Climate change impacts on freshwater availability for agriculture in Sundarbans, India

Report of Pump Priming Project

February 2020

INDIA-UK
Water Centre
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भारत-ब्रिटेन जल कें द्र एमओईएस-एनईसीआरसी(यूके) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओ के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

Front cover image: Field, Sundarbans (Emma Bennett, IUKWC). All other images: Alexandre Gagnon

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Executive Summary

This report presents an overview of the activities undertaken as part of a Pump Priming Project in Sundarbans from June through September 2019. The project activities were led by Professor Lalu Das in India and Dr Alexandre Gagnon in the UK, and included analyses of climatic data from observations, re-analyses and global climate models, interactive sessions with farmers and other water resource stakeholders, and a workshop with scientists, NGOs and government stakeholders working in the region. The report outlines a summary of the activities and its main conclusions, and is intended for the India-UK Water Centre members and stakeholders.

Figure 1: Rice field in Sundarbans, the main crop grown in the region.

1. Project Leads

The Pump Priming Project 'The influence of the monsoon on freshwater availability for agriculture in the Sundarbans region of West Bengal, India, under current and climate change conditions' was convened by the India-UK Water Centre (IUKWC) and led by the Activity Leads:

Dr Alexandre Gagnon

UK Activity Lead

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Dr Indrani Roy, Liverpool John Moores University (LJMU) and Professor Gautam Saha, Bidhan Chandra Krishi Viswavidyalaya (BCKV) were key collaborators in the project.

The activities of this Pump Priming Project were held in four blocks of the Sundarbans region and at BCKV from June through September 2019.

2. Project Aims

The India-UK Water Centre is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This Pump Priming Project focused on the themes: 'building cross-sectoral collaborations to understand the dynamic interactions across the water-energy-food nexus' and 'using new scientific knowledge to help stakeholders set objectives for freshwater management'.

This Project aimed to examine changes in the availability of freshwater resources in Sundarbans under current and climate change conditions, the impact of such changes on livelihoods, and how communities are adapting to those changes. Specifically the objectives were:

- To construct hindcasts of surface water resource availability using observations.
- To evaluate the performance of the General Circulation Models (GCMs) of the Coupled Model Intercomparison Project Phase 5 (CMIP5) over the Sundarbans region.
- To construct downscaled scenarios of rainfall under climate change for the Sundarbans region using the best CMIP5 model(s) identified above.
- To engage with stakeholders to understand how changes in water resource availability are affecting livelihoods and to discuss issues related to adaptation to those changes.

Figure 2: Community workshops held in different blocks of the Sundarbans

3. Project Participants

The project consisted of interactive sessions in four blocks of Sundarbans, with farmers and other water resource stakeholders such as NGOs and government representatives. The first two interactive sessions took place on July 30 and July 31, 2019, in Patharpratima and Sagar Island, respectively, while two additional sessions were conducted on August 29 and August 30 in Bali ward/G.P. (Gosaba) and Chunakhali G.P. (Basanti), respectively. Formal invitations were sent in writing to community leaders, NGOs operating in the region and relevant government employees, subsequent to a telephone conversation, but all residents were invited to join with the invitation to the community leaders passed on to farmers in each community.

Invitations to the scientific workshop at Bidhan Chandra Krishi Viswavidyalaya (BCKV) were sent to researchers, based in universities in India, who are currently or have previously worked on the climate, agriculture, soils, or water-related issues in the Sundarbans region, as well as to NGOs and government stakeholders such as the India Meteorological Department (IMD) and the Sundarbans Development Board, Government of West Bengal.

In total, there were more than 200 participants at the interactive sessions in the four communities (figure 2) and 63 participants at the scientific workshop. The agenda of the scientific workshop can be found in Annex A. Table 1 lists the 26 scientists who participated at the workshop. The research scholars funded as part of this project, as well as an additional 27 PhD students and 10 MSc students from BCKV attended the workshop. The UK project team from Liverpool John Moores University (LJMU) also presented at this workshop.

Table 1. List of delegates at the scientific workshop at BCKV

	Name	Institution
	UK	
1	Dr Alexandre Gagnon	LJMU
2	Dr Indrani Roy	LJMU
	INDIA	
3	Professor L. Das	BCKV
4	Professor S. Das	BCKV
5	Professor D.D. Patra	BCKV
6	Professor M.K. Nanda	BCKV
7	Professor S. Sarkar	BCKV
8	Dr A. Mukherjee	BCKV
9	Dr Gopal Krishan	National Institute of Hydrology, Roorkee
10	Dr S. Bandyopadhyay	Indian Meteorological Department (IMD), Kolkata
11	Ms P. Goswami	BCKV
12	Mr R.R. Choudhury	BCKV
13	Ms S. Bhowmick	BCKV
14	Mr R. Chakraborty	BCKV
15	Dr J. Akhter	Indian Institute of Tropical Meteorology, Pune
16	Professor S.A. Khan	BCKV
17	Professor A. Saha	BCKV
18	Dr P. Dasgupta	PRASARI (NGO), Kolkata
19	Mr A. Majumder	Sundarbans Development Board, Gov't of West Bengal

20	Professor G. Saha	BCKV
21	Professor M.K. Nanda	BCKV
22	Professor S. Banerjee	BCKV
23	Professor S.K. Acharya	BCKV
24	Dr S. Roy	BCKV
25	Mr S. Nayak	BCKV
26	Professor D. Mishra	BCKV

4. Project Structure

The Pump Priming Project consisted of desktop analyses of climatic data from observations, reanalyses datasets and global climate model outputs by the project team. The team consisted of two Professors: Professor Lalu Das (India Lead) and Professor Gautam Saha, together with four research scholars (PhD students): Ratul Roy Choudhury, Ratul Chakraborty, Purba Goswami and Sayani Bhowmick at BCKV in India, and one Senior Lecturer, Dr A. Gagnon (UK Lead) and Dr Indrani Roy, a PDRA at LJMU in the UK.

The interactive sessions in the farming communities consisted of presentations to introduce the project and the research team to the communities, as well as providing context to the research, raising general questions on water related issues impacting agriculture and livelihoods in the region, and taking feedback from the audience. Professor Lalu Das facilitated this introductory session prior to dividing the audience into breakout groups. The participants were divided into four groups, which on all occasions resulted in three groups of males and one group of females, without any a priori assigning of the participants to a specific group. The discussion in each group was conducted in Bengali and was led by one of the four research scholars employed as part of this project with the overall supervision of Professor Lalu Das, who was followed by a photographer to take photographs during the discussion. The task of each group leader was to ask questions from a printed version of a questionnaire (See Annex B, which summarises the questionnaire). The same questions were asked to all participants.

The questionnaires were completed with all participants in each facilitated group. The first series of questions aimed to gather personal information on the participants such as their place of residence, whether they own land (to differentiate between farmers and non-farmers) and contact details. Information on agriculture in each of the surveyed blocks was collected together with stakeholders' identification of issues related to freshwater availability and water quality. Then, the survey aimed to identify stakeholders' perceptions with regard to changes in climate in recent decades and their impacts on agriculture in the region prior to discussing adaptation actions and strategies to changes in surface water availability that they have experienced, for example, as a result of variability in the timing of the occurrence of the monsoon or an increase in salinity. The survey also inquired about government support (e.g. financial, technical) for agriculture in the region and on the availability of weather advisory services in their communities, notably on the onset and cessation of monsoon rainfall.

The scientific workshop took place at the Farmers Academy and Convention Centre, Lake Hall, of BCKV in Kalyani on September 3 2019, and was conducted in English (figure 3). Following an inaugural session with presentations by dignitaries of the host institution, i.e., the Director of Research, Vice-chancellor, Dean, and Head of Department, and the Project Leads from India and the UK, there were two scientific sessions. The first scientific session entitled: 'Establishing linkages between the variability of the monsoon, freshwater availability and agricultural productivity' included presentations by two invited speakers. These were followed by five presentations by the research scholars employed as part of this project in India and the UK PDRA who highlighted their activities and received valuable comments and suggestions by the

audience to improve their work and inform future research activities. The work presented by the project researchers focused on four different but interlinked topics such as temporal changes in freshwater availability in recent decades, the skills of General Circulation Models (GCMs) to reproduce the Sundarbans climate, the use of downscaling techniques to deal with GCM weaknesses, and uncertainties in the climate change projections over the Sundarbans region. The second session was titled: 'Ground truth observations about the water crisis and feedback from interactions with farmers' and consisted of presentations on the feedback received by the farmers and experiences gained during the field visits. The session began with two guest lectures, which were followed by presentations on the outputs of the current project and other projects with a focus on Sundarbans by BCKV scientists. The workshop concluded with an address by the project leads, who summarised the event and presented opportunities for further research and potential funding streams that the workshop participants could bid for to take forward ideas arising from the event and project.

Figure 3: Scientific workshop at Bidhan Chandra Krishi Viswavidyalaya

5. Project Conclusions and Outputs

The results of the interactive sessions in the farming communities of Sundarbans are summarised and put in the context of analyses of climatic data from observations and modelling outputs. This Project provides a general overview and preliminary future scenario of the water scarcity problem affecting Sundarbans, the contribution of climatic changes and anthropogenic influences to that problem, and its impact on farming practices and livelihoods. Local adaptations to changes in freshwater availability are described, as well as the information used and the resources needed by stakeholders to adapt. Recommendations for future research are then presented in view of the changes in climate and surface water availability projected for the region.

5.1. Key Points

- Approximately 80% of total annual rainfall in Sundarbans falls during the south-west monsoon season, providing sufficient water for the cultivation of Kharif rice;
- For many years community residents have perceived a delay in the onset of the south–west monsoon, together with a decrease in monsoon rainfall and warmer temperatures, with negative impacts on agriculture and community livelihoods;
- Decreasing trends are detected in surface water availability, mainly as a result of increasing trends in evapotranspiration, as precipitation was observed to have increased in half the blocks and decreased in the other half;
- Farmers in the region have been pumping groundwater to irrigate land for the cultivation of a second season of rice known as Baro rice, which they sow in the winter and harvest in the warm summer months, thereby lowering the water table and reducing access to water for domestic users;
- This man-made pressure on the groundwater resource, when compounded with decreasing trends in freshwater availability and an increase in water and soil salinity, is causing what the locals describe as a water crisis;
- Locals have adapted to changes in water availability by collecting rainwater in storage ponds and smaller lakes. Other adaptive actions, physical, managerial, technological and behavioural were proposed at the interactive sessions and scientific workshop;
- The ability of the CMIP5 GCMs in simulating the regional climate of Sundarbans was evaluated with the five best models used to provide climate change projections for the region;
- Outputs from the above CMIP5 GCMs were used to examine potential changes in monsoon precipitation under climate change;
- Various downscaling techniques were applied to examine their ability to simulate the regional climate of Sundarbans, with the best technique used to downscale GCM outputs for two climate change scenarios;
- Although the CMIP5 GCMs reveal uncertainty in the climate change projections for the region, which would make their use difficult to inform adaptation, the downscaled outputs from the selected GCMs project an increase in precipitation during the annual summer monsoon over Sundarbans throughout the 21st century.

5.2. Conclusions and recommendations from the Project

The Pump Priming Project assessed past changes in surface water availability over the Sundarbans region, which provided a scientific context to the stakeholders' perceptions. The impact of changes in the annual summer monsoon and associated variability in surface water availability

on livelihoods was also examined, together with issues related to adaptation to mitigate the risks. The ability of the CMIP5 GCMs to simulate the climate of Sundarbans was evaluated with the five best models selected to examine future changes in climate under two Representative Concentration Pathways (RCP) warming scenarios. These scenarios, downscaled for the Sundarbans region, reveal that monsoon precipitation is projected to increase. Although the selected models project an increase in precipitation in a warmer climate, evapotranspiration will also increase, offsetting, to some extent, the impact of an increase in rainfall on surface water availability. Moreover, the projected increase in monsoon precipitation should be considered in the context of sea level rising, which will inevitably increase saltwater intrusion into the coastal aquifers and increase the sensitivity of the region to the impact of cyclones, notably on surface water quality. The outcomes of this project provide a better understanding of how the impacts of climate change could alter the monsoon circulation and cascade through agriculture and livelihoods and to use this knowledge to target interventions and develop policies that are effective at mitigating risks.

Further research is recommended to understand the physical mechanisms explaining the difference amongst the CMIP5 GCMs not only in the magnitude of the projected change in rainfall over Sundarbans, but also in the direction of change, as well as to explain the contradicting results between the downscaled model outputs and the coarser resolution GCM outputs. In view of future climate change, the dependence of the Sundarbans communities on agriculture and the variability in surface water availability, and a diminishing groundwater supply, the next step would be to engage with stakeholders in the co-development of adaptation actions and strategies through the provision of visualisations of climate change risks, notably the translation of scenarios of key climatic variables to changes in crop yield. Given the loss of water in storage ponds to evaporation and its predicted increase under climate change, the assessment of potential methods to reduce evaporation is recommended as an adaptation strategy. The new phase of climate change scenarios, CMIP6, will soon become available to the scientific community and should be consulted to determine whether there is better agreement amongst the models in their climate change projections for the region. One important point to be studied is how rice production can be altered under changing freshwater availability, warmer temperatures and an increase in soil and water salinity using crop simulation models and data from experimental field trials. The provision of such climate change information to the communities is important, as adaptation should not only be reactive, that is, responding to changes that have occurred, but should also increase resilience to future changes in climate. An accompanying Brief summarizing the key thematic points arising from this Pump Priming Project can be found at www.iukwc.org.

6. Annexes

Annex A: Agenda of the scientific workshop at BCKV on 3rd September 2019

Time	Agenda Item
Inaugural session	
9:30-10.00	Registration
10:00-10:10	Inauguration – Lighting of lamp
10:10-10:15	Inaugural song
10:15-10:20	Welcome – Director of Research, BCKV
10:20-10:30	Background to the project, Prof. L. Das, BCKV
10:30-10:35	Address by UK Activity Lead, Dr A. Gagnon, LJMU
10:35-10:40	Special address – Prof. S. Das, Dean (Faculty of Agriculture)
10:40-10:50	Presidential address, Vice-chancellor, BCKV
10:50-11:00	Vote of thanks, Head, Department of Agricultural Meteorology and Physics, BCKV
11:00-11:20	*Tea break*
Technical session 1: Establishing linkages between the variability of the monsoon, freshwater availability and agricultural productivity	
11:20-11:40	Groundwater salinity and possible remedial measures, Dr G. Krishhan, National Institute of Hydrology, Roorkee
11:40-12:00	Linking monsoon forecasting and agricultural activity, Dr S. Bandyopadhyay, IMD, Kolkata
12:00-12:15	Block level climate change and freshwater availability scenarios over Sundarbans, Ms P. Goswani, BCKV
12:15-12:30	Evaluation of CMIP5 GCMs over Sundarbans, Mr R.R. Choudhury, BCKV
12:30-12:45	Reanalysis based climate variability and change over Sundarbans, Dr I. Roy, LJMU
12:45-13:00	Past changes and downscaled rainfall scenarios at the block level over Sundarbans, Ms S. Bhowmick, BCKV
13:00-13:15	Uncertainty of monsoonal rain and agricultural production, Mr R. Chakraborty, BCKV
13:15-14:30	*Lunch break*
Technical session 2 – Ground truth observations about the water crisis and feedback from farmer's interactions	
14:30-14:50	Farmers' perceptions on surface and groundwater variability, Dr Dasgupta, PRASARI (NGO)
14:40-15:10	Government initiative to protect Sundarbans water and agriculture, Mr A. Majumder, Sundarbans Development Board, Government of West Bengal
15:10-15:30	Linkages between farmers' perceptions and scientific findings on Sundarbans water and agricultural problems, Prof L. Das, BCKV
15:30-15:50	Mitigation and adaptation techniques to combat climate change over Sundarbans, Prof G. Saha, BCKV
15:50-16:10	Scope for further research and funding opportunities, Dr A. Gagnon, LJMU
16:10-16:30	Discussion about research needs, opportunities and reporting requirements
16:30-17:00	*Tea break and award of attendance certificate*

Annex B: Questionnaire used for the small group discussion during the interactive sessions in the Sundarbans farming communities

Personal information

- **Contact details**
  a. Name:
  b. Address (Island/Village):
  c. Phone no.
- **Do you own land?**
  - If yes, how much land do you own?

Information on agriculture in the region

- **What crops do you cultivate during the year and in what sequence?**
  - Mention approximate sowing and harvesting date.
- **Mention whether the crops are grown under rain-fed and/or irrigated conditions?**
  - List crops grown during Kharif (rain-fed) season.
  - List crops grown under irrigated conditions.
- **Mention whether the same sequence is followed every year.**

Water related issues in Sundarbans

- **Name the source of freshwater availability for agriculture in the region? (E.g. ponds, lakes, groundwater)**
  - Does the source of freshwater vary according to season?
- **Do you think water availability for agriculture and domestic purposes is adequate in Sundarbans?**
  - If it is inadequate, what are the problems? When do the problems occur during the year and how long do they last?
- **Have you noticed a change in the quality of your water (surface and ground)? (Prompt: change in salinity)**
  - If so, in what way?
  - And what do you think is the cause for this?
- **(If they refer to the water crisis in Sundarbans) Do you think the water crisis is natural or man-made?**
  - Why?
  - Do you think that pumping of groundwater for summer paddy cultivation may cause lowering of groundwater table and depletion of this resource?
- **Apart from water, what are the major problems associated in agriculture practice in Sundarbans?**

Recent changes in climate and their impacts on agriculture

- **For a typical monsoon, please mention, on average, the timing of the following:**
  - Onset of monsoon;
  - Duration of monsoon; and
  - Approximate amount of rain falling during the monsoon season:
- **Do you think the climate of Sundarbans is changing?**
  - If yes, in what way (prompts: temperature, rainfall, onset of monsoon, cyclone occurrence, sea level)
  - Does a good monsoon (above average rainfall) improve crop yield?
  - If you perceive the climate to have changed, has it impacted on agricultural activity? And if so, in what way? (Prompts: water availability, crop growing period, crop yield)

External support, including provision of climate information

- **Where do you get help for agriculture related advice and guidance? E.g. Government/NGOs**
  - What type of support do they provide? E.g. financial/technical advice on farming?
- **Are weather advisory services available in your locality/block?**
  - If yes, mention the source, timing, and format of the information provided (e.g. paper bulletin, SMS).
- **Are there any agro-meteorological services available during the critical sowing and harvesting period?**
  - If yes, what information do they provide?
  - Are GraminKrishiMausamSeva (GKMS) services available?
    - If yes, are they helpful?
    - If both information services are available, do the prediction match?
  - Can these agro-meteorological services reduce financial loss?

Adaptation

- **Do you get forecast information on the onset and cessation of the monsoon rainfall for Sundarbans?**
  - If a good monsoon is forecast, what preparations do you take with regard to farming?
  - If a bad monsoon is predicted (below average rainfall), what adaptive measure(s) do you take to deal with the forthcoming rainfall deficit?
- **Have you changed your farming practice as a result of the change in climate/ water availability that you mentioned above? (Prompt: type of crop, heat/ drought tolerant varieties, crop cultivation technique)**
- **What natural hazards are affecting Sundarbans? (Prompt: Alia)**
  - Are the damages due to Aila still persistent in Sundarbans?
  - If yes, what measures are taken to mitigate them?

- **Is there any government initiative to help farmers adapt to a changing climate over Sundarbans?**
- **(If they refer to a water crisis above – or problem with water availability) Do you think the water crisis (or issue with lack of freshwater availability) can be solved?**
  - If answer is yes, how?
  - What is the role of government, NGOs, and the community in solving the water crisis?
- **Are you facing difficulties cultivating due to salinity?**
  - If yes, how are you adapting to this problem? (Prompt: salt tolerant variety)

Back cover image: Field, Sundarbans (Emma Bennett, IUKWC)

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