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PROGRAMME REVIEW

POVERTY

# Developing Climate Services in India

christian aid

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## Developing Climate Services in India – A Review

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### ii) Acronyms

CMIP - Coupled Model Inter-comparison Project
DRCSC - Development Research Communication and Service Centre
EWS – Early warning system
GEAG - Gorakhpur Environmental Action Group
IFFCO - India Farm Fertiliser Cooperative
IMD - Indian Meteorology Department
IPCC - Intergovernmental Panel on Climate Change
MNREGA - Mahatma Gandhi National Rural Employment Guarantee Act
NDUAT - Narendra Deva University of Agriculture and Technology
NGO – Non-governmental organisation
NWP - Numerical weather prediction
PVCA - Participatory vulnerability and capacity assessment
SMS – Short message service
RCP - Representative concentration pathways
RTC – Rural training centre

### iii) Acknowledgements


Thanks to the following for generous use of their time and expertise in discussing the programme and its performance and facilitating community participation in the review: Community groups from Uttar Pradesh and West Bengal for their feedback on community resilience and climate change; Dr Bijai Singh, Kailash Pandey, Ravindra Tripathi, Ajay Kumar Singh, Ravi Prakash Mishra, Satyandra Kumar Tripathi, Hemant Singh, Vijai Pandey and KK Singh from GEAG; Professor Sugata Hazra from NDUAT; Somjita Chakraborty, Malay Mukerjee, Chandrani Das and Sujit Mitra from DRCSC; and the Christian Aid India Team, especially Subrata De (Programme Manager) and Reena Khan (Administrator) for their support with both technical and logistics issues.

Photographs: Richard Ewbank

## Executive Summary

In both Uttar Pradesh and West Bengal, farmer groups have described their perceptions of the usefulness of five day forecasts, early warning of cyclones and rain gauge data. In Uttar Pradesh, groups described a variety of impacts from forecast use with an emphasis on cost savings through better management of inputs, pests and diseases, irrigation and risk mitigation measures. Although not all of these could be quantified, especially damage avoided, in all groups, specific examples of cost saving were cited. Perceptions of yields increase were less readily estimated but nevertheless, farmers were able to give cautious, conservative values of 10-25%. There was also value expressed in terms of improving household resilience, something women members emphasised, in terms of both household food security and health. Elements cited by the participating communities as contributing to the success of the approach include the use of appropriate communication methods (SMS, village notice boards), the usefulness of the agro-meteorological information included with the forecast information and the feedback mechanism that ensures farmer groups the opportunity to review the system monthly and feed back to GEAG. The skilled capacity of GEAG to design and deliver the system is also crucial, but this does in itself raise issues as to the long-term sustainability of the service.

In West Bengal, communities have seen a substantial improvement in early warning time which contrasts with the situation experience with Cyclone Aila, although lack of adequate cyclone shelter capacity remains an urgent priority for local Government action. Some work on rain gauge use has also started and rainfall data has been collected since mid-2012. This has motivated considerable interest but with further training could be more useful in terms of assisting farmers with decisions on planting time and pest control. Some farmers have signed up to local SMS forecasting schemes and farmers emphasised the usefulness of locally generated rainfall information together with these forecasts, but it would be especially useful for DRCSC to gain a better understanding of the process managed by GEAG and deciding how a similar service could be made operational in West Bengal. Farmers in both projects also expressed interest in other forecast services, such as seasonal forecasts and loner-term climate change scenarios.

In both areas, climate services are provided through the participatory and vulnerability assessment process. Given the importance of climate-related shocks and stresses to the risk profiles generated, it is unsurprising that climate services have encountered the interest and usefulness they have. Whilst this review did not specifically focus on evaluating the PVCA processes, it has clearly been closely and effectively integrated with climate services, defining the framework for their delivery at community level. However, the evidence base for climate service effectiveness does need to be deepened beyond the encouraging findings presented here. Better data, especially quantitative evidence (as per the recommendations below), is needed to conclude with greater certainty whether or not climate services are having the impact this report’s findings have shown, especially with respect to improved productivity and income. The same can be said for the agro-ecological model in general – there is a lack of quantitative data presented to demonstrate its increased resilience, productivity and sustainability for these two areas – both could be very usefully addressed in the next 2 years of the projects.

# 1. Introduction

## 1.1 Methodology

Review of the climate services work supported by Christian Aid's South Asia programme was carried out in India over the period 9th to 22nd April 2014. It included interviews and group discussions with staff from two partners – Gorakhpur Environmental Action Group (GEAG) in Uttar Pradesh and Development Research Communication and Service Centre (DRCSC) in West Bengal – as well as direct consultations with communities involved focus group discussions and visits to community-managed interventions as planned using participatory vulnerability and capacity assessment. In both areas, a focus on climate services was prioritised although this was more explicit in Uttar Pradesh.

## 1.2 The project areas

In Uttar Pradesh, four communities were interviewed (54 women, 38 men) in villages ranging from peri-urban to rural. Other discussions included GEAG staff and a visit to the local IMD climate station. In West Bengal, three communities and one welfare society were visited to investigate how communities view risk from their PVCA processes and the increased focus on cyclone early warning and community-based climate monitoring through the use of rain gauges. Both areas are in the Indo-Gangetic floodplain, with the primary livelihoods being small-scale agriculture on mainly rented land and seasonal labouring. Communities visited typically have a significant (up to 10%) number of landless households that rely on labouring or in West Bengal, fishing (including the collection of prawn larvae).

Fig 1. Map of India showing Uttar Pradesh (orange) and GEAG location and West Bengal (green) and DRCSC location

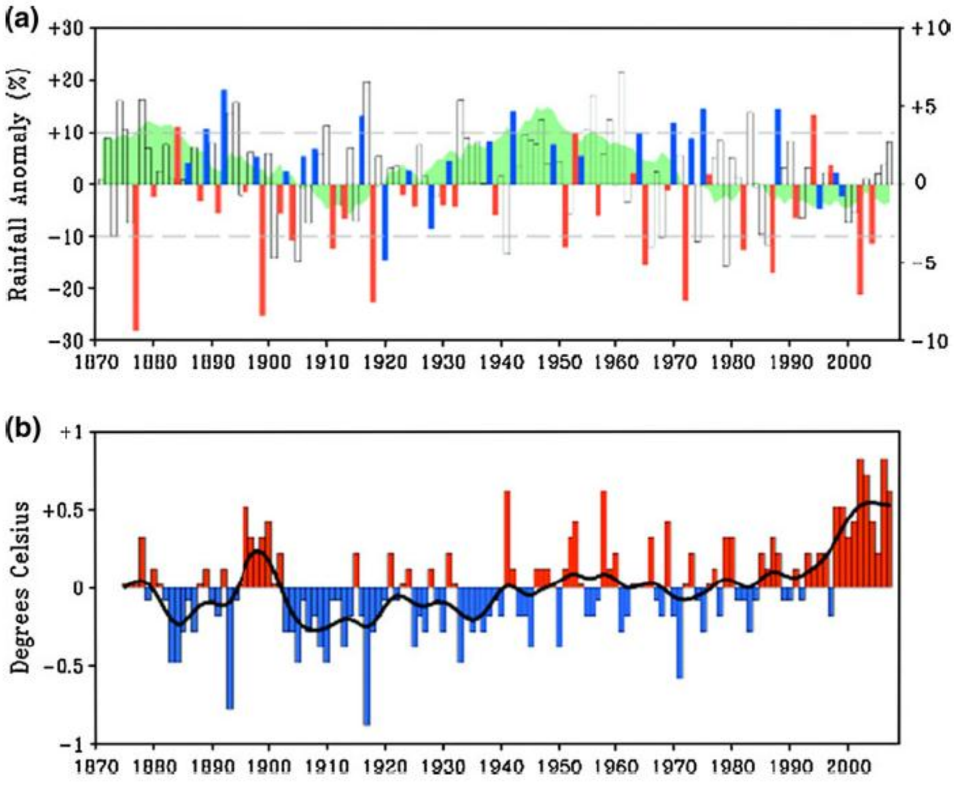
# 2. Background

## 2.1 Climate background

India has experienced an average temperature increase of about 1°C since 1850 from 23.5°C to 24.5°C[1]. Over the same period the mean rate of change has accelerated from 0.66°C/century to 2.3°C/century, indicating a speeding up of temperature increase that corresponds to the increase in greenhouse gas emissions globally. This average rise conceals a differing rate of warming depending on the time of year, with the period February to April (the transition period from winter to the pre-monsoon hot period) experiencing higher levels of temperature than other months (August showing the lowest mean temperature rise). Mean daily high and low temperatures have also risen in line with the average increase, with a slightly higher rate for mean daily low temperature.

Both these and changes in rainfall are show below (graphs b and a respectively). The strength of the summer monsoon is significantly affected by the El Nino Southern Oscillation, with weaker monsoons correlated with El Nino (red on Fig 1 (a)) and stronger ones with La Nina phases (blue on Fig 1 (a)) of the cycle.

Fig 2. Rainfall and temperature since 1870[2]




Monsoonal rainfall has been on a downward trend since 1950 (as per green shaded area on graph (a)) but climate projections made for the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2013) have been made using representative concentration pathways (RCPs) under the Coupled Model Inter-comparison Project 5 (CMIP5)[3]. These found that mean climate for 1860–2099 based on CMIP5 was closer to observed climate than any individual model. With respect to rainfall, average precipitation under the business-as-usual (between RCP6 and RCP8.5) scenario

[1] See Berkeley Earth Surface Temperature Group, http://berkeleyearth.lbl.gov/regions/India
[2] The Once and Future Pulse of Indian Monsoonal Climate – Kumar et al (Climate Dynamics, 2010)
[3] Multi-model Climate Change Projections for India under Representative Concentration Pathways – Chaturvedi et al (Current Science Vol. 103, 7, 2012)

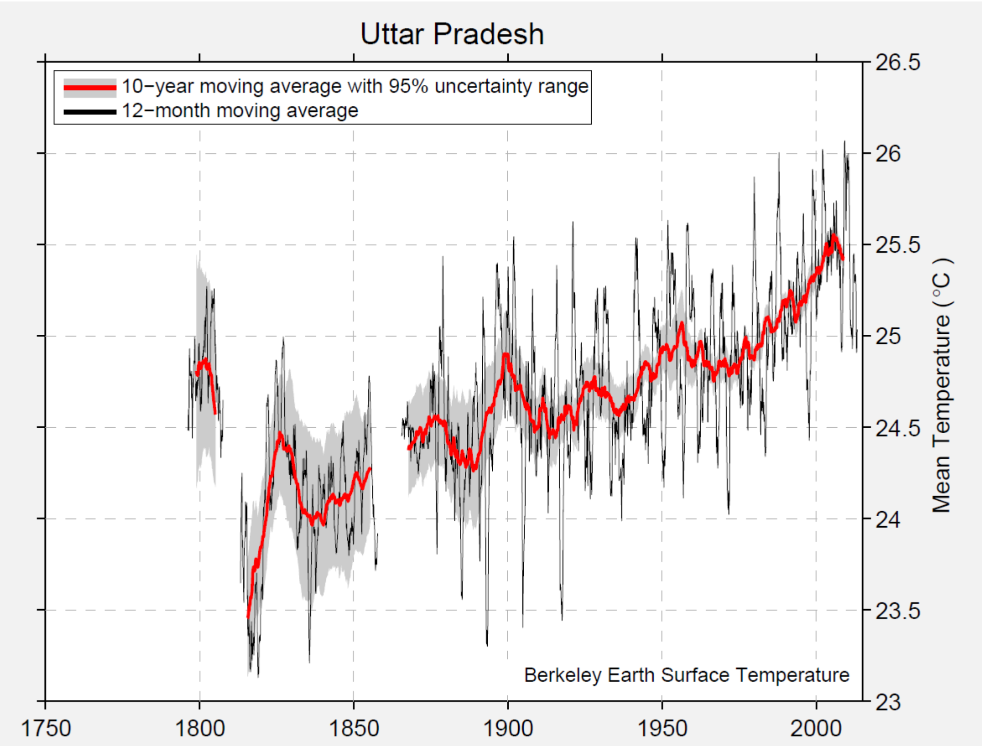
(i.e. greenhouse gas emissions continuing unabated) is projected to increase by 4 - 5% by 2030s and by 6 - 14% towards the end of the century (2080s) compared to the 1961–1990 baseline. This reverses the current trend, which might logically strengthen if climate change also promotes increased frequency/intensity of El Nino episodes. However, increased atmospheric moisture is projected to mitigate the potential impact of stronger El Nino, resulting in heavier monsoons. Rainfall outside the monsoon season is expected to decline, with a 10 - 20% decrease in the December – February period by 2045 - 65[4].

While precipitation projections are generally less reliable than temperature projections, model agreement in precipitation projections increases from RCP2.6 to RCP8.5, and from short-to long-term projections, indicating that long-term precipitation projections are generally more robust than their short-term counterparts. There is also a consistently positive trend in the frequency of extreme precipitation days (> 40 mm/day) from 2060. Mean warming in India is likely to be in the range 1.7 – 2°C by 2030s and 3.3 – 4.8°C by 2080s relative to pre-industrial times. Increases in southern India are likely to be lower than in northern regions.

### 2.2 Uttar Pradesh and West Bengal

Climate change impacts on the Indo-Gangetic Basin are derived from changes in temperature, rainfall, glacial melt and, for the lower parts in West Bengal, sea level rise. Increased variation in rainfall from one monsoon season to the next will create problems of both drought and flooding, with increased heat stress expected to have a significant impact on crop yields from the 2040s. With a 4°C rise likely for northern India, an extremely wet monsoon that currently has a 1 in 100 year probability will occur every 10 years[5]. Likewise drought risk will rise particularly in the North-Eastern states.  This puts the existing rice-wheat agricultural system of the Ganges Basin under particular strain. Although rice yields have continued to increase, they are estimated to be already 6% lower than would have been the case without climate change.

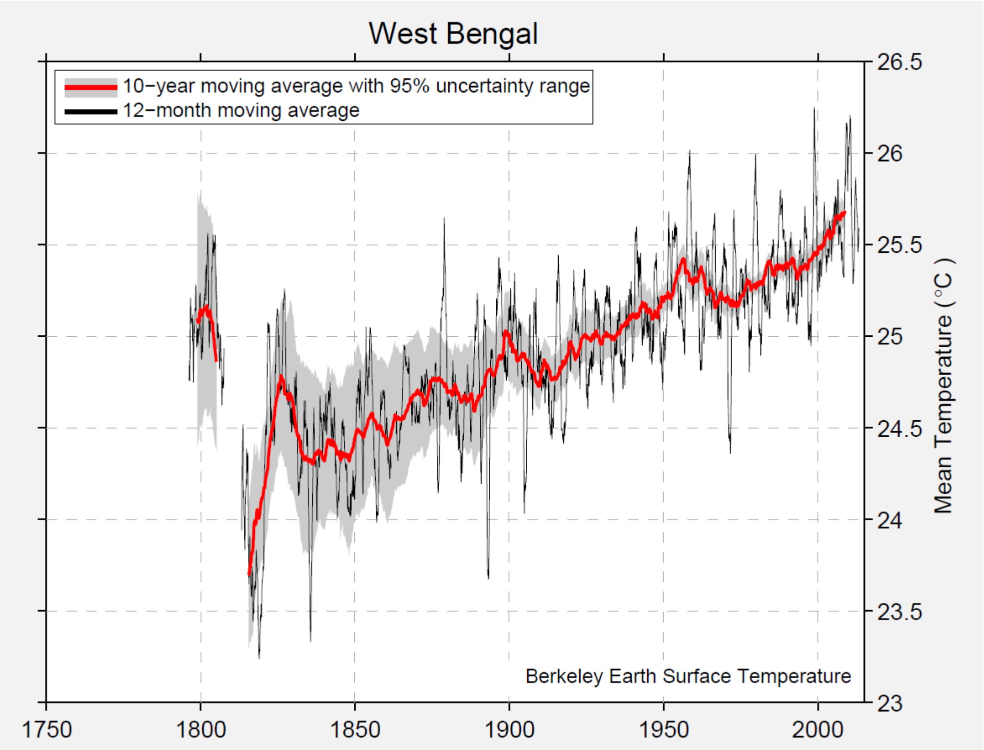
Fig 3. Average temperature rise in Uttar Pradesh[6]




[4] Region by Region - The Science of AR5 WG1 and the Consequences – IPCC (2013)
[5] Turn Down the Heat – World Bank (2013)
[6] Berkeley Earth - http://berkeleyearth.org/

Wheat has been even more severely affected with yield flat-lining since the beginning of the century despite increased fertiliser use. Increased temperatures (anything over 34°C) will have a particularly severe impact on wheat productivity in addition to the anticipated increase in moisture stress. Yields of non-irrigated rice and wheat will be significantly reduced beyond a 2.5°C temperature rise, reducing farm net revenue by 9 - 25%. Wheat is also grown mainly as a winter crop so will be additionally affected by the reductions in rainfall projected for the winter season, as will the winter rice crop in West Bengal. Changing patterns of glacial melt will affect hydrology and water security, with both states already exploiting groundwater at rates that exceed natural recharge. Increased rainfall is likely to offset reduced meltwater in average annual flows but the distribution of flows may change, with increases in the early monsoon period and decreases during the winter/spring (from December to February). As winter rainfall is also anticipated to decrease, freshwater supplies for both consumption and irrigation uses will be under particularly stress at this time. Faster melting periods will subside decade by decade as the volume of glacial ice declines with increased future temperatures.

Fig 4. Average temperature rise in West Bengal[7]




Coastal areas will encounter the additional problems of sea level rise. According to research carried out by Jadavpur University[8], the hydrological management of the Indian Sundarbans is having a profound impact on land loss, estimated at 210 km² over the past 40 years. A combination of reduced river flow, the construction of dams upstream reducing the sediment load of the Ganges , the diversion of smaller rivers also reducing silt deposition on the coast (and effectively becoming saline creeks or "headless rivers") and increased diversion of water for agriculture and urban settlements combined with climate change-related sea level rise means that net sea level rise has increased from 4 to 8mm per annum compared to the global average of between 3 and 4 mm per annum. This is accelerating the erosion of land and increasing the salinity of coastal groundwater, both of which have a profound effect on the resilience of rural livelihoods. Increased salinity in both cultivated and mangrove forest areas indicates that this sea level rise is the main cause of saline

[7] Berkeley Earth - http://berkeleyearth.org/
[8] The Sunderbans, Impact of Climate Change on People's Livelihood: Options for Adaptation - School of Oceanography Studies, Jadavpur University/Caritas India (2013)

intrusion into groundwater, as opposed to the increased conversion of land into brackish ponds for prawn cultivation (which accounts for about 15% of coastal land). Other changes recorded in the Sundarbans area include an increase in monsoonal and post-monsoonal rainfall of 116 mm and a decline in winter/spring rainfall of 21.3 mm with a delay in the onset of the monsoon of 5-10 days, periodically up to 25 days.

Community discussions

## 3. Application of PVCA and Climate Services

### 3.1 GEAG in Uttar Pradesh

The predominant livelihoods of the communities involved in the project are agricultural, with both own cultivation and labouring on larger farms, particularly among younger community members, or through the rural employment guarantee (MNREGA) being the mainstays of the village economy. The main exception found was in the peri-urban village of Sanghia, where other professions such as carpentry and masonry were also included. Holding sizes here are markedly smaller– average less than 1 acre with a large holding no more than 6 acres - and more likely to include rented land. The percentage of landless households was also higher (about 10%) and households rely more on vegetable production for the urban market than the main staple crops. Elsewhere, rice (in the summer monsoon) and wheat (as a winter crop) predominates with potato, groundnut, sugar cane and vegetables also grown. In general, holdings average about 1 acre with holdings categorised as large or very large in the 10 – 20 acre range. Between 85% and 95% (depending on the village) of the 92 farmers that took part in the community discussions were farming less than one acre.

- *Climate perceptions and spontaneous adaptation*

There was a high degree of continuity in the perceptions of changes in climate over the past 5 to 10 years from all villages. Summer temperature and particularly heatwaves are perceived to have increased. While total amounts of rainfall are either not thought to have changed or declined slightly, the rainfall pattern was cited as most significant change, with the monsoon starting 15 – 30 days later and rainfall less regular, more intense and with longer dry spells in between. Some respondents feel that all seasons had shifted forward and the duration of the winter season had declined. Others added that while summer temperatures were higher, winter temperatures had been lower in recent years. The main spontaneous adaptation measures have been to delay nursery development and transplanting for rice, using earlier maturing varieties for both wheat and rice in order to cope with a shrinking winter season and a later monsoon onset respectively. Two main features should be highlighted – firstly the high degree of agreement between the perceptions of farmers and the scientific evidence of climate change for Northern India generally, and secondly the pressure that this exerts on agricultural livelihoods. As climate changes increasingly affect production and the cost of inputs rise, farmers are caught in a vice of incremental stress on their livelihoods that can progressively reduce their ability to develop resilience. The ecological alternative to conventional chemical agriculture that GEAG promotes addresses both sides of this equation by reducing inputs use and therefore cost and increasing resilience, productivity and profitability through sustainable, ecological farming methods.

- *Developing and communicating climate information services*

The focus for climate information services has been on providing a regular, tailored 5 day forecast to farmers across 4 districts. As well as employing an in-house climatologist, GEAG have established a network of 6 rain gauges and 2 observatories (one automatic) to develop the forecast. To this is added data from a further 7 automatic weather stations and 2 observatories managed by the Indian Meteorological Department (IMD), giving a total of 17 measuring points. Access to IMD information is unlocked through a R5,000 subscription. Forecasts are developed using a numerical weather prediction (NWP) model on a 9 km grid, and so IMD data that adds to that obtained from the 17 direct measuring points is essential, such as upper wind speed and upper air temperature at 5-24,000 feet above sea level, mean sea level pressure, potential vorticity, convective available potential energy and temperature, and lifting condensation levels. Conventional forecasting methods are combined with NWP using norms to identify low pressure systems, wind troughs, cyclonic shear circulations, etc. During the monsoon, the location of the axis of the monsoon trough is important in anticipating how and where movement will occur that affects rainfall patterns. This is all interpreted to develop the 5 day forecast.

However, NGOs cannot release forecasts autonomously. This in-house forecast for basic temperature, humidity, rainfall, wind speed, etc. is then cross-checked with the IMD, the Ministry of Earth Sciences and the Narendra Deva University of Agriculture and Technology (NDUAT). Through this refining and tailoring process are added specific agro-meteorological recommendations depending on the time of year. For example, farmers near to harvest need wind gusting information as this potentially damages standing crops. Pest outbreak risks, often related to rising temperatures and humidity, are included with advice on which organic method of bio-pesticide use is most appropriate. This, like other agricultural recommendations, can also be used by farmers using chemical inputs but is tailored to ecological farming methods, which give are judged as provided superior resilience to climate extremes. If IMD issue a flood warning for the Rapti River basin, this is also added into the forecast.

The automatic weather station (temporarily relocated) being explained by Kailash Pandey, GEAG Climatologist (with the readout)

Communication of the forecast is primarily through SMS message sent to mobile phone owners registered with the GEAG climatologist. Currently these total 563 farmers in 50 villages, with a further 2,500 receiving the forecasts indirectly. Transmitted in Hindi, the SMS is worded carefully to ensure that it is clear to farmers. Training is also provided through farmer field schools on the forecast meaning and use and monthly reviews are carried out to enable framers to feed back on the reliability of the forecast, make recommendations for any changes and register new numbers for those wishing to join the network. Practical challenges include timeliness of the forecast development and approval process to ensure each is transmitted regularly. This can be particularly acute during the monsoon when power shortages are more frequent and IMD is under more pressure.

On the demand side, farmers sometimes change their number which creates a gap in transmission until their new number is registered and the SMS itself can get buried in numerous advertising text messages and so occasionally missed. Illiteracy can also hinder transmission by up to a day as the SMS recipient finds someone to read the message to them. To supplement the SMS method, noticeboards have been established in villages to transcribe the forecast and ensure that all farmers, not just those registered and owning a mobile phone, can access the information. These are situated in central gathering areas and/or near to rural roads or paths so that both residents and people from surrounding areas can easily locate the noticeboard. GEAG's own data shows that both numbers receiving and use of recommendations has increased, suggesting both increased demand and usefulness of information.

Fig 5. Growth in number of SMS recipients[9]

| | Direct recipients | | Indirect recipients | |
|---|---|---|---|---|
| Year | No. of receiving farmers | % using at least 50% of the recs | No. of receiving farmers | % using at least 50% of the recs |
| 2012 | 162 | 44 | 65 | 31 |
| 2013 | 350 | 61 | 145 | 55 |

- *User response*

In general, very little other forecast information was used by farmers receiving the 5 day forecast, either before the project started or subsequently. Most referred to the one day forecast through either TV or All India Radio but this only gave basic rainfall and temperature data. One group knew about a 2 day forecast in a local newspaper but indicated that this was not used for agricultural decisions. Likewise farmer field schools had included some general discussion about rainfall and temperature prospects for the next 2 years but not beyond this time frame.


Registering new users for the SMS message

Accuracy of the forecasts was considered good with a range of 75 to 100%, with no transmission reliability problems that seriously undermine access and use. One group explained that they were hesitant for the first 6 months but their initial hesitancy was overcome with increased awareness and knowledge of how to apply the information. The multiple channels of information and the ability to interact with the forecast providers were particularly valued. Groups explained how they received demand for the forecast – forwarding the SMS to a variety of family members and friends in

[9] The forecast network and associated activities have been co-funded by a combination of Christian Aid PPA, Rockefeller Foundation and DFID PACS (implemented through Christian Aid) but will rely on PPA support only from 2014

neighbouring villages is increasingly common and the notice boards have also generated significant interest both within the village and from those passing through.

In terms of specific decisions that farmers assess as improved through using the 5 day forecast, these tend to be related to timing of operations or improved targeting of inputs, including:

- Adjusting sowing times to cope with later/more variable monsoon onset dates, in particular when to establish rice seedling nurseries and transplant seedlings so that planting can be synchronised with the reliable onset of rain as well as direct planting of e.g. wheat, potatoes.
- Irrigation management – to avoid either unnecessary irrigation (and therefore irrigation costs) prior to rainfall or damaging a crop with excess moisture if irrigation is followed by heavy rain.
- Timing of pest control measures, using humidity and wind speed and direction information to decide bio-pesticide application e.g. applying chilli spray to mustard with an east wind
- Timing of frost damage control using irrigation and smoke to mitigate forecast frost episodes
- Compost/fertiliser application timed to maximise effects on crop growth and yield e.g. avoiding application prior to heavy rainfall to mitigate fertility loss through spoil erosion
- Vegetable nursery development based on temperature forecasts, especially for chillies, onions and seasonal leaf vegetables. This includes timing of operations and management of any potential risks e.g. heavy rainfall affected the nursery
- Timing the harvest so as to increase the likelihood of grain being stored at optimal moisture content e.g. avoiding cloudy weather that will result in higher grain moisture and therefore higher post-harvest losses.

Respondents, especially women, also cited a number of decisions about household welfare that forecasts had also assisted, including:

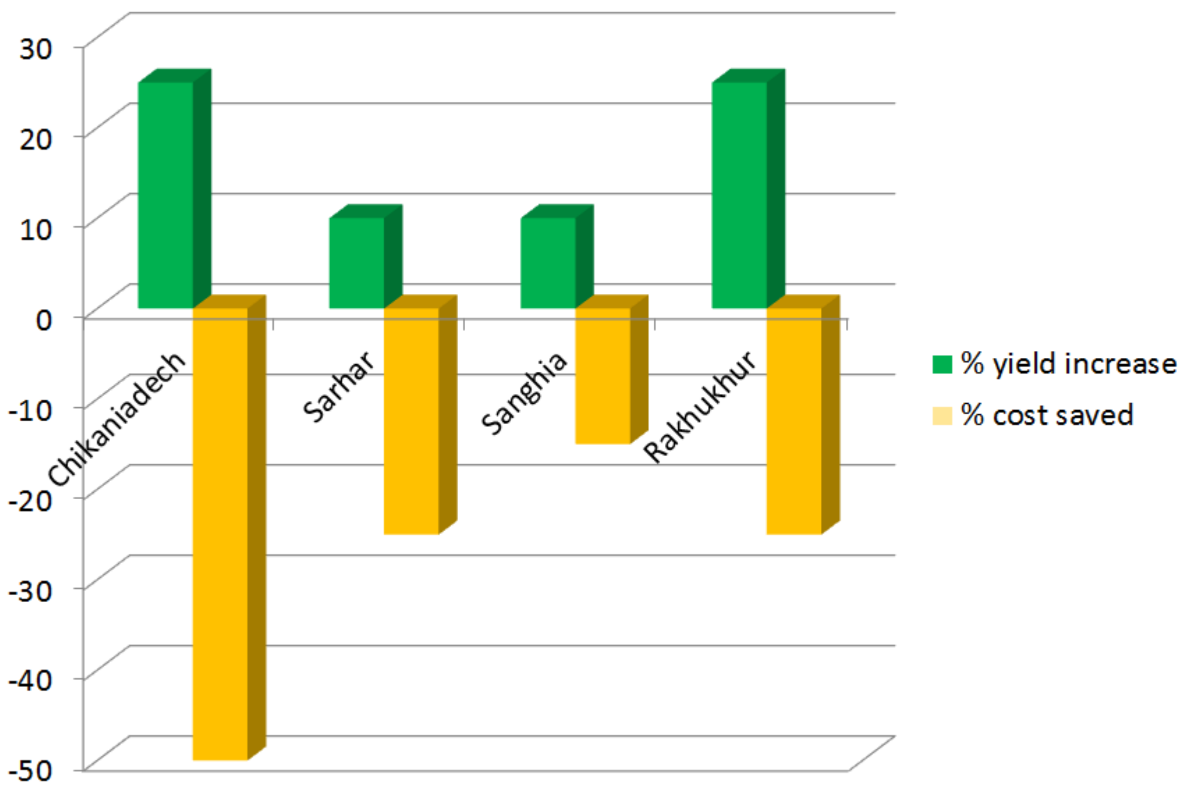
- Storing more wood, livestock feed and household goods (including food) if there is a forecast for persistent, heavy rain (over 3 or more days) that will reduce access to local markets and mobility locally e.g. through water-logging
- Focus on childcare to mitigate risks of colds and other disease
- Adjust any travel decisions based on the forecast
- Take pre-emptive maintenance to avoid e.g. a leaking roof causing problems within the house

Noticeboards with the forecast are put in busy places

The impact of these improved decisions were described by all communities with an emphasis on cost savings, as a result of either more efficient use of inputs or mitigation of damage to crops, as the most significant reason for use of the forecast.

Fig 6. Summary and level of impacts described by farmer groups

| Village | Impact |
|---|---|
| Chikaniadech | Increased crop yields – 70% of farmers agree the effect is positive |
| | Use forecast to decide whether to work on own farm or go for manual labour |
| | Avoiding loss e.g. protecting crop from extreme rainfall |
| | Reducing irrigation, labour and biopesticide costs by 50% |
| | Specific saving on fertiliser costs for wheat of IR2,400 per acre (about 25%) |
| Sarhar | Increased crop yields 5-10% |
| | Avoiding depressed yields through waterlogging e.g. if irrigation is then followed by heavy rain |
| | Reducing irrigation, labour and biopesticide costs by 25% |
| | Reduced labour by women especially |
| Sanghia | Increased crop yields by 10% |
| | Better fodder conservation improves livestock performance |
| | Reduced water and labour costs by 15% |
| | Reduced and/or more efficient use of other inputs also |
| Rakhukhur | Increased yield through more accurate use of inputs and better timing of planting |
| | Reducing input costs (mainly labour, irrigation and biopesticides) |
| | Reducing losses related to damage avoided |



A number of local indicators were also recognised as useful but these primarily focused on short-term onset of rain, including:

i) Sparrows taking a dust bath indicates rain within 24 hours; taking a water bath means no rain for next 10-15 days
ii) Ants moving their nest indicates rain in the next 2-3 days
iii) Emergence of dragon flies indicates rain in the next 2 days
iv) If wind shifts from a persistent easterly to a westerly, rain will arrive the following day
v) Frogs jumping on the roof means the monsoon is coming

Two villages also described drought indicators which were perceived as very reliable. Bamboo flowering, fruiting and dying indicated severe drought, as did the winter temperatures – warm in mid-January, cold nights in mid-May and heavy first rains from mid-April to mid-May all suggested a drought year. Opinions ranged from viewing these as very reliable so still used to dying out because (especially younger) people were embarrassed to be seen as relying on traditional views of weather and climate.

Communities highlighted the importance of climate services as part of the PVCA and action planning process. Initially, those involved in the PVCA were not aware of the various climate services available but the increase in risks associated with climate change – such as waterlogging, increased crop pests and diseases, livestock and human health – were the most important categories (especially waterlogging) cited. Since the action plans were developed, communities have been integrating climate services into its management and implementation in order to increase access e.g. through including registered mobile phone owners on the community map, identifying households that have mobile phones but are not yet registered or including communication methods that ensure those without mobile phones still can receive the information regularly. Monthly review of the forecast to feed back to the suppliers is also part of the action planning process. All communities agreed that the 5 day forecast had been a basis to increase their understanding of climate science and expressed interest in considering other climate services, such as the seasonal forecast, within the same system.

Community map with households receiving the SMS forecast recorded

### 3.2 DRCSC in West Bengal

Like their counterparts in Uttar Pradesh, the communities involved in DRCSC's resilience programming in the Sundarbans rely primarily on agricultural livelihoods with some fishing, collecting crabs and shrimp larvae for local shrimp farms and seasonal labouring. Holding sizes average about ⅔ acre, with 1 or more acres qualifying as a large holding, and are mostly operated under sharecropping arrangements with schools or local landowners. Rice (both monsoon and winter) is the main staple with a wide variety of vegetable crops – tomato, potato, eggplants, chillies, ridged gourds, pumpkin – grown, some of which e.g. chillies have taken a considerable time to recover from the soil salination caused by the Cyclone Aila storm surge in 2009.

- *Climate perceptions and spontaneous adaptation*

Three communities were interviewed and community representatives discussed the project and use of PVCA, climate services and community planning as part of a general meeting with Indraprastina Srijan Welfare Society. Much of the focus of the community plans developed has been to develop measures that will continue to improve the recovery from the storm surge that accompanied cyclone Aila and caused widespread salination of soils across the area in May 2009. In some cases, farmers were still unable to resume normal rice cultivation after 2 years. The major threat identified is from floods and waterlogging, with three main sources being:

  - High tides breeching river embankments (saline)
  - Tropical cyclone-related storm surges overtopping embankments (saline)
  - Intensive rainfall causing waterlogging and surface flooding (freshwater)

Vulnerability map showing village areas (in red) most susceptible to saline flooding

All three are perceived to have increased the risk faced by both households and livelihoods, with an accelerating loss of land due to coastal erosion. Several farmers highlighted the limited use of mangrove reforestation as a protective measure as "whole areas are slipping into the sea" whether they have mangrove areas or not[10]. Rainfall is perceived to have become more erratic and untimely, with a delay in the onset of the monsoon. This is related to both an increase in the intensity of heat, especially in summer, and changes in seasonality with winter transitioning more abruptly into summer, losing the milder spring season. There is also some concern about inter-seasonal variability in rainfall, with 2012 being comparatively dry and 2013 a very heavy monsoon year.

Some community members attributed loss of beneficial insects to climate change as well as the timing of cyclones. For example, Aila occurred in May prior to monsoon onset which accounted for the impact of the storm surge on soil salinity but it also affected the flowering of mango trees, which are the main source of nectar for local bee colonies. The resulted in a very poor honey harvest later in the year and the need for a prolonged recovery for honey production. In response to increased soil salinity, farmers have focused on drainage of soils to remove or manage salination and later nursery preparation and planting of rice to cope with later monsoon onset.

- *PVCA*

DRCSC has facilitated 39 PVCA exercises, primarily in the Sundarbans areas of 24 Parganas North and South. A variety of mapping exercises (resource, hazard and vulnerability), seasonal timelines, risk timelines and pairwise matrix assessments are all used to identify and prioritise risk and therefore what measures are need to mitigate. In general, the risks tended to be related to short to medium-term climate with e.g. climate risks characterised according to when in the year they occur. Other risks are identified, so for example the exercises carried out by Shantimata and Nibeditata Women's Groups also highlighted debt, lack of access to the rural employment guarantee (MNREGA) and domestic violence as drivers of vulnerability. Lack of access to the employment guarantee leads to a lack of resources to repair flood protection embankments, support land desalination and other resilience-building activities (all of which are eligible activities following MNREGA reform).
The actions plans developed by the women's groups and other community members and groups explicitly balanced and distinguished between activities to be implemented by the community without any direct external support, those requiring local Government support and those that DRCSC support could enable. Activities in the first category includes expansion of sustainable agriculture (biopesticides, soil fertility management, tree planting, vegetable gardens and seed systems) to reduce the impacts of more volatile climatic conditions. This requires technical support from DRCSC but no material aid.

Improved access to the MNREGA requires application of pressure on local Government to meet its commitments under the scheme. DRCSC and local Government worked together to address livestock health concerns with vaccination provision, including training local youths in vaccination provision. A priority post-Aila has been to improve the early warning system with respect to cyclones. The issues of debt have been addressed through a group savings scheme and women have advocated within the community on the impacts of domestic violence, which has included closing illegal drinking venues to reduce violence and the loss of daily manual labour wages. Shantimata and Nibeditata Women's Groups identified five key impacts resulting from the PVCA process through implementation of their action plan:

[10] This is consistent with the findings of the research carried out by Judavpur University (see chapter 2) highlighting sea level rise and loss of siltation increasing the risks of dramatic loss of land.

a) Increased awareness of disaster risks, including how to adapt to changes (where to go for shelter, preparatory measures such as stocking food and securing valuables).
b) Embankment repair and stabilisation through tree planting together with maintenance of drainage structures through labour under the MNREGA scheme. This has included influencing other NGOs and local government to increase tree planting in other village areas.
c) An increase in crop production but also crop security through a reduction in damage from saline flooding.
d) A change in the situation with respect to domestic violence which has been *"huge. Peace is restored in the house and the education of children has improved"*.
e) Increased confidence from forming a group that has enabled members to access government schemes such as MNREGA. Members are *"not scared to face anybody, any government office"*.

In Brajaballavpur village, community members outlined 18 activities currently identified as part of their action plan, which is reviewed annually to assess progress and revise as necessary. Completed activities include land shaping, a nursery of indigenous plants needs to stabilise flood protection bunds, use of indigenous saline tolerant rice varieties, and installation of grain banks, biogas units and smokeless challahs (stoves). A significant issue identified has been Government cutting trees, which the community feels is only exposing the area to increased climate risks. The development of saline tolerant rice varieties was facilitated by DRCSC with support from the Agricultural Technology Management Agency. Fifty experimental plots were established after investigation of farmers still growing these local varieties, often as a niche crop for household consumption, the aim being to identify the 5 varieties that show most promise for further seed production and extend these to farmers more widely.

Harvested rice is vulnerable to intense rainfall and flood damage as it dries during harvesting

- *Access to climate services*

The main project intervention with respect to climate services has been a focus on cyclone early warning. All communities highlighted the improvement in the situation by contrasting the response to Cyclone Phailin (October 2013) with Aila. With Phailin, communities received early warning 3-4 days in advance, with more certainty about its track two days before it made landfall (in the event Phailin, turned east and made landfall south of the Sundarbans). Even though the area was spared the main impacts, the early warning and concern about possible storm surges meant that a variety of activities could be carried out before any impact, including using MNREGA to repair embankments, moving the vulnerable (in especially low lying areas) and livestock to higher areas, and ensuring that valuables and documents are collected and stored in a safe place (losing ID cards and other documents can result in loss of access to public services, such as MNREGA). Early warnings were received by both SMS from DRCSC and through a public address system installed at Ramganga Rural Training Centre (RTC).

Early warning also enabled households to strengthen nursery infrastructure (thatched roofs, drainage) and delay their harvest to after Phailin so that the intense rainfall did not damage the crop so severely and reduce yields. Communities to moved water and food supplies to storm shelters so that the likelihood of these essentials being exhausted by a long stay is reduced. However, this highlighted the continuing lack of capacity in the available storm shelter system, which relies on a small number of shelters (often built by NGOs) and using local school buildings. For example, in Brajaballavpur, the two shelters combined capacity is only 300 people in an area containing 1,482 families – so covering just 5% of the population. Schools can also be used but these are not necessarily designed to withstand cyclones.

Mulching reduces the impact of soil salinity on vegetable crops

A variety of weather forecasting services are becoming available, largely through SMS. These include:

- A toll-free number established by the Ministry of Agriculture to get a one day forecast
- Farmers club SMS-communicated forecast from IMD (with temperature, rainfall likelihood and humidity)
- The India Farm Fertiliser Cooperative (IFFCO) provide a seasonal and general agricultural forecast for a IR85 registration fee
- The Department of Agriculture has initiated an e-governance programme in 4 districts of West Bengal to provide short, medium and long term (i.e. daily to seasonal) forecasts via SMS

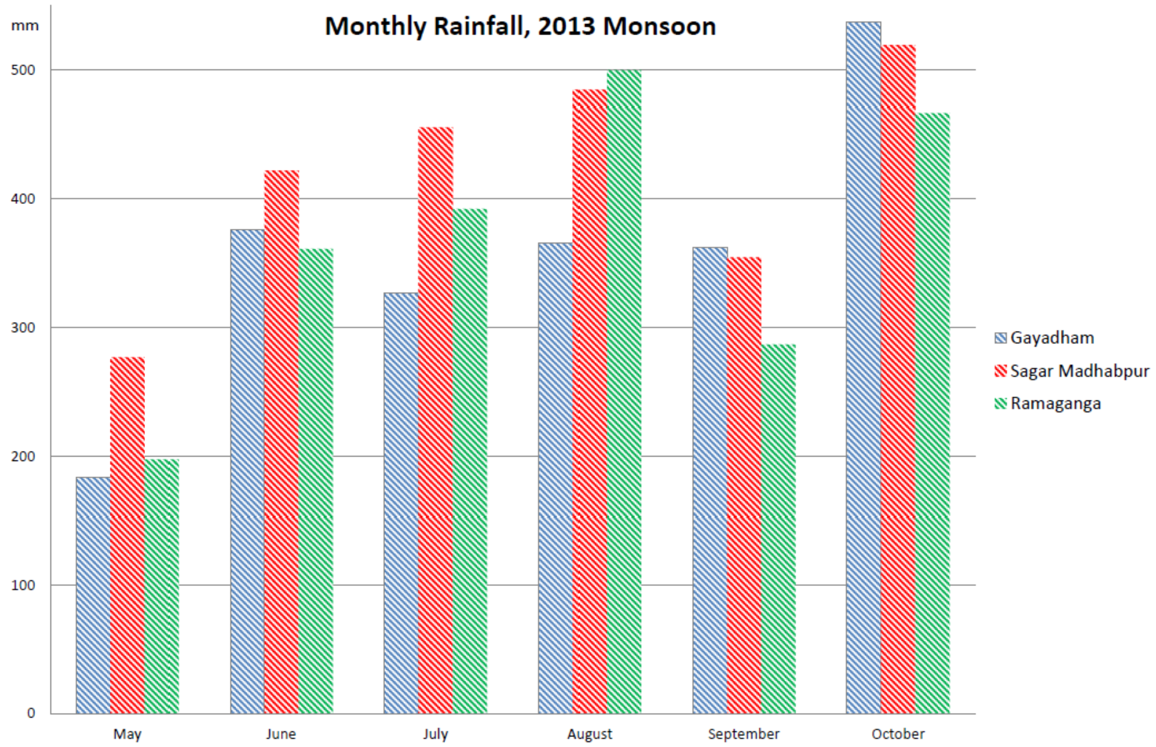
Other forecasts included the one day forecast on the radio and TV. Currently the utility of these forecasts seems limited – although discussions indicated that the monsoon start was more accurately forecast and one farmer used it to determine when to establish a vegetable nursery, the general view was that forecasts were not accurate, not relevant enough to the local area and did not include rainfall intensity guidance which was important. Brajaballavpur village also reported that a notice board was established by another NGO to show the short-term forecast for temperature, rainfall and humidity but as this lacked guidance how to relate this to normal or average conditions and as it was irregular, it failed.

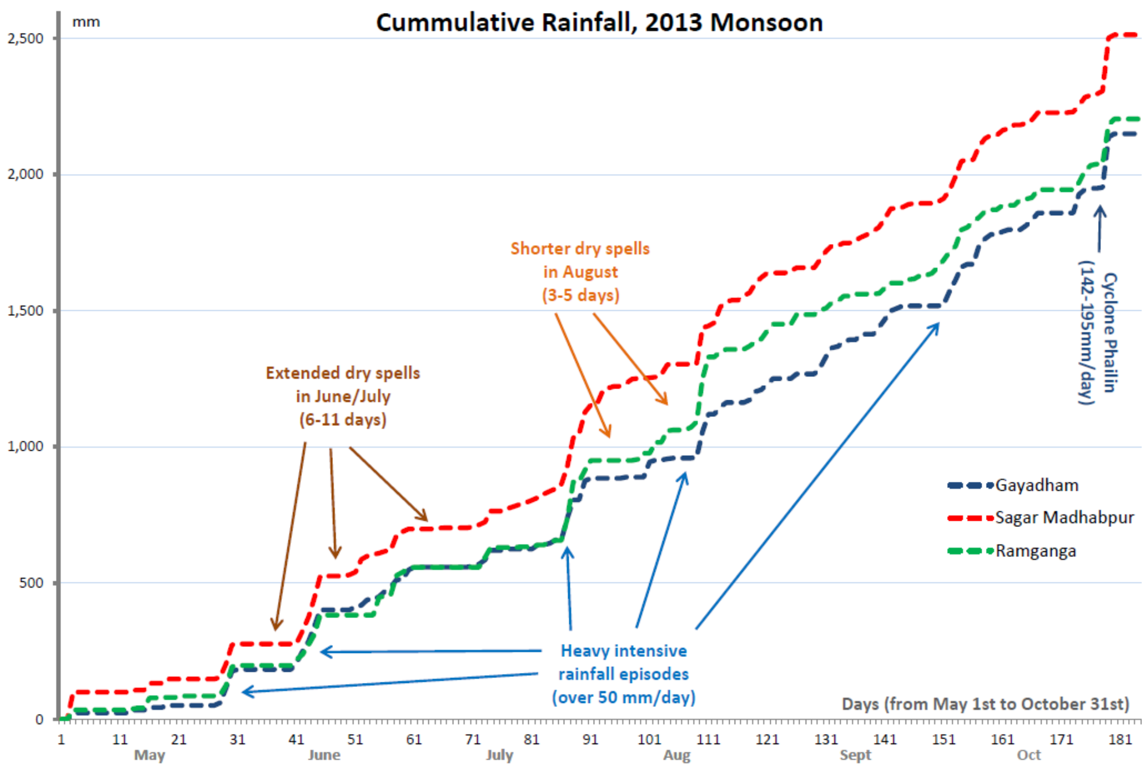
Community leaders review rainfall data with their local agricultural advisor

As the nearest climate station is 35 km away[11], DRCSC have supported the establishment of three rain gauges to enable communities to collect rainfall data and understand how this can be used for decision-making (see Fig 7 below). A feature of this has been to show how rainfall varies even between villages only 6 km apart.

[11] 3 automatic weather stations have been installed recently and access to their data is being investigated

Fig 7. Monthly and Cumulative Rainfall for the 2013 Summer Monsoon



The data also shows how the season started slowly with rainfall interrupted by long spells of dry weather well into July. Rainfall then became more intense, then steadying before the very heavy rainfall associated with Cyclone Phailin in October. Without this heavy late rainfall, amounts in October would have continued to decline towards the end of the monsoon but Phailin turned it into the wettest month, with potentially serious implications for the main rice harvest (as communities reported above).

According to the groups involved, uses of the data include:

a) Using daily rainfall data: 5 days of heavy rainfall suggests that the subsequent 5 days' rainfall will be less intense, enabling farmers to prepare or transplant seedlings.
b) Use rainfall data to compare with the situation in previous years and corresponding months. This includes using the monsoon rainfall data to estimate prospects for the winter crop (which relies more on irrigation) and guide planting options.
c) Provides guidance based on the cumulative rainfall on whether or not to lift water from ponds for crops now or conserve for later use.
d) Aids decisions on whether to release excess surface water through sluice gates to reduce the risk of waterlogging.

A Stevenson's screen has also been installed at the RTC to add temperature and humidity data to the rainfall record. Farmers also use their own local indicators which have changed with the changing climate but are still perceived as reliable. These include:

- Wind from the north instead of the south during summer (from May) indicates increased cyclone risk
- Red clouds, dogs barking and cows mooing all indicate a storm is imminent
- Ants taking eggs up a tree or house indicates intense rainfall during the monsoon
- Wind blowing strongly from the south before monsoon indicates a good monsoon season; wind from the north-east suggests a poor monsoon season
- Fog in April indicates a bad mango crop; in September indicates floods

These have changed with changing climate but are still perceived to be reliable. Group members indicated that it would be useful to know how they are changing so that they can continue to be used.

# 4. Conclusions and Recommendations

### 4.1 Conclusions

One clear feature of both projects is the high demand for climate services once end users (i.e. community members, small-scale farmers) have developed confidence in their application through direct training. This is more explicit in the 5 day forecast developed by GEAG, which is now informing a range of livelihood decisions that end users clearly assess as contributing to their resilience through both saving costs and adding productivity to their agricultural livelihoods. Forecasts are also used for household security decisions, with women emphasising the importance of this value as well as the more direction application to agriculture. SMS use has facilitated rapid spread, with registered users forwarding forecasts on to relatives and friends so that indirect users now outnumber direct users by 5 to 1. The current communication methods are the two most popular (SMS and noticeboards) – some forecast users also felt there was potential using radio if it could be locally specific enough and transmitted at the right time of day (usually evening). Regular review every month through farmer field schools was considered a valuable way of interacting with forecast developers, allowing user feedback on the accuracy of the forecast and the usefulness of the related agricultural information it contains. With users describing a change in their attitudes from initial scepticism to considerable enthusiasm for use of climate services, this interaction is an important and likely crucial aspect of understanding, gaining confidence with and applying forecasts to decision-making processes.

In West Bengal there was a clear distinction made with respect to early warning times from Aila in 2009 to Phailin in 2013, with the lead time improving from a few hours to 3-4 days. However the capacity of local cyclone shelters and other potential refuges is still only a small fraction of that required. With recent studies demonstrating the accelerating erosion of the Indian Sundarbans, the need for adequate cyclone shelter as well as the importance of addressing some of the more fundamental causes of land loss should both be advocacy priorities. As Professor Hazra pointed out *"the crisis coming is very big. We need scientists, NGOs and Government to work together or we will not solve it"*. The initial use of rain gauges has demonstrated strong interest in the use of this data and limited experience with existing forecast services suggests significant scope to expand access to forecasts if forecast users can also receive training on their use.

In both places, climate services are highly consistent with PVCA-based planning, from simple issues such as marking registered forecast receivers on community maps so all know where to get the forecast if they are not yet registered to potentially using longer-term information to guide action plan development and implementation.

### 4.2 Recommendations

In Uttar Pradesh:

- Diversifying access to climate services beyond 5 day forecasts in Uttar Pradesh – farmers expressed interest in both the seasonal forecast and understanding longer-term climate impacts. Farmers felt that if a seasonal forecast could assist them plan sowing, transplanting, crop management, etc. across a whole season, this would be useful and would then enable fine tuning through the 5 day forecast. Better understanding of the long-term impacts of climate change was also highlighted as important to action plans and to better understand the effective use of forecasts generally.
- Integrating rain gauges – these could add value to the forecast users through combining their own data with the forecast. As farmers in West Bengal highlighted, it could also increase their effective application of forecasts.

- All groups asked for more agricultural advice with the five day forecast. The advice they already get was considered especially useful as it was tailored to sustainable agricultural techniques, but they wanted more detail.
- Sustainability is a significant concern – the current system relies on a high level of in-house meteorological skill from the GEAG climatologist with the support of other project staff similarly specialised in agro-ecological agriculture to develop and communicate the forecast and advise and receive feedback from forecast users. It would be appropriate to initiate a process well in advance of the end of the project which presents the evidence of the work (see recommendations on impact assessment below), examines how it fits with any other forecasting initiatives in Uttar Pradesh and therefore how the essential elements of a system that remains highly useful to and valued by rural communities can be both continued and scaled up to cover demand across the whole state and inform practice in other states.
- Better integration of local knowledge – this is still valued and could be included in the forecast e.g. including the behaviour of local indicators on the village notice board forecast. This would enable users to see if they are more, less or equally effective in adding value to a forecast.

West Bengal

- The rain gauge data was very carefully measured and recorded and the communities involved indicated that they did use the information for some agricultural decisions. However, the potential value of rain gauge use could be more significant. There is some experience of using rain gauge data to help farmers time planting more efficiently (avoiding loss of seed caused by early season dry spells), which could assist with the rice transplanting system. Rain gauges also work well when used in conjunction with short-term and seasonal forecasts e.g. farmers can use their rainfall data to objectively judge for themselves how accurate these forecasts are and so how they should depend on them, a local forecast together with data from recent rain gauge measurements can assist water management, rain gauge data can be used in the event of drought to advocate for drought relief (especially when the drought is localised and not necessarily picked up by IMD), etc. Given the variation between villages picked up through the existing 3 rain gauges, supporting rain gauge installation for other communities would make sense but also further capacity building for communities on how to record their rain gauge data and what to use it for.
- Diversifying access to climate services beyond the early warning system and use of rain gauges - farmers expressed some interest in short-term and seasonal forecasts, with some getting some service through existing links. The general view seemed to that these were of limited use without relevant agricultural advice and guidance on whether weather conditions were average, above or below. While replicating the GEAG approach might not be appropriate, DRCSC could assess current services to understand which are likely to prove most useful to farmers and communities; what sort of added agricultural advice should be added to support existing sustainable farming models (and how these can be further promoted through the forecasting system); what role DRCSC should play as "intermediaries" of climate services, training communities on their use, adding practical advice and interpretation, etc.; what support do DRCSC need in order to play this intermediary role effectively.
- Responding to the evidence of Sundarbans research – through building a Sundarbans coalition to address the concerns raised by the conclusions of the Judavpur University research driving forward (a) a fully function EW and cyclone preparedness system (b) scaling up sustainable agriculture and increased access to effective climate services to incorporate resilience, especially to flood (saline and freshwater) (c) advocacy for improve hydrological management of the lower Ganges catchment, addressing the concerns about loss of siltation and sea level rise that are accelerating land loss in the Indian Sundarbans

In both areas, there is a critical need to ensure that evidence on the effectiveness of climate services is strengthened. The key information needed (as shown in the impact pathway described by Fig. 8 below) includes:

a) Showing how climate service users' understanding of forecasts, climate and climate change has improved so that
b) these climate services are used to make resilience-enhanced decisions in a way that they were not previously able to do
c) that has led to reduced costs (labour, inputs, etc.) and
d) increased productivity and income
e) that can in turn be (at least partly) invested in further resilience-building measures.

Although anecdotally and from the evidence presented in this report, the superior performance and resilience of sustainable, agro-ecological systems of agriculture is suggested, it has been challenging to get broader quantitative evidence for this and of the impact of the use of climate forecasts. For the two year extension of the PPA, we have the opportunity to establish a process of data gathering now that could strengthen the quantitative evidence base with respect to these two issues:

What are the key indicators?

- How does the agro-ecological model compare to the conventional, chemical approach to agriculture in terms of yield and income to farmers in both Uttar Pradesh and West Bengal?
- Is ago-ecological farming better at withstanding shocks and stresses?
- Which decisions have been changed by the use of forecasts?
- How much has this affected yield (e.g. yield data of farmers adopting forecast-based recommendations versus the average for the area)?
- How much has this affected costs (of inputs/labour, etc., suggested as more important by farmers in Gorakhpur, who also gave more precise figures for these savings)?
- How much has this improved household resilience?
- Are there any differences in access to and use of forecasts evident between men and women and between different social groups, such as landless or different categories of social status, vulnerability and/or wealth as identified by PVCAs?

To develop this evidence needs a reasonable sample of farmers, careful use of baselines (i.e. a focused set of priority questions based on these indicators), a mixture of impact assessment tools (including one-to-one interviews, focus group discussions, etc.) that efficiently assess impact to develop an evidence base that can be used to prepare case studies, graphs and (possibly) cost-benefit analysis. This will require continuous impact assessment, but designed to fit information gathering requirements with rural livelihoods, so more intense activities to match seasonality e.g. post-harvest yield assessments; with fast onset impacts e.g. a cyclone, a post-cyclone assessment to understand the effectiveness of early warnings; etc.

Both GEAG and DRCSC and other partners working on resilient livelihoods would benefit from sharing experience more actively on climate services work, understanding what works and what doesn't work, the ups and downs of linking up with specialist agencies such as IMD, how climate services fit with community planning approaches e.g. PVCA in different contexts; and how impact can be assessed and used for advocating more and better climate services. As partners in Nicaragua emphasised (see Developing Climate Services in Nicaragua), a multi-national event to bring a wide variety of stakeholders together to share these important experiences and lessons could also assist.

Fig 8. Understanding the impact pathway of (short-term to seasonal) climate services