-active in reaching out for support. CSRD is in contact with the ADB office in Bangladesh and regionally in the Philippines, and remains at ADB's disposal for assistance. • The *Climate Services Academy* will be presented and discussed in a Symposium on Climate Services in Bangladesh at the Gobeshona 4 conference 2018, on January 10th from 2:10 to 3:30 pm. Through the Academy, CSRD and CIMMYT will be involved in the following activities: • Provision of a forum to support decision makers in climate-sensitive sectors and those responsible for supporting adaptation in the Bangladesh government to elucidate and analyze how climate variability and change can shape and undermine the performance of sectors important to Bangladesh's economy and society. Decision makers will learn to identify which decisions could be improved by considering climate information, and will be empowered to work with the climate science community to develop new climate services initiatives in response to identified needs. • Development and implementation of need-based educational curricula and professional degree and certification programs for cross-sectoral training in climate science, relevant scientific products including decision support tools, early warning systems, and seasonal forecasts, and climate services communication and extension accessible to relevant Bangladeshi institutions. • Provision of technical support to and cross-institutional learning opportunities for existing climate services projects and initiatives across sectors in Bangladesh • Provision of long-term opportunities for increased use of climate information and services in sectors currently lacking consistent support in Bangladesh, including aquaculture and livestock, nutrition initiatives, and forecast-based disaster preparedness and response, weather-based index insurance, among others • Response to the priorities and interests of its members and students wishing to increase their climate services skills and knowledge, thereby facilitating the exchange of knowledge and learning opportunities • Improved access to climate data (forecasts, ground data, satellite data)

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
	2.3. Number of people benefitting from CSRD activities.	• Quantification of people and agricultural land area benefitting from CSRD activities	• Number of people (disaggregated by gender) participating in research activities and/or applying technologies or management practices resulting from CSRD research products • Number of people (disaggregated by gender) trained resulting from the CSRD partnership • Number of hectares upon which farmers participating in research activities and/or applied technologies or management practices because of CSRD's research products	**Achieved:** • *Number of people (disaggregated by gender) participating in research activities and/or applying technologies or management practices resulting from CSRD research products:* 415 people, 386 male and 29 female. Division by organization and gender (male/female) is as follows: CSRD staff and partners (47/8), additional DAE staff participating in CSRD activities (8/4), additional BMD staff participating in CSRD activities (5/2), farmers participating in CSRD focus group meetings (69/2), SAAOs participating in CSRD focus group meetings (59/10), farmers participating in preliminary PANI business model surveys (8/0), farmers participating in PANI field experiments (16/0), participants in drought monitoring and forecasting workshops (35/3), farmers' who permitted monitoring and sampling for wheat blast data collection (140/0). • *Number of people (disaggregated by gender) trained resulting from the CSRD partnership:* 119 people, 96 male and 26 female. Division by training event and gender (male/female) is as follows: CSRD Technical Exchange participants, Sept 17-19, 2017, (42/11), CSRD QGIS training, Sept 24-28, 2017, (11/3), CSRD PICSA Webinar, November 27, 2017 (19/5), IRI training participants to improve forecast skill (21/7) • *Number of hectares upon which farmers participating in research activities and/or applied technologies or management practices because of CSRD's research products:* Farmers on 35 hectares (140 farmers) participated in wheat blast model development activities by permitting disease monitoring and sampling in their fields in February of 2017 **In Progress:** • Since formal collaboration with BMD stated in late August 2017, most progress towards these indicators (specifically farmer numbers and land coverage) will be reported on in mid-2018 onwards. A substantial number of SAAOs of DAE and farmers in the study locations are expected to benefit from with the improved weather related advisories.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
Pillar 3: Build capacities and platforms	**3.1.** Number of new capabilities to operate, deliver, or utilize climate services that are demonstrated.	• At least 150 DAE agents trained as trainers to extend use of PICSA and CSRD DSTs to DAE sub assistant agricultural officers (SAAOs).	• Training inventories and pre- and post-training test scores	**In Progress:** • Planning with DAE are ongoing with respect to implementation of these work plans. Most training will take place in 2018/19 and will be reported on in the 2018 Annual Report
		• At least 350 SAAOs subsequently trained in interpreting and communicating meteorological information effectively to farmers.	• Training inventories and pre- and post-training test scores	**In Progress:** • Planning with DAE are ongoing with respect to implementation of these work plans. Most training will take place in 2018/19 and will be reported on in the 2018 Annual Report
	3.2. Number of efforts aimed at better understanding existing activities, new opportunities, and any limitations of climate services to achieve scale, replication or sustainability.	• Farmer decision making surveys	• Decision tree and/or choice experiment surveys deployed with farmers in CSRD field sites • Decision tree and/or choice experiment surveys data made publically available on DATAVERSE	**In Progress:** • Surveys were delayed and not completed in 2018. The reason for this set-back was the delay in achieving formal agreements with the BMD and hence DAE to participate in CSRD activities. Until agreements were reached BMD and DAE staff were prevented by organizational rules from commenting on and assistance with administering surveys. • Surveys are now under development and will be deployed and completed before the next reporting period (before Q3 of 2018).
		• PANI business model study	• Geographically explicit business model study (quantitative and qualitative) articulating the conditions under which irrigation scheduling services are most	**Achieved:** • An initial Literature review has been completed to determine components for business model studies in Bangladesh and India (see Annex 9) • A preliminary focus group discussion survey instrument has been developed for more detailed PANI assessment and is currently under pre-testing and refinement. • A survey for developing a business model for PANI has been completed

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
			feasible deployed in CSRD field sites	**In Progress:** • Due to technical implementation and coordination difficulties in India, CSRD has chosen to focus PANI work in Bangladesh alone. Complete business model study will be deployed with a summary document provided by Q2 of 2018. • Development of business model is under process.
		• Number of people (disaggregated by gender) in CSRD partner organizations contributing towards, operating, or using climate services to improve agricultural decision making	• Participant observation, listing, and validation of collaborators at BMD, DAE, ICIMOD, IRI and UPF, and BARI contributing towards, operating, or using climate services to improve agricultural decision making	**Achieved:** • *Number of people (disaggregated by gender) in CSRD partner organizations contributing towards, operating, or using climate services to improve agricultural decision making:* 74, 60 male and 14 female. Disaggregation by organization and gender (M/F): CSRD project and partner organization staff (47/8), additional DAE staff who have participated in CSRD activities (8/4), additional BMD staff who have participated in CSRD activities (5/2). **In Progress:** • Further progress will be made in 2018 and reported on in the 2018 Annual Report.
Pillar 4: Build knowledge	**4.1.** Number of captured and shared lessons learned (e.g., case studies) pertaining to the policy, practice, and research of climate services development, adoption, and maintenance.	1. **Report:** Initial report on crop specific climate thresholds and farmer decision making framework for key food and income staples identifying ways to incorporate meteorological information.	• Availability of short report/case study/success story	**Achieved:** • In initial progress a narrative report on crop-specific weather constraints and farmers' decision making processes with respect to crop management and weather in in Bangladesh has been made (See Objective 1, Sub-Objective 1.3, Activity 1.3.1, Product 1) **In progress:** • Crop specific climate thresholds for farmer decision making are being refined following CSRD partner feedback. A systematic literature review is under way. Results will be completed before Q2 of 2018.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
		2. **Report:** Farmer decision making survey analysis. Information used to further refine packaging of climactic information presented by BMD and DAE.	• Availability of short report/case study/success story	**In progress:** • As detailed above, this activity has been delayed. Surveys will be completed by Short report completed Q2 of 2018. • A preliminary short report completed Q2 of 2018
		3. **Report:** Potential for incorporation of maps and decision tools into existing decision support platforms (CARFT, LCAT, CPT, etc.).	• Availability of short report/case study/success story	**In progress:** • Report to be developed as part of IRI sub-grant completed in Q1 of 2019. Report results will be incorporated into scientific papers (see below).
		4. **Report:** Business model appropriateness and results of PANI calibration experiments.	• Availability of short report/case study/success story	**In progress:** • As indicated above, this activity has been slightly delayed. Business case study completed by the end of Q1, 2018. • Remaining Report to be developed based on field experiments conducted in Q4 2017–Q2 of 2018. Final report completed Q3 of 2018.
		5. **Graphical report (Maps):** Use of historical gridded climatic data to evaluate the past frequency of occurrence of the climactic conditions conducive to wheat blast outbreak	• Availability of short report/case study/success story	**Achieved:** • Initial modelling and preliminary back-casting and forecasting models for MoT disease risk completed for South and South-East Asia (see Objective 2, Sub-Objective 2.1, 2.2.3, Product 1. **In progress:** • This item is ahead of schedule and a short-report will be compiled for inclusion in the 2018 Q2 semi-annual CSRD report.
		6. **Report:** STEMPEDIA: Lentil *Stemphylium* blight disease forecasting systems in	• Availability of short report/case study/success story	**In progress:** • This item is on schedule. An initial report on 2017/18 lentil disease monitoring and model validation activities will be completed after by Q2 of 2019.

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
		Bangladesh, Nepal, and India		• An initial report on model performance in Nepal, Bangladesh, India will be supplied after the CSRD project.
		7. **Report:** BMD and DAE forecast and climate services assessment report	• Availability of short report/case study/success story	**Achieved:** • Completed as per schedule. See Annex 4 for the report.
		8. **Success story or Case study:** At least 10 CSRD case studies and success stories completed	• Availability of short report/case study/success story	**Achieved:** • Two success stories were included in the semi-annual report completed in April of 2017. • Three more success stories communicating CSRD's work considering the CSRD pillars completed and are included in this report. **In progress:** • At least five more success stories communicating CSRD's work considering the CSRD pillars to be completed (2 success stories or case studies) each to be completed by June end, 2018, December end, 2018, and as part of the final project report, anticipated in 2019.
		9. **Scientific paper:** Farmer decision making structures: What role is there for climate information in Bangladesh?	• Paper drafted and submitted to open-access, per review journal	**In progress:** • As indicated above, surveys to build the data needed for this activity have been delayed. Anticipated initial report submission before the end of 2018. • A scientific paper will be submitted to a peer-reviewed journal before the completion of the CSRD project
		10. **Scientific paper:** Opportunities and constraints for agricultural climate services in Bangladesh	• Paper drafted and submitted to open-access, per review journal	**In progress:** • Anticipated submission before the end of 2018
		11. **Scientific paper:** Incorporating forecast information into	• Paper drafted and submitted to open-access, per review journal	**In progress:** • Anticipated submission before the completion of the CSRD project

Pillar	Indicator(s)	Milestones	Measurement method	Progress report (November 2016 – June 2018)
		irrigation scheduling services in Bangladesh		
		12. Scientific paper: Towards early warning systems for MoT in South Asia	• Paper drafted and submitted to open-access, per review journal (BARI, BMD, DAE, UPF)	**In progress:** • Anticipated submission before the completion of the CSRD project
		13. Scientific paper: Feasibility assessment of drought forecasting for agricultural climate services: A comparison of resolution scales (led by ICIMOD with BARC)	• Paper drafted and submitted to open-access, per review journal	**In progress:** • Anticipated submission the completion of the CSRD project

Annex 4. Final agenda for the Climate Services for Resilient Development Retreat at the International Research Institute (IRI), Columbia University, New York, USA

The final agenda for the CSRD retreat that was held at the International Research Institute (IRI, Columbia University, New York, USA) from March 26 - April 6, 2018 can be found by clicking here. Data library information and maps specific to Bangladesh and representing work completed during the retreat can also be found at this link.

Annex 5. BACS design workshop report

Design Workshop Report
Bangladesh Academy for Climate Services (BACS)

Cofounded by
Bangladesh Meteorological Department (BMD)

International Centre for Climate Change and Development (ICCCAD) at Independent University, Bangladesh (IUB)

The International Research Institute for Climate and Society (IRI) at Columbia University, USA

The International Maize and Wheat Improvement Center (CIMMYT)

Prepared by:
Tasfia Tasnim, Research Officer, ICCCAD
Anne-Laure Pilat, Visiting Researcher, ICCCAD

Workshop Venue: **Bangladesh Meteorological Department (BMD)**
Wednesday, March 21, 2018

Background regarding Climate services

Climate services are the connecting link between climate scientists and the society. Indeed, climate services are helping in translating climate science information and communicating them to the users (non-scientists). In other words, climate services are making sure that the users understand the weather they are going to experience in a more simplified way at the most convenient time. Furthermore, climate services are also providing users with information related to soil moisture, sea level conditions, wind etc. with long and short-term projection.

The provision of climate and weather information assists various decision makers in evaluating and developing the best adaptation strategies. Various sectors can benefit from a better access to climate services from policy makers to individuals, as well as by industries and humanitarian workers. Thus, access to tailored and well-prepared climate services can help the society and the economic sector to cope with climate change and current variability in weather and resulting natural disasters risks.

Also, as for all services, the climate one needs to meet users' needs, be based on credible information and requires a mutual engagement from the users as well as providers (scientists or researchers). Having a dedicated academy for climate services in Bangladesh will help ensure that the country dispose of the best and most credible climate science information for dissemination to a large audience. Additionally, this project will help in engaging with various actors in order to have an in depth understanding of the kind of climate and weather information which is required and to satisfy it in the best possible way. This mutual engagement will also ensure not only that climate science information or knowledge are developed with a better understanding of contexts, but also that it is useful and understood by the final users. Finally, it will help ensure that effective climate information access mechanism will be developed and strengthen the already existing ones in Bangladesh.

Objective of the Workshop

In the welcome remarks, the objective of the workshop was set.

Dr. Timothy J. Krupnik, Systems Agronomist at Climate Services for Resilient Development (CSRD) in South Asia and Project Leader at The International Maize and Wheat Improvement Center (CIMMYT), set the tone of the workshop by sharing the objective of this workshop. He started by emphasizing that today, there is a need to better understand how climate and weather information can be used by the different sectors for better informed decision. "The goal of today's event is for you, the participants, to give us your ideas and thoughts on how to develop the educational and climate capacity in Bangladesh through BACS", he specified. Indeed, climate services are a valuable contribution to various sectors and we need to understand how we can strengthen those in Bangladesh. One of the way to achieve this is by creating the Bangladesh Academy for Climate Services (BACS). The Bangladesh Academy for Climate Services will support educational and capacity building related initiatives and networking across different sectors that can contribute to providing or working with climate information around Bangladesh. He finished by saying that "after the day long workshop, everyone will have better understanding on what kind of approach we need to follow in terms of setting up an academy".

Ms. Melody Braun, Research Staff Associate, Financial Instrument Sector Team, IRI, The Earth Institute, Columbia University, mentioned that when "we started working in Bangladesh on our next project BACS, one of the main point that came back a few times was the existing gap between the scientist and the non-scientist users of climate and weather information. We started to think about how we can make the current available information more directly usable in the field and more understandable for those in need of climate and weather information but who are not scientists. The idea that came up was to create the BACS and this was already presented by ICCCAD at the last Gobeshona conference. Currently, we are formalizing the process and we want your help in taking BACS further."

Dr. Saleemul Huq, Director, International Centre for Climate Change and Development (ICCCAD) in his welcoming address, mentioned that "capacity building in Bangladesh needs to be thought on the long term and involves all generation. In this context, my conviction is to do something on the long term and the idea to develop the BACS came up and was presented at the last Gobeshona conference". He also added that this meeting was a follow up to organize the concept on the academy by soliciting various experts' input on how it should be set up. The idea is to gather the different existing ideas and point of views to be able to have another meeting where we could seat and prioritize on the next actions that can be taken, as well as those that need to be considered in the future and in the long term. "We also hope that all of you will keep being involved not only with the building of the academy but also during its running and beyond to make it a long-term institution that can help set up a long-term capacity building for climate services in Bangladesh", he added.

A Representative from Bangladesh Meteorological Department (BMD) addressed that BMD is the only organization that is mandated to provide meteorological services in Bangladesh. "We are providing daily forecast for weather and warning for disaster as well as more field specific information. For example, we are producing each seven days an advisory note for farmers, informing them about weather, rainfall among other things so that they can effectively plan their agriculture activities. This also helps to strengthen food security in the country. Another example is aviation. We provide them with information about wind and weather situation on different highs. However, our climate service needs to be updated and a lot more needs to be done. Today's activities are a good opportunity to think about how to improve climate services in Bangladesh", she said.

Methodology

The workshop followed a participatory approach. **Dr. Timothy J. Krupnik** from CIMMYT facilitated the introductory session by encouraging the participants to network. The goal of this exercise was to stand up and to find two other people in the room that they didn't know and to meet each other and introduce themselves and talk about what they are doing. This helped them to find new networking opportunities and more actively take part in the next two exercises called: Problem and Solution Identification Exercise and BACS Design Exercise.

- **Methodology for Problem and Solution Identification Exercise**

The workshop exercise's main goal was to identify existing gaps in information network between producer of climate and weather data and users of it. The goal was to get a better idea of climate and weather information that can be used or need to be collected for various sectors as well as interaction between the different actors.

The participants were divided in four work rotating groups, each related to one of the four climate service topics: climate science, financial instruments, disaster risk reduction and food system. The exercise consisted of the three following steps:

1. Identification of key groups of actors and how they depend/ connect with each other.
2. Identification of challenges and risk preventing the achievement of use of climate and weather information.
3. Identification of solution (data, policies, tools etc.) to previous challenges and risks.

- **BACS Design Workshop**

The participants together brainstormed on how the Bangladesh Academy for Climate Services could be run. They discussed how BACS can align strategies, work plans, and partnerships in future.

Expected Outcome

The workshop aimed to explore the needs and demands for capacity building and educational training, including options for internships, certification and formal degree courses, around climate services in different sectors through various hands-on, participatory, and discussion.

Content of the Workshop

1. Problem-Solution Identification Exercise

The four outputs from the participatory exercise are discussed below:

1.1 Climate Science

Climate science or climatology is the scientific study of climate and more precisely of weather conditions averaged over a (specific) period in a specific region. Climate models have various purposes, including the study of the dynamics of weather and climate system. However, arguably one of the most important utilization of climate science resides in its use for the determination of future climate projection as well as short term weather forecasting. Enabling decision makers to anticipate changes in weather and climate conditions will lead to better informed actions today and in the future. Furthermore, understanding climate science information will continue to be crucial for decision making as climate change is becoming a more and more important variable affecting various economic and social activities.

However, different sectors are requiring a different set of climate and weather information. It is then important to deepen the understanding of the kind of information that will be the most useful and adapted to the various activities. This also requires a mapping of already existing and available information for the decision makers as well as identifying gaps that needs to be filled. The "climate science" group tried to address those needs.

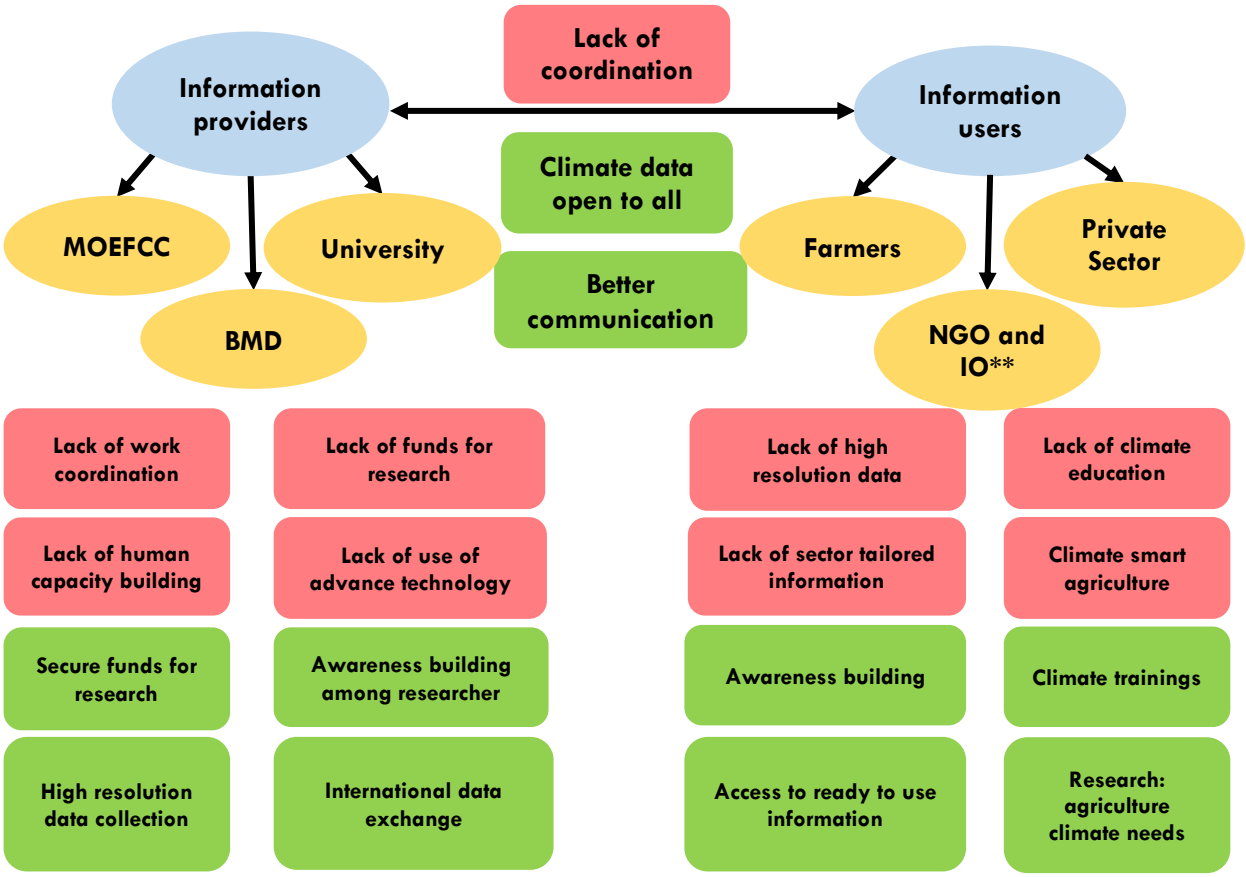


Figure 1: Climate science schema in Bangladesh

**MOEFCC: Ministry of Environment, Forest and Climate Change **IO: International Organizations*

In the climate science sector, two groups of main actors can be identified: those who are producing the information and those how are using the created information. The first group is composed of climate scientist who have the necessary tools to produce climate and weather information and can explain the link between climate and human life. They comprise of the Ministry of Environment, Forest and Climate Change, the Bangladeshi Meteorological Department as well as various public universities. In the second group there are actors who in their work need to use climate and weather information such as various NGOs, farmers and the private sector. Thus, having a better access to this information and being trained in climate literacy can help them to make better informed decisions and use climate and weather information as solid and valid arguments to support and justify their decisions.

Climate science has different branches and requires an ongoing process of research and application. It is understandable that one institution or individual will not be able to provide all required information and conduct necessary researches. Thus, all actors involved in climate and weather information creation need to cooperate with the aim to come up with a program of work covering the vast area of climate science (ex: low cost weather station network). This cooperation should be conducted not only on the national level but also with international climate scientist in order to share knowledge and build a better understanding of the global climate system. Another area prone to improvement is the collaboration between users of climate and weather information and providers of information. Indeed, users need to be able to know about available information and access it as well as voice their need

for specific data. This requires an ongoing dialogue and awareness building on this topic between providers and users of information. There are already existing thematic group between BMD and their clients, which produce tailored information related to specific needs of a specific sector such as fisheries, agriculture among others. Those initiatives are a good start and should be taken forward. It was suggested that one way of doing this could be the creation of an inter-Ministerial policy platform that integrates weather and climate information in various policies with the same direction and understanding as well as tailored to particular social issue covered by the said policy.

Another important issue raised was during the group discussion was that of climate and weather education. There is a lack of educated people in climate science in various sectors who are requiring or could tremendously benefit from the use of those information. The idea is not to create a new community of scientists who are going to put these information into practice, but rather to enable on larger scales various decision makers to understand the available information and use it more effectively (ex: aquaculture app of BMD). This can be achieved via various trainings which are tailored made for a sector or on a precise question that will help build the capacity to use climate and weather information of the recipient. The more climate science educated people existing in the different level and sectors in a society the better understanding of the influence of human activity on the climate and vice versa, that in the long term will result in an improved process of decision making for a better life for all. However, this also requires strong human and economic resources to contribute to the continuous growth of knowledge of the interconnected components of the climate system. As highlighted during the group work there is a considerable lack of human resources to produce research in this area as well as a lack of appropriate funds to enable those research. Indeed, there is a need to produce high resolutions data collection of various climate and weather conditions (air, temperature, rainfall, soil, wind speed etc.), better climate projection, various short and long-term weather forecast needed for example for flood prevention, specific data linked to particular region in Bangladesh and including climate change information (sea level rise, flash flood etc.).

During the discussion two sectors were identified as important. The first one is agriculture, were the participants made some suggestions on how to improve the link between climate science and agriculture. The working group identified the need for season based information for crop production, data and prediction for long term adaptation in water and crop sector, training targeting particularly farmers, translation of data in simple term for the farmers using vocabulary related to agriculture like savings, transplants, land preparation, crop change, harvesting, etc.

The other area that caught the participants' attention is linked to the Rohingya Camps that are facing risk disasters related to the upcoming heavy monsoon rain. There is a dramatically important need for early warning systems for cyclones and floods as well as better resolution forecast and projection.

1.2 Disaster Risk Reduction

The disaster risk is a forward-looking concept, expressing the probability of loss of life, destruction and damages from a disaster over a time period. A disaster risk is the consequence of three factors coming together which are hazard, vulnerability of people and of a given place to damage and finally the number of people exposed to the hazard. Disasters are often following natural hazards and are linked to the high exposure and high vulnerability of people

experiencing it. Additionally, each hazard can induce a set of sub-set of hazards (ex: cyclones can bring wind and rainfall causing landslides). Moreover, one of the driver of the three elements constituting the disaster risk are climate change and environmental degradation. Indeed, climate change is impacting the frequency and intensity of some natural weather-related hazards and affect the resilience of vulnerable and exposed people towards those events.

However, a risk disaster can decline following the decrease in vulnerability to natural hazard. Thus, a better use of weather and climate information to conduct preparedness activities in response to potential and foreseeable natural weather-related hazards can help decrease the risk disaster. A better understanding of climate and weather can help in making vulnerable and exposed population more resilient towards natural hazards via early warnings and appropriate preparedness actions. Thus, the importance to understand more deeply the kind of weather and climate information needed to achieve the goal of reducing disasters risk.

Three main categories of actors dealing with the question of risk disaster reduction and management were identified as follows.: governmental (Department of Disaster Management, Ministry of Disaster Management and Relief, BMD, Ministry of Water Resources, Upazilla Disaster Management Committees etc.), non-governmental (NGOs, Development Partners, International Organization etc.) and others (Media, local population, farmer, HCCTT coordinating body etc.).

Despite the variety of actors engaged in the sector, there are still some challenges that can affect the success of disaster risk reduction. One of the main obstacle is the centralization of the decision that are taken by the government without or with limited data of a given local situation. There is a need to have more local volunteers trained in the use of warning alert system and to climate and weather data. Another solution would be the creation of a timely feedback system of the situation on the ground to the central level.

Furthermore, there is also a lack of coordination between the different governmental bodies and the tasks they undertake for risk disaster management. The same lack of coordination can be observed among the various NGOs and developing partners, which calls for an increase in communication and joint work among them. All the governmental and non-governmental actors should exchange information and data on their activities as well as information on weather and climate in a particular region. This will help in better designing of long and short-term intervention to build resilience of vulnerable population more effectively.

Figure 2: Risk Disaster Reduction schema in Bangladesh

The last main challenge identified by the work group lies in the lack of funding and coordinated resources among the different actors for adaptation projects but also for specific data collections (early monsoon warning, wind speed increase, flash flooding, salinity risk, precise

weather forecast on the short and long term, early warning forecast, higher resolution maps, early flood forecast etc.). the available information should be repackaged in a language that can easily be understood by vulnerable communities and linked to specific actions that they can undertake to be better prepared to upcoming hazard. Secondly, the information needs to be effectively disseminated to the concerned population via Media and the Union Disaster Management Committees as well as digital application and sharing platforms.

Another sector discussed during the group work was agriculture and more precisely the lack of capacity of farmers to respond to natural weather-related hazards. Several solutions were identified to respond to farmers needs such as specific trainings and school targeting climate and weather information for disaster risk reduction, creation of farmers sustainable groups and usage of locally based technology use.

1.3 Food Systems

A food system includes all processes and infrastructures involved in growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. It also includes the inputs needed and outputs generated at each of these steps. Climate change will affect more in the agricultural yields and earnings, food prices, reliability of delivery, food quality, and, notably, food safety. Low-income producers and consumers of food will be more vulnerable to climate change owing to their comparatively limited ability to invest in adaptive institutions and technologies under increasing climatic risks.

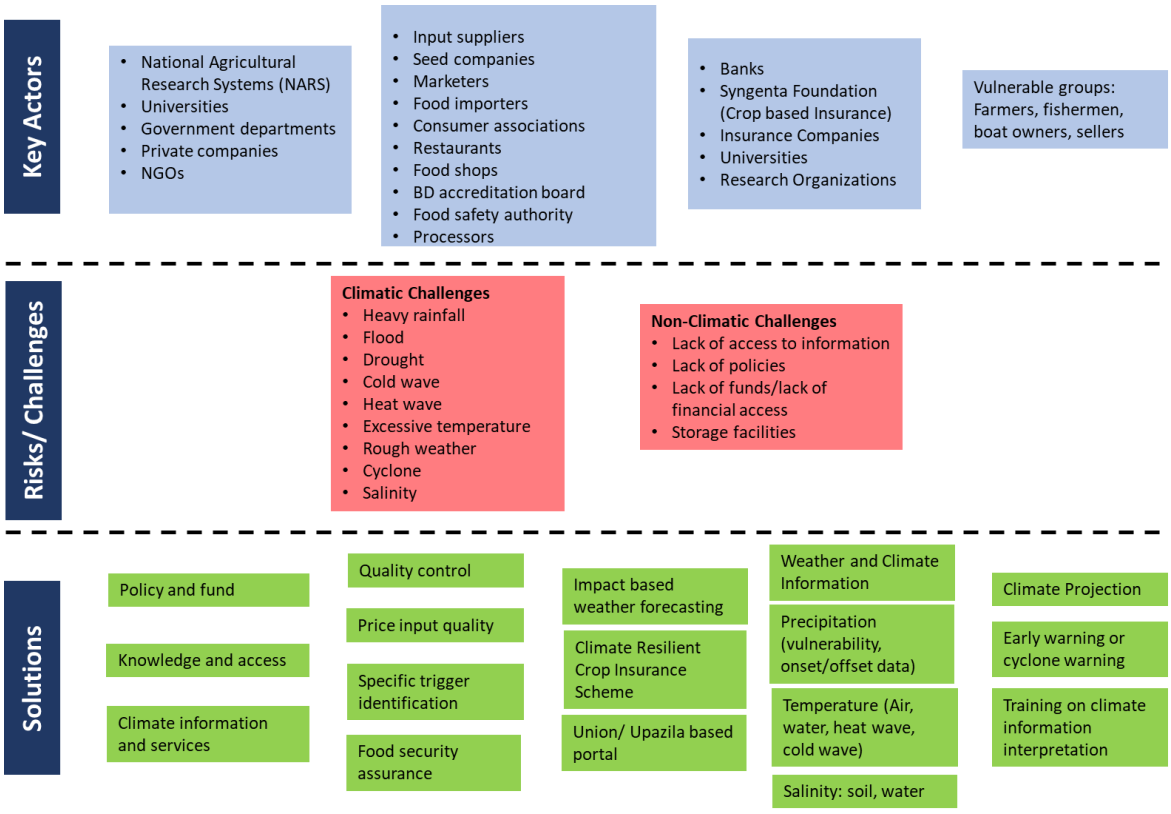


Figure 3: Food system mapping

The above diagram shows the key actors who are involved in the food system chain. It also shows how the food systems are being affected due to various climatic and non-climatic factors which have been mentioned in the above diagram.

From the top level, governance related issue such as policy and fund reformation is needed. The suppliers need to be careful about price input quality and quality control. Climate information and services should be made available and disseminated at the local level so they have knowledge and access to various services. As a solution to this issue, participants highlighted that the vulnerable groups need more weather and climate related information and data regarding climate projection. Monitoring tools for higher crop production will help. In addition, policy advocacy with development of short term (10 days), medium term (1-3 month), long term (1 or more year) courses for DAE staff will also be beneficial in this regard. Long term weather forecast will help the local farmers, fishermen. Having a portal or entity per Upazilla/ Union (for example: Union Digital Centre) to broadcast specific information to the community related to early warning, precipitation (vulnerability, onset/offset data), temperature (Air, water, heat wave, cold wave), soil and water salinity will be helpful for the local people. Farmers need to know the information regarding the best time for crop harvesting, fish harvesting and that's why they need to know the information related to early rainfall, or the starting of the dry season. With all these data, they also need to know how to interpret the climate information.

1.4 Financial Instruments

Climate change threatens development gains from water, agriculture, energy, and infrastructure in Bangladesh. Hence it is crucial to identify, develop and pilot climate finance instruments that can tackle the climate change adaptation and mitigation challenges in developing countries.

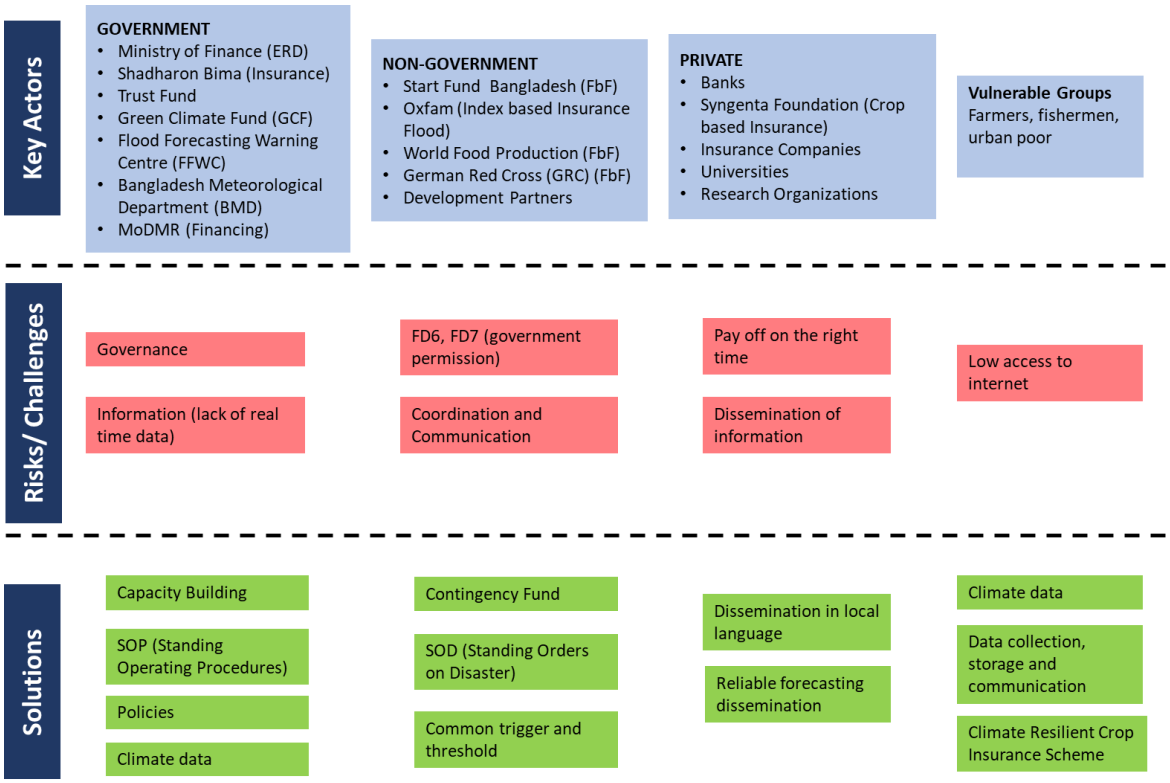


Figure 4: Financial Instruments mapping

Participants identified various government, non-government and private actors in the financial instruments area.

They identified that in the governance structure is the risk factor while working with the government actors. Sometimes the permissions from government take a long procedure before one can proceed. Lack of coordination and communication is a common problem within every actor. There is also risk associated with lack of real time data. With that, dissemination of information at the local level to the vulnerable group is also challenging. The right timing of paying off the insurance is also crucial to decide. Participants also mentioned separately about small farmer's vulnerability. They mentioned that poor farmers have lower access to internet.

There is a need of capacity building to understand the Standing Operating Procedures (SOP), and policies. During any disaster, the Standing Orders on Disasters should be followed. There can be some Contingency Fund to finance the loss during any disaster. The need for institutional capacity building with research NGOs and BACS universities is strongly voiced. University and research organizations have to act as the knowledge providers by working on more action oriented research. There was a further strong call for motivational training to farmers for participating through knowledge sharing with NGOs using the BACS platform. They need to learn and implement those mechanisms like ecosystem based adaptation for cropping and take decision accordingly. Universities were urged to carry out more research and training in this area.

Climate data has a great impact on crop or high yield crop. There should be infrastructural development for data collection and analysis, for example: software training for storage platforms for improved data analysis. Reliable forecasting dissemination is needed in this regard. It is necessary to be trained on how to practically acquire data from the field or from various organizations. Dissemination in the local language to the community is also necessary. There should be some separate training on data communication tools and workshop on communication. Financial instruments, for instance can provide climate resilient crop scheme so that farmers are more interested to cultivate climate resilient crops. Crop insurance scheme should be most provided to vulnerable groups of people, for example to the farmers so that their engagement in decision making can be increased.

2. Bangladesh Academy for Climate Services (BACS) Design Exercise

Ms. Melody Braun, IRI and Dr. Timothy J. Krupnik (CIMMYT) facilitated this session and in a group exercise welcomed participants to think about how their organizations could benefit more from climate information. The envisioned Academy has three main purposes: providing a platform to convene stakeholders around climate services that helps them to identify the need, introduce certification course for the professionals working around the various sectors of climate services, and finally to develop masters level module for students. The academy will also serve as a network for graduate student and awareness building as well as a platform for forecast based weather information hub in Bangladesh.

2.1 Working Groups

During the workshop, several working groups for the Academy were identified by the participants as follow : climate change and migration, climate and health, capacity building for

agriculture (workshop between universities researcher and farmers, solar power pumps, best practices, climate data specific to agriculture, development of saline tolerant variety development, soil less agriculture etc.), climate data and finance budgeting, development of weather information and finally modelling for threshold setting, data sharing and forecasting.

2.2 Short Training for Awareness Raising

Some short-term training on various issues or topics will help the different groups of stakeholders. Basic training on definition of climate change, social and physical impacts of climate change and climate change impact on people, specifically women and children will be helpful to create awareness among stakeholders. To learn better climate information, participants felt the urge to learn about climate data management, forecasting, climate data information for aquaculture, crop production, seasonal based crops, varieties and technologies addressing climate change, environmental aspects of crop production. Data collection techniques, analysis and maps were suggested as a helpful to present the results. For example, various saline tolerant, drought tolerant, submerge crop variety development related short courses can be initiated for adaptation to climate change. Forecasting application module with DRR and CCA can be developed for crop producers. More specific and regional climate change projection is required for the successful implementation of water management projects, which is further related to DRR. Specific projection on sea level rise is required for designing coastal polder to protect storm surge. Monitoring of climate change projection and impacts such as sea level rise is also an important aspect to consider in the learning. It was suggested that, University and college teachers need to be informed about short courses so that they can teach their students.

2.3 Professional Certification Programmes

In relation to these working groups, a set of specific professional certification programs have been identified and responding to a knowledge capacity building need for Bangladesh in terms of weather and climate information understanding. The certificates will be delivered in areas such as weather-related and climate data analysis and interpretation, soil less agriculture, technical training on climate data analysis software (ex: GIS), agro-meteorology, weather and climate forecast for better fisheries management and high-resolution image for climate events. The need to initiate a master degree course on climate variabilities related to flood, flash floods, drought was also suggested.

2.4 Graduate Degree

BACS can be run like a centre which can provide degree or training on climate Research and services which will help in brining all academic organizations on a single platform. The range of the research topics and course work may include: sea level rise and its impacts on the coastal region in Bangladesh, climate change, agro-meteorology, different types of modelling for agriculture, disaster risk reduction in humanitarian or emergency response, adaptive research on coastal belt of Bangladesh. Participants proposed that climate change science should be included in all disciplines in the undergraduate and postgraduate courses of universities. More importantly, civil engineering and water resources engineering need to include climate change courses in their curriculum.

2.5 Climate Science

Each working group, trainings, certification program and graduate degree will contain a climate science component. Indeed, a basic science knowledge is essential to give a complete understanding of climate and weather information. The science component will ensure that all participants of the academy have knowledge of climate science terminology, can interpret climate products and transactions, can execute climate analysis and downscale climate projections and receive necessary software training for climate analysis. Additionally, specific diploma on climate science will be delivered in the area of weather forecast, remote sensing (radar, satellite), seismology and interpretation of climate projection and its application.

Closing Remarks

The academy should be need-based with the aim to bring all diverse expertise together into one platform and create linkages so that everyone can help each other when it comes to climate services related information.

List of Participants

SL	Participant	Designation	Organization
1	Martin L. van Brakel	Scientist Livelihood Resilience	WorldFish
2	Md. Emdad Hossain	Project leader	WorldFish
3	Md. Wahidul Amin	Senior Specialist	Monitoring and Evaluation, HarvestPlus
4	Sajid Raihan	Country Manager	Start fund Bangladesh
5	Lamiya Mahpara Ahmed	Analyst	Start fund Bangladesh
6	Dr. Shawkat Begum	Country Representative	CIP (International Potato Center)
7	Shamsun Nahar	Senior Programme Associate (R1)	WFP (World Food Program)
8	Damien Joud	Cluster Coordinator	Food Security Cluster, Bangladesh (FAO/WFP)
9	Wais Kabir	Director	KGF
10	Mazharul Aziz	Project Director, Agrometeorological Information Systems Development Project	DAE (Department of Agricultural Extension)
11	Dr. M. Shahab Uddin	Additional Director Planning, Project Implementation & ICT Wing.	DAE (Department of Agricultural Extension)
12	. Rahana Sultana	Agricultural Economist, Planning, Project Implementation & ICT Wing.	DAE (Department of Agricultural Extension)

SL	Participant	Designation	Organization
13	Md Saiful Islam	Additional Deputy Director, Crop Wing	DAE (Department of Agricultural Extension)
14	Dr. M. A. Farukh	Professor & Head Department of Environmental Science	Bangladesh Agricultural University (BAU)
15	Md. Jafar Iqbal	Program manager, emergency response	CARE
16	Muhammad Iqbal Zuberi	Professor	Department of Environmental Science, Gono bishwabidyalay
17	Papia Rahman	Deputy Managing Director	Pragati Insurance
18	Anwarul Alam	Senior Specialist - Resilience (DRR & Agriculture)	Practical Action, Bangladesh
19	Rezaul Karim	Programme Head, Disaster Management and Climate Change	BRAC
20	Md. Jahangir Alam	Assistant Director	BDRCS (Bangladesh Red Crescent Society)
21	Md. Aminul Moven	Insurance Project Manager, SFSA-AIS	Syngenta Foundation Bangladesh
22	Tagdira Naznin Smriti	Actuarial Associate	Syngenta Foundation
23	Uthpal Kumar	PhD Researcher	Wageningen University & Research
24	Dr. Abdul Khaleque	Dean, Schollo of Environmental Science & Management	Independent University, Bangladesh
25	Zahirul Khan	Director	IWM
26	Mr. S Nahiduzzaman	Jonior Specialist	IWM
27	Professor Kawser Ahmed	Chairman, Department of Oceanography	University of Dhaka, Bangladesh (DU)
28	Dr. Nasreen Akter	Professor	Department of Physics, Bangladesh University of Engineering and Technology (BUET)
29	Dr Monirul Islam	Associate Professor	Department of Fisheries, University of Dhaka
30	Sukhee Chae	Project officer	IOM
31	Syed Hasan Shahriar Miraj	IT Officer	Bangladesh Institute of ICT in Development (BIID)
32	Md. Shahid Uddin Akbar	Chief Executive officer	Bangladesh Institute of ICT in Development (BIID)

SL	Participant	Designation	Organization
33	Md. Asaduzzaman	Distinguished Fellow	Bangladesh Institute of Development Studies (BIDS)
34	MD. Zoynal Abedin	Meteorologist	BMD
35	MD. Abdur Rahman	Deputy Director	BMD
36	Md. Muzammel Haque Tarafder	Deputy Director (Engineering)	BMD
37	Mahnaz Khan	Deputy Director	BMD
38	Mohammad Abul Kalam Mallik	Meteorologist	BMD
39	Md. Muzammel Haque Tarafder	Deputy Director (Engineering)	BMD
40	Mahnaz Khan	Deputy Director	BMD
41	Md. Shadekul Alam	Deputy Director	BMD
42	Mossammat Ayesha Khatun	Deputy Director	BMD
43	Md. Mohsin	Meteorologist	BMD
44	Dr. Saleemul Huq	Director	ICCCAD
45	Tasfia Tansim	Research Officer	ICCCAD
46	Anne Laurie Pilat	Researcher	ICCCAD
47	Feisal Rahman	Assistant Professor	IUB
48	Redwanul Haque	Student	IUB
49	Ms. Melody Braun	Research Staff Associate, Financial Instruments	IRI
50	Dr. Timothy J. Krupnik	Systems Agronomist and CSRD Project Leader	CIMMYT
51	Dr. Carlo Montes	Agricultural Climatologist	CIMMYT
52	Dr. Sk. Ghulam Hussain	Partner & Technical Coordinator(CSRD)	CIMMYT
53	Fahmida Khanam	Program Assistant	CIMMYT
54	Saleh Mohammad Shahriar	Data operator	CIMMYT
55	Sarah Gazi	Communication Intern	CIMMYT

Annex 6. In-kind letters of support from partners

UNIVERSIDADE DE PASSO FUNDO

PROGRAMA DE PÓS-GRADUAÇÃO EM COMPUTAÇÃO APLICADA

Campus I - Km 292 - BR 285, Bairro São José, CEP 99052-900
Passo Fundo/RS – Fone (54) 3316-8354
ppgca@upf.br

Date: June 5, 2018

From: José Maurício C. Fernandes
Professor/Senior Researcher
Universidade de Passo Fundo
BR 285, São José | Passo Fundo/RS | CEP: 99052-900
Brazil

To: Timothy J. Krupnik
Systems Agronomist
Climate Services for Resilient Development in South Asia (CSRD) - Project Leader
Cereal Systems Initiative for South Asia (CSISA) - Bangladesh Country Coordinator
International Maize and Wheat Improvement Center (CIMMYT) | Sustainable Intensification Program
House 10/B. Road 53. Gulshan-2. Dhaka, 1213, Bangladesh

Subject: Involvement with in-kind support with the development initiative along with Climate Services for Resilient Development in South Asia (CSRD)

Dear Dr. Krupnik,

This letter is here to confirm that our organization the Universidade de Passo Fundo has been involved with CSRD project since the beginning 2017. Currently, three faculty members are engaged in the CSRD project. Considering the involvement of our faculty members the total yearly cost per institutional policy and payment guideline has been calculated as USD$ 10,000 (ten thousand US dollars).

Thank you,

José Maurício Fernandes
Professor/UPF/PPGCA

Government of the People's Republic of Bangladesh
Bangladesh Meteorological Department
Meteorological Complex, Agargaon,
Dhaka-1207, Bangladesh.

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Web: www.bmd.gov.bd

Date: 06.06.2018

From
Shamsuddin Ahmed
Director
Bangladesh Meteorological Department (BMD)
Agargaon, Dhaka-1207

To

Timothy J. Krupnik
Systems Agronomist
Climate Services for Resilient Development in South Asia (CSRD) - Project Leader
Cereal Systems Initiative for South Asia (CSISA) - Bangladesh Country Coordinator
International Maize and Wheat Improvement Center (CIMMYT) | Sustainable Intensification Program
House 10/B. Road 53. Gulshan-2. Dhaka, 1213, Bangladesh

Subject: Involvement with in-kind support with the development initiative along with Climate Services for Resilient Development in South Asia (CSRD)

Dear Dr. Krupnik,

This letter is here to confirm that our organization Bangladesh Meteorological Department has been involved with the USAID supported project "Climate Services for Resilient Development (CSRD)" and are working to towards improving weather forecasting skills and providing better agro-meteorological weather forecasts since the beginning in 2017. Our three staff are involved and spending their time in this program. In addition, BMD has provided office space in the BMD campus for CSRD and are providing conference room, and other logistics support for organizing national level training, workshop, meeting, and seminar under this initiative. Considering the involvement of our staff members and physical facilities and logistics provided, the value (in-kind) for the collaboration from January 2017 to end of June 2018 is estimated at BDT 2,500,000 (in word two million five hundred thousand taka) or USD29,410.

Thank you,

06.06.18
Shamsuddin Ahmed
Director

WAGENINGEN
UNIVERSITY & RESEARCH

To
Timothy J. Krupnik
Climate Services for Resilient Development in South Asia (CSRD) - Project Leader
Cereal Systems Initiative for South Asia (CSISA) - Bangladesh Country Coordinator
International Maize and Wheat Improvement Center (CIMMYT) | Sustainable Intensification Program
House 10/B. Road 53. Gulshan-2. Dhaka, 1213, Bangladesh

Subject: Involvement with in-kind support with the development initiative along with Climate Services for Resilient Development in South Asia (CSRD)

Dear Dr. Krupnik,

With this letter, I would like to confirm that my organisation Wageningen University & Research has been involved with CSRD project since 2017. We have participated in meetings and more recently started to cooperate in the CSRD work to make hydro-climatic information more easy to understand for farmers and other decision makers in the agricultural sector. The work focusses on developing appropriate training and technical materials on climate services for extension services and farmers. Together with the University of Reading and CSRD, we introduce the Participatory Integrated Climate Services for Agriculture (PICSA) approach. A cooperation we support from our work in the WaterApps project and the DeltaCAP project.

So far, four members of our staff and students have been involved in CSRD in Dhaka and Khulna in particular. We have facilitated field visits with 70 farmers in peri-urban Khulna. Next to Wageningen University, Staff and students of Khulna University have provided support to CSRD.

Considering the involvement of our staff and students, the in-kind contribution to CRSD has been estimated as 10.000 euro (in words ten thousand euro).

We look forward to continue our cooperation with and support for the important CSRD work.

With kind regards,

Dr. Saskia E. Werners
Assistant Professor Adaptive Water Management

Chair Water Systems and Global Change

DATE
10 June 2018

SUBJECT
In-kind support CSRD

YOUR REFERENCE
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BANGLADESH AGRICULTURAL RESEARCH COUNCIL
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Ref. 12.20.0000.015.24.002.17 Date: 07/06/2018

To
Timothy J. Krupnik
Systems Agronomist
Climate Services for Resilient Development in South Asia (CSRD) - Project Leader
Cereal Systems Initiative for South Asia (CSISA) - Bangladesh Country Coordinator
International Maize and Wheat Improvement Center (CIMMYT)
Sustainable Intensification Program
House 10/B. Road 53. Gulshan-2
Dhaka, 1213, Bangladesh

Subject: Involvement with inkind support with the development initiative along with Climate Services for Resilient Development in South Asia (CSRD)

Dear Dr. Krupnik,

This letter is here to confirm that our organization Bangladesh Agricultural Research Council has been involved with ICIMOD supported by USAID under the Climate Services for Resilient Development (CSRD) and SERVIR HKH initiative, and are working to establish drought monitoring and early warning service since the beginning in 2017. Our three staff are involved and spend 20% of their time in this program. In addition, BARC is providing conference room, computer lab, and other logistics support for organizing national level training, workshop, meeting, and seminar under this initiative. Considering the involvement of our staff members and physical facilities and logistics provided, as per institutional policy and payment guideline the value (in-kind) for the collaboration from January 2017 to end of June 2018 is estimated at BDT 1,000,000 (in word one million taka) (11,904 USD) for that period.

Thank you

10.06.18

Dr. Md. Kabir Ikramul Haque
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Annex 7. CSRD success stories and communications pieces

New CSRD success stories and communications pieces developed in the first half of 2018 can be found on the following pages.

Education to boost climate resilience: Bangladesh Academy for Climate Services taking shape

On 21 March, 2018, fifty individuals from across 26 organizations came together to design an academy and learning umbrella for climate services in Bangladesh through a participatory and multi-stakeholder design workshop which took place at the Bangladesh Meteorological Department (BMD) in Dhaka, Bangladesh. The workshop was a joint initiative of the International Research Institute for Climate and Society (IRI), ICCCAD, CIMMYT and the CSRD in South Asia partnership. Supported by the United States Government and USAID.

Dr. Timothy J. Krupnik, International Maize and Wheat Improvement Centre's (CIMMYT) Systems Agronomist and Climate Services for Resilient Development (CSRD) in South Asia Project Leader, Ms. Melody Braun, Research Staff Associate of Columbia University and Dr. Saleemul Huq, Director of International Centre for Climate Change and Development (ICCCAD), founding members of the Bangladesh Academy for Climate Services (BACS) initiative, led the interactive workshop. Dr. Saleemul Huq said, "*We are hopeful to build such an institution that can help set up a long term capacity building movement for climate services in Bangladesh*".

The workshop encouraged the active networking of the participants from across sectors spanning health, agriculture, economic development and the financial sector, and disaster management. Participants discussed and identified constraints to long-term national capacity development in climate services, as well as ways to develop curricula and solutions to improve educational access to climate science and communication courses. The importance of developing both professional short course and advanced degree curricula was highlighted and discussed at length. This was the first of a series of events aimed at developing a self-sustaining cross-institutional academy for climate services in Bangladesh.

"*We are happy to partner with a broad range of organizations, committed individuals, educators, and universities to build a national platform to support education on climate services in Bangladesh*," commented Timothy J. Krupnik, "*While both my own and my organization's expertise lies in agriculture, we envision that the BACS will be cross-sectoral. It will therefore appeal to young students and professionals to apply and communicate climate science to the public to improve decision making, not only in agriculture, but in a diversity of sectors relevant to Bangladesh's national Development*".

Participants identifying constraints to long-term national capacity development in climate services, and also ways to develop curricula and solutions to improve educational access to climate science and communication courses.
Photo: Uttam Barma (CIMMYT)

Climate Services for Resilient Development (CSRD) is a global partnership whose core mission is to translate actionable climate information into easy to understand formats to spread awareness and use of climate services. The CSRD consortium in South Asia is led by the International Maize and Wheat Improvement Center (CIMMYT) in partnership with the Bangladesh Meteorological Department (BMD), Bangladesh Department of Agricultural Extension (DAE), Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), International Center for Integrated Mountain Development (ICIMOD), International Institute for Climate and Society (IRI), University de Passo Fundo (UPF), and the University of Rhode Island (URI).

Strategic alignment

Published by: International Maize and Wheat Improvement Center (CIMMYT); House 10/B, road 53, Gulshan 2, Dhaka 1212, Bangladesh
For more information pls. contact: t.krupnik@cgiar.org

Bangladesh's agriculture community drives creation of new climate services

A series of three workshops focused on improving climate information tailored for the agriculture sector took place starting in November 2017. These workshops were sponsored by the USAID funded *Climate Services for Resilient Development (CSRD) in South Asia and Bangladesh* project and have brought about improved forecasting capabilities of the Bangladesh Meteorological Department (BMD). The workshops also helped to strengthen the relationship between BMD and Bangladesh's Department of Agriculture Extension (DAE). The activities pave the way for new climate information products developed especially for DAE's needs, and ultimately to help the farmers it serves.

An interactive workshop held in 2018 at IRI in New York, USA where BMD scientists learned to use a new, automated version of the Climate Predictability Tool. Officers from DAE also participated in this training. Photo: Timothy Krupnik

The International Maize and Wheat Improvement Center (CIMMYT) is the lead partner of the USAID-funded project. Columbia University's International Research Institute for Climate and Society (IRI), BMD and DAE are the other major partners. The trainings included foundational climate science concepts, such as how to verify and calibrate forecasts, and improve the efficiency and quality of forecasting. In an extended two-week training held in March 2018 at IRI's headquarters in New York, the BMD scientists learned to use a new, automated version of the Climate Predictability Tool.

BMD scientists expressed the usefulness of learning of how climate services could be applied in different sectors. "*It is a very new dimension," said Bazlur Rashid, a BMD scientist. "In our country, people think that a weather forecast means it is disaster-related event. But we can apply climate information not only to the disaster sector but to other sectors as well, such as health and agriculture*." At the March training, DAE participants clarified the time and phases for activities in the production of several major crops, to BMD and other workshop participants so that the crop calendar developed showed where and when climate information could best be used.

"In the vegetative growth phase, we need rainfall and temperature information. In the reproductive phase of rice, we need humidity," Shehab Uddin, an agronomist from DAE said. "When it is hot and humid, more insects will come. But then if we know in advance we can advise farmers to take preparations to protect their crop from attack." Moving forward, close collaboration between BMD and DAE is essential to continue to develop effective climate services for agriculture in Bangladesh. "*This is easier said than done*", said Timothy Krupnik, an agronomist and CSRD Project Leader at the International Maize and Wheat Improvement Center (CIMMYT) and CSRD Project Leader. "*There aren't incentives for cross-ministry, cross-department collaboration in Bangladesh, but collaboration can add a significant value through our work with IRI, BMD and DAE to strategically leverage for impact, ultimately benefitting farmers by merging agronomy with climate and extension science*."

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On-the job training boosts national remote sensing skills for drought monitoring in Bangladesh

A two-week on-the-job training took place in March on the application of remote sensing in drought monitoring and crop mapping in Kathmandu, Nepal o build the capacity of young and mid-career professionals from the Bangladesh Agricultural Research Council (BARC), Bangladesh's apex agricultural research body, and the Bangladesh Agricultural Research Institute (BARI). The training was organized with the support of the USAID funded Climate Services for Resilient Development (CSRD) project under the lead of International Maize and Wheat Improvement Center (CIMMYT) led initiative in South Asia, in collaboration with the International Centre for Integrated Mountain Development (ICIMOD).

Dr. Suraya Parvin (left), Senior Scientific Officer of BARC, discussing with the facilitator in the training. Photo: Faisal Mueen Qamer

This learning exchange coached the BARC and BARI professionals to learn new tools in drought monitoring and forecasts. With these tools, farmers can be advised on how to address the risks for agricultural drought in north-western Bangladesh where farmers have limited access to irrigation, resulting in bottlenecks in crop productivity and adverse impact on the livelihoods of smallholder farmers who are reliant on variable and unpredictable precipitation. Access to quality drought monitoring and forecasts would assist farmers in adapting to these climactic risks and meteorological and agricultural research institutions play a crucial role in providing improved information flow and drought risks advisories to farmers. The training strengthened the remote sensing capabilities of professionals from BARC and BARI in using satellite-based remote sensing tools and crop mapping to monitor drought risks. Dr. Mir Matin, Theme Leader of Geospatial Solutions, organized the training on behalf of CSRD and ICIMOD, along with Dr. Rajesh Bahadur Thapa, Capacity Building Specialist and Bhoj Raj from ICIMOD's Bhoj Raj.

Dr. Suraya Parvin, Senior Scientific Officer of BARC commented that "*Bangladesh, especially the northern region, is most susceptible to drought and it is difficult to grow year-round crops here. To increase the cropping intensity in this region, drought monitoring is very essential. I think this training was extremely useful to prepare us for this challenge.*"

The CSRD partnership and ICIMOD are working together to establish user-oriented platforms for the provision of easily accessible, timely and decision relevant scientific information, in the form of climate services. "*This training, and the applied science products that will come from it, will be a crucial part of efforts to increase the resilience of Bangladesh's smallholder farmers to climatic risks*," commented Dr. Timothy J. Krupnik, Systems Agronomist and CSRD Project Leader. "*Working with the graduates of the training on a day-to-day basis, we expect to deepen BARC and BARI's contributions to applied climate services in Bangladesh*."

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Success stories and leaflets

1. Education to boost climate resilience: Bangladesh Academy for Climate Services taking shape
2. Bangladesh's agriculture community drives creation of new climate services
3. On-the job training boosts national remote sensing skills for drought monitoring in Bangladesh

Project news stories and blogs

1. "We need climate information." – Bangladesh's agriculture community drives creation of new climate services: https://iri.columbia.edu/news/we-need-climate-information-bangladeshs-agriculture-community-drives-creation-of-new-climate-services/

2. On-the job training boosts drought monitoring skills in Bangladesh: https://www.cimmyt.org/on-the-job-training-boosts-drought-monitoring-skills-in-bangladesh/

3. Building the Resilience of South Asia's Smallholder Farmers Through Effective Climate Services: https://www.agrilinks.org/post/building-resilience-south-asias-smallholder-farmers-through-effective-climate-services

4. Accelerating Smallholder Farmers' Access to Climate Services in Bangladesh: https://www.agrilinks.org/post/accelerating-smallholder-farmers-access-climate-services-bangladesh

Note: These will soon be posted on CCAFS landing page for CSRD in South Asia. The other materials and project information are already online:

https://ccafs.cgiar.org/flagships/climate-services-and-safety-nets/projects.