Understanding flood forecast information provision for agriculture in Bangladesh

Mst. Sharmin Akter

Propositions

1. Effective forecast information provision requires coordinated efforts along the entire information chain.
   (this thesis)

2. Improving the accuracy of forecast information without ensuring its availability at farm level is worthless.
   (this thesis)

3. Conducting qualitative participatory research poses more challenges than conducting lab-based experiments.

4. Job entrance examinations imposed by employers can steer students away from obtaining a true academic training.

5. Relief dependency undermines communities in utilizing their capacities.

6. Decentralization of the resources and power in Bangladesh would contribute to greater economic growth, working efficiency and environmental health in Dhaka city.

7. Forced lockdowns are equally deadly for resource poor people in Bangladesh as being exposed to Covid infection.

Propositions belonging to the thesis, entitled

Understanding flood forecast information provision for agriculture in Bangladesh

Sharmin Akter
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Abbreviations and acronyms

AESA	Agro-Ecological System Analysis
AWS	Automatic Weather Station
BDPC	Bangladesh Disaster Preparedness Center
BMD	Bangladesh Meteorological Department
BPH	Brown Plant Hopper
BRRI	Bangladesh Rice Research Institute
BTV	Bangladesh Television
BWDB	Bangladesh Water Development Board
CDMP	Community Development and Management plan
CFS	Climate Field School
CPP	Cyclone Preparedness Programme
DAE	Department of Agricultural Extension
DCRMA	Disaster and Climate Risk Management in Agriculture
DDM	Department of Disaster Management
DDMC	District Disaster Management Committee
DMB	Disaster Management Bureau
DMIC	Disaster Management Information Centre
DMO	Divisional Metrological Observatories
EPWPDA	East Pakistan Water and Power Development Authority
FFS	Farmer Field School
FFWC	Flood Forecasting and Warning Centre
GIS	Geographic Information System
GMT	Greenwich Mean Time
HRW	Heavy Rainfall Warning
ICT	Information Communication Technologies
IFMC	Integrated Farm Management Component
IPM	Integrated Pest Management
IVR	Interactive Voice Response
JMA	Japan Metrological Agency
MAC	Meteorological Application Centre
M&GC	Meteorological & Geo-Physical Centre
NATP	National Agricultural Technology Programme
NDRCC	National Disaster Response Coordination Centre
NGOs	Non-Government Organizations
NWP	Numerical Weather Prediction
PIO	Project Implementing Officer
PRA	Participatory Rural Appraisal

PTWC	Pacific Tsunami Warning Center
REA	Revised Extension Approach
RIMES	Regional Integrated Multi-Hazard Early Warning System For Africa and Asia
SAAO	Sub Assistant Agriculture Officer
SMS	Short Message Service
SPARRSO	Space Research and remote Sensing Organization
STORM	Severe Thunderstorm Observation and Regional Modelling
SWC	Storm Warning Centre
UDMC	Union Disaster Management Committee
UNDP	United Nations Development Programme
UNHCR	United Nations High Commissioner for Refuges
USAID	United States Agency for International Development
UzDMC	Upazila Disaster Management Committee
WFP	World Food Programme
WMO	World Meteorological Organization

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Chapter 1

Introduction

1.1 Background

Climate change has become a growing concern across the world that challenges the agricultural production, food security and livelihoods of millions of people around the world (Khatri-Chhetri *et al.*, 2017; IPCC, 2014). Bangladesh, the biggest delta in the world, experiences heavy rainfall and seasonal flooding from June to September almost every year, with a devastating flood every 5–8 years due to its geographical location, land features, and many rivers across the country (FFWC, 2004; Mondal *et al.*, 2013). Such floods inundate 34 percent of Bangladesh's land area (of which 80% can be characterised as flood plain) for about five to seven months every year, (Kabir and Hossen , 2019). During severe floods, the affected area may exceed 55 percent of the country's total area (Anonymous, 2008; Rahman, 2010). Climate change is likely to affect the frequency and impact of these risks, leading to increased vulnerability (Roy *et al.*, 2020; Alam e*t al.*, 2017; Alam, 2016; Jordan, 2015; Thomas *et al.*, 2013; Pouliotte *et al.*, 2009; Huq and Ayers, 2007; Choudhury *et al.*, 2005).

Bangladesh is an agricultural country, and the livelihoods of poor rural households largely rely on agriculture, which is severely affected by floods and unpredictable weather and climatic events (World Bank, 2016; Parveen, 2009; Islam and Hasan, 2016; Huq *et al.*, 2015; Khanom, 2016; Kumar, 2021).

Both the national and international communities recognise that developing weather and climate services is essential to minimize the effect of climate variability and change (Vaughan and Dessai, 2014; Ouédraogo *et al.*, 2018; Bruno *et al.*, 2018; Vedeld *et al.*, 2019; Nyadzi, 2020; Islam *et al.*, 2013) and to support the planning and management of agricultural activities, for example through better anticipation of flooding (Gbangou *et al.*, 2020; Paparrizos *et al.*, 2020; Naab *et al.*, 2019; Nyadzi *et al.*, 2018; Rahman *et al.*, 2020; Kundu *et al.*, 2020; Kumar, 2021).

The term weather and climate information services refers to a broad spectrum of forecast information services in terms of the production, translation, dissemination, and usage of the weather, climate, and flood related information to support societal decision-making (Vedeld *et al.*, 2019; Kruk *et al.*, 2017; Amwata *et al.*, 2018; Vaughan and Dessai, 2014; Kumar, 2021).

Since 1972 stepwise progress has been made in Bangladesh in flood forecasting and warning services, with new Information and Communication Technologies (ICTs) playing an important role (Paudyal, 2002; Islam *et al.*, 2013; Naab *et al.*, 2019; Partey *et al.*, 2020). Although the technological opportunities for the generation and dissemination of forecast information are considerable, previous research indicates that there also remain many challenges and gaps in being able to effectively provide forecast information to farmers.

1.2 Knowledge gaps and the focus of this study

Many studies have investigated the potential role of advanced forecast information services to enhance adaptation to climate change and improve agricultural production throughout the world (Owolade and Kayode, 2012; Sam and Dzandu, 2015; Roncoli *et al*., 2011; Heidekamp, 2014; Coulibaly *et al*., 2015; Sivakumar *et al*., 2014; Bruno *et al*., 2018; Templeton *et al*., 2014; Christel *et al*., 2018). Much research has examined forecast information services as a tool to support farm management decisions in the context of Bangladesh and other regions.

Many challenges to effective forecast information service provision have been reported through different studies, and typically they focus on several key problems or issues. A number of studies focus on the forecast information itself, and they typically point to the need to improve the timeliness, accuracy, and reliability and accessibility of information (Islam *et al*., 2013; DAE, 2018, Ahmed *et al*., 2019; Fakhruddin *et al*., 2015; Kumar, 2021). This is accompanied by the considerable interest in enhancing scientific forecast models related to climate, weather and floods (Hammer, 2001; Hansen, 2004; Esquivel *et al*., 2018), and developing novel ICT technologies as a vehicle to enhance access to such information (Kumar *et al*., 2020; Muzreba, and Rahman, 2014; Hasan, 2015).

Other studies have focused on the farmer level. These studies point to the limitations in farmers' capacities to interpret and understand forecast information and use it effectively in their farming practices (Archie et al., 2014; DAE, 2018). At the same time, several authors have signaled that forecast information tends to be provided in a supply-driven fashion, and is currently not very responsive to specific demands of farmers (Kumar, 2021). In response to this, several researchers have experimented with co-production approaches whereby farmers participate in the design of (mostly ICT-based) information services, demonstrating that this is a promising route to creating more relevant information services (Kumar et al., 2020; Sarku et al., 2021; Nyadzi, 2020).

In between information and farmer-oriented studies we see mostly quantitative studies that focus on information availability at the farm level, and at the sources and media that farmers use or prefer to gain access to information (Kumar *et al*., 2020; Nyamekye, 2020; Khan, 2012). Several such studies point to similar challenges and problems as mentioned above.

Less attention has been paid to the (inter) organizational and institutional set-ups through which forecast information is produced and made available, and how these contexts complicate or facilitate the ambition to enhance the provision of information services to farmers. Although several authors make a plea for tailoring information provision to farmers' needs (e.g. Kumar, 2021) there is limited in-depth understanding of how the large diversity in local agro-ecological conditions and community characteristics in Bangladesh may shape the uptake and use of information. Thus, there is a need to develop a greater contextual understanding of how and why different parties (e.g. information producers, authorities, intermediaries and farmers) interact with each other, and how this is shaped by the context in which actors operate.

Several studies in Bangladesh and elsewhere in the world suggests that the relevance of forecast information service might benefit from linkages with the existing agricultural knowledge and information systems (Islam et al., 2013; Kumar, 2020) so that it can be integrated with other advice of local extension services that aim at better-informed agricultural decision-making to improve agricultural production and food security in developing countries (Weiss *et al.*, 2000). While the importance of such integration has been acknowledged in the academic literature, very few studies have actually explored how extension intermediaries do, or could, play a role in integrating forecast knowledge with other knowledge. It seems that the role of regular extension organizations and media in providing information services has been partially overlooked in the face of strong belief in the potential of novel ICT (McCampbell, 2021; Munthali, 2021).

In essence, we see that considerable research has been devoted to explore the separate aspects involved in forecast information provision, such as forecast information characteristics, dissemination and the use of forecast information for farm level decision-making and hence only generate a partial understandings (Bruno Soares and Dessai, 2016; Lemos *et al.*, 2012; Dutta and Basnayake, 2018; Kumar *et al.*, 2020). Thus far, less attention has been paid to investigate the entire chain of information flow and the interactions in the network of actors that are involved in the production, dissemination, communication, integration and use of forecast information, and how such broader contextual dynamics influence forecast information provision at local level.

In all, there remains a lack of insight in: (1) how different elements and processes in the entire forecast information chain interact with each other and how this eventually shapes the usability of information by farmers, (2) how flood forecast information is integrated with other agricultural knowledge and information through different extension activities and (3) how the challenges and opportunities for the use of forecast information vary across and within farming communities in different locations.

In order to gain insights into the contextual dynamics and interconnections, and in order to complement the predominantly survey-based social science research in Bangladesh, this dissertation addresses the knowledge gaps by using an in-depth qualitative perspective to better understand the social logic of challenges along the chain in the provision of useful forecast information.

1.3 Research objectives and questions

The main objective of this research is to explore and analyse the entire chain in which forecast information is produced, disseminated, accessed and integrated in agricultural extension activities, with the view of identifying constraints and opportunities to effectively provide information to farmers. The study for this thesis investigated different steps of the whole process of information flow, particularly analysing how information is produced, disseminated, and integrated with extension activities for anticipating flood and climatic risk management in Bangladesh, as well the farming contexts to which this information is applied. Thus the main research question that the thesis addresses is: What constraints and opportunities to effective information provision exist along the chain in which forecast information is produced, disseminated, accessed and integrated within agricultural extension activities?

Four specific set of sub-questions emerge from this, as outlined below.

(1) *How do different organizations generate forecast information, what types of information are produced and why?*

(2) *Through what media and channels is forecast information disseminated to the local level, and how, and to what extent, is such information accessed by farmers in different communities?*

(3) *What are the existing farm management practices to deal with the flood and climatic risk across farmers operating in different agro-ecological conditions ?*

(4) *How is forecast information integrated with other information as part of extension activities to generate recommendations for flood and climatic risk management, and how are these valued by farmers?*

1.4 Conceptual orientations

It is often argued that information needs interpretation to become usable for decision-making and conversion into action in specific contexts (Sarku, 2021; Lemos et al., 2012). Therefore, it is necessary to explore how such interpretations and conversions take place in order to assess whether the information is usable or not. When considering the chain of forecast information flow, it is useful to think about some pertinent aspects and processes in the chain in order to better understand the factors that directly or indirectly influence the usability of information at the farm level.

The way forecast information is produced and then sent out to users, involves a wide range of organisations, social actors and technical procedures. In the field of social studies of science and technology, it has been argued that technologies are not neutral but carriers of particular social interests (Introna and Ilharco, 2004). The same has been argued for knowledge, information and communication (Leeuwis, 2013; Turnhout, 2016; Ludwig *et al.*, 2021). Thus information does not flow as a neutral element along a chain from information production to integration and utilization (see Figure 1.1). In order to be able to capture the social interests along the chain, this study makes use of a situated practice perspective (Suchman, 1987). Suchman (1987) studied human-computer interactions in a variety of contexts, and concluded that cognition and action are shaped by the environment in which these interactions take place. A situated practice perspective thus emphasises the need to investigate the perpetual interaction between cognition and action in specific environments.

Orlikowski (1993) similarly argues that technologies can be analysed as situated practices; that is, what people do with technological artifacts in their everyday lives. This perspective can be applied to the technologies used to produce and convey information, and also to information itself. In each situation and context, forecast information is given a particular meaning that results from social interactions among actors with different interests and perspectives through adjustment, re-shaping, or co-production within each particular situation.

The following sections describe how this broad situational perspective has been used to investigate the various processes involved along the chain from forecast information production to its integration in extension activities (see Figure 1.2). To study the various processes, the situational perspective is combined with concepts relevant to this process. These concepts are briefly introduced below, and further elaborated in the subsequent chapters of the dissertation.

Understanding the production of forecast information

First of all we need to explore how information is developed or produced by the relevant agencies in order to understand the chain of information. The production of forecast information is based on the extrapolation of collected climate data. The meteorological institutes and services in Bangladesh are government organizations, as they are in most countries. And as in most other countries, the process and procedures for collecting weather data and turning these into reliable forecasts includes a range of steps, involving various components such as technical equipment to measure basic weather indicators: such as temperature, rainfall and wind speed.

The measurements at the local weather stations enter a system of administrative procedures and routines to register such data and communicate them to the national climate centre, (in this case the Bangladesh Meteorological Department), where data from all the weather stations in the country, are put together and inserted into climate models from which weather and flood forecasts are made.

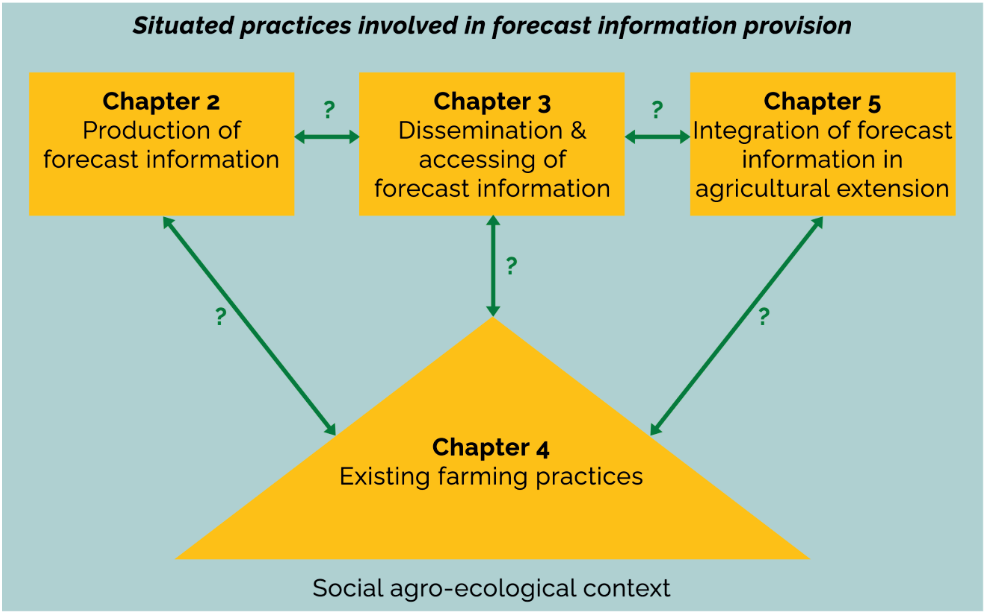

Figure 1.1. Chapters in the dissertation and their link to the chain in which forecast information is produced, disseminated, accessed and integrated into agricultural extension

A meteorological department thus functions as a centre of calculation, a notion developed by the French philosopher and sociologist of science Bruno Latour in his seminal book Science in Action (1987). The Bangladesh Meteorological Department is a classical example of such a centre, where climate data are accumulated and weather forecasts are send out, acquiring a scientific status and an image of reliability. Reliable forecasts thus are constructed through the activities of various technicians and climate scientists. As will become clear in chapter 2, the Bangladesh Meteorological Department is not the only organisation dealing with collecting weather data and turning these into forecasts. In addition, weather and flood forecasts require interpretation and further 'processing' to make them ready for use. As many studies have pointed out, understanding the entire chain from forecast production to use in Asian contexts and other regions is complex and dependent on many factors (Bruno Soares and Dessai, 2016; Dil-ling and Lemos, 2011; Lemos *et al.*, 2012; Dutta and Basnayake, 2018). The notion of situated practice is used in chapter 2 to look at the various organisations involved in producing weather and flood forecast information. These organisations are not monolithic units but each consist of various stations and sub-units. Moreover, these organisations have histories, which help to explain their overall features and mandates and *modus operandi*.

Dissemination and access: understanding whether, and how, people receive information

When disseminating information, information providers generally view themselves as dispatching usable information. However, in practical situations this information is often not used by farmers (Sarku, 2021). The mode of delivery (presentation and mode of communication) is one of the key processes that affects successful application of forecast information (Lemos *et al.*, 2002; Sarku, 2021). The mode of delivery can shape whether and how forecast information is accessed at the local level by different categories of farmer.

Dissemination can be understood as the spreading of information without necessarily getting direct feedback by the audience (Van den Ban and Hawkins, 1996; Leeuwis, 2004; Sulaiman and Hall, 2002). Information may be disseminated through different media, devices that provide and often combine different channels of communication, such as text, images (maps, photographs or videos) or sound. Thus, information and messages are disseminated in particular forms and/or languages that may or may not link effectively to the intended user in particular settings (Leeuwis, 2004; Munthali *et al.*, 2018). These concepts, derived from communication and extension studies, can help illustrate whether or not the media and channels used for sending information, and the media preferences and capacities at the receiving end actually match, and what the implications are for effective dissemination (Feleke, 2015).

Understanding the existing farming context(s)

After disseminating information, the usability of information depends on the context of the users where the information arrives (Sarku, 2021). In this thesis the users are those practicing farming along one of the main rivers of Bangladesh. Understanding their contexts is essential for effectively communicating this information to farmers (Vogel and O'Brien, 2006; Kumar, 2021). As many studies have pointed out farmers living along Bangladesh's rivers have to deal year in and year out with irregular weather patterns and yearly variations in floods (Anam, 1999; Nasreen, 1999; Del Ninno *et al.*, 2002; Few, 2003; Ahren *et al.*, 2005; Khandker, 2007; Baten *et al.*, 2018). There are some studies on adaptation to hydroclimatic variability that reveal that farmers have already modified a range of cropping practices (Chaudhury *et al.*, 2012; Talukder, 2016; Khanom, 2016). The overall picture emerging from these studies is that appropriate information about the weather and floods is important but not enough. A detailed look into the farming activates throughout the year thus will help us to understand how flood forecast information may or may not be effective and the factors that influence this.

Secondly, understanding the context(s) in which farmers work is essential to understanding the decisions they have to make throughout the year. Farming requires adaptive decision making in response to uncertain weather conditions and limited information (Patt & Gwata, 2002; Lemos, 2008). This adaptative decision making is rooted in local knowledge which informs farmers' perspectives and their attitudes towards introduced innovations (Loevinsohn and Kaiser 1982; Chambers and Jiggins 1987a, 1987b; Glover *et al.*, 2017). Chapter 4 shows that the practices of farmers along the rivers of Bangladesh contain a mixture of older and more recent adjustments to floods. These 'situated practices' of farmers thus entail flexibility and change, which raises issues about the ways in which flood forecast information can effectively contribute to farmers' practices.

Integrating forecast information with other knowledge within extension activities

The availability of forecast information at the local level does not guarantee that farmers will make use of it within their decision-making (Lemos *et al.*, 2012; Sarku, 2021). These contexts are complex, and require farmers to carefully navigate and coordinate their numerous activities and the decisions regarding different farming domains, locations and time horizons (van der Ploeg 1990; Leeuwis 2004). Forecast information needs to be linked with agronomic knowledge and information of various kinds in order to be useful and inform decisions, for example on cropping systems, management of soil fertility, pests and diseases (Weiss *et al.*, 2000; Nyadzi, 2020). This process has been referred to as knowledge integration as it involves linking knowledge from different domains and disciplines in a manner that is suited to decision-makers (Faraj *et al.*, 2011; Gardner *et al.*, 2012; Yoo, 2017; Hammer *et al.*, 2001; Meinke & Stone, 2005; Roger and Meinke, 2006; Berggren *et al.*, 2001). Hence, it is important to understand what happens at local level, beyond the dissemination and accessing of forecast information, and understand the situated practices and interactions where such information is linked, adapted and made relevant. In the context of Bangladesh and other developing countries, agricultural extension organisations play an important role in such local level translation and integration. They are mandated to connect and communicate with farmers on a broad range of issues related to technology, resource availability, markets and policy (Jones *et al.*, 2000; Jagtap *et al.*, 2002; Hansen, 2002; Weiss *et al.*, 2000) and offer practical guidance. Such guidance usually takes the form of recommendations given by the local level extension worker through different extension activities (farm and home visits, group discussions, farmer field schools, field days, etc). Hence, this dissertation will investigate extension activities and recommendations as important situations in which forecast information can (and should) be integrated with other knowledge and information, and how this resonates with the contexts in which farmers make decisions.

1.5 Research methodology

Research setting and context

The study for this thesis was part of a bigger project titled "Integrated management of crop-fish-water resources to enhance agricultural production systems towards sustainable food security in Bangladesh". The project thus had a clear focus on agriculture and this study focuses on the connection between flood forecast information and agriculture. The study was conducted in Jamalpur district in the north of Bangladesh (Figure 1.2). The district is located in a region where many rivers or branches of rivers such as the Jamuna, Old Brahmaputra, Jhenai, Banar, Jirjira and Chhatal flow close to one another (DAM, 2013). Jamalpur district is one of the poorest and most disaster-prone districts of Bangladesh. Floods in the monsoon period alternate with water scarcity in the dry period. River bank erosion changes the availability of land. An overall low literacy rate and high outmigration characterise the endemic local poverty (Mukta, 2020).

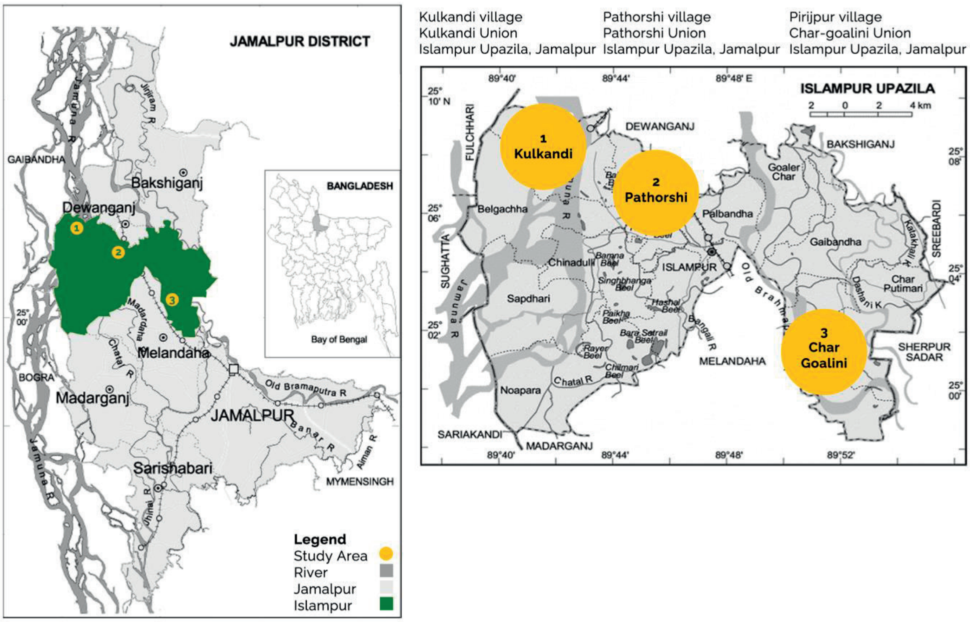

Figure 1.2. Left side map of Jamalpur district showing the study area (Islampur sub-district) and right side map indicating location of the three (study) Unions in Islampur Upazila, Jamalpur.

Jamalpur has seven sub-districts, locally called Upazila. Islampur Sub-district was selected because of its closeness to the Brahmapurta-Jamuna flood basin (Rahman, 2010). Besides the geographical setting, Islampur sub-district was also selected because of the various development initiatives by government organizations implementing and

disseminating forecast information to local people.
An Upazila contains several Unions which include several villages. The villages selected for this study are Kulkandi (25°07’41”N-89°42’90”E), Pathorsi (25°06’88”N-89°44’24”E) and Pirijpur (25°02’05”N-89°50’83”E). Kulkandi and Pathorshi are part of the same Union, while Pirijpur is part of the Char-goalini Union. People in the three villages face floods every year.
The villages differ in topographical and agricultural characteristics, for example land elevation and cropping pattern (see Table 1.1).

Research design
This dissertation uses a multiple case study design to generate an in-depth and rich understanding of the situation under study (Yin, 2009). The boundaries of the case-studies are defined along two lines. On the one hand the study focusses on and compares the experiences of farmers in three different geographically-defined village settings as outlined in Table 1.1. On the other hand, the study uses the different organisations and programmes that are involved in the production, dissemination and integration of forecast information as the starting point for the analysis. In several chapters these two points of entry are combined, so that the focus is on the experiences that exist within and between the different villages with the various organizations and programmes that are active in these settings in connection with, for example, dissemination of information.
The case study approach is chosen because the research questions posed in this thesis are mainly how and why questions (Yin, 2009).
Case-studies allow for in-depth empirical investigation and a comprehensive research strategy that involves multiple sources of evidence to examine a complex problem within particular context (Yin, 2003; Hyett, *et al.*, 2014). In addition, a case-study design makes it possible to combine a variety of data collection strategies and methods, and to use these to triangulate findings and work towards developing strong evidence.
The study for this thesis used a qualitative approach, that is suitable when the purpose is to explore new angles to examine an emerging field or problem (Flyvbjerg, 2006). A qualitative research strategy is especially suited for contextual research where it is not possible to assume clear boundaries between the studied phenomenon and the context (Bryman, 2004; Mason, 2002; Yin, 2009). This is in line with the situated practice perspective adopted in this study, and supports the generalization of the findings in theoretical and analytical terms rather than seeking to extrapolate them to other settings (Yin, 2009).
The main data collection methods used in the four chapters are briefly discussed in section 1.5.3, and are summarised in Table 1.3. More details are provided in the individual chapters.

Research methods, and data collection tools

The data collected for this thesis originates from three types of sources. The first source is documents and other written materials, such as leaflets from various organizations working on forecasts and agricultural extension. The second source is interviews with officials, mostly technicians, researchers and administrative officials of various government organizations. The third and most important data source is the interviews, focus groups and informal conversations with farmers. Alongside these three main sources, notes were taken from observations during the visits to the villages and various organizations. Field work was undertaken from February, 2015 to end of 2016. There were mainly two phases of data collection, as outlined below.

In 2015, data collection started with an exploratory study. Informal interviews and documentary analysis of relevant organizations were used to identify relevant personnel within the institutes and organisations that produce, collate and disseminate forecast information. These informal interviews helped to identify which officials are responsible for generating and disseminating forecast and related advisory information both at central and local levels and the questions and information that would be relevant for the subsequent in-depth interviews. In the villages the exploratory work consisted of informal discussions with the district and Upazila officials of the Department of Agricultural Extension (DAE), non-governmental organizations and scientists from the regional agricultural research stations. The district and Upazila officials put me in touch with local level extension workers in the three villages. In addition, informal visits to farmers' homesteads and fields were made and transect walks undertaken, during which informal conversations helped me to acquire an overview of the activities within and challenges facing farmers in the three villages. The exploration also included attending village markets and shops, farmer field school sessions organised by the DAE and group meetings of local disaster management committees.

After the exploratory work, appointments were made with various technicians and officials for interviews and field visits for follow-up data collection in the villages. Interviews were held with 44 staff members of the three main forecast-producing organizations. At the village level, interviews and conversations with other extension staff members formed an additional data source.

The in-depth interviews with officials responsible for generating and disseminating forecast information from central level to local level were set up around four main themes:

i) the process of making predictive forecast and other related advice;
ii) the ways of working and exchanging information with other organizations;
iii) the content and goals of the different forecast and advisory services, and;
iv) the kind of forecast information presented to local communities by different sources and the media and channels utilised.

Table 1.1. Main features of the study villages

Features	Kulkandi	Pathorshi	Pirijpur
Land type based on elevation	Low land (8-12 m) Medium low land (13-17m)	Low land (6-9m) Medium low land (10-13m) Medium high land (14-17m) High land (18-21m)	Low land (7-12m) Medium high land (13-18m) High land (19-24m)
Distance from river	The Jamuna River is very close to the village	The Jamuna river is one km away from the village.	The Brahmaputra River runs through the middle of the village
Distance from nearest market	½ Km	½ km	1km
Distance from closest agriculture office	13 km	6 km	8 km
Cultivated area	700 ha	600 ha	250 ha
% Farmers category based on landholdings	Landless (70%) Marginal to medium (30%)	Large and landless (25%) Marginal (25%) Medium (50%)	Landless (3%) Small to marginal (30%) Medium (60-65%) Large farmers (5-10%)
Infrastructural facilities			
Asphalted road	No	Yes	No
Earthen road	Yes	No	Yes
Electrification	Yes (partly)	Yes (full)	No
Health clinic	Yes	Yes	Yes
Union parishad office	Yes (but damaged by earlier flooding)	Yes, 1 km away from the village	Yes, 1.25 km away from the village
Means of transport	Foot, bicycle, motorcycle	Bicycle, motorcycle, rickshaw, auto-rickshaw, van	Foot, bicycle, motorcycle and boat
Number of social institution			
-Primary school	1	2	1
-High school	1	1	-
-Madrasa	1	1	-
-Mosque	3	3	3
-Community clinic	1	1	1
Number of development organizations			
Access to forecast and other information	Project of FFWC, UDMC, NGOs (Shouhardo-ii , The Red Crescent Society, BDPC), DAE (IFMC FFS),	DAE (Climate Field School, Integrated Pest Management FFS)	DAE (Climate Field School, Integrated Pest Management FFS), NGO (MforC)

The field work at the local level (for Chapter 4, 5 and part of Chapter 3) used group discussions, interviews and observations of activities during training sessions and meetings organised by the DAE as well as the activities of farmers in their fields. Local level extension workers within the three villages and model farmers helped me to build the acquaintances with the farmers.

Within the chosen villages, the selection of farmers was based on two sampling criteria i) whether farmers participated in an FFS or not, and ii) whether they were farming in the higher or lower parts of the village, or both. Using these criteria farmers were classified into 6 groups (see Table 1.2), and 2 farmers were selected randomly from each group. Thus, 36 (6*2*3 =36) farmers, who were willing to spend time for about two to three hours being interviewed, were selected for interviews.

In-depth interviews were conducted with these farmers to elicit qualitative data about their (differential) access to forecast information. Observations of training sessions and meetings gave good insights into the interactions between farmers and officials, facilitators and disaster committee members. The interviews focused on farmers' livelihoods and their strategies for managing agricultural risks, especially flood risks.

Table 1.2. Selection criteria and resulting sample groups of farmers in the study villages

Samples (n = 36; 6 per group; 2 per group per village)	**Fields in higher part**		**Fields in lower part**		**Membership field school (or other)**	
	yes	No	yes	No	yes	No
group 1	x		x		x	
group 2	x			x	x	
group 3		x	x		x	
group 4	x		x			x
group 5	x			x		x
group 6		x	x			x

Interviews with the extension workers at the sub-district and local levels were conducted in order to explore the extension activities employed in the three villages and how these activities include forecast information. Farmers were also asked how they valued the advice and recommendations provided through the extension activities. A number of field photos were taken in different phases of the research and small video clips were also produced in order to get useful insights about the institutional context of making and disseminating forecast information, the relationships and interactions between stakeholders with farmers through different extension activities and existing farming practices for flood and climatic risk management. Informants were asked for consent for recording (audio or film).

For the in-depth interviews with the farmers and local level extension workers semi structured interview schedules were used, based on open-ended questions and lists of relevant topics designed to elicit qualitative information in the form of experiences, examples and stories.
Depending on respondents' interest and availability, I often conducted more than one interview session with the same participant. Whenever possible, after getting consent from the informants, interviews, informal and group discussions, and observations were audio recorded and field notes were taken during and after the data collection. Whenever necessary, I checked the details from interviews and conversations with a follow-up phone call in order to get missing information or to clarify any confusions that arose when I was working on my field notes.

Data Analysis

Audio records of interviews, discussions and observation were transcribed, focusing on the main issues. Initially, all the transcribed data and field notes were read repeatedly to get a sense of the main ideas and themes. The texts were then divided into smaller parts ('meaning units') which were then condensed further without changing the core meaning. After that, a coding system was developed based on the specific research objectives and the concepts used, and with the aim of bringing together all the relevant information around each topic (Weber, 1990; Steve, 2000). Then through iterative re-reading, coding categories and themes were developed to get an overview of the responses of the interviewees about each topic (Erlingsson and Brysiewicz, 2017). After completing the coding the collected data were examined to find patterns and draw conclusions in response to the research questions. Further details of the methods and analysis are provided in the respective chapters.

Table 1.3. An overview of the data collection used in the research

Research question	Chapter	Objective of the approach	Data collection
1	2	Assess how forecast and related information is produced in the formal settings of different organizations and the effect of institutional settings on the creation of forecast information.	-Informal interviews with different officials of FFWC, BMD, BWDB & DAE and extension personnel at different levels and documentary analysis of respective organizations.
2	3	Investigate the existing forecast information dissemination strategies at the local level; identify and describe the differential (if any) access to that information and the obstacles facing farmers in the study villages of accessing that information.	Informal discussions with local level stakeholders; in-depth interviews with different stakeholders Including farmers within the three villages; group discussions with participant farmers and observing different local activities for disseminating forecast information (disaster management meeting, NGO meeting, farmer field school activities)
3	4	Assessing farmers' existing or current management practices for dealing with flood and climatic risk, and; understanding different farm management practices employed by different groups of farmers (especially who only have access to low land).	Informal and group discussions with farmers to prepare the participatory GIS mapping of the study villages, and aid in selecting sample farmers. Focus group discussions with farmers from the study villages to aid preparing semi-structured questionnaire. In-depth interviews with a sample of farmers from the three villages. Observing how farmers manage their farms over two seasons, especially the flood seasons. Narrative and descriptive recordings were used to record the observations.
4	5	Investigate how forecast information is integrated with other knowledge and information within different extension activities, with special attention to the analysis of recommendations and their appreciation by farmers.	Literature review and secondary document analysis. Informal discussions with district and sub-district level DAE (extension) officials, non-governmental organizations and scientists from the regional agricultural research station. Participatory rural appraisal techniques (transect walks, village map exercises, informal conversational interviews, and interactive group discussions) with farmers from the study villages. Group discussions and informal conversational interviews with members and non-members of farmers' field schools (FFS) to prepare the detailed (schematic) map of the villages, and to aid in selecting sample farmers. In-depth interviews with sample farmers. In-depth interviews with the sub-district extension workers involved with local level extension activities and the field facilitator. Ethnographic observations of the meetings and FFS sessions and extension activities.

1.6 Thesis outline

This thesis has six chapters. This introductory chapter is followed by four empirical studies (Chapters 2 to 5) and a conclusion Chapter (6). The empirical chapters are organized in a sequence that enables the reader to follow the flow of information from its production (Chapter 2), to its dissemination to the local level (Chapter 3), to the farming context to which it is supposed to have relevance (Chapter 4), and finally to its integration within extension activities and recommendations geared towards supporting farmer decision-making (Chapter 5). Chapter 6 brings the findings together and reflects on them from broader perspectives.

Chapter 2 explores the systems and the formal organisational settings through which forecast information is created, showing how and why organisations produce particular forecast information.

Chapter 3 explores how different organizations disseminate forecast information to the local level through various media and channels, and investigates how this connects to the media that farmers from the different communities use to access such information.

Chapter 4 seeks to understand how farmers have developed their own ways and means in farm management practices on different types of farmland. The focus is on the interactions between elevation and choices about particular crops, crop varieties and crop management.

Chapter 5 focusses on how forecast information is made usable beyond its dissemination, and investigates how forecast information is integrated with other agronomic knowledge and information within agricultural extension activities and messages.

Chapter 6 provides a synthesis of the empirical chapters. This chapter presents the main findings from the separate chapters and discusses cross-cutting issues and themes. The chapter also makes recommendations for research, policy and practice to improve forecast information provision in Bangladesh and enhance its relevance and understandability to farmers.

2

Chapter 2

The Construction of Forecast Information

2.1 Introduction

Low lying areas of Bangladesh are regularly inundated by seasonal floods due to their geographic position. Many of these floods are within tolerable limits as the local population has found ways to deal with them without casualties, food shortages or heavy damage. However, floods are unpredictable, both in time and severity, and some have devastating effects. During severe floods, the affected area may exceed 55 percent of the country's total area (Anonymous, 2008; Rahman, 2010). As the unpredictability and severity of floods increase farmers face greater problems with agricultural production, such as damaged crops and drowned livestock as well as more indirect effects, for example higher levels of pest and disease infestations. Besides damage to agricultural systems, floods can displace large numbers of people living on river banks and in low lying areas and heavy floods can often result in thousands of casualties if not fatalities (Brocklesby and Hobley, 2003).

Bangladesh has a long history of flood control and drainage projects. A major programme was introduced after the devastating flood of 1963. However, structural measures alone failed to protect the people and infrastructure from floods. An important aspect of flood control programmes is the development of flood forecasting and warning systems. These systems provide early warnings so that people, communities, agencies and organizations can take action to take safety measures and reduce damage (Bhuiyan, 2006). With technological advancements, there has been stepwise progress in the flood forecasting and warning services since 1972. After a catastrophic flood in 1998, a computer-based forecasting and warning system was first used as part of the Flood Action Plan. Upgraded forecasting systems and more advanced communications technology have increased its predictive efficacy. However, evaluation studies have pointed out that forecast systems only cover the main rivers and have limited relevance for local populations outside of these catchments (Paudyal, 2002; Islam *et al.*, 2013).

Bangladesh's flood warning systems are an example of a wider set of technologies for climate forecasting, that are increasingly important in many developing countries where the effects of climate change are increasingly affecting the livelihoods of already vulnerable people (Roncoli *et al.*, 2011; Heidekamp, 2014; Jones *et al.*, 2000; Bruno *et al.*, 2018; Templeton *et al.*, 2014). These technologies are not neutral instruments and there are major differences between (and within) countries in, for example, capacity for data collection, transforming data into useful information, and disseminating and evaluating this information (Weiss *et al.*, 2000). Many of these conditions are related to the institutional context in which forecast technologies are created and made operational. This chapter looks at the institutional context of flood forecast technology in Bangladesh. The central argument is that the current flood forecast system and related advisory information in Bangladesh are the outcome of the interaction between technical capacity and the organizational settings from which they emerge. Flood forecast information in Bangladesh is developed by three organizations: the Flood Forecast Warning Centre, the Bangladesh Meteorological Department and the Department of Agricultural Extension. Based on the notion of situated practice (Suchman, 1987) the central questions are i) how are practices of producing forecast information influenced by the organizational demands, preferences, routines and setting of the organizations? ii) how do the interactions between the organizations and their institutional background affect the integration and application of flood forecast information?

Before exploring the background and activities of these organizations, the next section looks at the literature that addresses questions about how institutional settings affects the making of scientific models and the conceptual insights that these studies offer and covers the historical background of the three organizations. The three subsequent sections explain the ways in which data are collected, compiled, processed and turned into forecast information by these three organizations.

2.2 Methodology

This chapter explains how the three government organizations in Bangladesh go about the process of making forecast information. The approach adopted in this chapter is based on an understanding of technology as situated practice, the central concept for this thesis developed by Lucy Suchman (1987). Situated practice refers to the interaction between specific operations and tasks of an organization, which in this chapter refers to the collection and processing of climate data, and the institutional characteristics of the work floor. The particular way a work routine or operational practice is situated can turn out to be problematic when transferred to a different situation or when different organizations have to work together. For example, Pronk *et al.* (2016) show how cooperation between various organizations in tsunami risk management in Portugal is hampered by diverging perceptions of risks and what information and facilities are needed to deal with these risks. Likewise, Henshel, (1982) argues that predictions are presented as straightforward facts but are inherently social processes, influenced by, and anticipating, various social factors, such as organizational demand, experience and social practices. Based on these insights, this chapter takes a closer look at the three organizations providing data for the flood forecast technology in Bangladesh.

The objective of the chapter is to identify how the flood forecast system in Bangladesh and the related advisory information are created from within the formal settings of different organizations from where they emerge.The findings in this chapter are based on documents about and interviews with key players in the three organizations. The documentary analysis helped to get an overall insight in the history and functioning of the organizations. The interviews were held between February, 2015 and March, 2016. In order to identify the people to interview, the literature study was followed by informal interviews with different officials of the organizations producing forecasts. These informal interviews helped to identify the officials responsible for generating forecast information both at central and local level, and key questions that should be asked within the in-depth interviews. The interviews were held with various members of the Bangladesh Meteorological Department (BMD), the Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board (BWDB), and the Department of Agricultural Extension (DAE). I also used the opportunity, when visiting these organizations, to have informal discussions with employees, and make observations of the ongoing processes of climate data collection. Interviews were held with in total of 44 staff members of the three organizations, at national and local levels, mostly forecast and meteorological experts. (Table 2.1).

The interview questions focused on these peoples' work routines. This covered topics such as the structure of the organization, the position and responsibilities of respondents, the process of collecting weather climate data, their way of interacting with machines and other workers within the organization, the ways of archiving and processing the data collected by the organizations and their characteristics, uncertainties related to instrumentation and work performance. Different stages of climate data collection at the local stations were observed. Transcribed interview data and field notes were read repeatedly to get an overview of the contents.

The material was then divided into smaller parts that were coded. Through iterative re-reading, coding categories (Table 2.2) and themes were developed to get an overview of the responses of the interviewees about certain topics (following Erlingsson and Brysiewicz, 2017). After completing coding the collected data was examined to find patterns and draw conclusions in response to the research questions.

Table 2.1. Interviews by organisation and roles

BMD	
Stakeholders	**Participants**
BMD staff (Storm Warning Centre (SWC), Dhaka	Assistant Director (1) Assistant meteorologist (2) Computer operator (1) Plotter (1)
BMD staff (Agro Metrological Division of Storm Warning Centre (SWC), Dhaka	Meteorologist (1) Assistant Meteorologist (1)
BMD staff of the Meteorological Geo-Physical Centre (M& GC), Chittagong	Assistant Metrologist (1)
BMD staff of the agro-meteorological pilot balloon, and radar stations in Rangpur and Mymensingh district	Assistant metrologist (2) Met assistant (1) Senior observer (2) Balloon maker (2)
FFWC of BWDB	
Stakeholders	**Participants**
BWDB staff of the Hydrology Division (head office)	Sub-divisional engineer (1) Assistant Programmer (1)
BWDB staff of the Hydrology Division	Sub-divisional engineer at district level (2)
BWDB staff at sub-district level	Rainfall recorder of the Hydrology Division of BWDB (1)
BWDB staff of the Hydrology Division at sub-district level	Section officer of BWDB (1)
Flood Forecasting and Warning Centre (head office)	Executive engineer (1) Sub-divisional engineer (1) Assistant engineer (2) Assistant programmer (1)
Staff of FFWC (at observatory of sub-district level)	Gauge reader of river water level recorder (2)
DAE	
Stakeholders	**Participants**
Extension officer (Head office)	Additional director (extension and coordination) of the field service wing (1) Deputy director (monitoring) of field service wing (1) Agriculture extension officer, control room of the field service wing (2) Project director of IFMC (1) Project director of IPM (1) Project monitoring officer of IPM (1) Project director of disaster and climate risk management in the agriculture project (1) Project director of Bangladesh of the Weather and Climate Services Regional Project (1)
Extension officer (district level)	Deputy director (1) Sub-assistant agriculture officer (1)
Extension officer (sub-district level)	Upazila agriculture officer (1) Agriculture extension officer (2) Sub-assistant plant protection officer (1) Sub-assistant agriculture officer (3)

Table 2.2. Coding categories

Category	Sub-category	Sub-category-2
Historical background	Goal/mission	Initial focus/purpose/objective Changes in goal /objective Target group
	Technical dynamics	Initial set up Changes in measurements and equipment Data collection, transfer and processing
	Institutional changes	Funding sources Causes for interventions Effects of interventions
	Collaboration and interaction with other organizations	Projects and activities
Construction of forecasts and advisory services	Data collection at local level	Organizational capacity (staff numbers, observatory, instruments used) Roles and responsibilities Work procedures Monitoring system Problems and constraints
	Data transfer from local to central level	Process Instruments/tools used Frequency and time
	Data processing at central level	Organizational capacity (staff numbers, technical skills) Roles and responsibilities Work procedures (ways of receiving and processing data) Output details Problems and constraints

2.3 Short institutional histories of the three organizations

This section provides a brief historical overview of the three major forecast and related advisory information producing organizations in Bangladesh. These histories help to understand the capacity and limitations of these organizations in their contribution to flood forecast information.

The Bangladesh Metrological Department (BMD)

The BMD is a meteorological institute under the administrative control of the Ministry of Defence of Bangladesh. The BMD was established under British colonial rule in 1867, then as part of the India Meteorological Department. The two observatories located in current Bangladesh were in Narayanganj and Jessore districts, providing inland river ports with warning signals for cyclones and storm surges (Hussain, 2007). The main focus of the meteorological department was to protect military expeditions and commercial shipping. The metrological services had little wider public reach (Mannan, 2013). The establishment of the India Meteorological Department was a response to the great Bakerganj Cyclone of 1876, which had a recorded storm surge of 45 feet and cost the lives of about 200,000 people (Hussain, 2007). Following Partition in August 1947, this part of the India Meteorological Department was renamed the Pakistan Meteorological Department.

In 1954 a seismic institute was set up for the registration of earth quakes in Chittagong. Before Bangladesh seceded from Pakistan (in 1971), a Cyclone Preparedness Programme was established in 1966 in order to provide relief and rehabilitation in case of floods. The political changes in the period made the programme largely dysfunctional. A devastating cyclone in 1970 caused about 300,000 deaths and enormous economic loss (Mannan, 2013). Bangladesh became independent in 1971, and its metrological department was renamed the Bangladesh Metrological Department (BMD). With the help of the International Federation of Red Cross and Red Crescent, a Cyclone Preparedness Programme (CPP) was inaugurated in 1972, setting up a community-based early warning systems, search and rescue, evacuation, sheltering, first aid, relief distribution and rehabilitation activities (DDM, 2014).

A further expansion of the flood protection activities came after the cyclone in 1991 that, according official estimations, took the lives of 140,000 people. In 1993, the government established the Disaster Management Bureau (DMB), a Disaster Management Council and Disaster Management Committees across the country to implement measures under the guidance of a new Ministry of Disaster Management and Relief (Mannan, 2013). The bureau continues to disseminate hazard warnings from the BMD. The BMD also established an 'agromet' division in 1984, with UNDP support, to provide a forecast and climate outlook for agriculture. Besides these national projects, the BMD also coordinated its activities internationally. After the 2004 Tsunami in the Indian Ocean Region, the BMD was connected to the Pacific Tsunami Warning Center (PTWC) and the Japan Metrological Agency (JMA). International linkages were also established for its meteorological services. In 2005 the India Department of Science and Technology created the Severe Thunderstorm Observation and Regional Modelling Programme (STORM) to which Bangladesh contributed, together with Bhutan and Nepal (Das *et al.*, 2014).

The tsunami also spurred the expansion of geological research, resulting in three new seismic observatories (at Dhaka, Rangpur and Sylhet). The meteorological system, currently active, called the Numerical Weather Prediction (NWP) system was set up after 2000. This included a further increase of the number of observatories, most prominently the addition of two more radar stations (bringing the total across the country to four) and an additional 14 weather stations in the riverine areas.

Table 2.3. Recent project activities of BMD

Implementation period	Project and activities
2010- 2012	Development of human capacity on the operation of weather analysis and forecasting. -conducting training on meteorological observation, the basic NWP system, data acquisition, quality control and maintenance of the instruments. - revising the existing guidelines on meteorological observation in accordance with latest WMO edition. -establish the correlation between actual rainfall and estimated rainfall for quantitative rainfall forecasting.
2011-2014	Establishment of numerical weather prediction system (2nd phase) -renovation of the existing observatories. -training BMD's personnel to run the NWP system -installation of a super computer and other NWP equipment -real time data dissemination.
2011- 2014	Establishment of automatic meteorological observing system and wind profilers for the Bangladesh Meteorological Department. - establishing automatic weather stations and disseminating gathered data through reliable telemetry on a real time basis -upgrading the existing system to Automatic Weather Station (AWS) for integration in the Numerical Weather Prediction (NWP). -to make air navigation, landing and take offs safe.
2009- 2013	Upgrading the agro-meteorological services - proper maintenance & technical adoption and, - manpower training and capacity strengthening for timely and accurate forecast/ warning.
2013- 2015	Establishment of solar panels in existing observatories Bangladesh -installation of photo voltaic cells for solar panel system. -physical connection of all the sensors. -power back up during load shading time.
2011- 2013	Preparation of wind map of coastal areas feasible study of areas of with power generation potential
2009- 2013	Establishment of 1st Class Observatory at five places [Panchagar (Tetulia), Kishoregonj (Nikli), Khagrachari (Dighinala), Cox's Bazar (St. Martin) and Bandarban -acquisition and development of land -construction of buildings. -equipment installed -manpower developed
2011- 2014	Improvement of Divisional Metrological Observatories (DMO) Sylhet and Pilot Balloon Observatory (PBO) Feni & construction of residential building at Dhaka for operational officers and staffs of BMD -proper maintenance & technical adoption. -upgrade of observation system and dissemination for meteorological data. -Improvement of accommodation facilities of operational people.

Since 2010, BMD has modernized its observatories and improved its measurement systems through the installation, upgrading and renovation of equipment at the observatories and providing training to staff. BMD staff are trained in data acquisition, quality control, maintenance of the instruments as well as analysing weather and forecast through the NWP system. Table 2.3 provides an overview of recent projects and the activities of BMD for the development observatories and its work in refining its measurement system.

Through these developments, BMD delivers weather forecasts & warnings for all extreme events, aviation forecasts, agromet forecasts, climate data and information and earthquake information and tsunami warnings to relevant public and private stakeholders in order to reduce risk to human life, property and social and economic activities.

The Flood Forecasting and Warning Centre (FFWC)

A second organisation involved in flood forecast information was set up by the Bangladesh Water Development Board, the government agency responsible for surface water and groundwater management under responsibility of the Ministry of Water Resources. The board was established in 1959 as the East Pakistan Water and Power Development Authority (EPWPDA) to initiate projects for flood control, drainage and irrigation. After the independence of Bangladesh, the EPWPDA was renamed the Bangladesh Water Development Board that since then has included a Flood Forecasting and Warning Centre (FFWC). The FFWC had (and has) the task of processing and integrating meteorological data from the BMD with hydrologic data into forecast models (Hossain, 2009).

FFWC used a gauge-to-gauge statistical correlation method for predicting water levels. Data were provided by six stations along the Padma, Brahmaputra, and Jamuna rivers. In 1981, the World Meteorological Organization (WMO) and the United Nations Development Programme provided technical assistance for computerization. After the floods of 1987 and 1988 a new computer-based technology was implemented for numerical modelling river water flows. The model was developed by the Danish Hydraulic Institute and named MIKE11.

The MIKE 11 model has three components, a rainfall run-off model, a flood routing model and flood forecasting model (Hossain, 2009). The model enabled FFWC to produce flood forecasts for 16 locations with a one day lead time (the length of time between issuing a forecast and the occurrence of the flood). In the late 1990s the model was upgraded to MIKE11 Super Model that provided flood forecasts at 30 locations with a two-day lead time. Since 2000, FFWC has monitors flood risk for the entire country, incrementally improving its accuracy and extending the lead times. Since 2014 FFWC has provided flood forecasts for 54 locations on 28 rivers with a five day lead time. The forecasts were further improved with international support, most prominently the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), resulting not only in greater lead times but also working on the communication channels, for example setting up a website in the Bangla language and the introduction of telephone services through Interactive Voice Response (IVR) through which people can acquire the latest forecast information for their area.

The Department of Agricultural Extension (DAE)

The third organization, DAE, differs somewhat from the other two. The DAE is a service oriented government organization under the Ministry of Agriculture charged with disseminating agricultural information among farmers in Bangladesh.

Although modern agricultural extension was established in Bangladesh over the last half a century, it has a history of more than a 100 years, starting in 1870, as a response to the severe famines of 1862-1866. The Agriculture Department set up in the 1870s was part of the British colonial regime covering the Bengal region as part of the undivided Indian sub-continent (DAE, 2015). An independent department was created 1960 by the then Pakistani Government.

The colonial Agriculture Department for the Bengal region was located in Monipur area of Dhaka city and included an experimental farm covering 1000 acres. In 1909 activities were expanded and a laboratory for conducting agriculture research was added. From 1914 the colonial department recruited an Agriculture Extension Officer for each district (64 in total). However, none of the officers had a training in agricultural science until 1943, when graduates of the Bangladesh Agriculture College (now Bangladesh Agricultural University) began entering the extension service (DAE, 2015).

In 1950, the then East Pakistan government initiated extension and development programmes for farmers through the VAID project. Several new sections were added, such as a Plant Protection Wing in 1956, the Bangladesh Agriculture Development Corporation in 1961, an Agriculture Information Centre in 1962, the Directorate of Agricultural Extension and Management, and Directorate of Agricultural Research and Education in 1970. After the independence of Bangladesh, there were changes in the organization in order to strengthen the agricultural extension programme and the government established different boards for cash crops. Between 1972 and1975 a cotton development board, tobacco development board, and horticulture board were established, as well as a jute directorate.

Although these sub-divisions aimed at increasing production of various cash crops, they had little relevance for smaller and resource-poor farmers. In 1982 a major reorganisation of the Department of Agriculture resulted in the creation of the Department of Agricultural Extension (DAE) by merging several of the crop-specific divisions into a single entity. Since 1990 the DAE has formulated and implemented the Revised Extension Approach (REA), implying a shift from individual advice to working with groups of farmers and becoming more responsive to farmers' needs. The approach was reformulated and adjusted in 1996 in the New Agriculture Extension Policy. The

1996 changes also implied that the DAE included in its advice measures in response to disaster and rehabilitation, in particular floods. Currently DAE has eight divisions or wings. The field services wing is the largest and responsible for spreading extension information across 14 regions, 64 districts, 48 upazilas, 15 metropolitan offices and 14,023 block levels across the country. Some of the major responsibilities of the field service wings are presented in Box 2.1. In the light of these developments, the Field Service Wing of DAE produces monthly advisories of standing crops based on the crop calendar of the DAE.

In sum, we see these three organizations have rather different backgrounds, and two of them the BMD and DAE have a longer history than the third, the FFWC which was established more recently. In the next section I will examine in more detail how the organizations operate in terms of making forecast information.

Box 2.1: Major Responsibilities of Field Service Wings of DAE

- Planning, implementing, monitoring and evaluating annual farmer-responsive extension programmes in every sub-district of Bangladesh
- Developing general extension policy options related to crop development and plant protection
- Co-ordinating extension policy and planning between DAE and other extension providers and research
- Preparing adequate revenue and development budgets for wing and field activities
- Disseminating information obtained from research institutes, business and overseas by transforming them into extension messages through media and training programmes
- Supervising the conversion of information from relevant research institutes and other sources into extension messages and information packages on technical issues (especially on soil, fertiliser, seeds and farm economics and marketing)
- Liaison with the Planning and Evaluation Wing in the collection and analysis of data on monitoring and evaluating field services, information on crop production, prices and input availability for farmers.

Source: DAE, 2016

2.4 The construction of forecast information by different organizations

The role of the Bangladesh Metrological Department

During interviews, an assistant meteorologist from a local level station told me that the observatories are mainly responsible for data collection and that the data analysis is done at the Storm Warning Centre (SWC) in Dhaka, the central office from which forecasts are sent out. The BMD has different categories of stations: 35 synoptic stations, equipped with a set of fixed instruments that are read at regular intervals; 12 agro-meteorological stations that measure different values; ten stations where pilot balloons are released for high-altitude measurements, and; five radar stations that, together, cover all of Bangladesh. Data from the synoptic stations are collected by senior observers who read the instruments (Picture 2.1) as well as the automated graphical instruments (Picture 2.2).

Picture 2.1. Manual operated instruments for measuring synoptic data

Picture 2.2. Automated graphical instruments for measuring, air pressure, temperature, relative humidity, and solar radiation

Data about clouds and vision are collected from direct observation. At the pilot balloon observatories data are collected from balloons that are released four times a day. The direction and speed at which the balloons drift are observed with special binoculars in order to gauge wind direction at higher altitudes, which is plotted on a graph. The agro-meteorological observatories measure weather data that are relevant for crop growth (Picture 2.3). This covers rainfall, air temperature, wind speed, solar radiation and evaporation as well as soil moisture and soil temperature at various depths. These data are collected twice a day, at 0000 GMT and 1200 GMT, by observers to prepare a weekly forecast specifically for the agricultural sector. All stations use a combination of automated measurements and observations and registration by the station staff.

Picture 2.3. Self-recording rain gauge with rain graph at left and manual operated rain gauge at right for measuring rainfall amount

At the stations all data are sorted and coded before being sent to the national office of the BMD. The data is sent through internet, a landline telephone or mobile telephone. The process of checking the collected data and sending data from observatories before sending to the central office is the responsibility of the observer or balloon maker. When interviewing observatory staff at various stations they mentioned that due to staff shortages there was limited monitoring of observations, data sorting and coding of the data at local level stations. Such monitoring is the responsibility of an assistant meteorologist who is supposed to visit the observatories on a regular basis and then reports to a senior officer at the national office.

The making of weather forecasts at the central meteorological office is done at BMD's Meteorological Application Centre (MAC). Here all the received data are decoded and charted by a plotter office. The produced graphical charts are analysed in combination with other data by forecasting officers. All the data are entered into computer models designed for particular components of weather forecasts. Some of the collected data enters more than one model. An overview of the data flows and model outcomes is given in Figure 2.1. Based on these models the BMD produces three types of weather forecasts, a national, district-level and agricultural forecast. The national weather prediction, is a short range (24 hours) forecast and provides the basic weather forecast, basic values for Dhaka and an overall three-day outlook (Box 2.2) and contains an overview of the main measurements from each of the stations (Appendix 1a).

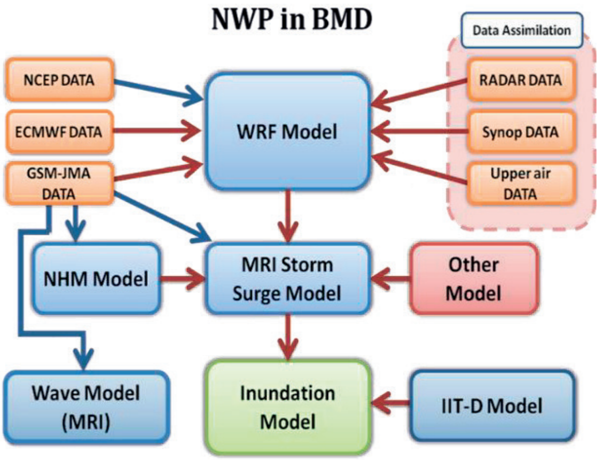

Figure 2.1. Numerical Weather Prediction (NWP) preparation by using different models Source: (Country Report of Bangladesh, 2011)

As these illustrations make clear, the forecast and information provided is rather general and basic. It is focused on the capital city and likely provides enough information for people in Dhaka and other cities to plan their activities for the coming day. The overview of basic values from the various stations, as illustrated in Appendix 1a, serves the double function of providing the information as given as well as giving the impression that the national weather forecast is based on solid data.

Box 2.2: Example of National Weather Forecast for 24 Hours

Date : 13-02-2017
Weather Forecast Valid for 24 Hours Commencing 09 AM Today:
Synoptic Situation: Ridge of Sub-continental high extends up to Bihar and adjoining area. Seasonal low lies over South Bay extending its trough to Northeast Bay.
Forecast: Weather may remain dry with temporary partly cloudy sky over the country.
Light fog is likely to occur at places over the country during late night till morning.
Temperature: Night temperature may fall slightly and day temperature may remain nearly unchanged over the country.
Wind direction and speed at Dhaka: North/Northeasterly, 06-08 kph.
RH at 06 A.M. of Dhaka : 65%
Today's sunset at Dhaka : 05-52 PM
Tomorrow's sunrise at Dhaka : 06-32 AM
Outlook for next 72 hrs : Little change.

Besides the general forecast, BMD's central office also issues various more specific forecasts. One is a weather forecast for the eight country provinces or divisions. This provides the same set of values and predictions as the national forecast and is also valid for 24 hours (Figure 2.2). Another forecast that is also focused on a specific part of the country is the marine forecast. This is split up in a forecast for fisherman and one for the coastal zone. The maritime forecasts as well as several other forecasts for the inland area are more specific in that they provide a variety of figures and maps. Such forecasts, labelled Numerical Weather Prediction (NWP), provide information that requires some basic understanding of meteorology and therefore are mainly for a professional or otherwise educated public.

The longer-term forecasts cover three days, seven days and one to three months. The three-day forecast mainly focused on district-wise expectations of rainfall humidity, surface wind and wave height at sea. The seven day and monthly forecast projects the same values over a longer term and are presented on maps using a coloured scale. It has no explanation of the legend and scale, which underlines the observation of the trained audience these forecasts are made for.

Similar specific forecasts are made for extreme weather events, mainly heavy rainfall and storms, basically warnings for the maritime sector at sea and for the main river ports inland. These forecasts are generally made during the pre-monsoon and monsoon seasons. Finally, the BMD produces a weekly weather forecast for the agricultural sector. It includes values about the hours of sunshine and various other details that are relevant for crop growth. These forecasts include the measured values from the 12 agromet observatories. In sum, the BMD produces a range of forecasts combined with overviews of the measured values at its various meteorological stations. BMD clearly is a general meteorological institute which is operationally situated at the national and (partly) international level and provides a general weather forecast that is understandable to a wide audience.

Although general, the forecast does include some less general elements, particularly its focus on Dhaka as the capital city. Other forecasts information provided by BMD are much less general. A first set of forecast is focused on the coastal and inland river maritime sectors and typically requires interpretations that assume a professional interest and a certain level of meteorological knowledge. The forecasts for the agricultural sector provide detailed information about the measured values relevant for crop production but do not address specific flood forecasts along the coast and inland river areas. The more location-specific river based flood forecasts are made by a separate organization.

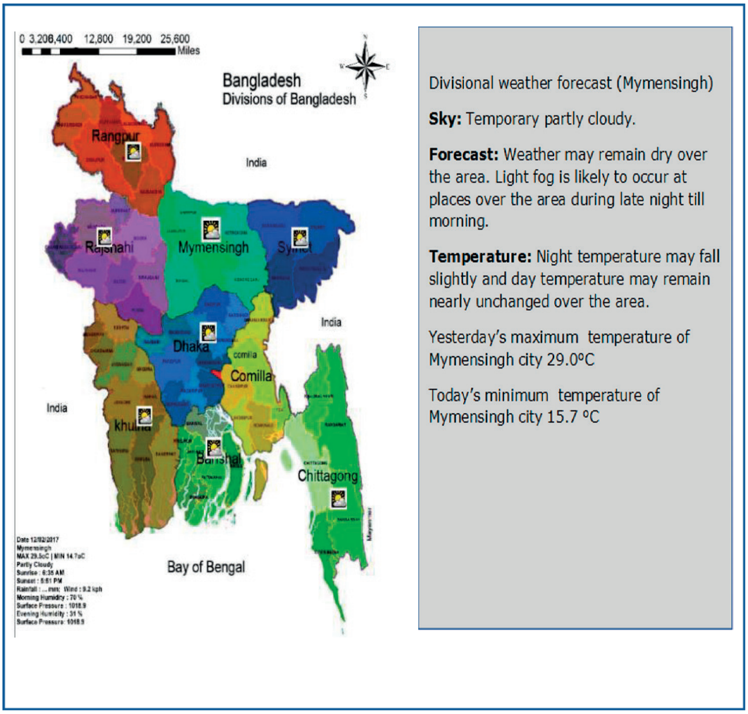

Figure 2.2. Example of divisional weather forecast for 24 hours both as image and in text form

The role of the Flood Forecasting and Warning Centre (FFWC)

The FFWC is the organization established by the government to enhance the disaster management capacity of national agencies and communities. FFWC operates 85 river stations, all installed along the major rivers and their tributaries. For flood forecasting purposes, the real time river water level data are collected by a gauge reader five times a day (6am, 9am, 12pm, 3pm and 6pm) through manual gauge reading. The daily river water levels, evaporation and rainfall readings are recorded in a note book. The station staff then make a summary of each month's data. These observational data are sent by mobile phones (SMS) to the executive engineer of the Flood Forecasting and Processing Circle of the Bangladesh Water Development Board, the overarching organization of FFWC. During the monsoon period (April to November), hourly river water level data are collected and sent directly from stations to the FFWC office through mobile phones (SMS).

Rainfall data are collected by a gauge reader who sends the observed values to the data entry operator at the FFWC head office. These data are sent using a mobile phone. The data received are checked and converted to a text file after which the data is entered into the main platform computer by the assistant engineer of the FFWC. The data are then turned into a flood bulletin and summary, using the MIKE-11 model. The data used for the MIKE-11 model come from different sources. In addition to the data from the river stations, additional meteorological data from BMD and data about rainfall and water levels from India, where the upper catchment areas of Bangladesh's main rivers are located, are used to prepare flood bulletin using the MIKE-11 model. This flood bulletin describes the situation for each river station, including the recorded highest water level, danger level, and is updated twice a day so that the trend in water level can be monitored (see Appendix-1b). The bulletin also contains information about recorded rainfall at various locations (Appendix-1b).

The flood summary describes the predicted water level at various locations for the next five days, the expected changes in water level (rise/fall) and the water level relative to the danger level at given points (Figure 2.3).

Rainfall and river situation summary

Outlook

- All the monitoring water level stations are flowing below their respective danger levels
- According to the information of Bangladesh Meteorological Department (BMD), the central, north-central and north-eastern part of Bangladesh is experiencing heavy rainfall which may continue in next 24 hours
- All the major river systems are in rising trend which may continue in next 48 hours

Stations above danger levels: Nil

Station name	River	Rise/fall	Above danger level

Rainfall:

Significant rainfall recorded during last 24 hours ending at 06:00 AM today

Station name	Rainfall in mm	Station name	Rainfall in mm
Sylhet	75.00	Kanaighat	64.00

General river condition:

Monitored water level stations	84	Steady	02
Rise	47	Not reported	14
Fall	21	Above danger	0

Figure 2.3. Example of flood summary

The FFWC distributes the Flood Bulletin and summary via fax and email to all the offices, agencies, organizations involved in flood disaster management such as ministries, development partners, district and sub-district disaster management committees, media, and research institutes. One contentious element of the Flood Bulletin is the ten-day probabilistic flood forecast. This forecast uses three value ranges, the highest expected level, lowest level and the middle or average water level in ten days (Figure 2.4). From the interviews, it emerged that the FFWC does not have the capacity to issue long-range flood forecasts and this ten-days probabilistic flood forecast was only provided for 38 of the 85 locations, and on an experimental basis. It was unclear when the experiment will be evaluated and/or what next steps will be made. Another shortcoming of the FFWC mentioned by all relevant respondents was that the FFWC suffered from a manpower shortage, which is felt as an acute problem at the stations where river water levels are monitored.

In addition the measuring instruments are in a poor condition and some stations do not have rain gauges and/or evaporation facilities. One informant, from the central station said that 'in some cases when the gauge reader lives far away from the observation station, it is difficult for him to collect readings six times in a day, which increases the possibility of making data without observing the real record.'

Medium Range (10-day) Water level forecasts on the major rivers of Bangladesh
Summary of 10 day forecast:
During next 10 days:

- The Brahmaputra-Jamuna river systems may start falling in next 48 hours and continue.
- The Padma may start falling in next 48 hours and continue, while the Ganges may continue falling.
- The Surma-Kushiyara river systems may continue falling.
- The Upper Meghna river system may rise, while the Lower Meghna river system may fall.
- Rivers around Dhaka city may continue rising.

Figure 2.4. An example of 10 days probabilistic flood forecast

In sum, the FFWC data collection is more specific than the general meteorological data collected by the BMD. It is both specific in the sense of being focused on river water levels and in that it has 85 stations along the rivers. What the accounts of the FFWC respondents made clear is that 'specific' is not merely a matter of scale or technical precision but also involves having trained staff and interactions between the staff and measuring devices, with such interactions creating station-specific outcomes. The produced forecasts are thus not produced by straightforward technical procedures but emerge from the situated practices at each of the 85 stations. One of the organizations receiving the Flood Bulletin from the FFWC practices is the agricultural extension service.

The role of the Department of Agricultural Extension

The field service division of the DAE produces its own forecast bulletin based on data received from offices in the 494 sub districts, the temperature data from BMD's daily weather forecast and flood information from the FFWC. The DAE actually produces several forecast bulletins. One presents the expected rainfall and temperature for the next seven days, split up for national, district and sub-district levels. This report combines two information sources. These are temperature information from the BMD, and rainfall data from DAE itself, gathered from all the districts of Bangladesh.

The DAE releases a monthly advisory bulletin about flood and climate risk management 'in principle', issued at the beginning of the month. This monthly advisory bulletin is based on four information sources, three of which provide weather and climatic data. These are temperature information from the BMD, flood information from the FFWC and the rainfall and temperature reports of the DAE itself. The fourth source is the crop production report. This report is made by extension workers who collect information about the major crops and varieties grown each season, the growth stage, production data from the previous year and the expected production for the coming season. Other details include the amount of land under irrigation and the demand for seeds of different cultivated varieties of rice. This monthly advisory bulletin thus connects weather forecast information to cropping practices, in particular where and when crops may endure stress or damage due to flood, water scarcity, cold stress, cyclone, tornado etc. For example, the monthly forecast of the month of Kartik (mid-October to mid-November) of 2017 mentioned that a cyclone is likely to happen with floods as a result, followed by advice provided by extension officers to famers. The bulletin does not offer direct instructions but advice and options that extension officers can select and apply in their work area. Examples of the advice options might include delaying the planting date until after the cyclone, using varieties that are more robust and thus likely to survive the flood, preparing for early planting of crops for the next season straight after the flood and adjusting the fertilizer application procedure and measures for pest and disease management.

During the monsoon season, additional memorandum warning letters are circulated twice or three times a month based on necessity. The rainfall and temperature reports of the DAE, along with daily weather and monthly climatic information of the BMD, provide the basic weather and climatic information for the field service wing of DAE to prepare this memorandum warning letter for agricultural extension officers to use for to give advice related to agricultural operations for standing crops.

Interestingly, the monthly report uses rainfall information of the 495 sub district agriculture offices rather than the rainfall data of the BMD. According to interviewed extension workers this provides better information about location specific actual rainfall (as the DAE has more observatories than the BMD) for all the sub-districts of Bangladesh, In other words, their own measurements were considered better than the information from BMD, as the occurrence and intensity of rainfall can vary over short distances However, this information might not be considered better in a strictly technical sense. Interviewed extension staff expressed concerns about their use of simple rain gauges to collect rainfall data from each sub-district (see Picture 2.4).

Picture 2.4. Rain gauge in local level agriculture office premise at left and extension officer explaining how to use a rain gauge to measure rainfall

Moreover, they stated that rainfall data collection was rarely supervised by senior agriculture officers from the sub- district office of DAE. The recorded rainfall data are sent to the district level sub-assistant agriculture officers via a phone call. Data from various local level agriculture offices, received at the district level offices of the DAE are then compiled to prepare average rainfall data for each district.

In sum, the DAE has its own practice for collecting rainfall data, using a similar procedure as the BMD but using different rain gauges and observational procedures. As with the procedures of the FFWC, the DAE procedures show that trusted or accurate data are not a matter of technical sophistication but an outcome of situated practice.

The findings so far show that three major organizations in Bangladesh produce meteorological data that are processed into general weather forecasts, flood forecasts and agricultural advisory reports that combine weather forecasts with suggested interventions in agricultural practices. In the next section we will have a clear look of how each organization produces its output based on particular area coverage and operational procedures, that are rooted in the institutional histories.

2.5 Analysis and Discussion

This study has served to provide insights into the institutional context in which weather forecast and related advisory information are produced. The study indicates that the weather and flood forecast information of the different organizations is mutually accessible. It also shows a somewhat hierarchical or linear connection between the various organizations, in that the information that the BMD produces is included as an input to the forecasts made by the FFWC and the DAE, each of which adds their own specific data. Some of these data collection methods overlap, most clearly in the case of the rainfall data collection by the DAE. However, there is also overlap between the BMD and the FFWC. As explained by an assistant engineer of the FFWC, 'we use rainfall data, forecasts and heavy rainfall warning from the BMD as an input to operationalize our flood forecasting and warning system as well as to generate flood forecasts more precisely by using data from stations data, which also helps us to cross check the data collected by the FFWC'. This example and the earlier given example of the parallel rainfall data collection by the DAE make clear that there is no direct hierarchy or planned or designed linearity in the meteorological data collection procedures of the three organizations. Table 2.4 provides the main characteristics of the production of forecast and advisory information by the three organizations.

Further evidence for the overlap and parallel practices of the three organizations is that there is no real communication and coordination about data collection, the use of models and the formulation of forecasts and bulletins. Each organization or department is only responsible for their part of the process. One might expect some exchange of expertise or shared procurement of equipment, such as rain gauges, to standardize measurements and procedures.

One recent development might bring some change to this. Since 2009 the BMD has been active in an international network, the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). Part of the initiative is to organize a National Monsoon Forum in which various organizations are supposed to contribute and discuss ways to improve and integrate the work of various forecast providing agencies. The BMD and the FFWC are participating in this forum but so far there has been no contribution from local-level disaster management committee members and extension workers of the DAE. Chapters 3 and 5 will explore how the forecast information is disseminated by the disaster management committees and the DAE.

Table 2.4. Summary findings of role of the organizations involved in weather forecasting in Bangladesh

Key characteristics	Organizations		
	BMD	FFWC	DAE
Objective and target group	Producing forecasts and warnings of all extreme meteorological events such as tropical cyclones, severe thunderstorm/tornadoes, heavy rainfall, drought, cold and heat waves and storm warnings for fisherman and shipping	Generating river water level and flood forecast for riverine inhabitants	Mainly providing extension advisory services for farm people
Scale of operation and area coverage	49 stations and 31 automated weather stations provide data to generalize forecast for the eight divisions of Bangladesh	The FFWC collects data from 85 stations to make flood forecasts for 54 stations along the major rivers of Bangladesh	Rainfall data is collected from 492 sub-districts of Bangladesh to prepare rainfall reports
Parameters used to collect data based on their goal	Air temperature and pressure, humidity, wind, solar radiation, rainfall, evaporation, soil moisture and temperature	River water levels, rainfall and evaporation	Only rainfall
(Capacity) Equipment used for data collection	Manual and automated graphical instruments and automated machines (at 31 stations)	Simple rain gauges and evaporation pans	Simple rain gauges
Type of output	Daily weather forecast, warnings, short and long range NWP products, weather forecasts for seven days, special weather bulletins and warnings for cyclone, moon coordinates, drought monitoring, aviation forecasts and climate outlook	Daily monsoon bulletin, river situation report, 5 days river water level deterministic forecast, 10 days probabilistic forecast, flood situation report, flood forecast maps	Monthly forecast of overall country along with advice related to production, and management of field crops
Interaction and opportunities to exchange information and resources	Input into generating the forecast and advisory services of the FFWC and the DAE No option to the use the DAE's expert knowledge for producing advisory reports	Reliant on rainfall data from the BMD to generate accurate forecasts	Partly use metrological and climate outlook information No option to use metrological expert knowledge to collect rainfall data

2.6 Conclusion

The findings presented above reveal the ways in which the three main organizations for the production of weather and flood forecasts operate in Bangladesh. Each produces a particular type of forecast and advisory information. The choices and capacities of each organization concerning what and who to include in terms of instruments, technical skills and manpower and procedures for data collection and data processing result in three different kinds of forecasts. These findings are in line with other studies that have emphasized that organizational objectives, operational procedures and institutional characteristics affect forecast and warning systems and thus the value of these forecasts for other organizations (Pronk *et al.*, 2016). Weiss *et al.*, (2000) suggest that the accuracy of forecast information depends on the capabilities for collecting data, changing this data into useful information, and then disseminating and evaluating this information.

Although this chapter has not explicitly focused on accuracy, the findings make it clear that there is an overlap between the three organizations in the collection of data and producing forecast information and that decisions to use their own data are based on an institutionally framed interpretation of covering all the local level administrative units of Bangladesh and preparing advice based on actual rainfall information rather instead of prediction, as exemplified with agricultural extension officers collecting rainfall data from their localities.

The findings also show the importance of historical legacies, sometimes going back to colonial times. The forecasts offered by the BMD are influenced by its historical role related to commercial shipping and providing cyclone warnings for fisherman in coastal areas. They are targeted at just eight of the bureaucratic divisions of Bangladesh. By contrast the FFWC is devoted to aid riverine people through providing river water level forecasts for the country's main river. On the other hand, the DAE as an agricultural advisory service, uses forecasts and climate information to provide guidelines for provide advice to extension workers and thereby farmers. Their work procedures are focused on providing advice tailored to local-level situations, which is reflected in the way they collect rainfall information of the each sub-districts (492) of Bangladesh, where agricultural production depends largely on rainfall amount and intensity. It is also relevant to consider how the institutional capacity, setting, objective and policy play a role in the external interactions and exchanges of information and capacities between the organizations. and feedback between the actors in each of the organizations is limited.

It was found that all three organizations rely on their own data collection system, and sharing of technical expertise. Poor interactions among the forecast and advisory producing agencies reduces the opportunities for expert professionals to be involved in producing and translating the forecast information such as agricultural advisories working with the BMD and meteorologists in producing outlooks for the DAE).

To conclude, the findings make clear that the forecast information produced by the three organizations in Bangladesh largely run parallel and without much coordination. The forecasts and advice provided are an outcome of the situated practices for data collection and processing by each of the organizations. This leads me to investigate, in the subsequent chapters, how the interactions between the organizations and their institutional backgrounds affect the integration and application of flood forecast information at local level.

3

Chapter 3

Media mismatches in disseminating forecast information to farming communities

3.1 Introduction

According to the IPCC, different disaster events, such as water scarcity, coastal flooding and water scarcity created by climate change will affect billions of people around the globe, depending on the mitigation and adaptation measures implemented in the coming years (Solomon *et al.*, 2007; Kniveton *et al.*, 2014). The report proposes various strategies to enhance coping with the impacts of climate change, including enhanced access to relevant information and technology and strengthening decision-support mechanisms and capacities to cope with uncertainty (Yohe *et al.*, 2007; Kniveton *et al.*, 2014). A study by Washington et al., (2006) suggests that the challenges of climate change require more effective engagement with climate variability through better integrating the work of climate science and the needs of user communities (including early warning and disaster management systems), improving the dissemination and communication of information and developing seasonal and intra-seasonal information (Kniveton *et al.*, 2014).

The global development of information and communication technology has made meteorological and climate information more accessible for the wider public (Weiss *et al.*, 2000). However, these technologies are not a neutral instrument and there are major differences between applications in developed and developing countries, in terms of the capacity for data collection, transforming this data into useful information, disseminating this information and end-users' capabilities to make best use of it (Weiss *et al.*, 2000). According to Dutta and Basnayake (2018), despite the enormous technological advances that have been made in strengthening forecast warning systems in south-east Asian countries, losses in livelihoods and agriculture from different disasters such as cyclones, storms, prolonged droughts, floods and flash floods, are still increasing. The Global Assessment Report (GAR, 2011) highlights the nuanced advances achieved in flood forecasting: "in theory there has been gross development of disaster management, however in practice challenges remain when it comes to [the] implementation of effective forecast warning in terms of timely and meaningful dissemination of warning information".

Bangladesh is a highly flood-prone country: floods inundate 34 percent of Bangladesh's land area (of which 80% Fcan be characterised as flood plain) for about five to seven months every year, (Kabir and Hossen , 2019). During severe floods, the affected area may exceed 55 percent of the country's total area (Anonymous, 2008; Rahman, 2010). As a developing country with a weak economy, it is a big challenge to install the infrastructure needed to control floods caused by some of the world's mightiest rivers (Gumiskey *et al.*, 2015). Early flood warnings are recognised as an important strategy in flood risk management, and can help save lives and livelihoods in vulnerable communities. In the last few decades, there has been significant technological advances in flood forecasting systems, although these advances have mostly emphasised the improvement of the accuracy, reliability and lead time of forecasts (Parker *et al.*, 2009). In addition to flood forecasting, the weather and climate forecasts of the Bangladesh Meteorological Department (BMD) have been established over a period of time to aid farmers with their agricultural production and help them to adapt to flooding and related climatic risks. However, it has been reported that communication and dissemination of these warning messages often receive less attention than the production of the information and the technical dimensions of forecasting systems. This may result in information gaps and poor provision of warning messages to fragile and remote rural communities (Deltares, 2015).

Lemos et al (2002) report that successful application of climate forecast depends on the presentation of the forecast and its mode of communication to policymakers and farmers: i.e. how climate forecasts are channelled to and interpreted by end users (see Chapter 5). Several studies have found that the ways in which climate forecasts are communicated and processed (at both the individual and collective levels) affect the ways that farmers perceive the credibility and accuracy of the information (Cash *et al.*, 2006; Crane *et al.,* 2010; Patt and Gwata 2002; Peterson *et al.*, 2010; Roncoli, 2006; Roncoli *et al.*, 2011) and how the successful uptake of climate information in decision-making depends on the interactions and dialogues between climate scientists and decision-makers (Kniveton *et al.*, 2014). However, a prerequisite for interpretative activity and dialogue at the community level is that information actually arrives where it is needed, and that it is accessed and understood by farmers. In addition, climate studies in other regions of the world have argued that the accessibility and usefulness of weather information should be considered as one of the most important factors affecting farmers' ability to adapt to climate change (Bryan *et al.*, 2009; Feleke, 2015).

Existing studies from Bangladesh have primarily focused on flood forecast systems and their dissemination from the perspective of data specialists and how the technical systems operate (Khan, 2012; Islam *et al.*, 2013) while limited attention has been paid to issues of access and communication. Similarly, a study by Kumar *et al.* 2020 explores the influence of available hydroclimatic information on farmers' decision-making in the lower delta of Bangladesh (Kumar *et al.*, 2020), without analyzing in detail how different sources and formats of information are passed on at the local level and what media and channels farmers use to access information and why. This chapter aims to fill this gap by investigating the dissemination of forecasting information and (differential) access to that information found in different villages.

3.2 Analytical framework

Dissemination of forecasting information is a largely communicative process, and hence this analysis draws on key concepts from communication and extension studies (Van den Ban and Hawkins, 1996; Leeuwis, 2004). Dissemination is generally associated with the spreading of information without the possibility (or attention) for the audience to provide direct feedback (Sulaiman and Hall, 2002). Thus, dissemination is a largely one-sided form of communication where senders encode messages and broadcast them through media and channels without any insights into the way in which these messages are processed and decoded by receivers (Leeuwis, 2004). This chapter only studies *dissemination* to farming communities, even though it is recognized that *the way farmers interpret and process information* is critical to its eventual value for decision-making at the farm level (see Chapter 5). However, restricting the focus to dissemination is of interest as a number of obstacles to effective communication may already occur in the process of getting information to farmers in the first place.

When analysing the dissemination of forecasting information to farmers, there are likely to be different senders of information. Some of these senders may be the actual source or producer of information (see Chapter 2) while others are intermediaries that merely pass-on or modify the information they receive from others to farmers. Thus, dissemination of information to farmers is likely to take place through a network-like structure (Kilelu, *et al.*, 2011; Carolan, 2014). When considering the content of the forecast information one needs to be aware of its spatial and temporal characteristics; it may, for example, focus on a province, district or village and/or have a horizon of a month, a week or a day. In other words, the information may differ in terms of its level of granularity and precision, which can shape its relevance from the perspective of a specific farmer or farming community at any particular point in time (Roncoli *et al.*, 2009; Nyamekye *et al.*, 2018). In relation to this, research indicates that forecasting information that is more refined and precise in space and time tends to be appreciated more than information that is less time and space specific (Sarku *et al.*, 2021).

In addition, information can be disseminated through different media, which can be seen as devices that enable and/or combine different channels of communication, ranging from communication through text, visual images (e.g. maps, photographs or video) or sound (e.g. spoken language). Thus, information and messages are disseminated in a particular form and language that may or may not connect well with the intended audience (Leeuwis, 2004; Munthali *et al.*, 2018). This is because audiences (in this case farmers) tend to have particular media preferences in light of the resources that they have available for gaining access to a particular medium (e.g. a website or television broadcast) or their level of literacy and capacity to process particular information formats (e.g. understanding a particular language, ability to read text or visuals, etc.). Clearly, effective dissemination requires that there is a match between the media and channels used by those sending information, and the media preferences and capacities at the receiving end (Feleke, 2015).

Finally, it is important to acknowledge that the social and institutional context in which dissemination takes place also impinges on the process. There is a diversity of information providers these days, both public and private, and the availability of new technological opportunities (notably modern ICT) has not only influenced the media used but also led to the emergence of new actors and modes of governance in the field of information provision (Munthali *et al.*, 2018; Hoefnagel, *et al.*, 2013; Mol, 2006; Sarku *et al.*, 2021). It is likely that state agencies, non-governmental organisations and commercial companies involved in providing forecast information operate in different ways that are affected by their different institutional rationales (Thornton *et al.*, 2012). Such organisations may have diverse interests in providing information, have different organisational cultures, financial or business-models and different ways of operating and how they perceive and relate to their audience. Similarly, farmers are likely to have different relationships with organisations that are active in the pluralistic landscape of information provision and the media channels they use. For example, farmers may differ in their awareness and use of particular sources, senders or media and evaluate them differently in terms of knowledgeability, credibility and trustworthiness.

In relation to the above the following research questions emerge:

(1) What kind of forecast information is presented to local communities by different sources and through what media and channels?
(2) What media channels do farmers use to access information?
(3) How is access to media related to farmers' ability to use different media, their media preferences and to strategies for dealing with different media and sources?
(4) How do the features of the social and institutional context affect the effective dissemination of forecast information?

This study addresses these questions in three villages in Bangladesh in order to explore possible local differences and similarities.

3.3 Methodology

The study was designed to follow the dissemination and communication of forecast information from national to the local level. Several organisations were selected as cases to gain an understanding of dissemination practices, and modes of accessing forecast information were investigated in three different village settings. Case-study methods included in-depth interviews, informal discussions and secondary document analysis, as well as observations of different activities occurring at the local level. This strategy provided an opportunity to make an analytical generalisation based on gaining contextual and qualitative insights (Yin, 2009) of the processes studied.
Organizations were selected on the basis of being involved in disseminating and communicating forecast information from central level to local level, and included the

Bangladesh Meteorological Department (BMD), the Flood Forecasting and Warning Centre (FFWC), the Department of Disaster management (DDM), the Department of Agricultural Extension, and several NGOs working at local level to disseminate forecast information. The research site was located in Jamalpur district, one of the poorest and most disaster-prone areas of Bangladesh due to floods, seasonal water scarcity, river bank erosion, a low literacy rate, poverty and the migration of poor farmers (Mukta, 2020). After considering seven sub-districts, Islampur sub-district was chosen as the field research site, based on the criterion of being prone to flood risk every year and the uniqueness of institutional linkages and having many local organizations involved in disseminating forecast information to local people. The study was carried out in Kulkandi, Pathorshi and Pirijpur villages, which were purposively selected to guarantee a degree of variation in the geographical setting, the communities' exposure to floods and the frequency and extent to which they are exposed, as well as the number of development organizations that supply them with forecast information. Prior to the selection of these villages, basic information about these (and other) villages was collected through informal discussions with development personnel and key local persons. Data for this chapter were collected between February, 2015 and March, 2016.

In order to identify senders and receivers (including intermediaries) of forecast information, the types and forms of forecast information disseminated by different organizations and the media used for dissemination, I first reviewed the relevant literature. Additionally, in-depth interviews were conducted with key informants from different organisations to i) understand their way of working and exchanging information with other organizations, ii) analyse the content and goals of the different forecast and advisory services and iii) to investigate what kind of forecast information was disseminated and communicated to local communities by different sources and through what media and channels. Within the chosen villages, the selection of farmers was based on being a member and non-member of a farmer field or climate school or disaster management committee. A total of 36 farmers (divided between members and non-members of these organizations) who were willing to spend about two to three hours being interviewed were eventually selected for interviews. These in-depth interviews were designed to elicit qualitative data about (differential) access to forecast information across the villages and farmers' perceptions of the value of the forecast information. In addition, various meetings related to FFS activities (oral and demonstration sessions, field days) at the local level and the monthly meetings of the disaster management committees during the flood season were observed. The observations of training sessions and meetings were triangulated with in-depth interviews and group discussions to give a better insight of what was going on within the FFS and disaster management committee meetings, and to see the interactions of farmers with relevant officials, the facilitator and disaster committee members.

After conducting the interviews, the audio recordings of the informal interviews and in-depth interviews were transcribed together with observations focussing on the main issues, differentiating between the responses of farmers and other stakeholders. For the purpose of triangulation, secondary sources of data from a wide range of institutional reports and field notes taken from the interviews and office visits were used. Through iterative re-reading, coding categories and themes were developed to get an overview of the responses of the interviewees about certain topics (Erlingsson and Brysiewicz, 2017). After completing coding the collected data was examined to find patterns and draw conclusions relevant to the research questions.

3.4 Results

The next sections present the results of the investigation. It starts with an overview of the 'formal routes' for disseminating forecast information through different actors and media channels to the end users. To analyse the forecast information dissemination network in Bangladesh, I first portray how different sources and senders of information pass forecast information from the national to the local level. The next section presents the information that farmers actually access and how, this links to their media preferences and general appreciation of different kinds of information, as well as to the broader social context. A more in-depth discussion of how information is integrated into advice and recommendations beyond its immediate dissemination is provided in Chapter 5.

Overview of the forecast information dissemination network

From the literature analysis and interviews with forecast providing stakeholders, the senders and receivers (including intermediaries) of forecast information were identified, along with the type of information they disseminate, the form in which the information is communicated and the media through which information arrives at local level. Table 3.1. provides a detailed overview of these findings for each key actor, while Figure 3.2. presents how information flows in the network. The dissemination of forecast information from different organizations is elaborated in more detail below.

Dissemination by the Bangladesh Meteorological Department (BMD)

The BMD produces weather and climate related information for a wide range of sectors in Bangladesh. As detailed in Table 3.1, there are three main types of short range weather prediction: the national weather prediction, the Dhaka and neighbourhood weather prediction and divisional weather predictions (see Figure 3.1).
One type of warning relates to heavy rainfall warnings (see Appendix-2b). In addition, related to agriculture, the BMD produces weekly weather forecasts and long range climate outlooks for one and three months (see details in Table 3.1 and also Chapter

2). On the BMD website all this information is available, and the interviews suggested that other information providers such as ministries, policy makers and the personnel of DDM, FFWC and DAE make regular use of this medium. These weather forecast, warning and climate outlook are also disseminated to the relevant ministries and policy makers through email or fax. The BMD also disseminates the daily divisional weather forecast and heavy rainfall prediction through various mass media such as TV, radio, newspaper and by an Interactive Voice Response (IVR) system.

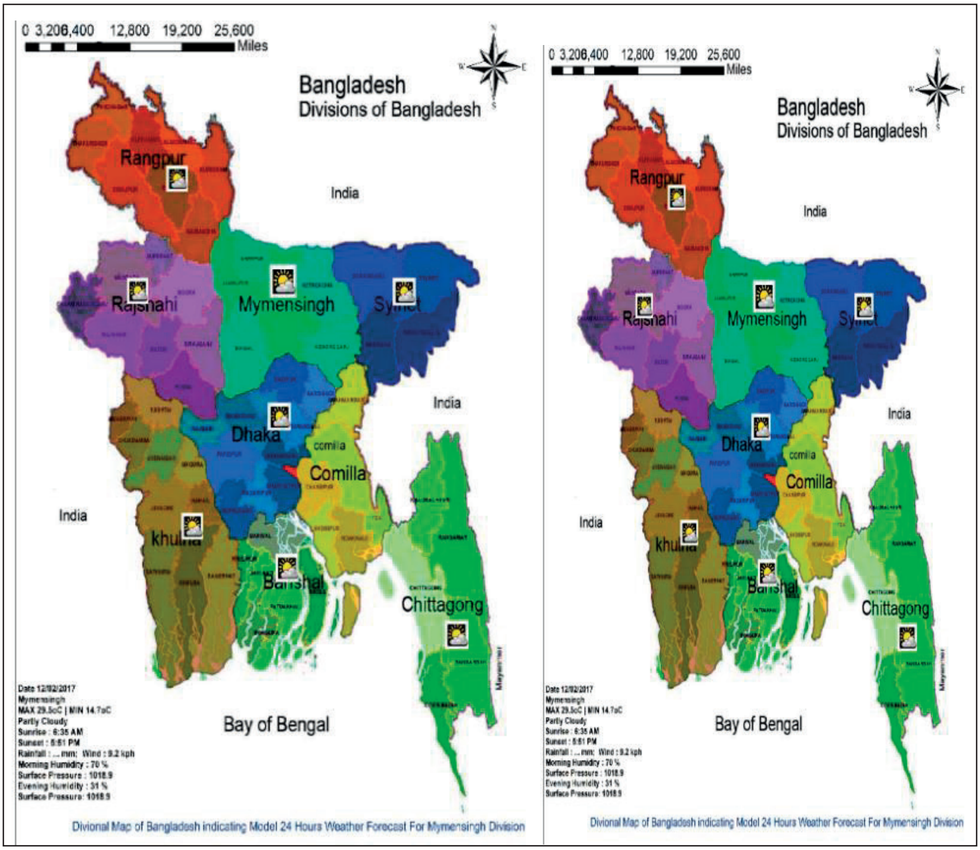

Figure 3.1. Example of divisional weather forecast for 24 hours both as image and text form

Weather and flood news are broadcasted daily through a number of TV channels, radio news (broadcast at the national level), and different national newspapers. Weather and flood news are dispersed through TV and radio news both in Bengali and English at different times of the day.

Table 3.1. Dissemination of forecast information by different organizations through different medium and form

Sender	Information content	Time horizon	Medium (M)	Form & language	Scale	Intended target group
BMD	**Information 1: National Weather Prediction** - indicates probabilistic prediction of synoptic situation, weather forecast, temperature, rainfall situation over the country - For an example see Appendix 2a	next 24 hours	National TV channel (M-1)	Spoken message with live video; Bengali & English language	Whole country	All citizens and policy makers
			National radio programme (M-2)	Spoken message; Bengali & English language		
			National newspaper (M-3)	Written text with picture; Bengali & English language		
			Website (M-4)	Written text in English language		
			Email (M-5)	Written text in English language - PDF form		DAE
BMD	**Information 2: Weather Forecast For Dhaka and Neighbourhood** - indicates sky, weather, wind and temperature information for Dhaka and surroundings	next 24 hours	National TV channel (M- 1)	Spoken message with live video; Bengali & English language	Dhaka city	All citizens
			National radio programme (M-2)	Spoken message; Bengali & English language		
			National newspaper (M-3)	Written text with picture; Bengali & English		
			Website (M-4)	Written text in English language		
BMD	**Information 3: Divisional Weather Prediction** - anticipates probabilistic forecast of sky and weather condition of particular division	next 24 hours	National TV channel (M-1)	Spoken message with live video; Bengali & English	Eight divisions of Bangladesh	All citizens
			National radio programme (M-2	Spoken message; Bengali & English		
			National newspaper (M-3)	Written text with picture; Bengali & English		
			Website (M-4)	Written text in English language		
			Email (M-5)	Written text and tabular information in English language as PDF form		DAE

Table 3.1: Dissemination of forecast information by different organizations through different medium and form (Continued)

Sender	Information content	Time horizon	Medium (M)	Form & language	Scale	Intended target group
BMD	**Information 4: Heavy Rainfall Warning (HRW)** - Indicates expected affected divisions only, - approximate time of commencement and severity of heavy rainfall - issued during the pre-monsoon and monsoon seasons - For example see Appendix-2b	next 24 hours	National TV channel (M-1)	Spoken message with video Bengali & English	Eight divisions of Bangladesh	All citizens
			National radio programme (M-2)	Spoken message; Bengali & English		
			National newspaper (M-3)	Written text with picture; Bengali & English		
			Website (M-4)	Written text in English language uploaded as PDF file		
BMD	**Information 5: Weekly weather forecast** - Predicts the apparent value of sunshine hours, weather conditions i.e. the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness and temperature and the likelihood of occurring rain showers or thunder throughout the country - station specific rainfall analysis and average temperature ..	seven days.	Website (M-4)	Textual, graphical and maps Bengali & English	Weather condition for overall country; rainfall situation for 35 stations of BD	All citizens
			National radio programme (M-2)	Spoken message; Bengali & English		All citizens
			Email (M-5)	PDF text file Bengali & English		Policy makers
BMD	**Information 6**: Weather Information for Sea Goers, inland river port warning and signals, & daily divisional weather forecast including previous day's max. and min. temperatures	next 24 hours	Email (M-5)	PDF text file Bengali & English	- |sea port rea - inland river port area	DDM at national level
			Website (M-4)	Written text in English language uploaded as PDF file	- divisions of BD	All citizens

BMD	**Information 7: Climate outlook for one and three months** - Provides numerical prediction concerning rainfall indicating normal and predicted rainfall,, normal and predicted rainfall days and soil humidity - indicates the probable value of temperature changes and explains the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness and rainfall situation.	one and three months	Email (M-5)	Tabular and textual information in PDF Bengali	Overall country, divisions (7) of BD	Concerned ministries
			Website (M-4)	Tabular and textual information Bengali		All citizens
FFWC (Project period)	**Information 8: River water level forecast** - Indicates the likely rise or fall in water levels (in centimetres and metres) from 54 stations on 29 rivers - Example: + 20 cm, next 05 days at JC/KK	5 days	Mobile phone SMS (M-6)	Text SMS English	For particular stations (river based); only Kulkandi received inf.	Selected farmers in Kulkandi (under the network coverage of Grameen Phone in Kulkandi)
			Voice SMS (M-7)	Voice message Bengali		
FFWC	**Information 9: River water level forecast** - river water level forecast for the major rivers of Bangladesh - Example: During next 10 days- The Brahmaputra-Jamuna river systems may start falling in next 48 hours and continue	10 days	Email (M-5)	PDF text message with tabular information	For 38 particular (river based) stations	Local level disaster management committee and elected members during project implementation period

Chapter 3

Table 3.1: Dissemination of forecast information by different organizations through different medium and form (Continued)

FFWC	**Information 10: Flood forecast warning bulletin** includes key information on the flood situation in the major rivers. This includes the rise or fall of water levels on the previous day as well as forecasts of water levels at key locations for the next 24, 48 and 72 h. - For an example of these forecasts see Appendix 2c	- rise or fall of water levels over the past 24 hours. - forecast of water levels at key locations for the next 24, 48 and 72 h.	National TV channel (M-1)	Spoken message with live video; Bengali and English	River based stations	All citizens
			National radio programme (M-2)	Spoken message Bengali & English		
	Information 11: Information 8, 9, 10 and all other output of FFWC		Website (M-4)	Textual, graphical and maps Bengali & English	-overall country -station wise inf.	
DDM	**Information 12: Weather & flood information from BMD & FFWC** i) Weather message for seafaring fishermen , ii) inland river port warning news, iii) daily weather news, iv) cyclone warning of BMD and v) flood information for major river of Bangladesh from FFWC - For an example of these forecasts see Appendix 2d	- Seafaring fisherman: 24 hours - River port warning; For 24 hours - daily weather news; 24 hours - cyclone warning for next 24 hours	IVR application system of mobile phone (M-8)	Recorded voice by dialling 1090 Bengali	- sea port area -inland river port area - weather forecast for seven divisions of Bangladesh. - station wise flood inf. of major river	All citizens

DDM	**Information 13 :Disaster bulletin (weather & flood information input from BMD & FFWC)** - includes marine and inland river port warnings and signals and the daily divisional weather forecast of the BMD, - flood information from the FFWC and the flood damage situation from the BD - See details in the Appendix-2e	- Weather forecast for 24 hours - flood forecast for 72 hours	Email (M-5) & official letter (M-9), website (M-4)	PDF text message Bengali		- sea port area - inland river port area - division wise weather inf. - station wise flood inf.	- local level disaster management committees - concerned ministries - policy makers
DAE	**Information 14: Monthly forecast & memorandum letter** - predictive interpretation of stress conditions, such as flooding, water scarcity, cold stress, cyclone, tornado etc - rainfall information **- See details in the Appendix-2f**	the particular month	Website (M-4), Email (M-5), official letter (M-9)	PDF text message Bengali		For the overall country	Different levels of extension agents of DAE down to the sub-district level

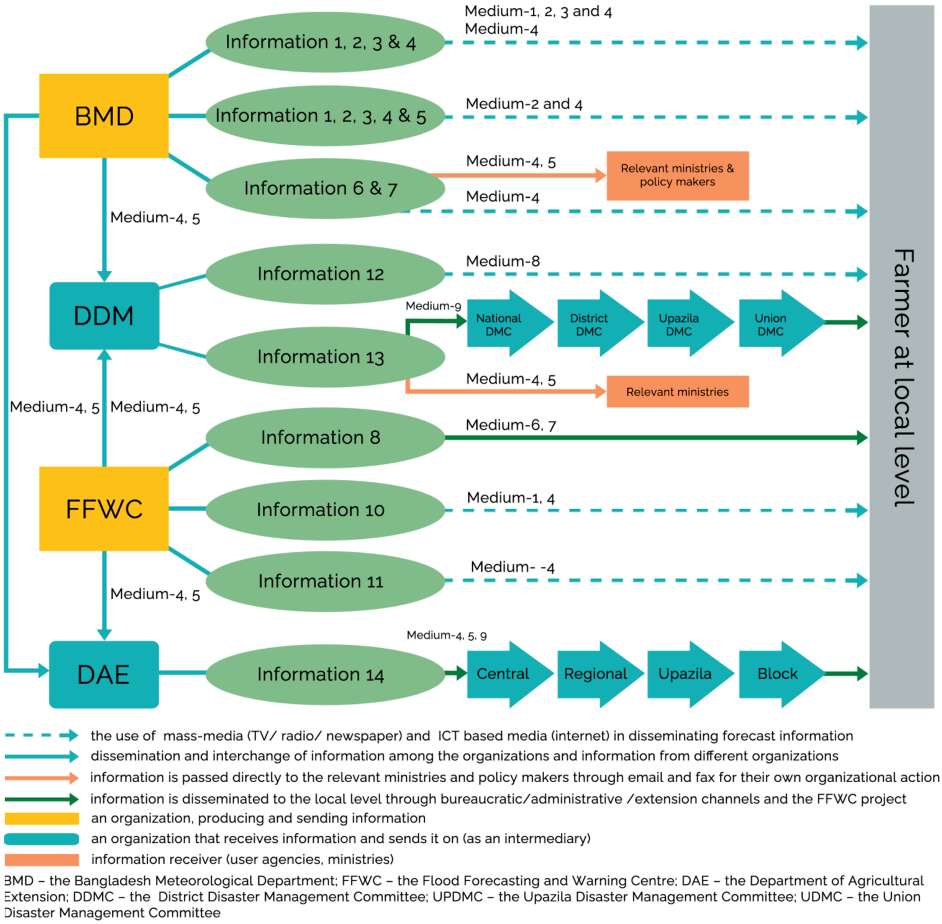

Figure 3.2. The structure of the network through which messages arrive at the local level (media number see table 3.1).

A weekly agricultural forecast is made available to end users through the website of BMD and by radio. The long range climatic outlook is not communicated through mass media and is only sent to policy makers via fax, telephone and email. In addition, BMD sends information such as the sea bulletin, inland river port warnings and signals and daily divisional weather forecasts to the DDM through email for preparing disaster bulletins (see Figure 3.2).

Dissemination by the Flood Forecasting Warning Centre (FFWC)

The FFWC is a focal point for disseminating flood related information in Bangladesh. The FFWC disseminates forecasts at the national and district levels through emails, its website and Interactive Voice Response (IVR) service (see Figure 3.3 for a screen shot of FFWC's flood forecast and warning page (see chapter 2 for more details). Flood summaries (rainfall and the river situation for each day) and flood bulletins are sent daily through email and fax to selected policy makers and the Department of Disaster Management for further dissemination at the local level.

The flood bulletins provide an overview of river situations in the country and consist of tabular summaries of absolute water levels at each station along the main rivers, as well as the observed and predicted rise or fall of water level in the next 24, 48 and 72 hours (see Appendix 2c). These flood bulletins are prepared as a Word document for dissemination in the form of hard copies, faxes and downloadable files from their website. Flood forecast and warnings for major rivers are disseminated through national TV channels, radio programmes and daily newspapers (Table 3.1).

Together with DDM, FFWC also implements a project that gathers remote sensing data for river basin management in some pilot areas of Bangladesh, such as Jadur Char in Kurigram District and the Kulkandi Union in Jamalpur District. The major objective of the project is to provide early warnings by using upper catchment data to generate a five day early warning and inundation map.

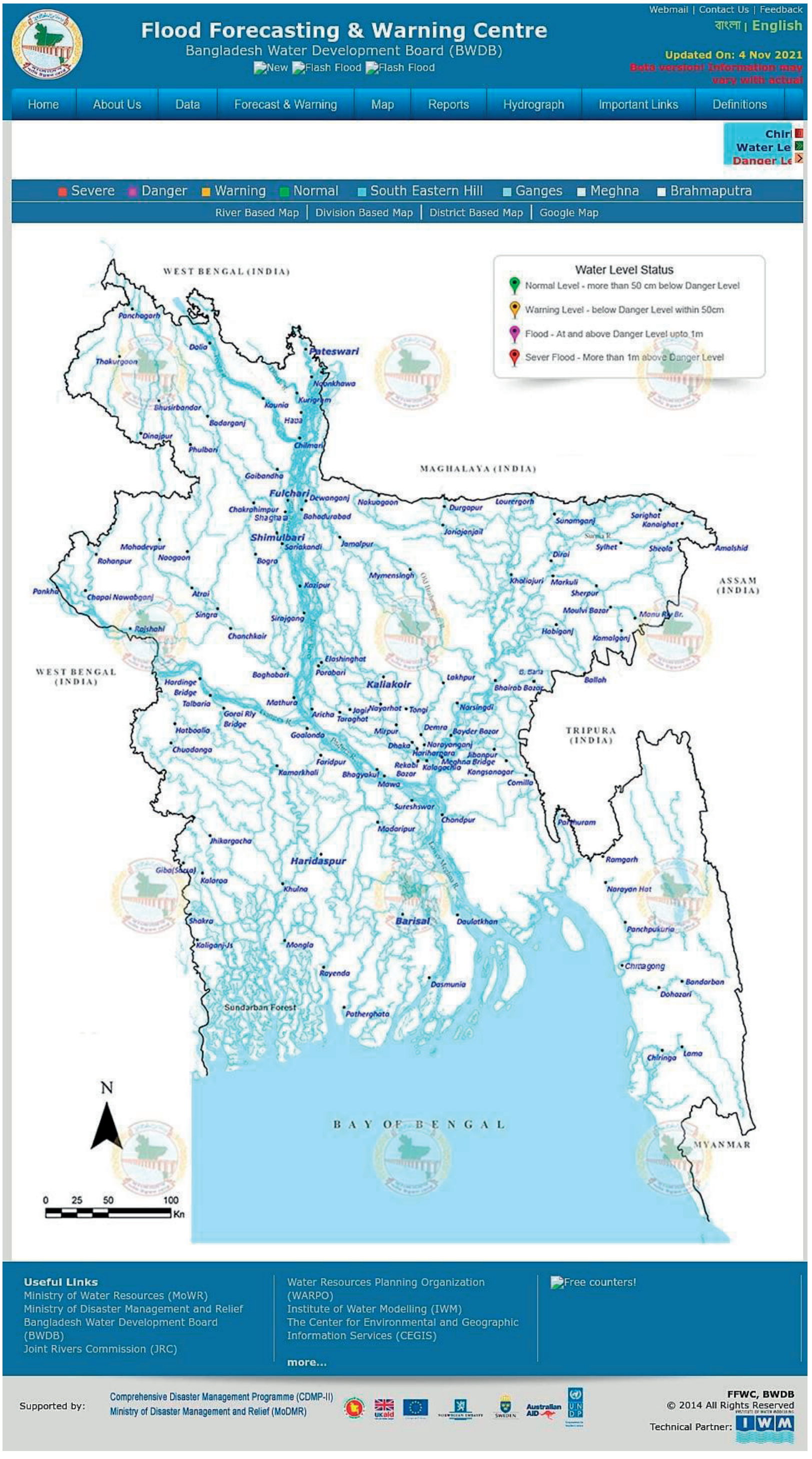

Figure 3.3. A page from the departmental website of FFW

This information is sent to selected farmers (i.e. listed farmers under the coverage of the Grameen phone network in Kulkandi village) via SMS text and voice call. This five day flood warning indicates the expected rise or fall of water level in numerical value (centimetres) in the next five days for a particular river station (Figure 3.4).

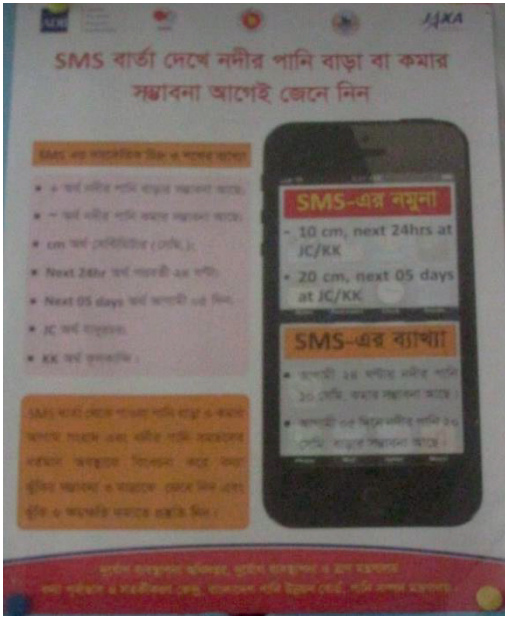

Figure 3.4. Leaflet showing 5 days flood forecast in cell phone and it's explanation

Technology is swiftly improving in Bangladesh yet not all mobile phones enable Bangla script. For this reason, messages in this pilot are being sent in the English language instead of Bangla. With financial and technical support from USAID and RIMES, the FFWC implemented another project 'Enhancing Early Warning System for Community Based Responses in Bangladesh' under the CARE Bangladesh (SHOUHARDO II Programme) during 2012-2014.

The main goal of the project is to enhance the lead time for flood early warning and preparedness in Bangladesh by increasing the number of stations that are able to provide a 10 day forecast from 18 to 38 stations. According to the executive engineer of FFWC, 10 days flood forecast are sent as PDF texts (see Figure 3.5) via email to the local level disaster committees, SHOUHARDO-ii NGO volunteers and local leaders (union chairman) for further dissemination to farmers in the villages.

Medium Range (10-day) Water Level Forecasts on the Major Rivers of Bangladesh:

Summary of 10 day forecast:

During next 10 days:

The Brahmaputra-Jamuna river systems may start falling in next 48 hours and continue. The Padma may start falling in next 48 hours and continue, while the Ganges may continue falling. The Surma-Kushiyara river systems may continue falling. The Upper Meghna river system may rise, while the Lower Meghna river system may fall. Rivers around Dhaka city may continue rising.

Forecast made on: 06-09-2015

Forecast made on: 06-09-2015 (Page 1/5)

River	Station	D.L	today 06-09 0600	1-day forecast 07-09 0600	2-day forecast 08-09 0600	3-day forecast 09-09 0600	4-day forecast 10-09 0600	5-day forecast 11-09 0600	6-day forecast 12-09 0600	7-day forecast 13-09 0600	8-day forecast 14-09 0600	9-day forecast 15-09 0600	10-day forecast 16-09 0600	Forecast type
Jamuna	Bahadurabad	19.50	20.15	20.04	20.24	20.08	20.03	19.67	19.57	19.48	19.53	19.45	19.44	Upper Range
				19.94	19.92	19.59	19.32	19.13	18.84	18.92	18.51	18.52	18.73	Lower Range
				19.99	20.18	19.79	19.55	19.53	19.24	19.17	19.10	19.04	19.15	Mean
Jamuna	Sariakandi	16.70	17.47	17.40	17.52	17.45	17.39	17.14	17.00	16.93	16.94	16.90	16.87	Upper Range
				17.33	17.26	17.06	16.84	16.63	16.38	16.32	16.14	16.00	16.12	Lower Range
				17.37	17.47	17.25	17.02	16.96	16.77	16.63	16.56	16.48	16.53	Mean
Jamuna	Kazipur	14.85	15.60	15.52	15.65	15.60	15.50	15.21	15.01	14.92	14.91	14.88	14.84	Upper Range
				15.44	15.33	15.10	14.85	14.66	14.45	14.35	14.22	14.04	14.13	Lower Range
				15.48	15.58	15.36	15.04	14.94	14.79	14.65	14.59	14.52	14.55	Mean
Jamuna	Serajganj	13.35	14.10	14.02	14.15	14.12	14.00	13.69	13.43	13.31	13.28	13.26	13.21	Upper Range
				13.94	13.81	13.55	13.23	12.98	12.72	12.57	12.44	12.18	12.28	Lower Range
				13.98	14.07	13.86	13.47	13.33	13.16	12.95	12.88	12.79	12.81	Mean
Jamuna	Aricha	9.40	9.32	9.33	9.35	9.40	9.33	9.20	8.94	8.83	8.75	8.69	8.63	Upper Range
				9.29	9.18	9.05	8.84	8.64	8.43	8.24	8.16	7.89	7.82	Lower Range
				9.31	9.29	9.26	9.02	8.87	8.75	8.57	8.47	8.35	8.29	Mean
Ganges-Padma	Hardinge Bridge	14.25	13.13	13.16	13.11	13.20	13.24	12.98	12.32	12.36	11.78	11.45	11.25	Upper Range
				13.09	12.90	12.58	12.60	12.12	11.75	11.48	11.13	10.60	10.53	Lower Range
				13.12	12.99	12.92	12.85	12.44	12.12	11.97	11.59	11.06	11.03	Mean

Level in [m]

1 | Supported by USAID through SHOUHARDO II Program of CARE-Bangladesh with technical support from RIMES

Figure 3.5. Text and table showing first page of PDF text message of 10 days water level forecast

As part of this project, NGO workers, along with local level disaster management committee members, organised monthly meetings that were attended by some of the selected farmers in Kulkandi to discuss the disaster warning and related advice.

Dissemination by the Department of Disaster Management (DDM)

The Department of Disaster Management (DDM), under the Ministry of Disaster Management and Relief, was set up in November 2012 following the implementation of the Disaster Management Act 2012. The disaster management objective of the Government of Bangladesh is to reduce the risk to people, especially the poor and the disadvantaged, from the effects of natural, environmental and human-induced hazards, to a manageable and acceptable humanitarian level, and to have in place an efficient emergency response system capable of handling large scale disasters.

One of the responsibilities of the DDM is to disseminate weather and flood forecasts at the local level, and this is done mainly in two forms: through disaster bulletins in written PDF form and an IVR application system. DDM personnel indicated that the disaster bulletins are prepared by the National Disaster Response Coordination Centre (NDRCC) of the DDM, with the actual information coming from the BMD and the FFWC (Table 3.1 and Figure 3.2).

The disaster bulletins (see Figure 3.6) are PDF textual messages and include daily weather forecasting for 7 divisions of Bangladesh, daily river water situation summaries for 22 recording stations of the FFWC and an assessment of the flood damage situation in flood-affected districts (see details of content in Appendix 2e).

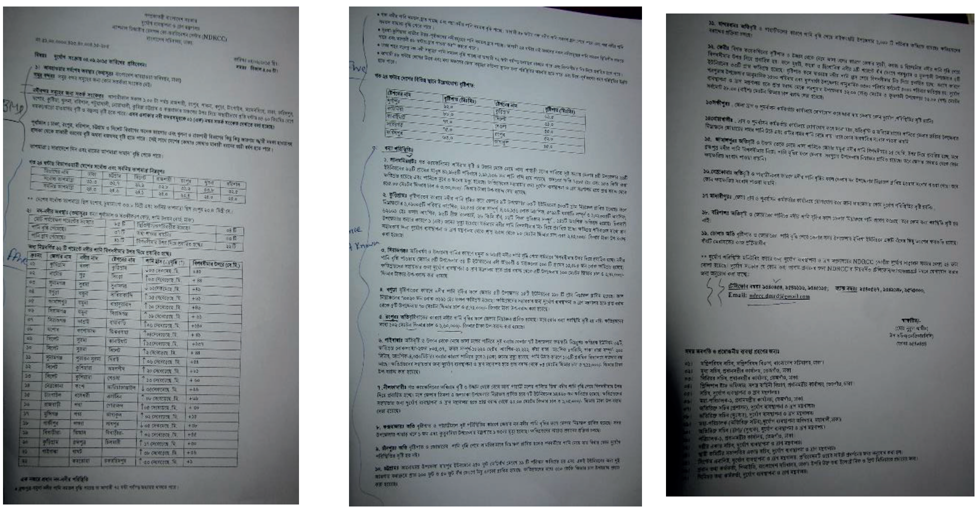

Figure 3.6. Sample of a disaster bulletin. Source: Secondary document of DDM

This disaster bulletin is communicated vertically through governmental organizations via email and fax. These organizations can be divided into four tiers: the National Disaster Management Committee, district disaster management committees, the Upzila sub-district disaster management committees and union disaster management committee at local level (Figure 3.2). After receiving disaster bulletins from the DDM, the district level disaster management committees are responsible for disseminating this information to the sub-district levels. In the Upzila sub-district, the key representative of Upazila Disaster Management Committee (UzDMC) - usually the Upazila Nirbahi Officer (UNO) or Project Implementation Officer (PIO) - plays a vital role in receiving and disseminating warning messages to the next administrative tier (the union level). Subsequently, the key representative of the Union Disaster Management Committee (UDMC) - usually the Chairman or Secretary of the Union Parishad level - is responsible for further dissemination of warning messages to the village level. The DDM also uses an IVR system that anyone on any mobile phone network can call in order to access the daily recorded information (in Bengali) on weather, flood and cyclone warnings.

Dissemination by the Department of Agricultural Extension (DAE)
The central field service wing of DAE routinely issues monthly national forecast and advice at the beginning of each month. This written forecast provides predictive information regarding stress conditions, such as flooding, water scarcity, cold stress, cyclones, tornadoes etc., for the month ahead and includes advice on protecting crops in the field. In addition, the central field service wing of DAE also issues a memorandum letter two or three times a month during the monsoon season when there are special circumstances (extreme flooding, continuous heavy rainfall, extreme cold, dense fog). This contains information about the rainfall situation and any necessary advice related to agricultural operations (see Appendix 6). These monthly forecasts and memorandum letters can be accessed directly through the internet (via the departmental website of DAE) and is disseminated in PDF format from the central to the block level through the various bureaucratic tiers in the government system (Figure 3.2). Extension workers at the sub-district level have the responsibility to inform grassroots local level extension workers (SAAO) about the monthly forecast and related advice. To this end, there is supposed to be a special meeting once a week at the sub-district level office to keep the local level extension workers informed about this information. Chapter 5 of this thesis explores how these local extension agents integrate this information in their everyday advisory work.

Media-use and access to forecast information at local level
This section presents results of how the forecast information that is disseminated by various sources and intermediaries (see Section 3.1) is accessed in the three villages and the different media channels that are used to receive this information. It explores the

value that farmers attach to the various media, and their reasons for using them (or not), based on findings from the interviews and focus group discussion. The farmers and local level development workers interviewed or participating in focus group sessions for this research mentioned five broad categories of media channels that they use to access different types of forecast information: mass media (TV, radio, and newspapers), written disaster bulletins, mobile phones, modern ICT tools and personal contacts. Given that the information sources and intermediaries disseminate information through specific media, there is a close link between the media used by farmers and the type of information that they access. In addition, there were meaningful differences between the three villages in terms of the media that are available and used (see Table 3.2).

Accessing daily weather and flood forecast warning through mass media

Results show a difference in the availability of mass media in the three surveyed villages: TV in Kulkandi and Pathorshi; radio in Pirijpur and other sources only in Kulkandi. Most of the farmers of Kulkandi and Pathorshi expressed a strong preference for watching weather and flood forecast news on TV and sharing this forecast news with neighbours and relatives in the market place or shop, providing an informal source of information (see Table 3.2).

Farmers in Pirijpur village who participated in the focus group discussion and interviews said that they mostly received weather and flood forecast information from radio news. They mostly use battery powered radios to access forecast information as they do not have access to electricity or TV in the village, although they occasionally watch TV news in a neighbouring village during their visits to markets or shops when they have time after work. In Pirijpur farmers also received weekly weather information from radio news, whereas in the other two villages radio was not popular medium to access forecast information.

A ranking exercise (with 50 farmers, in two groups from Pirijpur village) revealed that the radio and interpersonal exchanges were the most preferred medium for accessing the daily weather and flood forecasts. Watching TV on battery power was considered too costly, and going to neighbouring villages to watch TV was impractical. A farmer from Pirijpur village commented why he used the radio to access forecast news:

> "*I watch less TV. It is necessary to cross the river to see the TV news. So I don't go there often. I normally see TV news when I go the neighbouring village's market. I go two or three times a month and then I watch the TV forecast news. But I don't normally hear the weather forecast through the TV.*"

Table 3.2. Available mediums of forecast information and the value farmers attached to information accessed through different media/channels. (Data drawn from interview results and focus group discussions)

Media/ channels used	Village	Reason the medium and/or information accessed was or was not valuable to farmers	Value
TV	Kulkandi Pathorshi	- Easy to understand - Easy access at village level - Easy to watch at night after finishing work (without hampering work) - Easy to share and discuss forecast with other at market place while watching TV	High value
	Pirijpur	- No electricity access in the village - Little time to visit another village to watch TV	Low value
Radio	Kulkandi, Pathorshi	- Not popular - Very rarely used by the farmers	Very low value
	Pirijpur	- News time easy to listen at night - Easy access	High value
Mobile SMS and Voice SMS	Pirijpur, Pathorshi	- Not available	Very low value
Mobile SMS	Kulkandi	- Difficult for illiterate farmers to understand the English language - Limited expertise on operating a cell phone or to find and open SMSs - Difficult in carrying a cell phone while working in the field - Access to messages was not continued to all farmers after the termination of the project	Low value
Voice SMS	Kulkandi	- Not possible to repeat - Easy to understand - Lack of access after project termination to general farmers	Medium value
IVR System	Pathorshi, Pirijpur	- Not popular/known to all - Not used	Low value
	Kulkandi	- Easy to get information by dialling 1090 - Only a few (ca. 1%) farmers were aware of this application - Limited knowledge/expertise on using IVR - Not popular	Low value
UDMC	Kulkandi	- Limited access for general farmers - Limited service for disseminating the forecast - Lack of skilled manpower to receive forecast through email/ website	Low value
	Pathorshi Pirijpur	- Not functional for disseminating forecast information - Limited service for disseminating forecast - Lack of skilled manpower to receive forecast through email/ website - No access for general farmers	Very low value

Table 3.2. Available mediums of forecast information and the value farmers attached to information accessed through different media/channels. (Data drawn from interview results and focus group discussions) (Continued)

Informal contact with peer farmers, neighbour at market place	All villages	- Easy to communicate - Always available and accessible - No conflict with working hours - Easy to share and discuss - Detailed understanding of local conditions and contexts	High value

According to many farmers in our sample (half of the farmers interviewed) the overall quality of the forecast information (divisional weather forecast & heavy rainfall warning) available through mass media was unsatisfactory in terms of relevance and accuracy. Farmers indicated that predictions such as "heavy rainfall due to active monsoon is likely to occur at places over Rangpur, Rajshahi, Dhaka, Khulna, Barisal, Chittagong and Sylhet divisions during the next 24 hours" was not very valuable as such statements do not mention the exact sub-districts or local areas that would receive the forecasted rainfall.
Some of the farmers of Pirijpur village who listened to Radio forecast news commented that

> *"[t]he weather forecast news says that rain may happen in some districts such as Rajshahi, Rangpur and Mymensingh, but I do not rely on weather forecasts that mentioned the names of other districts. If the forecast says there is a possibility of rain today in Jamalpur (the farmer's district), or Mymensingh (close to the farmer's district) at 12 pm then I will wait to do my work in the field – for example sowing or fertilizing- after 12 pm."*

Most of the farmers mentioned that they would use the weather forecasts for agricultural decision making if it was more location specific, had a longer time horizon and was linked to advice on how to manage standing crops in the field. For example, farmers would prefer a lead time of forecasts of more than seven days because many production decisions (e.g. crop and variety choices on specific pieces of land) are made well ahead of the planting season.

Accessing the disaster bulletins

Member farmers (2-3% of the total population) of the Disaster Management Committee in Kulkandi indicated that they had access to flood warning information during the joint DDM-FFWC project implementation period, but this access declined after the project ended. One of the member farmers mentioned that during the project, the disaster management committee in Kulkandi started to organize monthly meetings and training sessions with the assistance of Shouhoardo-ii NGO and BDPC NGO, where information from the disaster bulletin was made available and participants learned how to receive messages via cell phones or through IVR applications. In addition, a volunteer committee was developed by UDMC to disseminate forecast information to farmers in the market place. Volunteer committee members were trained to understand the messages and explain them to others as well as how to protect human lives under disaster conditions. However, these volunteer committee people were not paid for their work and their activities were not effectively continued after termination of the FFWC project, when the monthly meetings were also discontinued. Several respondents indicate that the local administration and higher authorities were not at all involved in monitoring the activities of local level disaster management committees or whether their dissemination of flood warning information was timely.

In contrast, the farmers in Pathorshi and Pirijpur villages did not receive disaster bulletins through the union disaster management committees and said that that these committees were only involved in distributing emergency relief to local people when needed. Interviews with farmers and disaster committee members revealed that it would be better if farmers could get timely access to river water level forecast information (as presented in the disaster bulletin), and suggested that the mosques would be an appropriate place to distribute this. Respondents stated that the Chairman and Secretary of Union Parishad were always busy with other development activities, and did not pay sufficient attention to disseminating warning messages.

Overall, access to the forecast information was limited in all the study villages. Interviews and observations suggest that the bureaucratic mode of dissemination through several tiers of bureaucracy was replete with obstacles and delays. After arriving at the district level, there were often delays in passing on information to the sub-district level, due to technical issues with fax, internet email and electricity facilities and a lack of skilled manpower for maintenance of the equipment. Similar issues were reported at sub-district level. It was also noticed that when physical equipment (computer, modem and printer) was available at the district and sub-district level, it was used for regular activities and not specifically for managing disaster information. During the interviews with the stakeholders at different levels it became evident that the DMCs are not fulfilling their intended role. At all levels they lack clear assignations of responsibility for receiving and timely disseminating information from one level to another. In addition, members of the local level disaster management committees indicated that they found it very difficult to interpret the information provided in the three page PDF format bulletins.

Accessing forecast information through the Internet and mobile phone ICT platforms

Although 97% of the sampled farmers (both interviewed and farmers participating in group discussions) used a personal mobile phone, none of the respondents in Pathorshi and Pirijpur knew about the IVR system (dialing 1090) to access forecast information and in Kulkandi only disaster committee members and very few farmers were aware of its existence. Even local level extension workers in some villages were not aware of the

IVR system. Similarly, in Pathorshi and Pirijpur it was observed that there was no clear mandate for the local level disaster management committees to raise awareness and skills among farmers on how to use IVR system to receive weather and flood information.

Farmers participating in the interviews said that most of the farmers (who used the Grameen Phone network) in Kulkandi received river water level forecast through the SMS and voice calls of FFWC, but after the project ended only UDMC members (an estimated 1-2% of total farmers) continued to receive such messages. Flood warning messages received by these farmers included information on the rise or fall of the river water level for 'x' days (i.e. the next 24 hours at 5 days at Kulkandi). It was also noted that lists of farmers' contact information was not updated regularly and the FFWC and local level disaster management committee had not taken any steps to sustain the dissemination process.

Among the farmers interviewed, only a member of the disaster management committee and a school teacher in Kulkandi indicated that they used websites to access forecast message after termination of the project:

> *"Last year I got flood forecast news from the FFWC by cell phone. However, this year (2017) I didn't get any messages from them and I tried to go through the FFWC website to get the forecast message directly. But website seemed to have a different look than the one that I learnt on in the training session. In addition, I had difficulties in understanding the English language."*

It was also observed that farmers and disaster management committee members were not aware of the flood inundation map (including 5 to 10 day flood forecasts) that was prepared and uploaded on a daily basis to the departmental website of FFWC and web-GIS as part of the FFWC project.

In all, access to forecast information at village level through modern ICT platforms such as websites and phone applications (SMS and IVR) was very low. Even in Kulkandi where there had been a project to stimulate and facilitate the use of modern ICT, the number of available places to train farmers in the use of cell phones was limited (to 25 farmers) and as a consequence many farmers don't know how to get the best out of their cell phones, and especially how to find an unopened SMS message. Many farmers also found it very difficult to understand messages in the English language, and most would prefer to receive messages in Bengali. Similarly, hardly anybody could access forecast news directly from websites due to limited access to the internet and smart phones and limited digital literacy.

Notwithstanding these challenges, those farmers and local level disaster management committee members in Kulkandi village who did receive and were able to understand the messages send by SMS and IVR as part of the FFWC project expressed their appreciation of the accuracy and usefulness of the flood forecast warnings.

Accessing monthly forecast information through DAE extension workers

As can be noted from Table 3.1 quite a lot of forecast information is disseminated to local level agricultural extension officers (SAAO), who are supposed to further disseminate the forecast information and/or translate it into agricultural advice. Chapter 5 elaborates, in more detail, on the activities organised by extension agents and on how they integrate this forecast information into their advisory work. At this point, it is sufficient to indicate that both extensionists and farmers spoke of delays in the provision of forecast information. A local level extension worker (SAAO) from Kulkandi block said the following:

> *"It takes time to for the advice to work its way down from the Head Office of the DAE to the sub-district level. This year we (SAAOs) received the monthly advice for November, 2015 on 25th November even though it was sent from Head Office on 1st November. We only had the monthly forecast and advice in the last week of the month, by which time it was too late to be of any use for the farmers to take any action based on it . Farm households had already taken their decisions about standing crops and their practices through their local knowledge or farming experience."*

Another local extension agent also spoke about delays of the information to reach the sub-district level, as the frequency at which local level extension agents visit sub-district offices can vary. On his own initiative a Upzila agricultural officer at sub-district level sometimes accesses the internet to retrieve monthly forecast information directly from the DAE website, but no structural initiatives are taken to circulate the information among the local level extension workers. However in most cases, local level extension workers do not have computers or the skills to access forecast information from the DAE website.

Some local level extension workers are also reluctant to visit villages in their area every week during the flood season to inform them about the monthly forecast and advice due to the poor conditions of the roads and infrastructure, while the local level extension worker (SAAO) in Kulkandi and Pirijpur attributed their inability to visit local villages to the poor availability of travel allowances and other remunerations needed to visit remote areas:

> *"We want to visit our block (field) regularly, but poor road conditions and transport facilities make it problematic and costly to visit the field. We are offered very small monthly travel allowances and if the assigned village is in a remote area then it is difficult for us to perform our duties of office as well as provide quality service at local level".*

In line with the above, many farmers found that their interactions with extension workers were unsatisfactory. For example, farmers of Pirijpur village said that they were not visited regularly during the flood season, and that extension workers tended to visit mostly during the less flood prone *boro* season. Farmers in Kulkandi also said that they were rarely visited by extension workers, and that extension agents were more available at their local office when managing the input distribution programmes.

3.5 Analysis and Discussion

This study has served to gain insights into the kind of forecast information that is disseminated to local level communities through different communication media and channels. In addition, it investigates the kind of media and channels that farmers use to access forecast information and how this relates to their abilities and media preferences.

Diverse and differentiated media environments per village
Our study indicates that forecast information is typically generated by central agencies (see also Chapter 2), and that there is substantial variation in how different types of forecast information are subsequently disseminated to the local level. There is a rich media landscape in which conventional mass media such as radio, television and newspapers play an important role, alongside a number of dissemination efforts that make use of internet and mobile phone based technology (SMS, voice call, IVR and websites). Written documents (e.g. bulletins and letters) are also digitized and forwarded via email along the lines of hierarchical bureaucracies. Our results show that the available media differed across villages and that this has implications regarding the possibilities of accessing the forecast information. In relation to weather and flood forecast, our findings showed that farmers in Pathorshi and Pirijpur could only access to daily weather and flood information directly through traditional mass media (TV in Pathorshi, and Radio in Pirijpur). In Kulkandi there was a greater variation of media/channels available for accessing weather and flood forecast warning. Apart from mass media (TV, newspaper), mobile phone based services, such as SMS and voice call services, were also available and a NGO volunteer microphone speaker at village market places.

Factors shaping access to media and forecast information
The study indicates that the availability of media opportunities and/or the presence of intermediaries such as extension agents and disaster management committees does not guarantee farmers' actual access to the forecast information that these organisations disseminate. Several factors play a role in this, including organisational, infrastructural, institutional, financial, technological, geographical and personal factors.
First of all, we see that the actual availability of mobile phone based information services

(and farmers' ability make use of them) was contingent on the (continued) presence of projects such as that promoted by the FFWC, which promoted the use of SMS and IVR services, provided training and supported the availability of locally specific information content. Farmers from other villages which had not had the benefit of such a project, did not use such services, even if in theory they could dial the same phone number to receive IVR messages or subscribe to an SMS service. And, even in Kulkandi, where the use of SMS and IVR services was positively evaluated by the limited group of farmers that could access them, the conditions for the actual use of services deteriorated quickly after the pilot project ended. Similarly, even conventional mass media, such as television, was not uniformly available across villages, and was absent in those that lacked electricity infrastructure.

Second we can see that institutional hierarchies and procedures clearly influence whether and/or how fast forecast information becomes available at the local level. Several types of forecast information are distributed through different administrative tiers by email and/or fax, and the results show that this tends to result in significant delays as a result of the malfunctioning of technical equipment, poor internet connectivity, staff availability and attentiveness, transport facilities, travel allowances, budgets and so on. Depending on local conditions and/or the commitment of extension staff or members of disaster management committees the magnitude of delays varied between villages and over time. These delays also reflect coordination challenges between disaster management committees at the Upazila and Union levels, and an absence of government guidance regarding the responsibilities of government officials. Similarly, the efficiency distribution of forecast information (e.g. the disaster bulletin) along the administrative tiers varied significantly was not sufficiently monitored. This is line with several studies indicating that disaster management committees tend to be only activated when there is a need for flood response activities but can lapse into somnolence when dealing with early warning (Deltares, 2015).

Third we see that the capabilities, conditions and preferences of farmers play a role as well. These include having the financial resources to buy equipment (radio, television, mobile phone, etc.), mastering the skills to operate them (e.g. digital literacy), proficiency in English, exposure to training and a capacity to interpret textual, visual and spoken information. In environments where media are abundantly available and where audiences have considerable resources it may be appropriate to talk about individual 'media preferences' as an important factor in shaping media choices. However, the situation in many villages in Bangladesh is clearly different. In many villages access to some forms of media is limited by a range of conditions, thereby limiting access to forecast information and farmers' ability to develop 'preferences'.

The valuation of media and forecast information in terms of relevance and accuracy

In relation to the above findings regarding the challenges in local media environments, it is not easy to disentangle how people value different media versus how they value the forecast information provided through them. Table 3.3 provides a synthesis of findings from the in-depth interviews and focus group discussions, and gives an indication of how farmers from different villages value various media that are used to disseminate forecast information. Here it is striking to see how important conventional mass media still are, if available. Informal exchanges with other farmers in various settings are also regarded as very important. Many respondents mentioned that, during the flood season, they often watch the flood forecast news from TV at the marketplace, especially in the evening and at night. In such informal social settings (market place, tea stall, mosque) the forecast information and its implications are frequently discussed with other farmers.

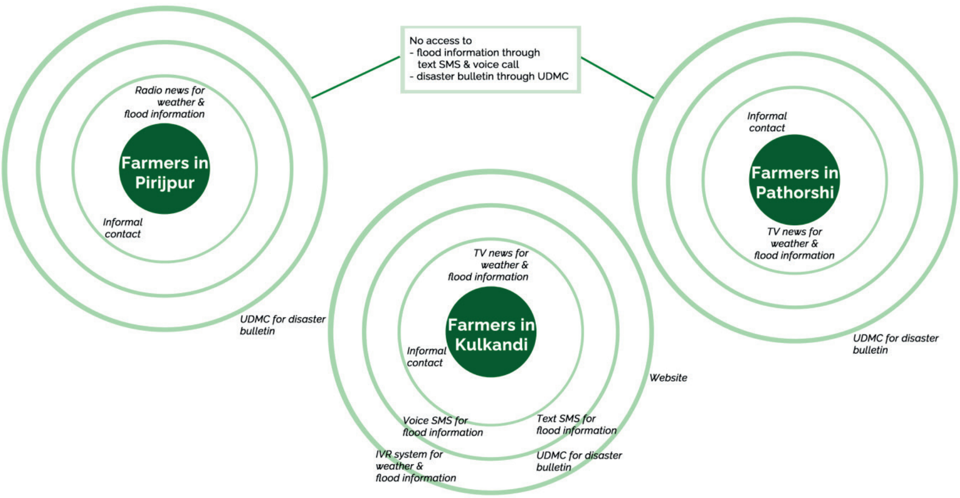

Figure 3.7. Three concentric circle showing access to forecasts at the village level through different media/channels and their closeness to farmers

The importance of such informal settings relates is partly related to the poor accessibility of modern ICTs and partly to the, often, limited availability of extension agents. Yet it may also be a reflection of the limitations in the information received through formal media.

Farmers raised several concerns relating to the quality and value of forecast information. Daily divisional weather forecast and rainfall warnings disseminated through mass media were often not perceived as location specific enough by the local farmers in Pathorshi and Pirijpur, who had no direct access to other type of forecast. Similar comments were made regarding forecast information that was distributed through administrative channels (i.e. by the extension and disaster management committees) and here the issue of delays and timeliness further undermined the relevance of information at given points in time. The few farmers mastering the use of SMS and IVR services were more satisfied with the information provided, but there was a lack of awareness about the service (Cumiskey *et al.*, 2015) and questions about its continuity. A general issue, however, was that forecast information was often not connected to contextual advice and/or recommendations in relation to specific agronomic practices. That is to say, farmers frequently indicated that they would appreciate more guidance on what the implications of a particular forecast were for dealing with a particular crop or agricultural activity. These findings concur with a study based in India by Dash (2002) who revealed that warnings failed to provide adequate and specific information and did not provide sufficiently detailed information for taking appropriate preventive actions.

Bringing these findings together, Figure 3.7 captures how access to media differs between the three villages, with the 'closeness' of the media to the centre indicating farmers preferences to access forecast information by using those media and/or channels. As mentioned, the importance of informal contact among farmers may reflect the weaknesses in formal information provision mentioned above (e.g. limited accessibility, problems regarding location specificity, timeliness and relevance) and at the same time point to the strength of farmers' local networks and their intimate contextual understanding of local agroecological and hydrological conditions and the contexts in which they operate.

3.6 Conclusions

This chapter demonstrates that while there are many efforts to disseminate forecast information to local communities, there is a mismatch (to varying degrees) between the media and channels chosen to get information to the village level, and the actual accessibility of such media and channels for farmers. Although there are differences between and within villages, access to timely forecast information is often constrained by a number of different factors. These include poorly functioning equipment and infrastructure, delays due to coordination problems across administrative hierarchies, a lack of organisational resources and discontinuities in the provision of support, coupled with farmer level constraints pertaining to poverty, digital literacy, English language proficiency and interpretative capacity. Beyond the issue of access, we also see that the features and qualities of forecast information provided do not necessarily reflect what farmers would value. In particular, farmers would appreciate having access to forecast information that is more location and time specific, and that specifies more clearly (e.g. in the form of recommendations) what such information implies for the decisions they can take regarding the various crops and agronomic practices that they engage with. Given these circumstances and conditions, farmers continue to rely mainly on information provided by conventional mass media and related discussions with their peers in informal settings, while promising opportunities in the sphere of mobile ICT platforms remain under-utilized. In all, we see mismatches in terms of both media choices and content. In the short term these can only be remedied by a greater appreciation of the everyday realities in which farmers and local level intermediaries operate, followed by a greater anticipation of their needs, demands, conditions and capacities. Doing this requires considerable creativity and imagination in overcoming the tension between, on the one hand, the ever more sophisticated technological opportunities for delivering targeted and timely forecast information, and, on the other hand, the scarce organisational and institutional resources that are available to accommodate and embed such technologies effectively.

4

Chapter 4

Farmers' strategies for dealing with flood risks

4.1 Introduction

Bangladesh is a country that is highly vulnerable to natural disasters. The geographical location, land features, many sizeable rivers, monsoon climate and the coastal morphology create a precarious flood-prone environment. Intense floods occur on an annual basis. About 80 percent of the land of Bangladesh lies on flood plains and as much as 34 percent of its land area is inundated for between five to seven months every year (Baten *et al.*, 2018; Rahman, 2010; Kabir and Hossen , 2019).

The impact of floods is wider than the areas under water and continues to be felt after the water has retreated. Crops flushed away or damaged by high water, animals drowning and increasing pest and disease infestations affect the livelihoods of farmers and agricultural production throughout the year (Banerjee, 2011). Riverbank erosion is another hazard in times of flood and occurs every year, erasing the livelihood opportunities of many families.

Considering the negative impacts of flood and flood-induced river bank erosion, various measures have been introduced by the government of Bangladesh. As shown in Chapters 2 and 3, there are three government organizations providing weather and flood forecasts. These information services, as well as other government projects aimed at flood protection, will only be effective when the recipients, the rural population whose livelihoods mainly depend on farming and fishing, are willing and able to incorporate flood forecasts and protection measures within their own practices. Therefore, we need a better understanding of what exists locally in the way of measures to address the problems of flooding. In this chapter the focus is on farming as the main livelihood of the rural population. The overall objective is to explore the ways in which farmers deal with flood risks, in particular through variations and adjustments of their farm management practices. Analyzing these practices reveals some of the underlying local capacity as well as major obstacles in overcoming flood problems.

A number of studies in Bangladesh have focused on flood vulnerability and their management (Hoque *et al.*, 2019; Khandker, 2007; Baten *et al.*, 2018). Some studies have addressed how floods and disasters affecting the whole country can be managed institutionally by government and non-government aid (Khandker, 2007; Baten *et al.*, 2018). A recent study by Ferdous *et al* (2019) explores the socio-economic effects of repeated floods and river bank erosion on rural households, using survey and focus group data to assess how households adapt to floods. In addition, a study by Kumar (2020) investigated the agricultural practices of farmers in three growing seasons in the southern part of Bangladesh, although without analyzing in detail the contexts of end users and their local farming practices for flood and climate risk management. Farmers' adaptation strategies vary from place to place and the diversity in farm management and livelihood strategies is affected by a range of local conditions including social, economic and political factors (Scoones, 2009).

The findings presented in this chapter provide a complementary analysis by addressing the detailed practices through which farmers deal with floods and farming. The methodology, detailed below, included three villages in the Islampur sub-district and is set up around the following research questions:

(1) *What are the existing or current management practices to deal with flood risks?*
(2) *What differences (if any) can be detected between groups of farmers for dealing with floods in each of the villages?*
(3) *What are the main factors that influence seasonal choices and overall adaptation strategies among farmers?*

The results reveal that farming practices to manage flooding are diverse both across and within the villages, largely based on local agroecological conditions. The next section presents the methodology, followed by sections that describe farm management practices in relation to flooding on different type of land, a discussion and conclusions.

4.2 Methodology

The research was carried out in Islampur, one of the flood prone sub-districts of Jamalpur, Bangladesh. Field data were collected between March 2015 and October 2016. The sub-district was selected for two reasons. Firstly, Islampur is a highly flood prone area and, secondly, it contains a variation of production systems and farming practices. The three study villages, selected for covering sufficient variations in topography, cropping patterns and accessibility, are Kulkandi, Pathorshi and Pirijpur. The study was carried out using a technographic approach. One important method within technography is observation and using visualization tools to show the details of practices, alongside descriptive methods, such as participant observation, semi-structured interviews with key informants and focus group discussions. A technographic approach employs these research methods to closely observe and analytically describe the way practitioners use tools, farm inputs, skills and knowledge as an integrated part of social interactions within a community of practice (Sigaut, 1994; Richards, 2001). This chapter focuses on farming practices, particularly the activities and strategies involved in growing crops. A first step was to acquire basic information about the villages through transect walks and informal discussions with local level agricultural extension officers and key local people, such as school teachers, local leaders, and prominent farmers. From these initial meetings a number of farmers were invited for group discussions and to participate in a participatory mapping exercise that resulted in the schematic maps of the villages and to discuss their farm management practices in relation to different field positions and crop growing seasons (Kharif-i, Kharif-ii and Rabi[1]). Farmers were asked to draw out different types of land based on elevation (low, medium and high), explain the ownership of land, the land use pattern, cropping intensity, infrastructure, resources, and the settlement patterns of the study villages. The hand drawn maps of the villages were scanned and geo-referenced using a handheld global positioning system (GPS) device. The collected elevation data of different types of farm land were then indicated on maps.

During these group discussions and participatory mapping exercises across the villages, a sampling frame was prepared by using a snowball sampling strategy. Names were collected from farmers of individuals who fitted within each of the following groups. Group 1: farmers with fields in both the high and low parts, group 2: those with fields only in the high parts, group 3: those with fields only in the low parts.

After that, farmers were selected from this sampling frame for focus group discussions and in-depth interviews. Farmers in each group were approached and asked if they were willing to participate until at least 4 farmers from each group in each village agreed, making a total sample of 36 (4*3 per village) farmers. The interviews consisted of a standardized questions designed to collect information about the sequence of activities, their use of inputs and other details about crop management throughout the growing season. In addition, different stages of their farming activities were observed over two growing seasons. During these observations, conversations with farmers unfolded around their activities.

For analysis, the transcription of the interviews, group discussions and the field notes from observations were coded. The code structure followed the research questions and were grouped as shown in Table 4.1.

1 Kharif-i: Mid March to mid July; Kharif-ii: July-October; Rabi: October to March

Table 4.1. Coding categories

Category	Sub-category-	Sub-category-2
Farm land type and farmers' related information.	Land wise farmers' information	Number of farmers and their access to different types of land Causes of variation across the villages
Current management practices for flood risk management.	Land related cropping patterns.	Crop choices, cropping patterns by field, changes in cropping patterns in relation to flooding & reasons for changes.
	Variety selection.	Variety selection in relation to type of land and flooding and reasons for any changes.
	Seedbed and seedling management.	Current practices across the seasons and fallback options in relation to flooding.
	Planting and harvesting time adjustments.	Sowing and planting times for seedbeds and main fields and reasons for changes (if any).
Factors influencing farmers' responses to flood risk.	Flood related factors.	Height, duration and timing of flood, river bank erosion, impact on different fields and stages of farming.
	Ecological and topographical factors (land type, soil condition and distance from the river).	Seedbed preparation, seedlings sown, crop and variety selection in relation to flooding, planting and harvesting time adjustments.
	Socio-economic factors.	Seedbed preparation, seedlings sown, crop and variety selection in relation to flooding, planting and harvesting time adjustments.

4.3 Results

Land use and elevation

Farmers apply very different strategies for dealing with floods. I will first address the strategies related to the availability of land at various levels of elevation, distinguished in the participatory mapping (Figures 4.1a, b, and c).

Figure 4.1. (a). Showing land type in Kulkandi village (source: participatory GIS mapping)

Figure 4.1.(b). Showing land type in Pathorshi village (source: participatory GIS mapping)

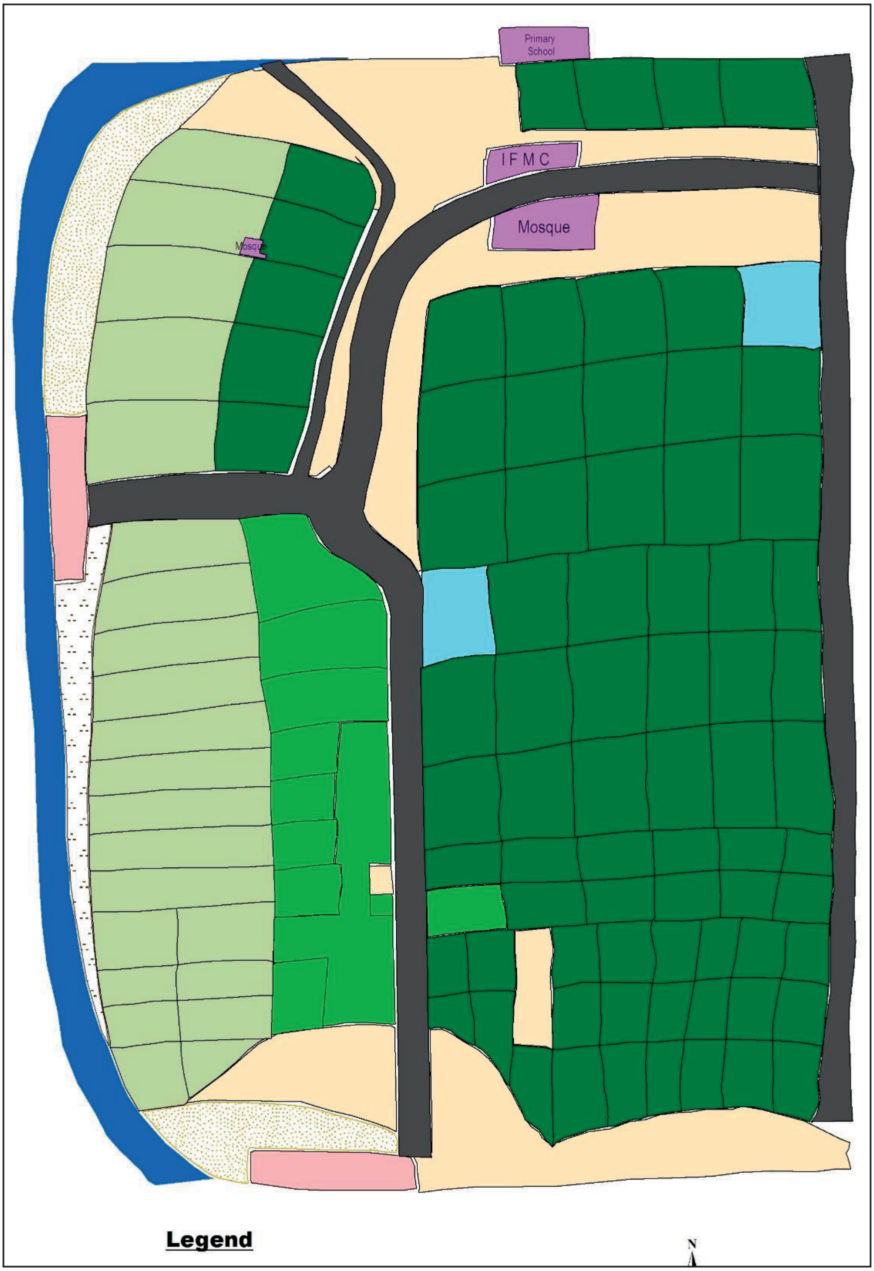

Figure 4.1.(c). Showing land type in Pirijpur village (source: participatory GIS mapping)

The subsequent sections will focus on the cropping patterns, choices for particular crop varieties and crop management. As will become clear, the various choices, patterns and strategies are all closely related and vary depending on the arrival time, severity and duration of the flood.

Farmers with land in the lower parts explained that there are frequent changes to the size of their land as the floods may wash parts away or sedimentation may create an unevenly raised land surface. The lower parts have an elevation of, on average, 8 metres above sea level. The wet season starts from June and continues until the mid or end of October. At several points river gauges measure the river water level that allow technicians, like anyone else who can read, the exact height of the river at that point. The gauge in Figure 4.1 is near Kulkandi, showing the water level on 25 August 2015. The river generally floods these lands for more than 30 days during the monsoon season and these lands get flooded every year. A farmer from Kulkandi recalled the experiences of river bank erosion:

> *"In the past I had 30 bighas[2] of farm land including the homestead area, but today I have no farm land and homestead area. I lost all my agricultural farm land (30 bighas) and the homestead area due to river bank erosion and flooding in 2010. Every year the low-lying flood basins and surrounding floodplain agricultural land and homestead areas are inundated due to flooding. In some severe cases abnormal flooding widens the Jamuna river and erodes the farm land closest to the river, due to the failure of the embankments. Since 1990, river bank erosion started and farm land alongside the river has been eroded little by little every year, but after the 2010 flood we lost all of our agricultural farm land and homestead area."*

Farmers also said that the soil structure changes due to flooding. In Kulkandi and Pirijpur village, the lower fields close to the river receive considerable amounts of silt, resulting in uneven land surfaces with sandy soil and less water retention capacity. Farmers of low to very low land areas in Kulkandi and Pirijpur considered this as having negative effects on rice production, obstructing land preparation and creating uneven water availability for late Aman and Boro rice.

2 A bigha is about 0.25 hectare

Picture 4.1. River water level gauge on the Jamuna river in the initial phase of the wet season. (Photo taken 25 August, 2015 by the researcher)

Farmers from all the study villages stated that plots in the low to medium areas are prone to flood water. Seedlings planted on these fields are prone to damage and in the months of July, August and September there is a high risk that a part of, or the entire, crop will be lost. Rice fields in medium low to medium land that are severely damaged are generally re-planted immediately after the water has receded (See Table 4.2).

Table 4.2. Main land use strategies in the three villages

Village/Decision	Kulkandi	Pathorshi	Pirijpur
Preventive strategies before the flood			
Growing seedlings on raised land.	Not possible.	Home yards and fallow land.	Home yards.
Renting land or buying seedlings	From farmers owning higher land in the same village (for Pathorshi) or nearby villages (for Kulkandi)		Not required
Strategies during flood			
Timing of transplanting.	Delay transplanting Aman seedlings.		Delay transplanting eggplant seedlings.
Fallowing.	Low land farmers keep land fallow during flooding time.		Not required.
Recovery strategies after flood			
Late transplanting.	Growing rice after flood water recession.		

Besides the main fields at different elevations, there are also small pieces of higher land, mostly home yards but also other patches too small for a main crop, that are used as seedbeds for vegetables, mostly eggplant (Picture 4.2). The eggplant seeds are sown in mid-July to mid-August (*Srabon*) and transplanted to the main field in mid-August to mid-September (*Vadro*).

Picture 4.2. Eggplant seedlings are grown in the yard and backyard of houses

Another strategy used by farmers in Kulkandi and Pathorshi is to rent land for growing seedlings. This is an important back-up for farmers who only have land in the lowest parts, although farmers with land of the middle elevation level also rent additional fields in higher parts. The plots are used for seedbeds, mostly of Aman rice, the late planted rice crop, and eggplant. Such plots often belong to farmers in neighbouring villages. As Figure 4.1a indicates, Kulkandi does not have any higher land so this is an important strategy for them. Alternatively, farmers can buy seedlings from other farmers or at the market.

A farmer from Pathorshi village remarked:

> *"Seedlings are grown every year on the rented land by relying on the almighty creator. If planted seedlings remained unused due to the long time presence of flood water in the main field, they are used as cattle feed. This year, we failed to grow seedlings in the rented raised land because of prolonged standing water in the seedbed and we had to buy seedlings from the market to plant in the main field after the flood water receded."*

There is a mutual dependency between farmers with fields in the higher and lower parts. Farmers from Pathorshi and Pirijpur said that they rented low-lying land to plant seedlings of Boro (dry period) rice, which comes right after the rainy season. Rice seedlings grown in the lower fields at the end of the monsoon, when the water has receded, can then be transplanted to the higher fields right after the harvest of the Aman rice crop. The young rice plants profit from the river sediment and the quick start reduces the risk of crop damage from very early floods in the harvest period of the Boro crop.

Overall, farmers with fields in the low and medium areas indicated that their main challenge is anticipating when the water will start to flood the fields. In addition, if the flooding lasts a long time this has negative impacts on growing Aman rice in low lying fields. Although rice grows well in water, growth is reduced when the leaves no longer can absorb sunlight and the plants may be toppled or uprooted by the currents created by incoming and receding water. For the lowest fields, farmers prefer to wait to grow rice until the water has receded to an acceptable level. These farmers (in Kulkandi and Pathorshi) then use a short-duration, late-planted local rice variety (Ganja). If the water level has not dropped enough towards the end of the wet season (Kharif-ii), farmers abandon planting entirely and will plant Boro rice or other crops in the Rabi season.

Cropping patterns and flood risks

There are three main seasons in each year: the Kharif-1 season that lasts from mid-March to mid-July, the Kahrif-2 season, from mid-July to mid-November, the main season in which floods occur, and the Rabi season from mid-November to mid-March. The rice crop grown in the Kharif-1 season is called Aus rice and is typically combined with jute and vegetables. In the Kharif-2 season transplanted Aman rice is mostly combined with vegetables. The main crops of the Rabi season are Boro rice, wheat, potatoes, mustard and winter vegetables.

The crop choices across the seasons are not fixed and the floods during the Kharif-2 season have knock-on effects on the other seasons. The dry season crops and the early wet season (Kharif-1) crops need to be fitted with the timing and severity of the flood. Most of the Rabi season crops can be consumed by the farm households or sold, but not all crops have the same market value. Farmers were well aware of cross-seasonal effects.

As explained by a farmer from Pathorshi:

> *"Depending on the circumstances, availability of money and rice for household consumption, I decide to grow either wheat or mustard after harvesting Aman rice. If I grow wheat or potato in the month of Kartik [late October, early November] then I can harvest them in Chitra [late April, early May]. By selling the wheat I can grow a jute crop in the next season with little investment. On the other hand, if I grow mustard after harvesting Aman or instead of Aman rice then I have to grow Boro rice in the following season, which costs more than jute."*

This statement shows that growth duration, investments for planting and revenues vary between crops. Wheat takes about six months to mature, and spans the entire Rabi season. Late receding floods at planting time and early floods at harvest time pose a serious risk of harvest failure. In the case of a late harvest of the Kharif-2 crop, there is a very narrow time window left for growing wheat. For those in Kulkandi village, with only low and medium level fields, floods largely cut out a third crop.
As one farmer put it:

> *"We can grow two crops in a year, either chili or wheat after harvesting jute in medium to low land. If we want to plant wheat after jute then we have to keep the land fallow because of the presence of flood water until the last week of November. Then we sow wheat seed in the first week of December."*

Wheat is a staple crop that is easy to sell for a good price. Nevertheless, farmers in all three villages stated that they preferred not to put wheat on all their land and spread their risks by growing crops with a shorter growth duration in the Rabi season, primarily mustard and vegetables, such as chili, eggplant, radish, ladies finger and spinach.
One crop that is much less sensitive to seasonal fluctuations is sugarcane, which has a growth duration that varies from nine months up to a year. When planted in the dry season, the crop reaches a height in the wet season that exceeds that of the average flood. Sugarcane can survive water logging for a period of several weeks. Most sugarcane and most sugarcane mills are located in the north-west of the country. However, given its tolerance to floods, the government has encouraged cane cultivation in the river areas since the 2000s. It is now a common crop in the riverine areas and almost every farmer in Kulkandi grows sugarcane (see Fig. 4.4). The plant's height and root system make it a robust crop, suitable for flood-prone sandy soils. These features also reduce the burden of land preparation. In particular, levelling gullies and dunes created by the in- and out-flowing water is not necessary when growing cane.
Sugar cane is relatively labour intensive, farmers have to protect the cane crop from flood damage by propping up the stalks (Picture 4.3). This is done in two stages. In the early growth phase two young cane plants are tied together. About two weeks after the

first round, more leaves are tied around the bundle and this is repeated once again later in the growing season. In Pathorshi the same technique is applied to banana plants, using bamboo leaves.

Picture 4.3. Sugarcane crop during and after flooding

Farmers in Pathorshi mentioned that they can sometimes grow four crops in a year, at least two of them vegetables. Almost half of the respondents from Pathorshi village said they prefer to grow vegetables in three seasons and bananas all year round. Farmers from Pirijpur, with medium and higher level fields, can grow three crops in a year and the cropping patterns include either maize-potato- jute or rice, or rice-vegetable-vegetable. On the medium and higher plots of Pirijpur, a range of vegetables are grown, such as eggplant, cucumber, chilli, onion and potato. Since 2009 farmers here have started to grow eggplant more than other vegetables in the Rabi season. Vegetables are typically intercropped. These can be either combinations of cash crop vegetables but mostly a cash crop is combined with various other vegetables, oil crops, herbs and spices for home consumption.

In Kulkandi intercropping included linseed, coriander, black seed, red amaranth, spinach and onion. Farmers from Pathorshi also grow potato in banana fields or combine potato with bottle gourd, pointed gourd and eggplant. Similarly, Pirijpur farmers combine vegetables as diverse as radish, stem-amaranth, red-amaranth, chili and eggplant._The various combinations of crops across the seasons and in the same fields change from year to year. In brief, farmers practice crop rotation in all their fields.

Table 4.3. Overview of adaptive practices

Adaptation to flood risk	Land type	Village		
		Kulkandi	Pathorshi	Pirijpur
Planting in Kharif-2 season				
Planting early variety of T. Aman rice.	Medium to high land.	Not practicable due to limited access of medium to high land and vulnerability.	Able to tolerate short term flooding by planting early variety of HYV rice.	
Growing late-planted rice variety through double transplanting.	Medium to high land.	Not possible due to limited availability of high land.	Allows farmers to plant rice after flood water recession without reducing yield.	
Strategies during flood period				
Growing flood tolerant crop.	Medium to low land.	Growing sugarcane in flood conditions		
Recovery strategies after flood (Kharif-ii and Rabi season)				
Growing late-planted local rice variety (Ganja).	Low land.	Farmers delay planting T. Aman rice.		
Growing late planted Aus rice or vegetables	Low land.	Farmers delay planting rice or vegetables.	Not popular.	
Growing different combinations of crops and vegetables.	Low to medium low land.	Allows farmers to grow crops based on their own preferences and situation.		

Flood-adapted rice varieties

A final set of adaptive strategies relates to varietal choices. Although these are relevant to all crops, rice is a crop with a wide range of varieties, for various seasons. Rice varieties have different characteristics, the most important ones for the riverine areas of Bangladesh are flood tolerance, growth duration and response to mineral fertilizer. Traditional Aman rice varieties, grown in the Kharif-2 season can tolerate floods relatively well but give lower yields. Farmers can also choose short-duration Aman varieties which are planted late, after the flood has receded. The Bangladesh Rice Research Institute (BRRI) has developed a number of improved varieties by crossing traditional flood-tolerant varieties with improved rice varieties. Common improved rice varieties, developed by the International Rice Research Institute from the late 1960s, only perform well in Bangladesh during the dry season under irrigated conditions. The improved Aman varieties developed by BRRI require application of mineral fertilizer and tolerate moderate floods.

A farmer from Pathorshi explained the main reasons for choosing Aman rice:

> *"If the seedling is 1.5 to 2 months old and we transplant it to the main field, it can tolerate short-time flooding (15-20 days). If we fail to grow a high-yielding flood tolerant variety then we grow late-planted Aman rice [a local variety named Ganja dhan]."*

The 'failure' expressed by the farmer would mostly be due to the earlier planted rice having been washed away, but some farmers deliberately opt for a late-planted variety.
Farmers in Kulkandi do not have access to higher fields and thus cannot prepare seedbeds. They can rent land or buy seedlings from farmers in nearby villages but this adds to their costs without reducing the risk of damage from the floods. Very few of the Kulkandi farmers grow improved Aman rice varieties. Farmers from Pathorshi prefer early-ripening Aman varieties, such as Sharna, BR-11, BRRI dhan-49, BRRI dhan-51 and BRRI dhan-52. Four of the interviewed farmers had land in the higher parts of Pathorshi and they explained that they apply double transplanting, first from the seedbeds to the higher fields and then back to the lower fields when the water level goes down. This labor-intensive strategy is typically applied to scented rice (Pijam and Jmaiaduri varieties) that sell for higher prices. Picture 4.4 shows a higher field with rice after the first transplanting. After about 80 days the rice will be transplanted for a second time into the lower fields.
All the interviewed farmers stated that in 2016 the flood was severe and water levels stayed high until the first week of September, preventing them from growing improved Aman varieties. Discussions with farmers from Kulkandi and Pathorshi revealed that during 2016 they planted improved Aman varieties twice. The first time was at the beginning of June, but these were washed away by an early flood. After the water receded they made new seedbeds and transplanted in the beginning of August. However, a second severe flood in the same year once again destroyed the rice fields. Farmers then made a third attempt to grow Aman rice, using the local rice variety (Ganja).

Picture 4.4. Scented rice field in the higher parts of Pathorshi. The rice is transplanted a second time to lower fields after about 80 days.

After the flood season, farmers can grow Boro rice, the rice crop of the Rabi season. In all study villages where farmers grow Boro rice, there are two preferred varieties: BRRI dhan-28 and BRRI dhan-29. These two varieties have different growth durations and thus are harvested at different moments. During the Rabi season vegetables are a major source of income, so the farmers try to reduce their labour input for Boro rice. As one farmer from Pathorshi explained:

> *"In the month of Kartik, there are many farming activities that need doing: preparing the Boro rice seedbeds, planting sugarcane, potato, wheat and maize, mustard, and some seasonal vegetables, as well as harvesting Aman rice. At the end of the season we are busy with harvesting Boro rice and preparing the land for planting jute in the next season. For a farm household like us, who do not have additional family labour, it is not possible to do all this before the early floods unless we grow BRRI dhan-28 and -29."*

After the Boro rice, the rice in the early wet season, called Aus, is cultivated. Aus rice is broadcast seeded in April after the pre-monsoon rains and harvested between July and August. A late Aus crop overlaps with the Aman rice. In a few cases, farmers in Kulkandi will broadcast late-planted Aus rice instead of transplanting seedlings of Aman rice. This is an important back-up for farmers if silt has accumulated in the low land after the receding flood waters. Farmers from Kulkandi village stated that late Aus rice can be planted as a late-planted crop as late as the first week of September, a practice locally known as *katar* or *gaibachra*. The Aus varieties used are irregular in size and ripen at different times. This rice is not of high quality but serves well in times of shortage and provides good straw for the cattle. Farmers from Kulkandi village said that this technique does not work if flood water remains longer (i.e. to the end of September) and alternative crops (short-growing vegetables, such as mustard and chili) were grown instead after the flood waters recede. This is highlighted in the following statement by a farmer from Kulkandi village:

> *"When there is flooding I cannot grow Aman rice. If the flood water recedes in September and silts are accumulated, then we will broadcast Boro rice. If I cannot grow Boro rice then I will grow chilli in the first week of Aswin (again by broadcasting). The advantages of growing chili is that I can get crop within a short time, it requires less investment for cultivation and sells for a good price".*

4.4 Discussion and conclusions

The practices presented in this chapter illustrate that farmers have various strategies to anticipate, and respond to, flooding in different types of farm land. Farmers manage risks through diversified practices that involve crop and variety choices, planting methods and adjusting crops to cross-seasonal effects and land elevation. The usage of these strategies varied across and within the villages and among the farmers (see Table 4.4).

The practices described in this chapter are not the only adjustments that farmers make to floods. A number of other farming activities are directly affected by the floods. Most of these activities are simply impossible when fields are flooded and, consequently are picked up after the water has receded. Examples are additional tillage and urea fertilizing in the sugarcane fields after the flood (mid-September to November). Farmers also apply fertilizer to the Aman rice crop after the flood and spray the rice against pests. Another activity affected by the floods is jute rotting. When the mature stems of harvested jute plants are soaked in water, this starts a rotting process that allows farmers to separate the fibre from the woody stem without damaging the fibre cellulose. This is usually done in natural or artificial ponds. Floods create a large number of options to do this but the water levels largely determine availability and access to the ponds. Because it is a time-consuming process, it needs to be carefully planned around other farming activities. All in all, the immediate post-flood situation is a busy time for farmers in which a number of important decision need to be made.

Table 4.4. Major adaptations in farm management practices in different villages

Decisions	Kulkandi	Pathorshi	Pirijpur
Diversified crop choices in different farm land.	Growing only sugarcane year after year due to less / no access to medium to high land, sandy soil and water logging.	A wider variety of crops (banana, vegetables, jute rice, sugarcane) are planted throughout the season in medium to high land.	Various type of crops (rice, jute, vegetables, banana) are planted all the year round in medium to high land.
Land and input management practices.	Not possible to utilize the homestead area during flooding.	Possible to utilize the raised homestead area for growing seedlings.	Possible to utilize the raised homestead area for growing seedlings.
Changing planting method	Not possible due to a lack of access to high land.	Double transplanting (utilizing high land) allows for growing rice in the low land after flooding.	Not popular.
Fallowing	Needed for low land farmers.	Needed for very low land farmers.	Not needed.

A key insight from this chapter is that farmers' responses to floods have a dual time frame and immediate responses to the fluctuation of floods have knock-on effects for subsequent seasons. This not only applies to linkages between the early and late monsoon, Khariff-1 and -2, when the effects of floods are immediate and often severe, but also for the subsequent Rabi season, when farmers grow a number of different vegetables, potato, maize, wheat and Boro rice. These knock-on effects imply complicated decisions for farmers, based on the visible effects of floods they experience during the Kharif season, as well as the unknown timing and severity of the floods in the next year. The decision to grow wheat is a prominent example. A good wheat crop is a valuable contribution to farmers' income but the growth duration of wheat makes it a tight fit with the Boro season. A delay in the sowing date, due to late recession of flood water, results in a harvest time that coincides with preparations for the Kharif-1 season. Early rains or very early floods not only pose a direct risks to the wheat harvest, but also complicate the planning of the other activities.

Intercropping and growing short duration vegetables reduce the risk of crop failure and subsequent economic loss. Short duration vegetables ensure the availability of food and income, although it is questionable to what extent this compensates for harvest losses to staple crops such as rice. As vegetables are more perishable than rice, storage for later consumption or anticipating better market prices is less of an option. Although this thesis does not address the economic effects of floods, increased market dependency typically implies more cash income but that does not necessarily imply more household food security or purchasing power throughout the year. A similar picture emerges from the decision to grow sugarcane. The physical characteristics of the cane plant make it a resilient crop for low and medium low fields, yet its long growth duration implies that fields planted with cane can only provide one harvest a year. Although a relatively secure harvest, the floods can have an overall negative effect on the yield and the costs of harvesting and transportation further reduce the net income from cane growing. The cultivation of sugarcane is stimulated by the Bangladeshi government and may be a welcome alternative for farmers, although it also shifts the risk of income loss due to floods to income loss due to price fluctuations. Although there is some local consumption of cane, the crop has little value as a buffer for food security in times of scarcity.

The findings in this chapter show that farmers' access to fields at higher elevation is of critical importance as a coping mechanism. Practices such as growing seedlings in raised land are very valuable for securing a harvest in the Kharif seasons. Farmers with low land in Kulkandi and Pathorshi villages usually rent higher land or purchase late planted seedlings from the market to secure an Aman rice crop after the flood. Access to higher fields is of benefit, even if the field is very small. Farmers who have built their homes on higher ground typically use the spaces around the house for growing seedlings. Farmers living in the lower parts construct houses in a way that they still have a living space during the floods but no fields around the house. They simply have to wait until the water recedes before they can start planting. Unless seedlings are purchased from other farmers, this causes a delay in planting, with consequences for the next harvest as well as the previously mentioned knock-on effects across the seasons. Overall, farmers who only have fields in the lower parts can plant only up to two crops per year whereas farmers with higher fields typically grow three crops a year. The value of higher fields is further underlined by the example of high-value scented rice, which is transplanted twice in order to make optimal use of the changing water levels.

The findings in this chapter are largely complementary to other studies that looked into flood adjustments of farmers. For example, studies by Paul (1984), Ayeb-Karlsson *et al* (2016) and Younus (2010) all show the importance of the time and severity of floods in regulating cropping patterns, especially in low-lying flood-prone areas. The particular relevance of this chapter is, firstly, a further confirmation of the variation within and between villages of the options farmers have to deal with the seasonal floods. Secondly, the chapter has shown the importance of timing, in particular the dual time frame of short-term, immediate effects of floods and their longer-term, seasonal knock-on effects. The combination of varying options and a dual time frame makes it very challenging for flood forecast services to deliver information that can be applied to such a dual time frame. As highlighted in Chapters 2 and 3, forecast services that predict floods and extreme rainfall in a timely manner have improved considerably, and there are various communication channels by which the information is distributed to the villages. Such short-term warning systems potentially contribute to farmers' choices and planning of farm activities in the flood season. but provide no information relevant for long-term planning. The next chapter further looks into the way the agricultural extension services support farmers in their decision making and farming practices.

5

Chapter 5

Integration of forecast information in agricultural extension activities and recommendations

5.1 Introduction

Climate change is emerging as a significant stress, challenging agricultural production, food security and the livelihoods of millions of people in many parts of the world (Khatri-Chhetri *et al.,* 2017; IPCC, 2014). According to Alam *et al.* (2017), the greater share of resource-poor rural households livelihoods in developing countries such as Bangladesh largely rely on agriculture and this sector is the most vulnerable to climate change and variability.

As many studies have pointed out, climate change will aggravate the unpredictability and severity of weather phenomena typical for Bangladesh, such as floods, drought, cyclonic storm surges, riverbank erosion, salinity intrusion and water logging. (e.g., Alam *et al*., 2017; Alam, 2016; Choudhury *et al*., 2005; Huq and Ayers, 2007; IPCC, 2007; Jordan, 2015; Thomas *et al.,* 2013; Pouliotte *et al.,* 2009; Roy *et al*., 2020;). These changes are likely to increase the loss of lives and put further pressure on the livelihoods of people living in the lower and flood prone parts of the country.

While people have always faced weather related risks and uncertainty, climate scientists have began to make advances in probabilistic forecasting of seasonal and interannual variations in climate conditions as a means to enhance climate adaptation and mitigation in the world (Adger *et al*., 2009; Vaughan and Dessai, 2014; Singh *et al*., 2016; Lobo *et al*., 2017; Vedeld *et al*., 2019, Vedeld *et al*., 2020).

There is a consensus among social scientists that providing credible, usable information about the weather and climate to farmers has the potential to alleviate risks to their livelihoods and to improve food security and incomes (Edward et al., 2014; Sarku, 2021) as well as providing more and better hydro-climatic information that will improve farming practices (Weiss *et al.* 2000, Okello *et al*., 2012; Anoop *et al.,* 2015; Etwire *et al*., 2017). However, several authors have shown that institutions that are mandated to produce climate and hydrologic forecast products are producer rather than user-driven (Cash and Buizer, 2005; Feldman and Ingram, 2009), and typically engage in broad dissemination of forecast information products from a central point to a diverse set of users. In addition, the existing literature has highlighted several obstacles and challenges for ensuring the uptake and use of forecast information (Islam *et al*, 2013; Austen *et al*, 2002; Ash *et al*, 2007). One of the challenges is that, in order to become usable, forecast information needs to be effectively linked to knowledge and information about cropping systems, seed varieties, pest and disease control, soil fertility management and other agronomic domains. In line with this, a study by Weiss *et al.* (2000) stresses the need to co-ordinate agro-meteorological information with other advice offered by local extension services or specialized advisory services in agricultural policy and science in order to improve agricultural production and food security in developing countries. More specifically, studies from Bangladesh have argued the need to incorporate hydro-climatic information services with the existing agricultural knowledge and information systems to foster shared learning and better-informed agricultural decision-making (Islam *et al*, 2013; Kumar, 2020). Several authors stress the importance of agricultural extension in translating forecast information into usable advice for farm management (Jones *et al.*, 2000; Jagtap *et al.*, 2002; Hansen, 2002).

In Bangladesh, the Department of Agricultural Extension (DAE) is one of the leading agencies working to implement agricultural policy in Bangladesh (Uddin, 2008, Kamruzzaman *et al.*, 2018). This organization might be considered as a bridge between the scientists and governmental bodies and agricultural practices or farming (Timmer, 1982; Ahmed, 2012). In order to ensure sustainable and profitable increases in crop production, the DAE aims to provide tailor-made extension services to farmers operating in different agro-ecological environments and with differential access to resources (DAE, 2016, Kamruzzaman *et al.,* 2018). Over time, extension agencies included more interactional activities such as field visits, demonstration, and different types of farmer field schools (Van den Berg and Jiggins, 2007), and such methods are also used to support farmers in dealing with the adverse flood and climatic risks.

A recent study in Bangladesh by Kumar *et al.* (2020) explores how farmers respond to information about seasonal weather forecasts, water availability, input prices and availability, crop selection, disease control and market prices as well as how they value sources of agricultural information, particularly extension advice. However, there are few studies in Bangladesh that provide a detailed understanding of how flood and climate forecast/messages are integrated into the activities and information of the DAE, and how these are linked to other agronomic knowledge and information. This limits our understanding of how usable forecast information is for extension agencies and farmers collaborating to implement improved farming methods. Therefore, this chapter aims to understand what happens beyond the dissemination of forecast information, in terms of whether and how flood forecast messages and climatic information is integrated with broader agronomic knowledge and information during extension activities. At the level of extension workers, we assess whether and how forecast information is integrated into specific and usable recommendation through the activities and interactions of DAE. At the level of farmers, we seek to understand whether and why some activities, interactions and recommendations are appreciated over others and how forecast information is linked to farm specific contextual knowledge and information.

5.2 Analytical framework

The dissemination of forecast information is largely a one-sided form of communication where senders encode messages and broadcast these through media and other channels without much idea about the ways in which these messages will be processed and decoded by their recipients (Van den Ban & Hawkins, 1996; Sulaiman & Hall, 2002).

Chapter 3 examined the dissemination of forecast information to farming communities, and this chapter sets out to explore what happens beyond dissemination, with a special focus on how forecast information becomes linked and integrated with other knowledge and information during agricultural extension activities. Hansen (2002), points out the challenge of arriving at an appropriate interpretation of forecasts in the context of farm-level decision-making, indicating that translating forecasts into meaningful directions for action is not a straightforward task. Yoo (2017) also pointed out that knowledge and information is of limited value unless it is adapted and linked to a task-specific context. In other word, forecast information alone does not suffice and needs to be integrated with other information in order to become usable. In relation to this, Leeuwis (2004) argues that farming is a very carefully coordinated set of activities, in which farmers have to manage a complex set of relations between different levels, domains and time horizons (see also Van der Ploeg, 1990). Farmers' decisions may focus on different hierarchical levels (e.g. an individual animal, a herd or the set-up of a mixed farming system) and decisions regarding one level are likely to have implications for other levels. Similarly, farmers need to consider different domains and aspects at the same time. When managing an agricultural field, for example, farmers need to take into account and coordinate various technical aspects, such as crop health, soil fertility and water management. At the same time, various economic variables need to be considered (e.g. cost effectiveness, credit requirements, prices) as well as social aspects (e.g. labour availability, relations with household members or neighbours, the feasibility of collective action, etc.). Finally, farmers need to take into account that their activities are linked through time, and that a decision taken at one moment (e.g. a variety choice) can have implications at a later point in time, for example for marketing potential or resilience against floods (as mentioned in chapter 4; see also Leeuwis, 2004). Thus, decisions and changes in an activity that take place in one domain, level, or time-frame have implications for other levels and domains and it is important that these are considered and anticipated. Such anticipation requires not only that farmers have access to applied knowledge and information regarding separate domains and areas of activity (e.g. pest management, soil fertility, economics, water management, etc.) but also that such knowledge and information is or becomes connected and integrated (Faraj *et al.*, 2011; Gardner *et al.*, 2012; Hammer *et al.*, 2001; Meinke and Stone, 2005; Roger and Meinke, 2006; Yoo, 2017).

Typically, agricultural extension is an activity aimed at supporting farmers in linking knowledge and information about different topics and domains, and this often happens in the form of messages and recommendations that are communicated through various activities and media (Van den Ban and Hawkins, 1996). Recommendations and advice are of particular interest when it comes to knowledge integration and usability, as these constitute condensed statements where explicit linkages are made between different areas of knowledge and information, resulting in proposed courses of action in a specific context. A recommendation may for example state something like:

> 'If your field is prone to short term flooding, then use variety X that is able to survive short term inundation, and use fertilizer Y instead of Z to ensure that nutrients are taken up by the plant before the flood strikes'.
>
> Or:
>
> 'Heavy rains are expected in area A in the near future, so do not apply chemical fertilizers or pesticides in the coming week if your fields are located in area A'.

In these statements we see references to the context ('if your field ...'), connections between different bodies of knowledge and information (e.g. linking forecast information to soil fertility management) as well as prompts for action ('do's and don'ts). Thus recommendations have a type of 'grammar' that is suitable for identifying explicit attempts geared towards knowledge integration, as well as for pinpointing the proposed uses of information.

Although recommendations tend to include forms of knowledge integration and can serve to make forecast information usable, their actual usability will of course depend on additional features as perceived and evaluated by farmers, including for example the quality of inferences made, the timeliness of the recommendation, and the actual relevance of contextual references used in their formulation.

To understand how forecast information is made usable beyond its dissemination, particular attention is paid here to two important dimensions of extension delivery: 1) understanding the activities of local level extension worker and their interactions with farmers, and 2) identifying the messages and recommendations formulated in connection with different areas of agricultural activity and the way in which these are linked to forecast information. Analysing these two dimensions enables me to assess whether, how, and where, forecast information is integrated with other relevant knowledge and information, which is a precondition for enhancing its usability.

In line with the above, the following research questions guided the study:

(1) *What extension activities exist in the three villages?*

(2) *In what way, and through what activities, is forecast information regarding flooding and climate integrated with other information as part of extension recommendations and advisory messages?*

(3) *Which extension activities and recommendation are considered to be most valuable by farmers and why?*

5.3. Research setting and methodology

Selection of research locations and respondents

In order to identify what type of extension activities were implemented by local level extension workers for flood and climatic risk management I first reviewed the relevant literature, with special attention to Jamalpur district. Jamalpur district is one of the poorest and most disaster-prone areas of Bangladesh due to floods, seasonal water scarcities, river bank erosion, a low literacy rate, poverty and the migration of poor farmers (Mukta, 2020).

At the outset of this study on forecast information and how it is integrated with different extension activities, informal discussions were conducted with the district and Upazila (sub-district) level DAE officials, non-governmental organizations and scientists from the Regional Agricultural Research Station in Jamalpur in order to identify major flood affected sub-district and villages and different types of ongoing extension activities. Different extension activities were identified and selected for further investigation, including individual contact and group based training activities, some of which were labelled as Farmer Field Schools (IPM-FFS, IFMC-FFS) or Climate Field Schools (CFS) and were part of externally-funded projects.

After several orienting field visits, three study villages (Kulkandi, Pathorshi and Pirijpur) in three different unions (Kulkandi, Pathorshi and Chargoalini) were selected as villages highly affected by floods and river bank erosion. They were also selected as they had, or would have, different Farmer Field School (FFS) activities, such as a Climate Field School (CFS), Integrated Pest Management (IPM-FFS) or Integrated Farm Management Component (IFMC-FFS).

In the study villages, the research applied qualitative research techniques such as transect walks, village mapping exercises, informal conversational interviews and interactive group discussions to gather information about the demographics, physical set up, cropping patterns, problems of getting extension services, the frequency and nature of extension contacts and other pertinent factors, and to help set up a schedule of semi-structured interviews. In addition, group discussions and informal conversational in-depth interviews were conducted with members of the FFSs and non-member farmers to prepare the detailed (schematic) maps of the villages. A purposive sampling design was used in this study. The selection of farmers was based on two sampling criteria i) whether farmers participated in an FFS or not, and ii) whether they were farming in the higher or lower parts of the village, or in both. Using these criteria farmers were classified into 6 groups (see Table 1.2 in chapter 1) per village, and from each group 2 farmers were selected randomly. Thus, 36 (6*2*3 =36) farmers who were willing to spend up to two to three hours on an interview were eventually selected for interviews.

Methods for data collection and analysis

As will be specified below, multiple methods were used for data collection and analysis. These methods included in-depth interviews, informal discussions, group discussions, analysis of secondary document (manuals, organizational and reports, leaflets, etc.), as well as observations of different extension activities occurring at the local level. This strategy provided an opportunity for making analytical generalisations based on gaining contextual and qualitative insights (Yin, 2009) about the processes involved in integrating forecast information into agricultural advice.

First, the content and goals of different local level extension activities were analyzed. This was done through multiple procedures. The extension advisory recommendations, FFS and CFS course materials and manuals were obtained from the relevant websites and the sub-district extension office. The contents were analyzed in terms of the nature of the forecasts and advisory information provided through different activities.

In-depth interviews were also conducted with the different extension worker at the sub-district level and the local level extension workers and field facilitators in the selected villages to understand i) the type of activities employed at local level, ii) the way in which information about forecasting, flooding and climate was integrated with other information to generate recommendations to use in extension activities, and iii) the mode of working and exchanging information with farmers. Within the chosen villages, in-depth interviews were conducted with sample farmers to elicit qualitative data about i) accessing different type of flood and climate risk adaptation-related advisory information through different extension activities across the villages, ii) the nature and type of extension activities that farmers participated in, and iii) farmers' evaluation of these extension activities and the different types of forecast recommendations.

Furthermore, various meetings related to IFMC-FFS activities (oral and demonstration sessions, field days), result demonstrations, and individual contacts at local level were attended and observed by the researcher. These ethnographic observations of the activities, meetings and FFS sessions were triangulated with in-depth interviews and group discussions and gave good insights into the nature of interactions between farmers and local level extension workers.

The audio recordings of the informal interviews, in-depth interviews and observations were transcribed, focussing on the main issues, with a different focus between the interviews with farmers and those with extension workers. An additional source of information consisted of the institutional reports, manuals and field notes of the DAE. Then, through iterative re-reading, coding categories and themes were developed to provide an overview of the responses of the farmers and extension workers about how well forecast information was integrated with agricultural advice and the outcomes of this process (Erlingsson and Brysiewicz, 2017). After completing the coding, content analysis was used as the main analytical tool for interpreting data and drawing conclusions in response to the research questions.

5.4 Results

The following subsections depict the activities that DAE performs at local level and where forecast information is integrated into advisory messages or recommendations. I first describe the various extension activities performed and then dissect the recommendations found in the bodies of knowledge that they integrate. Each subsection provides information on how these activities and recommendations are evaluated and appreciated by farmers.

Activities and interactions employed by the Department of Agricultural Extension

In this part, I will discuss the DAE's main traditional communication platforms for providing information at local level, as identified by the interviewees, which provides an answer to the first research question of this chapter. The subsection will give an overview of different types of activities and interactions between farmers and field level extension workers and how these are valued by farmers. Before analysing the different types of activities and interactions between farmers and field level extension workers, I first provide a general description of the roles and tasks of field level extension workers.

The roles and tasks of field level extension workers

The Department of Agricultural Extension (DAE), under the Ministry of Agriculture, is the largest extension service provider to the grass roots level in Bangladesh. To manage agricultural extension work, DAE has agricultural offices at different levels: regional, district and Upazila. An Upazila consists of three Unions that are the locus of local government, and each Union is sub-divided in three blocks. Each block is assigned with one field level extension worker (or SAAO). In practice this means that such officers service between 1000-1200 households (1200 in Kulkandi, 1100 in Pathorshi, 1000 in Pirijpur).

Each field level extension worker is required to prepare a fortnightly work programme 15 days ahead of time. Typically, field level extension workers are expected to plan four working days per week to visit farmers in their location, with the remaining working day reserved for attending official meetings and conferences. As the field level extension worker of Pathorshi indicated, the three SAAOs in their Union are supposed to stay at the Union Service Centre in three rotations (09.00 am-11.00 am, 11.00 am-2.00 pm, and 02.00-05.00 pm) in order to provide agricultural information and suggestions as part of the NATP project that has been active since 2015.

Based on the fortnight's planned activities, each field level extension worker is supposed to visit farmers' homes or fields, organise group discussions and field days, organise and inspect demonstration trial plots (where they exist), provide early warnings for pest outbreaks and conduct special surveys in case of natural hazards or emergencies (DAE, 2016). During the home and farm visits, field level extension workers are supposed to deliver monthly advice sheets issued by the DAE (see Appendix 3a for an example) for the current field crops, based on monthly forecast information and a memorandum for that particular period (see Chapter 3). This monthly advice for the existing crops contains information about crops and variety selections, seed bed preparation, irrigation, fertilizer and pest management in relation to each particular month.To record the actual work completed and to identify what needs to be done further in the upcoming week(s), field level extension worker use a diary (see example of the format in Figure 5.1) to monitor and fulfil their responsibilities.

In the following paragraphs I will explain what actually happens in the three villages in terms of the type of interactions that take place between extension worker and farmers, how often and when. At the same time I will provide information about the challenges reported by farmers and extensionists, and indicate why these occur.

Individual contact with extension workers through telephone, visits or at input shops

There was a different pattern of interactions between field level extension worker and farmers in Pathorshi and Pirijpur villages on the one hand, and Kulkandi village on the other. Discussions revealed that the majority of the farmers (both FFS or CFS participants and non FFS or CFS participants) of these villages were able to meet with the extension worker once or twice in a week either at an input dealer shop or during a weekly visit to farmer's homes. The field level extension workers at Pathorshi and Pirijpur indicated that they visited local input shops at least twice a week because they were only a short distance from the sub district agricultural office and easy to reach.

The input dealers indicated that it was important to them to maintain good relationships with field level extension workers as it could help them to boost sales. One of the input dealers at Pathorshi said 'as farmers trust the advice of field level extension workers, so we encourage them to visit our shops on regular basis. This visit of extension worker is not only advantageous for us but also helpful for them in terms of reaching more farmers with less effort'.

From interviews and observations it became clear that extension workers visited larger farmers more than smaller ones. One of the larger CFS farmer in Pathorshi said that 'the field level extension worker usually visits our home and farm once or twice a week during the flood season (June-October)'. In various informal discussions in Pathorshi and Pirijpur, large farmers spoke of frequent interactions (twice a week) with the field level extension worker to discuss field related problems (mostly fertilizer and pest management issues) through direct contact during farm or home visits or through phone calls. Larger farmers typically found their cell phones be helpful in allowing them to contact the extension worker easily and whenever necessary. It was observed that other farmers with smaller land holdings were less frequently visited by extension workers and less inclined to use their mobiles to contact extension workers to receive advice.

1422 2016
………………………………………………………………
27 Choitro Saturday
10 April………………………………………………………………

Location & farmer visit	Subject/topic
	1.
	2.
	Problem:
	1.
	2.
	Solution:
	1.
	2.
Follow up and Next things to do	
Follow up : Review the progress of previous work (if it is same place and person) during visit	
Probable lists of work for the upcoming week	

Figure 5.1. Field level extension worker (SAAO) diary page layout

Field observations and informal discussions with Kulkandi farmers revealed a far lower level of interaction with the extension worker than in the other two villages. Farmers indicated that they received little advisory support from the extension worker before, during and after floods. One respondent from Kulkandi stated: 'the extension worker rarely visits farmers' homes and farms. We only see him when there is subsidized input distribution in the village after floods'. Only one of the large farmers (out of six interviewed) in Kulkandi was found to have had contact with the field level extension worker by cell phone and face to face, when the IFMC FFS was operational in 2015.

Even though different types of interactions with extension workers were found in Pathorshi and Pirijpur, there was still sharp contrast between what is supposed to happen, according to formal extension guidelines, and what really happens on the ground. Interviews with field level extension workers revealed that the bureaucratic procedures involved in communicating information from the central level to sub-district level, and the way of circulating messages within the sub-district agriculture office posed major barriers for the timely reception and dissemination of information.

Extension workers at Kulkandi attributed their limited interactions with farmers in their homes or fields to the long distances involved (the village is 13 km away from the sub-district agricultural office) and poor road transport facilities. One of them added 'we are offered only a very small amount of travel allowance to visit the fields, which is not sufficient to go remote areas like Kulkandi'. In addition, extension workers from all the villages indicated that the absence of an office space at the village level was an obstacle to making enough home visits to farmers. Since 2015 extension workers are supposed to have local level office facilities in the multi-purpose Union service centre, but in practice rooms and furniture were not available in the Union service centres of Pathorshi and Pirijpur, while in Kulkandi there was no operational service centre at all due to damage to the building that was caused by river bank erosion.

Group based activities and training programmes

Several group-based activities were identified. In this subsection I first discuss those activities that are part of externally funded projects (farmer and climate field schools) and then turn to more standard activities organised by the DAE (demonstrations, group discussions and field days).

Integrated Farm Management Component (IFMC) and Farmer Field Schools (FFS)

The IFMC programme was implemented nationally by the Department of Agricultural Extension (DAE) between July 2013 and June 2018. The programme made use of farmer field school methodologies (van de Fliert *et al.* 2002; van den Berg & Jiggins, 2007) and was implemented in two villages (Kulkandi and Pathorshi) in the study area- for one rice season, starting at the onset of the Kharif-II season (end of May, 2015) until the harvesting of the crop. Each IFMC FFS was facilitated by a pair of farmer facilitators (FF), who were selected from promising and enthusiastic IFMC FFS participants from earlier FFS projects. After selection they were trained to facilitate the sessions. A sub-district level DAE official mentioned that one field level extension worker was assigned to monitor the activities of the sessions. He also reported that the nine modules (see Appendix-1) included information about rice, livestock, fisheries, homestead vegetable production and family nutrition. In the IFMC FFS curriculum, messages about farmers' organization and climate-change related issues received special attention in four sessions while the other 42 sessions focused on a range of topics. There were two sessions per week, with each session lasting for 3 hours. In total 50 participants from 25 households (one female and one male from each household) participated. In Kulkandi, the participants were selected from different farmer categories, such as landless, marginal and small farm households cultivating up to 2.5 acres of land, whereas in Pirijpur participants were selected from the existing farmer's organization (IPM club) with similar farmer categories. In the IFMC-FFS topics such as variety selection, seedbed management, fertilizer and pest and disease management were discussed in group sessions, also using poster presentations and brain storming methods. The sessions in Kulkandi focused on rice while those in Pirijpur focussed on vegetables.

Variety selection was demonstrated through experimental plots to compare the performance of local and high yielding flood tolerant varieties. In both villages (Kulkandi and Pirijpur) the nearest plot belonging to a large farmer participant was chosen for demonstrations, and free fertilizer and seeds were given for growing rice and vegetable respectively. Farmers conducted forms of agro-ecological system analysis (see Integrated Farm Management Component, 2016; Mukta, 2020), which constituted an important experiential learning tool in the IFMC FFS and served to reinforce the importance of local observation in informing decision-making on e.g. pest and disease management. In the IFMC FFS set-up, a small group of participating farmers was asked to make agro-ecosystem observations in the demonstration plots near to the FFS premises including observations on soil conditions, water management, the field weather station, pests and diseases and progress in crop growth. This was then followed by collective discussion, interpretation and analysis among farmers, with input from the participating facilitator and the local level extension worker (Picture 5.1).

Picture 5.1. Different stages of the AESA being performed by participant farmers

At the end of the IFM FFS training modules the participants, facilitator and extension worker organised a field day near to the FFS club premises in which they displayed the different activities of each session and explained the different activities. This field day allowed non-participating farmers in the villages to hear about lessons learned and acquire more information about the technologies for agricultural production experimented with.

More than half of the participating Kulkandi FFS farmers appreciated the AESA activities in principle and expressed an interest in using them to support decision-making on crop protection. However, the participant farmers in Kulkandi were reluctant to form a cooperative for sharing information among themselves after the completion of the IFMC FFS project. The members did not deposit any money for the club, and one of the FFS farmer stated that: 'they feared that the club fund would be misappropriated'. He also stated that no initiatives were taken by the extension worker to ensure the type of close monitoring needed to run such a farmers club'. In all, the topic of establishing the recommended FFS club raised considerable tension among prospective members, with some farmers claiming that 'everyone was too busy with their own work, so did not meet each other to discuss club matters'.

In contrast, farmers in Pirijpur had already set-up a cooperative FFS club focussing on pest management before joining the IFMC FFS, (after the termination of an earlier IPM FFS). They considered the IPM club to be useful and this led them to continue the activities of the FFS. One FFS farmer in Pirijpur said, 'after selecting the participants (for the IFMC-FFS) we collected money from each member and created a new room which we used to conduct the IFMC classes and a monthly meeting after terminating the FFS '. According to the SAAO for Pirijpur, this well-organized IFMC FFS club captured the attention of the Upazila's agriculture office, which subsequently involved the participating farmers in several other collaborative programmes (group discussions, demonstration and field days run by NGOs and research organizations), which non-FFS farmers were also free to join.

Climate Field School

Climate Field Schools (CFS) are part of a project on disaster and climate risk management in agriculture (DCRMA) that was run in Bangladesh between December 2010 and December 2014. This project was implemented by the DAE and aimed at assessing climate change induced vulnerability in farmer's livelihood systems and supporting livelihood adaptation to climate change in the climate vulnerable areas of Bangladesh through the promotion of appropriate technologies. The project covered 52 flood risk prone sub-districts in 26 districts of Bangladesh. The programme was a follow-up to earlier projects in ten sub-districts of Bangladesh, which responded to calls and demands for disaster risk reduction and climate change adaptation in disaster hotspots.

Within the research area, CFS activities were implemented at Pathorshi village during the rice growing season of 2014. The extension worker of Pathorshi mentioned that the CFS manual favoured the inclusion of both male and female participants from different categories of farmer. 25 farmers and their wives (a total of 50 participants) were selected from the previously established IPM Club. A module was prepared as a guideline for the facilitators to achieve these objectives. The module was divided into 15 sessions of group discussions and field trial experiments (See Appendix-3b).

From the interviews and observations it was clear that participating farmers finished the course with better knowledge about weather and climate, the causes of climate change and floods, flood timing and the possible impacts of the flooding and climate change on crop production. One CFS farmers recalls that they learned about the environment and the agricultural environment, the causes of climate change and how to respond to its adverse effects. Participant farmers were also instructed on how to measure the local temperature and rainfall using instruments provided during CFS sessions. Finally, at the end of all the sessions a field-day was arranged at the CFS premises for purposes of awareness raising and dissemination among non-participating farmers. The CFS farmers stated that, monthly meetings were arranged by the member of CFS to collect money for collective savings and discuss agricultural problems. Participating farmers acknowledged the value of the information that they gained from CFS, and appreciated that they could combine it with other forecast information and their own farming knowledge (see also section 5.2). However, they complained about the availability of and access to instruments for measuring local temperature and rainfall, which they felt was not monitored and after the termination of CFS.

Other group based activities of DAE

In various informal discussions at Kulkandi, farmers indicated that there were no group-based activities organized other than IFMC FFS which continued for one crop season in 2015. By contrast, discussions in Pirijpur and Pathorshi, revealed that there were additional group meetings and collaborations besides the various FFS and CFS activities (in Pirijpur an IPM FFS and an IFMC FFS were functioning from November 2012 to February 2013 and from June 2015 to October 2015 respectively, and in Pathorshi a IPM FFS and CFS were active in 2012 and 2014 respectively. In Pathorshi and Pirijpur, we observed demonstrations for flood tolerant rice varieties (BRRI Dhan-51, BRRI Dhan-52) and HYV rice which were jointly facilitated by DAE and a research organization. Extension workers selected farmers from the ongoing FFS club and the experiments were undertaken to inform farmers about sowing seed, planting times, intercultural operations and input management. After harvesting the crops, field days were organised to disseminate the findings among other farmers. We also observed that the extension worker in Pirijpur jointly facilitated different group discussions, result demonstrations and field days in collaboration with an NGO, Making Markets Work for the Chars.

In Pathorshi we also witnessed collaborative surveying activities to generate and provide forecasting and early warnings of pest outbreaks. The field level extension worker of Pathorshi explained:

> *"After performing a survey, we use certain formula to predict the pest and disease outbreak and share the findings with other field level extension workers during our official meeting. After that, pest outbreak information about what to do for pest management before and during a severe pest infestation is shared with participant farmers of the plots, through personal interactions and the mass media . For example, last year we advised farmers to plant rice by the logo system of planting, grow a pest resistant rice variety (BR-11) in T. Aman season and to timely plant the seedlings to reduce infestation by the Brown Plant Hopper insect."*

As mentioned no such activities (demonstrations, collective surveying) were implemented by the DAE in Kulkandi. One field level extension worker in Pathorshi mentioned that most demonstration plots are located in villages that are close to the agricultural office, and that sites are selected for having good road transportation facilities so that FFS field-days can be easily visited by the regional agriculture officer.

Integrating different kinds of information within official recommendations

This subsection will give an overview of whether (or not) and how climate, forecast and flood information is linked to other information and integrated in recommendations to farmers, as well as how particular types of recommendations are evaluated by farmers. In addition, this section examines the knowledge that farmers add themselves to apply the recommendations for flood management.

Crop and variety selection

Interviews and discussions in the study villages revealed that crop and variety related recommendations were mainly provided through CFS activities and the individual contact that extension workers had with farmers at input shops, or at farmers' homes during visits. During the running period of CFS, recommendations were provided mainly through flip chart presentations, group discussions and at the variety demonstration plot. Variety demonstration plots were also implemented in the context of the IFMC-FFS, with special attention to the crop life cycle, starting with seed sowing and ending with the harvesting of the crop. Interviews, observation and discussions in Pathorshi and Pirijpur revealed that information on flooding and climate was integrated with information about crops and varieties in the form of recommendations that focus on what can be grown, when and where (see Table 5.2) .

In the following sub-section I will explain how farmers valued these recommendations and the information or new methods that farmers considered useful and added to their existing farming knowledge and practices.

Observations and discussions showed that more than half of the CFS framers in Pathorshi had a clear idea about the flood tolerant rice varieties and related recommendations on the age (plant age) for transplanting these rice seedlings to the main field to overcome flood problems. Many non-CFS farmers also heard about 'flood tolerant variety' from the field day of the CFS demonstration plot and informal discussions with CFS farmers. The majority of CFS farmers gained their information from observing the variety demonstration plot that showed how these 20-25 day old flood tolerant varieties (BRRI dhan-49 and 52) seedlings can withstand 15-20 days of water-logged conditions.

Table 5.2. Crop and variety selection recommendations provided through the activities of the DAE

Advice/recommendations	The elements that are integrated	Activities and interactions
Growing early and short duration AUS rice varieties, to harvest before the flood.	Flood and climate change adaptation information was linked with variety selection.	Discussion at CFS Extension worker interaction at input shops/ farmers' homes
Growing flood tolerant Aman varieties that tolerate 10-15 days of being water logged.	Flood & climate change adaption (before flood) information was linked with variety selection, soil and seedling management, intercultural operations and pest and disease management information.	Variety demonstration plot & discussions at CFS and IFMC FFS
	Flood coping information is linked to variety selection.	Extension worker interactions at input shops and farmers' home visits
To prevent flood damage, planting fast growing crops and vegetable that can be harvested before flooding.	Flood and climate change adaptation information was linked with crop selection	Flip chart presentations & discussions at CFS
If Aman rice cannot be planted in low land farms due to floods or excessive rainfall, late planted local Aman rice variety (ganja) seedlings can be planted as soon as the water recedes.	Flood information (coping after flood) is linked to variety selection.	Extension worker interactions at input shop/ farmers' home visits
Grow high yielding varieties of mustard without prior cultivation as soon as the flood waters recede.	Flood information (coping after flood) was linked to variety selection.	Extension worker interactions at input shop/ farmers' home visits
Crops and vegetables that can be grown quickly after flooding.	Flood and climate change adaptation (after flood) information was linked with crop selection	Flip chart presentations & discussions at CFS
Growing pulses (kheshari, mashkali) alongside the roads, char and fallow land as soon as the flood waters recede.	Flood and climate change adaptation (after flood) information was linked with crop selection and location	Flip chart presentations & discussions at CFS

This led them to consider the recommendation to be useful and they started to grow these varieties in the Aman season after the CFS activities. One CFS farmer stated: 'I grew traditional BR-11 and Mukta as Aman rice before participating in the CFS, but over the past two years I have started to grow these flood tolerant varieties during Aman season'.

In Kulkandi the FFS farmers acknowledged the information provided on crop and variety selection through various activities, but some farmers were not able to apply the acquired knowledge about selecting a flood tolerant rice variety as they did not own or have access to fields in medium or higher locations. Informal discussions with Kulkandi FFS farmers who only had fields in low areas revealed that they did not consider the IFMC rice sessions useful for them as the training sessions focused mainly on rice-based production systems, while other major crops (e.g. sugarcane) grown in low areas were not discussed in detail. Interviews with farmers of all three villages revealed that nearly all farmers (CFS/IFMC, non-CFS/IFMC) already knew about the recommendations regarding growing late planted Aman rice (Ganja -dhan) and other crops (mustard, vegetables), and had been applying these for a long time (see details in Chapter 4). However, some farmers from Pathorshi said that they had followed their SAAO's suggestion, and planted a HYV mustard crop instead of local mustard as a late planting crop after the floods.

Seedbed and seedlings management

Table 5.3 shows that most of the seedbed and seedling management related recommendations for coping with floods were provided through discussions at the CFS held in Pathorshi, or during individual contacts with the extension workers. These recommendations mostly related to protecting seedbeds against floods, the timing of planting seedlings in connection with flood risks, and protecting seedlings from cold weather with the help of polythene covers. Another set of recommendations involving the design and management of ideal seedbeds were discussed and practiced by the participant farmers as part of the IFMC FFS in Kulkandi and Pathorshi.

These recommendations for improved seed bed management included the ideal size of a seed bed, keeping a furrow in the centre of the bed for easier irrigation, providing drainage facilities, performing different intercultural operations and sowing seeds at certain intervals for easy aeration and enhanced growth of the plant.

Table 5.3. Seedbed and seedling management advice given via the DEA's activities

Advice/Recommendations	What elements are integrated	Activities and interactions
Growing seedlings in raised seedbeds during the flood time for timely planting in the main field.	Flood coping information was linked with seedling growing in raised land.	Extension workers' interactions during farmers' home visits/input shop visits.
		Flip chart presentations & discussion at CFS.
Preparing a floating seedbed during the flooding period for timely planting in the main field.	Flood coping information was linked with information about growing seedlings.	Flip chart presentations & discussions at CFS
Delay planting eggplant seedlings in the main field.	Adjusting planting time in relation to flooding	Extension workers' interactions during farmers' home visits/input shop visits
Preparing a community seedbed in anticipation of flooding.	Seedbed preparation advice was linked with flood coping information.	Flip chart presentations & discussions at CFS
Covering seedlings in seedbed with polythene sheet to raise temperature and increase germination during winter.	Advice on seedling management in the seed bed was linked with weather forecast.	Flip chart presentations & discussions at CFS
Improved seedbed design and management, including measures for drainage and aeration to deal with rain and floods.	Ideal seed bed measurement information was linked with climate information, seedbed management for easier intercultural operations as well as drainage information.	IFMC FFS

In all three villages, the majority of the farmers knew the usefulness of growing T. Aman seedlings on raised land and they indicated that this was a traditional flood management practice which enabled them to transplant seedlings to the main field when the flood waters had receded.

One CFS farmer said- 'we knew this advice of growing T. Aman seedlings in raised land from the past as well as from the CFS sessions'. However, several farmers in Kulkandi and Pathorshi indicated that they were not able to grow seedlings on raised land because they had no access to medium or high land (see details in Chapter 4).

In 2016, many farmers (both FFS and non-FFS) of Pirijpur also used their raised land (usually their homestead area) for growing eggplant seedlings during the flood season, saying that this was something they had already done for a long time. The recommendations about seedbed design were regarded as more novel and close observations, confirmed by informal chats, revealed that about half of farmers participating in the IFMC FSS in Pirijpur started to follow some of the seedbed and seedling related recommendations (preparing ideal seedbed, taking care of the seedlings in the seedbed, and transplanting the seedlings at the proper age) for preparing eggplant seedlings during times of flooding (Picture 5.2). Similarly, CFS farmers in Pathorshi, started to follow new practices of seedling management during winter such as using a polythene sheet to covering the seedlings in the seedbed in order to raise the temperature and increase germination.

Picture 5.2. Ideal seed bed preparation and management activities performed by farmers at IFMC FFS

CFS farmers appreciated the recommendations regarding seedbed and seedling management in case of fluctuating temperature, especially the guidance on how to measure the local temperature and rainfall. However, they felt that they lacked sufficient information on what to do with seedlings in case of high temperatures and/or when heavy rainfall was predicted. When heavy rainfall and flood were predicted, the majority of farmers from Pathorshi and Pirijpur villages delayed seedling transplantation. They relied on their own observations or on forecast information provided through radio and TV to assess the appropriate planting moment. However, many felt that insufficient information was available regarding the timing of floods and rains in their specific location.

Fertilizer and soil management

Interviews and group discussions revealed that a range of fertilizer and soil management related recommendations were discussed at the CFS, aimed at improving soil health, optimizing nutrients in the soil, filling soil fertility deficits with mineral fertilizers, combatting pest and weed pressure and maximizing productivity (see Table 5.4). Such recommendations focussed on the application of organic manure, improved fertilizer management practices, such as applying essential micronutrients at a proper time, the balanced use of organic and inorganic fertilizer in recommended doses, appropriate crop rotations and the use of bio slurry.

Table 5.4 indicates that several (but not all) recommendations had a direct link with forecast information in that they include considerations regarding flood or weather conditions. Two soil fertility related recommendations given through individual contacts with extension workers were linked to flood timing and post-flood management, while another recommendation related to how to fertilize when cold weather was forecast. One of the interviewed SAAOs from Pathorshi said: 'when we visit farms after flooding we also tell farmers to provide fertilizer and apply light irrigation to the flood affected plant to remove the silt accumulated on the leaves and allow for better sun-exposure'. In contrast, recommendations provided through IFMC activities (see Table 5.4) were more oriented to linking soil fertility management to field observations regarding crop growth and symptoms of nutrient deficiencies in the plants. IFMC-FFS farmers collected such information through systematic AESA analysis in the demonstration fields (a rice field in Kulkandi and a vegetable field in Pirijpur) which included careful observation of crop performance, soil conditions and weather station measurements.

Observations of the IFMS sessions suggest that farmers talked a lot about their own crop situation during the AESA activities, and that the facilitators were asking questions to initiate such discussions and to stimulate critical thinking. These detailed analysis and discussions in the field seemed to have contributed considerably to making decisions about soil fertility management. FFS farmers at Kulkandi and Pirijpur also mentioned several soil treatment recommendations in which linkages were made with soil-borne pest and disease management rather than with flood or weather forecast information (see Table 5.4).

Farmers stated that the participatory process employed in the AESA enabled them to more effectively assess fertilization needs on the basis of observations of nutrient deficiency symptoms in their plants. However, feedback from the IFMC FFS farmers revealed that they found it difficult at times to translate these insights into action as they lacked location-specific information on the expected times of flooding.

CFS farmers from Pathorshi voiced similar concerns and indicated that the recommendations about the soil fertility measures to take after flooding were clear, but that it was risky to apply fertilizers in the absence of precise information about when floods and heavy rainfall were likely to happen.

One of the member farmers from Kulkandi village stated 'we decide not to apply fertilizer in Aman rice and vegetable plantations in order to avoid it being washed away'. What emerged from the interviews is that most farmers simply postponed fertilizer application according to their own estimations of when floods or rains were most likely to happen. In relation to this, a farmer from Pathorshi stressed that: 'we wait for the recession of the flood waters or rainfall from the field before applying fertilizer to Aman rice'.

Pirijpur FFS farmers indicated that they appreciated the soil management recommendations regarding soil-born pests and diseases from IFMC FFS and that practicing them in their seedbeds and main field helped them to reduce pest infestation and ultimately the cost of applying pesticides.

Table 5.4. Fertilizer and soil management related recommendation provided at farm level through different activities of the DAE

Advice/Recommendations	What elements are integrated	Activities and interactions
Applying chemicals (Furadan) in seedbeds and main field to treat the soil before planting.	Soil-born pest and disease management related information were integrated with increased crop yield	Discussions and practice sessions at IFMC FFS
Application of organic manure, crop rotation and using bio slurry to improve soil health, optimizing nutrients in the soil and combating pest and weed pressure.	Information about the use of organic fertilizer and crop rotation was integrated to improve soil health and fertility as a climate adaptation measure.	Flip chart presentations & discussions at CFS
Dosage and timing of applications of both organic and inorganic fertilizers.	Balanced and proper doses of fertilizer information was linked to plant growth.	Flip chart presentations & discussions at CFS
After the flood waters have receded, apply light irrigation to clean plant leaves of the remaining flood affected seedlings and apply fertilizer (urea) for vigorous growth.	Irrigation & fertilizer information was integrated with crop growth (post flood management).	Extension worker interactions through farmers' home visits/ input shop visits
Apply potash fertilizer after flooding - to make the plant strong and stout.	Fertilizer information was linked to plant growth.	Extension worker interactions through farmers' home visits/ input shop visits
Fertilizer application in eggplant based on nutrient deficiency symptoms (colour, growth and size of the leaves & fruit of the plant).	Information about the types and doses of fertilizer was linked with deficiency symptoms on the plants.	Extension worker interactions through farmers' home visits/ input shop visits/ phone contacts
Applying and testing different combinations of fertilizer to compare the yields.	Improving fertilizer management practices was linked with an analysis of the crop field situation.	Fertilizer management experiment trial at IFMC FFS; through AESA at IFMC FFS
Applying essential micronutrients to plants: using balanced and recommended doses of fertilizer after analysing the field conditions based on deficiency symptoms		

Crop protection

Table 5.5 indicates that several recommendations were provided on crop protection, and that those with a link to weather and flooding mostly originated from individual contacts with extension workers. The interviews, focus group discussions and observations of FFS activities revealed that the recommendations delivered at the IFMC FFS and the CFS on crop protection were mainly geared to integration with soil fertility management information rather than with weather forecast information about flooding and weather.

Table 5.5. Crop protection related recommendations provided at farm level through different activities of DAE

Advice & recommendations	What elements were integrated	Activities and interactions
Observe BPH infestation in rice crop. As soon as the attack is observed, drain the excess water quickly and control the crop with pesticides after flood.	Water management information was linked with pest management after flooding.	Extension workers' interactions through home and farm visits
Apply Vertimegh and Tundra insecticides when the insect infestation increases due to lower than usual rainfall from mid-April to mid-June	Insect infestation & management information was related to amount of rainfall.	Extension workers' interactions through home /input shop visits
Pest related information for all crops.	Identification of insects and solutions whenever possible.	Extension workers' interactions through home / input shop visits or phone contact
Use of IPM for pest management.	Application of a set of knowledge and practices in which judicious application of pesticides was suggested as a last resort.	IFMC FFS, CFS
Analysis of fields under crops to observe the presence of insect pests; identify beneficial & harmful insects and employ cultural, biological, mechanical and /or chemical controls. Emphasis on proper timing and doses of pesticide application in order not to ham beneficial predator insects.	Insect pest management information (using IPM) with soil fertility management related information through proper analysis of field situation.	AESA or IFMC FFS
Spray chemicals on the crops (mustard, potato) in the field to protect from injury from cold.	Cold weather forecast was linked with chemical protection measures to prevent injury from cold.	Extension workers' interactions through home/ input shop visits

As indicated in the previous section, AESA analysis and IPM principles played an important role in these activities. Farmers were recommended to spray chemicals in order to protect their potato and mustard crops during the cold season.

This advice was given by extension agents through cell phone contact and during visits at input shops, with the argument that protection against injury from the cold would also make the crops more responsive to soil fertility improvements. Farmers in Pathorshi and Pirijpur were more willing to integrate new knowledge and practices for pest management than those in Kulkandi. Discussions with farmers revealed that more than half of the CFS farmers in Pathorshi and several farmers in Pirijpur had started to use AESA methods in their own fields to assess infestation status and take appropriate actions. Observations and discussions showed that many farmers in Pathorshi and Pirijpur (including non FFS or CFS participants) were aware of IPM knowledge and practices.

The comment below by a farmer in Pathorshi is typical for many in the village:

> *"Prior to participating CFS, we used pesticides without much consideration and relied heavily on them. After participating in the CFS, we started to use the AESA method for analysing insect and pest infestation in our fields, and started to use pheromone traps, light traps and bird perching. Pesticide application has now become the last resort."*

Two CFS farmers stated that different experiential learning exercises employed during CFS increased their confidence and ability to identify insects, understand the severity of damage at different stages and take appropriate action, based on the situation. According to the CFS farmers from Pathorshi 'The biggest encouragement to apply the IPM practices in farming is economic since we can reduce the cost of using pesticides and still increase our yield and income.' At the same time most farmers from Pathorshi and Pirijpur who participated in the group discussions and interviews confirmed that they followed the recommendation to spray chemicals to protect their potato and mustard crops during the cold season.

While several FFS farmers in in Kulkandi appreciated and expressed interest in using the AESA methods for crop protection and fertilizer management, the number of participants in the FFS in Kulkandi using these methods seemed markedly lower than in the other two villages. For instance, the proposal to launch an FFS club which to continue the process of sharing information between farmers never materialized and no follow up meetings were organised. The extension worker also made little attempt to monitor post FFS activities. This may be partly because the AESA methods were geared towards rice and vegetable production, while a number of farmers in Kulkandi were growing sugar cane (see Chapter 4). As a result very few farmers in this village actually made use of the AESA methods to inform their decision-making and during observations and interviews these farmers did not talk much about what they had learnt during the FFS sessions.

Although observations suggested that little attention was paid to the linkages between crop protection and specific weather forecast information during the IFMC FFSs that were conducted in Kulkandi and Pirijpur, the large majority of farmers in all the villages stated that they stopped or delayed pesticide application when they were aware of imminent rainfall or flood risks either through weather forecasts (discussed in Chapter 3) or through their own observations and prediction.

5.5 Discussion

This study has set out to develop a more detailed understanding of what happens beyond the dissemination of forecast information. Assuming that the usability of forecast information is enhanced when it is linked to other agronomic information, the study has focused on whether, and how, such linkages are established in recommendations and advisory messages from the extension service that are conveyed through various means.

Linking weather forecasts to other agronomic information is important but not sufficient

The identification and analysis of recommendations described in section 5.4 makes it clear that forecast information is indeed integrated with a broad range of other topics on which farmers have to take decisions. In the spheres of crop and variety selection, as well as in seedbed and seedling management, we see that all of the identified recommendations were linked somehow with issues pertaining to floods, weather and/or climate. For recommendations in the sphere of soil fertility management and crop protection we see that around half of the extension messages were linked to forecast information, while other messages focus on integration with other relevant knowledge domains. Thus, extension organizations and workers do indeed make an active effort to translate information on floods, weather and climate into guidance for farmers in domains that are clearly relevant to them. However, qualitative evidence on the valuation of recommendations by farmers makes it clear that there is still considerable scope to enhance the usability of forecast information. Importantly, farmers indicate that there is a large number of recommendations which would be more useful if they were combined with more specific information about the likely timing of the occurrence or cessation of floods in their location, and more targeted and precise weather and climate forecasts. Much of the information that is linked to flooding is currently provided on a monthly basis and broken down into Bangladesh's eight regional divisions.

In order for farmers to take decisions on seedbed and seedling management, soil fertility management and crop protection, they need tailor-made advice, with respect to time horizon and geographical scope. In addition, farmers indicate that there a considerable number of recommendations they received are already common (or at least partially known). Table 5.6 captures some of these evaluations by farmers.

Thus, we see that extension workers do manage to link forecast information to knowledge regarding different fields of farming activity, with an emphasis on practices that take place early in the growing cycle (variety selection and seedbed/seedling management). However, the usability of recommendations in nearly all knowledge domains could benefit from more time and location specific forecast information.

Table 5.6. Farmers' evaluation of the DEA's recommendations in terms of novelty and the need for more time and location specific forecast information

Recommendations	Novelty of information			Recommendations would benefit from more precise forecast information	
	Entirely new	Partly new	Well known	Yes	No
Growing early variety AUS rice			✓	✓	
Growing flood tolerant varieties	✓			✓	
Planting fast growing crops and vegetables before flooding			✓	✓	
Growing late T. Aman rice variety (Ganja) after flooding			✓		✓
Growing seedlings (eggplant, T. Aman) on raised land		✓		✓	
Delay planting seedlings (rice and eggplant) in the main field			✓	✓	
Use polythene sheeting to increase the temperature and germination of seedlings	✓			✓	
Ideal seedbed, seedling management in the seedbed, and seedlings' age for transplantation	✓			✓	
Growing crops (mustard and pulses) and vegetables after flooding			✓		✓
Cultivating HYV mustard after flooding		✓			✓
Applying chemical spray to potato and mustard crop during cold season.	✓			✓	
Fertilizer management: use of both organic and inorganic fertilizer in proper doses		✓		✓	
Observing BPH infestation in rice crop. As soon as the attack is observed, quickly drain the excess water and control the plot with pesticides after the flood		✓		✓	
Apply Vertimegh and Tundra insecticides when insect infestation increases due to less than normal rainfall from mid-April to mid-June		✓		✓	
Pest management through IPM based on AESA	✓			✓	

Group-based extension activities have potential but suffer from discontinuity

As can be observed from the tables in Section 5.4, many of the recommendations that link forecast information with other bodies of knowledge are conveyed through farmer field school-type of extension activities such as the climate field schools and the integrated farm management component field schools. The interviews and observations suggest that farmers highly appreciate such activities as they include intensive methods, such as AESA analyses and demonstration experiments and allow for discussion among farmers and extension workers. While such activities are known to contribute considerably to learning and knowledge integration (Van de Fliert et al., 2002; Leeuwis, 2004; van den Berg and Jiggins, 2007), the findings suggest that these activities Thus, extension activities that appear conducive to developing shared understanding and an integration of knowledge are not broadly available on a long term basis, due to the lack of a robust and sustainable funding system for group-based agricultural extension activities.

Individual contact with the extension service is limited and selective

In the absence of group-based activities, individual contacts between farmers and extension workers remain the most important way in which recommendations are provided to farmers. These individual contacts are also the main channel through which monthly forecast information is (supposed to be) provided. However, the findings suggest that there are several constraints to conducting individual farm visits regularly and on a wide scale. These include: resource constraints (limited transport allowances, poor village-level office facilities), time constraints (not enough extension agents to serve many farmers) and poor transportation facilities and infrastructure (see also Mukta, 20020; Ahmed, 2012, Ageyi and Stringer, 2021). As a result, contacts with extension workers often take place outside the immediate farming context, for example at input shops or through phone contact. Such interactions are not ideal as they do not allow for integrating local observations and other contextual information on local conditions into advisory recommendations. The limited capacity to conduct farm visits implies that extension workers need to be selective and there are strong indications that this results in a bias towards relatively well resourced and easily accessible farmers. Many smallholder farmers (especially in the more remote village of Kulkandi) indicated that they have little or no contact with extension workers, and feel that extension workers are more interested in serving larger farmers. These findings are in line with the findings of Ahmed (2012), who suggests that front line extension officers have a tendency to provide services to wealthier farmers.

Differential provision of extension services to accessible and less accessible villages

The findings indicate that the relevance and significance of the above observations differs to some degree across villages. In Pathorshi and Pirijpur there is more regular contact between farmers and extension workers than in Kulkandi, even if such contact does not reach the levels that are expected according to formal plans and guidelines. Similarly, in some villages (notably Pathorshi and Pirijpur) it was noted that group-based activities continued after the closing of the farmer field school (FFS) or climate field school (CFS) through farmer organized 'clubs' of the former participants of these groups. Such clubs provided platforms for member farmers to share agricultural information and were also often attended by local level extension workers, establishing a regular conduit of contact. In order to maintain these clubs, member farmers are often expected to make a monthly financial contribution, with the collected funds often used to provide soft loans to member farmers. Although, this ensured the continuation of group-based knowledge sharing-activities, farmers also noted the lack of proper equipment and resources for intensive learning activities and novel curriculum development.

It is not entirely clear why farmers in Pirijpur and Pathorshi organized themselves in order to maintain more intensive group-based knowledge-sharing activities, while the farmers in Kulkandi did not. Mukta (2020), who did research in the same area, noted that there may be significant differences between villages in terms of their social integration (e.g. competition vs. collaboration) and authority patterns, which her study demonstrated can have profound effects on farmers' ways of networking and knowledge sharing. She found that Pirijpur was a village with relatively strong cooperative relationships, and it may be that Kulkandi has a less cooperative culture. However, such a cultural explanation seems to provide only part of the answer. There are also indications that Kulkandi receives considerably less attention from extension workers and other government officials than other communities, because of its relative inaccessibility; this was signaled by respondents and is also reflected in the absence of a functioning Union service centre. In addition to this, it is relevant to note that Kulkandi is the most flood prone village as it does not have fields with a higher elevation (see also Chapter 4). As a response, Kulkandi farmers have a greater interest in sugar cane production than farmers in the other villages, who tend to focus on rice and vegetable production (see Chapter 4). It is quite possible that their relatively disadvantaged location and particular cropping system makes the farmers of Kulkandi less attractive and important to extension workers and other governmental authorities. This would imply that those who are most vulnerable to floods receive the least support. More research is needed to find out about the background of the differences found across the three studied villages.

5.6 Conclusions

This study provides insights into how forecast information is integrated with other domains of knowledge and practice after it has been disseminated to the local level. Extension recommendations play an important role in making forecast information usable and constitute condensed messages in which explicit linkages are made between forecast information and other areas of knowledge and information (e.g. crop and variety selection, soil fertility management, etc), as well as to specific contextual conditions. Ideally, such recommendations provide proposed courses of action that are specific to farmers' realities on the ground. An analysis of the recommendations made by the extension services suggests that forecast information is mainly integrated within domains that are linked to activities early in the growing cycle (variety selection and seedbed/seedling management) and to soil fertility management and crop protection. Nevertheless, the usability and novelty of such recommendations in all knowledge domains could still benefit considerably from more time and location specific forecast information. Another conclusion is that intensive group-based extension activities, such as farmer field schools are appreciated by farmers and provide important opportunities for developing and integrating knowledge, as they support detailed observation and analysis of field conditions and allow for discussions between farmers and extension agents with different expertise. However, such group-based activities are not structurally integrated within extension policy and tend to take place only occasionally as part of externally funded - and therefore temporary and short term - programmes. Individual contact between farmers and extension workers therefore remains the most important vehicle for the provision of recommendations that integrate forecast information with other knowledge domains. In view of financial, logistic and organisational constraints facing Bangladesh's extension service, it seems that many, especially less resourced farmers are still largely excluded from individual contact with extension workers. Moreover, contacts often take place in settings (e.g. input shops) that are not necessarily conducive to the inclusion of contextual knowledge.

In all, this analysis of extension activities and recommendations shows that attention is certainly paid to integrating forecast information with other fields of agronomic knowledge. While this enhances the usability of this information, there also remain constraints in terms of the limited time and space specificity of forecast information, the novelty of information provided, the type of extension activities that are conducted and the scale at which they take place.

6

Chapter 6

Synthesis and Discussion

6.1 Introduction

Farming in Bangladesh is obstructed by heavy rainfall, seasonal floods and numerous weather and climate change related phenomena such as flooding, droughts, cyclonic storm surges and riverbank erosion. This thesis addresses the connections between flood forecast information and agriculture in one particular context: the challenge of gathering and transmitting useful forecast information to vulnerable riverine smallholder farmers. The core of this thesis is to understand why it is difficult to make forecast information usable at local level. Earlier studies have typically pointed to challenges with regard to the timeliness and accuracy of forecast information (Islam *et al.*, 2013; Ahmed et al., 2019; Fakhruddin *et al.*, 2015; Kumar, 2021) and to limitations in farmers' capacity to interpret and understand the information that is increasingly available through mobile phone technology (Archie *et al.*, 2014; DAE, 2018; Kumar *et al.*, 2021; Sarku *et al.*, 2021). Less attention has been paid to the challenges arising from the institutional set-ups through which forecast information is produced and made available, and to the role of agricultural extension services in making forecast information relevant to different contexts. Therefore, the main objective of this dissertation is to explore and analyse the entire chain in which forecast information is produced, disseminated, accessed and integrated within agricultural extension activities, with a view to identifying the constraints and opportunities to effective information provision and how these may vary across, and within, farming communities. To this end the study focussed on the different organisations and programmes that are involved in the production, dissemination and integration of forecast information, and compares the experiences of farmers in three different geographically defined village settings.

The introductory chapter of this thesis sets out the following four research questions:

(1) *How different organizations generate forecast information, what types of information are produced and why?*
(2) *What media and channels are used to disseminate forecast information to the local level, and how, and to what extent, is such information accessed by farmers in different communities?*
(3) *What are the existing farm management practices used by farmers operating in different agro-ecological conditions to deal with flood and climatic risk?*
(4) *How is forecast information integrated with other information as part of extension activities to generate recommendations for flood and climatic risk management, and how are these valued by farmers?*

After presenting the main findings from the empirical chapters, I present the cross-cutting themes and the more general lessons and implications of the findings in response to the overall objective of the study. This is followed by a discussion on the implications for policy, practice and follow up research and a general conclusion.

6.2 Main findings

Understanding the construction of forecast information (Chapter 2)
Most studies on climate forecasting in Bangladesh have looked at the transfer and dissemination of forecast information without addressing the institutional context in which forecast and related advisory information are produced. In Chapter 2, I used the notion of situated practice to examine how the institutional characteristics of the various organisations play a role in the production of weather and flood forecasts. The findings show the particular ways of working and the operational routines of these organisations.

The guiding research questions were: *i) how are practices of producing forecast information influenced by the organizational demands, preferences, routines and setting of the organizations? ii) how do the interactions between the organizations and their institutional background affect the integration and application of flood forecast information?*

The three organisations studied in the chapter are the Bangladesh Meteorological Department, the Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board and the Department of Agricultural Extension (DAE). The histories of these three organisations are quite different and influence several characteristics of the way that each of the forecast producing organizations collect meteorological data and other information that are processed into weather and flood forecasts. For instance, the Bangladesh Meteorological Department aims to produce forecast mainly for the coastal area and eight bureaucratic divisions. The Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board is specifically focused on riverine areas, where it runs its own measuring stations to monitor water levels. The historical development of the Department of Agricultural Extension shows a recent change from a classical extension service to an organisation that incorporates farmer field schools and similar participatory methods to work with farmers.
Their presence in 492 sub-districts is used to collect basic meteorological data that is used for forecast information. The findings of Chapter 2 thus reveal major differences in the mandates, operational procedures and work routines of the three organizations, including different ways of data collection, using different instruments for measurements and different procedures for processing the collected data. There is little sharing of technical expertise or feedback between the organizations. Despite these differences, each of the organisations faces the same challenge of predicting water levels for the future based on data from the past. The capacity to do so is largely determined by the capacity of computer models and automated forecast information services. The

computer-based systems are developed through foreign aid budgets and international consortia. Based on insights from the notion of situated practice, the chapter thus shows parallel practices within the three organisations as well as an increased reliance on computer models developed in international contexts that aim for better predictions for very local contexts.

Understanding the dissemination of forecast information (Chapter 3)
The eventual usability of forecast information at local level is not only shaped by the processes and conditions that occur in the settings where information is produced. The next process involved is the dissemination of forecast information from mostly national level organisations to the local level. Chapter 3 therefore focusses, *on the networks, media and channels through which providers disseminate different types of forecast information to the local level, as well as how, and to what extent, such information is accessed by farmers in different communities*.

The findings demonstrate that forecast information is disseminated along the hierarchical lines of bureaucracies to the local level, using a wide variety of media. Written documents (e.g. bulletins and letters), emails and websites play an important role as information cascades down within organisational networks, while conventional mass media such as radio, television and newspapers also play an important role. New internet and mobile phone based technology (SMS, IVR and websites) have been experimented with as part of special projects, but they were used by a limited number of farmers and the conditions for the use of such services deteriorated quickly after projects ended. As there appeared to be a substantial variation in access to the media, channels and intermediaries (e.g. extension agents) across the villages, access to this forecast information also varied considerably. And even when media opportunities and intermediaries are available, this does not guarantee actual access to the disseminated forecast information.
Numerous factors; organisational, infrastructural, institutional, financial, technological, geographical and personal influence the actual access to forecast information from the available sources. The presence or absence of externally funded projects has a major influence on the possibilities to use mobile phone based information services, and conventional mass media, such as television, is not uniformly available across villages, depending on the availability of electricity infrastructure. The results reveal that institutional hierarchies and procedures play a significant role in determining whether and/or how fast forecast information becomes available at the local level. Significant delays were observed in disseminating several types of forecast information through different administrative tiers by email and fax, and these delays were linked with the functioning of technical equipment, internet connectivity, staff availability and attentiveness, transport facilities, travel allowances, budgets and so on. Access to disaster bulletins, for example, was hampered in some villages as the local level disaster

management committee was not functional, due to a lack of continuous internet facilities, poor office facilities, an absence of trained staff and limited monitoring of activities by higher administrative authorities. Besides these issues, coordination challenges between the disaster management committees at the Upazila and Union levels, and an absence of government circulars regarding the responsibilities of government officials, also influenced the timely distribution of forecast information at the local level.

Apart from these organizational, institutional and ICT related issues, there were constraints among the farming communities that inhibited their access to forecast information: these included a lack of financial resources, of digital literacy, of English language proficiency and interpretative skills and capacities. In addition, farmers raised several concerns regarding the quality and value of the forecast information that they could or did access. The relevance of such information was typically hampered by delays, and farmers indicated that forecast information was often not connected to contextual advice and/or recommendations in relation to specific farm management practices.

In all, the study on dissemination signals a number of frictions and mismatches in terms of how providers go about spreading and packaging forecast information, and the everyday opportunities that farmers have to access such information.

Understanding farmers' management strategies in relation to flood (Chapter 4)

There is a wide variation in farmers' strategies to adjust to the situation in which floods are a known certainty but their timing and severity is largely unknown. Farmers have developed a wide and impressive array of strategies to anticipate and adjust to floods. Chapter 4 addresses the varied ways in which farmers anticipate and respond to recurrent floods, which are analysed from three perspectives: *1) the existing management practices to deal with flood risks; 2) the detectable differences between groups of farmers in each of the villages for dealing with floods; and 3) the main factors that influence seasonal choices and overall adaptation strategies among farmers.*

The findings show some clearly visible patterns. Perhaps the most obvious of these patterns is the strategic use of farmland at a higher elevation. Access to even a small patch of land that is not, or only shortly, under water in the flood season provides opportunities for growing seedlings that can then be planted in the main fields as soon as the water has receded. Farmers with larger plots on higher ground strategically use these fields in combination with the lower fields that get flooded. Another pattern is the selective use of crops and crop varieties in flood-prone fields. Sugar cane, for example, is a robust crop that survives a flood but has the disadvantage of standing in the field for almost a year. The implication is just one harvest, that can still partly or entirely fail due to flood-related damage. Farmers decisions on what crop and crop variety to plant are largely informed by three criteria: growth duration, flood resistance and value of the crop. The chapter also shows that farmers' decisions in one growing season have implications for the next growing season and thus also have a temporal dimension. This knock-on effect between the seasons implies that farmers' response to floods in one year already anticipates the flood risks of the following year. Meteorological models, no matter how technically advanced, are of no help for such long-term strategizing.

The integration of forecast information into agricultural extension activities and recommendations (Chapter 5)

One of the findings of the study on dissemination, presented in Chapter 3, was that farmers would appreciate more guidance on the implications of a particular forecast for dealing with a particular crop or agricultural activity. This observation resonates with other studies that suggest that forecast information becomes more usable when it is effectively linked to knowledge and information about important agronomic issues, such as cropping systems, soil fertility management and/or pest and disease control (see e.g. Leeuwis, 2004; Faraj et al., 2011; Gardner et al., 2012; Yoo, 2017; Roger and Meinke, 2006). Therefore, chapter 5 identified how forecast information is made usable by extension organisations after it has been disseminated to the local level.

To this end the study for Chapter 5 analysed two important dimensions of extension delivery: 1) *the activities and interactions between local level extension workers and farmers, and 2) the extent to which forecast information was incorporated within extension messages and recommendations regarding different agronomic activities*.

The analysis of recommendations shows that forecast information is indeed integrated with a broad range of other issues on which farmers have to take decisions. Forecast information is especially linked to activities early in the growing cycle such as variety selection and seedbed management, as well as soil fertility management and crop protection. However, farmers' valuation of these recommendations indicated that they would be more useful for farming if they were combined with more time and location specific forecast information.

Most farm households in the study villages greatly appreciated the intensive group-based extension activities such as farmer field schools, particularly because these activities created opportunities to observe and analyse a variety of field conditions and discuss these with other farmers and extension agents who bought different expertise. It is widely considered that such group-based observations and discussions are particularly conducive to learning and knowledge integration (Van de Fliert *et al.*, 2002; Van den Berg and Jiggins, 2007). However the findings suggest that these are not structurally integrated within extension policy and are rather *ad hoc*, tending to only take place occasionally as part of externally funded, and therefore temporary, programmes. In the absence of such projects, individual contacts remain the main channel through which forecast information is provided and integrated with other knowledge and information. However, such individual contact does not occur sufficiently frequent due to a number of constraints: insufficient resources (limited transport allowances, poor village level office facilities), time constraints (few extension agents to serve many farmers) and poor transportation facilities (see also Mukta, 20020; Ahmed, 2012; Ageyi and Stringer, 2021). Moreover, some villages were more able than others to organise themselves and continue with group-based activities after the closure of temporary projects, and that the nature and extent of extension workers' activities varies across villages and types of farmers. In particular resource-poor farmers and the village that is most remote and most vulnerable to floods received less attention from extension workers. Thus, while attention is paid to integrating forecast information with other fields of agronomic knowledge, farmers and farming communities have different opportunities to benefit from this.

6.3 Synthesis - integrating the main findings

To address the research gap of better understanding the social logic of challenges in the provision of useful forecast information, my purpose was to explore and analyse the entire chain in which forecast information is produced, disseminated, accessed and integrated within agricultural extension activities, with a view to identifying the constraints and opportunities for effectively providing forecast information to farmers. In this section, the main results of the four empirical chapters (2-5) are synthesized, identifying the cross-cutting constraints, and linking these to the findings of other studies.

The centrality of organizational and institutional constraints

When looking at the chain of forecast information production, dissemination and integration, it is possible to identify several recurring organisational and institutional constraints.

Organizational incompatibilities

The findings from several chapters show the limited extent to which organizations exchange and share data, technologies, resources and information. For example Chapter 2 revealed that the diverse goals and histories of forecast-producing organisations lead them to produce specific types of forecast information, which has implications for other processes in the chain of information. Likewise, a common element in the findings of Chapters 2 and 5 is that decisions related to when, and what type of, data and information from the central organization, the BMD, is shared has implications for the way in which the FFWC and DAE can integrate this information in their daily work. Besides an overall lack of interaction between the forecast-producing organisations, the dissemination of forecast information happens in a largely parallel way between a variety of channels (see Chapter 3). Other studies, for example by Heidekamp (2014) in Indonesia and Pronk *et al.* (2016) in Portugal, show a similar lack of communication and coordination between different departments for climate risk management. Each organizations' possibilities for producing and exchanging forecast information are largely determined by their institutional capacity and setting, their objectives, history and mandate. Therefore, it is important to understand the underlying organizational and institutional issues that influence the provision of effective (or less than effective) forecast information.

Bureaucratic procedures and resource constraints

In line with the previous observation, institutional constraints also play an important role within each of the organisations. The most prominent constraints were hierarchical and bureaucratic working procedures that follow administrative tiers, poor coordination and limited resources (such as travel allowances, technical equipment or available staff), which all limit the availability of forecast information at the village level (Chapters 3 and 5).

The findings from chapter 3 also show that coordination of activities between the disaster management committees at the Union, Upazila and village-levels is far from optimal, and hampers the effective distribution of forecast information through disaster bulletins. The research findings presented in Chapter 5 indicate that interactions between extension workers and farmers were infrequent, and that the main extension methods used are not well-suited for achieving an integration between forecast information and farm-specific observations that include other agronomic knowledge and information. Intensive group-based methods, such as farmer field schools, are only used in an *ad hoc* way, when external finance is available, and farm visits are far from frequent; with contact between farmers and extension workers tending to be concentrated in input-shops and/or through phone contact. As pointed out by Mukta (2020) and Ahmed (2012), limited resources and poor road connections constrain the timely delivery of monthly advisory services to the many different farmer communities. These constraints also inhibit the use of methods that are known to contribute considerably to learning and knowledge integration.

Discontinuities and dependence on externally funded projects

A third institutional constraint is the average duration of projects, typically 3 or 4 years, that restricts the long-term continuation of services and support offered to farmers. In Bangladesh, the existence of temporary, externally-funded, projects designed to enhance production, dissemination and integration of forecast information is a structural feature that fosters discontinuities. Project-based activities geared towards accessing forecast information via mobile phone based technologies (Chapter 3) and intensive group-based learning spaces for flood and climate change adaptation (FFS and CFS; Chapter 5) are rarely continued by the relevant local level stakeholders after the termination of the project period. Such discontinuities have resulted, for example in a gradual reduction in the effectiveness of forecast information through cell-phones as no-one takes responsibility for updating and maintaining the contact lists. Likewise, attempts to continue the FFS approach after termination of the IFMC and CFS projects suffered from a lack of equipment and reduced support from extension staff (Chapter 5). In some cases farmer groups, such as the one in Pirijpur village, are successful in continuing their and continue to have meetings, supported by the extension worker, that they pay for from self-generated funds.

In all, there are several organisational and institutional obstacles that affect the effective provision of forecast information. In particular, we see that there are challenges in terms of the coordination and exchange of resources within and between organisations involved in the production, dissemination and integration of forecast information. Although there was an attempt to establish a National Monsoon Forum in 2009 to enhance exchanges and coordination among forecast-providing and user agencies (Chapter 2), this forum was limited to the higher or national level stakeholders, without enough involvement or feedback from lower level stakeholders and farmers. In addition the study also indicates that the Forum does not have the operational framework to coordinate the activities of forecast providing and user agencies.

Different communities face different constraints and opportunities

Several chapters suggest that there is considerable diversity within and between villages, and that this is at least partly associated with differential opportunities to access or make use of forecast information. The analysis of farmers' management practices in relation to flood risks (Chapter 4) showed that farmers' choices are seriously constrained by uncertainty about the level and duration of floods. When it takes a long time before the water recedes, the growing season can be completely lost. These conditions differed across villages. Farmers in Kulkandi, the village where all the fields are seriously flooded every year, basically miss the late monsoon (Khraiff-2) harvest. Households in Kulkandi (and similar areas) thus have substantially less income opportunities from agriculture. For such households, flood forecast information services are primarily useful to start evacuating their premises in advance. In other communities, forecast information could be used, at least in principle, for a broader set of decisions (see Chapters 4 and 5).

The analysis of dissemination and communication of forecast information (Chapter 3) also showed that there were significant differences in access to media between communities. For instance, two villages (Pathorshi and Pirijpur) had access to forecast information through traditional media such as TV, radio, and newspapers, whereas Kulkandi could also access forecast information through internet and mobile phone-based technologies (SMS, voice call, IVR, websites). Although IVR was technically available in Pirijpur, the system was unknown due to absence of an FFWC project and a moribund local level disaster management committee. Moreover, accessing forecast information in this village through traditional media (TV) was also constrained by the lack of availability of electricity.

When looking at the role of extension, it became clear in Chapter 5 that the intensity of contact between farmers and extension workers differed across villages, with farmers in Pathorshi and Pirijpur villages having more regular contact than those in Kulkandi (Chapter 5). Villages also differed in their capacity to self-organise in order to maintain group-based knowledge sharing activities after the closure of temporary projects. In addition, there are indications that extension workers have less intensive contact with resource-poor farmers and prioritize farmers with larger fields and more resources. Hence, the diversity within villages also matters.

In all, we see that farmers face differential constraints and opportunities when it comes to accessing and/or benefitting from forecast information, depending on agro-ecological, community and households' characteristics.

Constraints on the use of modern ICT

The emergence of ICT is generally perceived to create new opportunities for information sharing through different forms of connectivity (Van Lammeren *et al.*, 2017; Witteveen *et al.*, 2017; Danes *et al.*, 2014; Karpouzoglou *et al.*, 2016; Van Vliet *et al.*, 2014; Bennett and Segerberg, 2012; Munthali *et al.* 2018). ICT platforms are often seen as ways of enabling the production and dissemination of location and time specific forecast information (Kumar, 2021). This dissertation shows that the forecast producing and disseminating organizations do use new-ICT tools to facilitate data collection and production (Chapter 2), and are building platforms to disseminate forecast information to the local level (Chapter 3). The study confirms that there is demand from farmers for more time- and location-specific forecast information, and that they appreciate this when it is available. The logistical challenges of providing such information to large numbers of dispersed farmers may well be overcome with the help of ICT tools (see Chapters 3 and 5). However, the study also indicates that there remain important challenges and that ICT should not be regarded as a magic bullet.

A first constraint is that access to tailored forecast information alone is not sufficient. In order to become usable, forecast information needs to be integrated with knowledge and information from different agronomic domains as well with farm-specific contextual information (see Chapter 5). Bringing together knowledge and information from different disciplines and agricultural knowledge domains is notoriously difficult and hard to realize within ICT platforms (Leeuwis, 2004), especially when there is considerable diversity in farmers' agro-ecological contexts, cropping systems and rationales (see Chapter 4 and also Van der Ploeg, 1990). Having better and more specific forecast information may also require there being more opportunities for interpretative discussions, learning and exchange, which are not structurally available in the current system (see Chapter 5).

A second constraint is that many farmers still lack the resources to buy ICT equipment and do not have the capacity to deal with digital media that mostly require English language literacy to operate them (Chapter 3). The frequent use of the English language messages in ICT platforms is perhaps illustrative of the supply-driven fashion in which many ICT tools are developed and promoted (Carr and Onzere, 2018, Kumar *et al.*, 2020, Pennesi, 2011, Vedeld *et al.*, 2019), and the tendency to ignore human abilities, preferences, and motivations (Toyama, 2011; Marchewka and Kostiwa, 2007, Munthali *et al.* 2018). There are currently several initiatives to use participatory design approaches to develop ICT tools (Kumar *et al* 2020; Sarku *et al*, 2021; Nyadzi, 2020) in order to make them more user-oriented, and this seems indeed a promising route to tailoring information services to farmers' needs and contexts, even if this does not always succeed (on the latter see McCampbell 2021). However, in the context of Bangladesh, the large scale use of ICT platforms will require major investments in training and maintenance of technical infrastructures and software, as well as continuous investment in content management and the improvement of services. All this will require a sustainable funding model as well as collaboration between a variety of organisations at different levels. Both are currently largely lacking .

Finally, it is important to note that ICT platforms are a medium for communication that will need to have sufficient added-value and be able to 'compete with' traditional media, especially mass media such as radio, television and mass-media. Even though such media are not available in all villages (see Chapter 3), these are much better established and they currently still perform an important role in accessing a variety of forecast information at village level. Farmers appreciate such media for various reasons. They are familiar with them, find them easy to understand and they meet with others at social gathering places (market places, tea stalls, mosques) in the evenings after finishing their work to listen and discuss whatever is being broadcasted. The significance of such discussions should not be underestimated. Several other studies emphasize the continued importance of conventional mass media in the context of ICT based service delivery (Hansen *et al.*, 2014; Heeks, 2008; Chapman and Slaymaker, 2002, Munthali *et al.* 2018). Therefore, designers and policy makers should think carefully about whether or not different ICT tools will be effective in comparison to existing communication channels, and investigate what combination(s) of media may be most useful for providing forecast information (Munthali et al. 2018).

In all, we should not have naive expectations about the potential of ICT platforms in improving the provision of forecast information and extension services (see also McCampbell, 2021). Such technologies cannot function well without conducive embedding in wider media landscapes, sustainable funding models and additional interpretative support services.

6.4 Recommendations for policy, practice and research

Based on the findings and cross-cutting themes, as discussed in the previous sections, some overall recommendations for policy and practice can be formulated.

Strengthening coordination
The identified lack of coordination and exchange of resources within and between organisations that are active in the production, dissemination and integration of forecast information is arguably a main cause of mismatches, frictions and inefficiencies along the forecast chain, and eventually results in the sub-optimal provision and incorporation of forecast information in farm-level decision-making and practices. A coordination platform might potentially help resolve this, by facilitating the coordination and cooperation between organisations such as the BMD, the FFWC, the BWDB, the DDM and the DAE, and enhancing meaningful interactions and feedback among stakeholders across different levels along the chain of information flow. Such a platform, the National Monsoon Forum, was actually created after 2009 (see Chapter 2). However very little was realised in terms of concerted action and any real exchange of information and feedback from local level. This suggests that it is quite a challenge to connect organisations that operate on national and international levels to devise procedures and action that connect effectively with lower levels. One possible way forward might be to create platforms at the local level, bringing together stakeholders, such as the DAE, Union and Upzilla Disaster Management Committees and village leaders. In addition to fostering local-level collaboration to enhance the delivery and integration of forecast information, such local level platforms could then make specific requests to higher administrative levels that may help to foster and focus national coordination and cooperation.

Strengthening two-way communication
When looking at information flows and media use in the chain of forecast information production, dissemination and integration, we see that most, if not all, of these information flows are from the centres of national institutes towards the villages. One clear window for improvement is to create a balanced two-way information flow. This resonates with the previous recommendation to strengthen exchanges along the forecast information chain and establish local level platforms to make demands on higher administrative tiers. Strengthening the role and facilities of disaster management committees might be a first step to establishing such platforms and increase the upward flow of information. Establishing two-way information flows may also require the use of different types of communication media. Clearly platforms will need to use forms of face-to-face communication in physical meetings, but there may also be potential for making use of social media platforms. Studies elsewhere suggests that the use of such platforms in professional organisations and networks can strengthen interactions and

coordination across a variety of actors in agricultural knowledge systems (Munthali *et al.*, 2021).

Enhancing specificity

Farmers' evaluations of forecast information indicated that the available forecast information was not location- and time-specific, and that the recommendations and solutions incorporating such information were not well-adapted to location-specific conditions and diverse farming strategies. This indicates that there is a clear need for a better connection between forecast information and advice for farming practices. The research findings also show that forecast warnings for flood risk only make sense if they are given at least 15 days in advance (especially at the time between sowing rice and transplanting) with high levels of certainty. Only with such advance notice, can farmers start preparing seedbeds for rice with confidence.

In recent years a large programme has been started by the three main forecast producing organisation (the BMD, the FFWC and the DAE, supported by the World Bank) to improve forecast information. It is important to examine the initiatives of this programme and the outcomes for the complex issue of integrating forecast information with concrete interventions that help farmers and villagers in flood-prone areas.

Capacity building around new media opportunities

The findings in Chapter 3 show that there are opportunities to provide forecast information more quickly through the use of the new ICT platform media (IVR system) and other phone based technologies. However, as discussed in 6.3, there are several constraints to the large scale use of ICT platforms among farmers in Bangladesh. To address these, ICT platforms need to be embedded and combined with more traditional media and extension methods, such as farm visits and farmer field schools, that are more amenable to integrating forecast information with contextually relevant knowledge and information from a variety of agronomic domains. It will also be important to develop an appropriate task division between popular traditional mass media and ICT platforms. Moreover, ICT interventions require ongoing support in the form of training and examples on how to translate the forecast information into improved strategies and concrete actions to ameliorate the destructive effects of floods. Training and capacity building will also be necessary beyond the farmer level, as it will require new skills and modes of working on the part of a variety of actors along the chain in which forecast information is produced, disseminated and integrated into recommendations and practice (see e.g. Klerkx *et al.*, 2019).

Fostering stable resources

Local-level extension workers can play a proactive role in supporting the continuation of group-based education and training activities such as farmer and climate field schools. Such activities play an important role in making forecast information usable for farmers (see Chapter 5). However, the findings from Chapters 3 and 5 showed that there is a structural problem with funding and the continuity of project activities. Investments, either from public or private funds, should not only address more sophisticated models or advanced ICT platforms but should also be oriented towards developing local-level community facilities and committees, in order to create long-term continuity of FFS or CFS initiatives. As currently organised, important aspects and elements in the chain of forecast information production, dissemination and integration rely on externally funded projects with a relatively short time horizon. This fosters discontinuities and undermines the sustainability of the system. It is therefore essential that the actors involved develop funding models that ensure adequate and ongoing provision of extension services, support the continuity of group based activity at community level, as well as the further development, maintenance and content management of both novel ICT platforms and traditional mass media of relevance to providing forecast information. Such a funding model may need to include structural contributions from both government agencies and the private sector, including actors in the agricultural value chain, input providers, telephone companies, media establishments, service providers and farmers. Contributions from multiple sources would be justified since the effective provision and use of forecast information is not only in the interest of farmers but also of wider relevance to society.

Suggestions for further research

The focus of this thesis has been on qualitative research, which has the strength of allowing the voices of various stakeholders, in particular local-level technicians, extension officers and farmers to be better heard. In-depth qualitative research based on small-sample case studies provides important complementary insights to equally important studies based on quantitative analysis of larger survey samples and other data. Both types of research are important and needed, although typically the latter get preference over the first. As evidenced in the previous sections, the use of qualitative and context-sensitive research approaches (see Chapter 1) can help considerably in identifying bottlenecks and opportunities along the chain in which forecast information is produced, disseminated, accessed and integrated in agricultural extension activities. However, there are also several gaps in understanding that have newly emerged or that still need to be addressed follow-up research, as listed below.

(1) It is important to investigate why previous attempts to foster exchange and coordination in the forecast information system in Bangladesh have not yielded the desired effects. In connection with this, it is equally important to explore how this challenge has been dealt with in other settings and the models of collaboration that have been effective elsewhere.

(2) The study has shown that there exists considerable diversity across villages in terms of their intensity of contact with extension services, the available media landscape and their capacity to self-organise around the exchange of agricultural knowledge and information. It would be interesting to gain a deeper understanding of the factors that shape such differences. This may offer insights that can inform more effective provision of forecast information as well as broader strategies for supporting agricultural and rural development.

(3) The study indicates that social differentiation affects the effective provision of forecast information, in that resource-rich farmers seem to have better access to forecast information than others. However, the study has not looked into other possible dimensions of social differentiation, such as gender and ethnicity. It would be interesting to look more deeply into how differences in wealth and access to (forecast) information intersect with gender and other social differences (example studies are Teeken *et al.*, 2021; Rola Rubzen *et al.*, 2020).

(4) In connection with the issue of diversity and social differentiation, it would also be of interest to further study how information services are, or can be, tailored to the needs of different contexts and groups in society. This may also involve studying how processes of developing such services can become more inclusive and how barriers to this may be removed (example studies are McCampbell, 2021; Opola, 2020; Heeks *et al.*, 2013, 2014; Heeks 2021)

(5) In view of the recommendation to work towards new public-private funding models for effective forecast information provision, it will be necessary to study in more detail how funding streams are currently organised in Bangladesh, and how this compares to situations elsewhere where more sustainable funding systems have been achieved.

6.5 Conclusions

This thesis has aimed to enhance insights in (1) how different elements and processes in the entire forecast information chain interact with each other and how this eventually shapes the usability of forecast information for farmers; (2) how flood forecast information is integrated with other agricultural knowledge and information through different extension activities, and; (3) how the challenges and opportunities for the use of forecast information vary across and within farming communities in different locations. These questions have been addressed in the various chapters of the dissertation, and have been brought together in this final chapter.

Overall, the thesis finds that there are important constraints along the forecast information chain that impede the effective provision of forecast information to farmers. Several of these constraints are of an organisational and institutional nature, relating to organisational mandates and procedures, hierarchical forms of steering and communication, resource constraints and in-built discontinuities in activity and funding. These features lead to sub-optimal collaboration and inhibit the exchange of knowledge and resources among those involved in the production, dissemination and integration of forecast information. This means that important feedback on local level requirements is overlooked, that there are significant delays in information provision, and that there continue to be mismatches in terms of how providers go about spreading and packaging forecast information and the everyday opportunities that farmers have to access such information. Thus, the challenges to effective forecast information provision are much broader than the oft-reported problems with regard to the poor accuracy or timeliness of information or assumed limitations in farmers' capacities to assimilate this information.

With regard to the role of agricultural extension, the dissertation identifies that conventional extension activities and recommendations play an important role in making forecast information usable as they do effectively link forecast information to knowledge and information about other topics (e.g. crop and variety selection, soil fertility management, etc) as well as to farm-specific contexts and rationales. Thus, such activities are an important complement to traditional or novel ICT-based modes of disseminating forecast information, even if the timing and accuracy of information provided by extension workers can still be improved. However, we find that extension methods that are especially suited for knowledge integration are either not structurally integrated within extension policy (in the case of group-based activities) or only available to a limited number of farmers (in the case of individual farm visits).

A third overall conclusion from this dissertation is that there are important differences within and between communities in terms of the specific agro-ecological conditions that are relevant, the strategies and practices that farmers employ, the media channels to which farmers have access, the strength of linkages with agricultural extension workers and the capacities of communities to self-organize to maintain and fund group-based knowledge sharing activities. These differences are associated with differential opportunities to access or make use of forecast information: thus the provision of forecast information services does not take place on a level-playing field.

In order to address these constraints and opportunities, this dissertation emphasizes the need to develop and monitor new forms of collaboration, coordination and exchange in the forecast information system, as well as to explore and develop new public-private funding models that can help foster the sustainable delivery of extension and forecast information services. While new ICT platforms can undoubtedly play useful roles in the provision of more specific forecast information to larger audiences, they should not be regarded as a silver bullet solution. In order to be effective, such technologies need to be embedded in wider media landscapes, be supported by a sustainable funding model and be complemented with additional interpretative support from extension workers.

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Supplementary Materials

Supplementary materials:

Appendix 1: Additional illustrations to Chapter 2

Appendix 1 a) National weather forecast

Appendix 1 b: Flood bulletin

FLOOD FORECASTING AND WARNING CENTER, BWDB

RIVER SITUATION AS ON 08-10-2015 AT 15:00 HOURS

SL	RIVER	STATION NAME	RHWL (m)	D.L. (m)	WATER LEVEL 08-10-2015 9.00 AM	WATER LEVEL 08-10-2015 3.00 PM	+ Rise - Fall in cm	Above D.L. in cm
	BRAHMAPUTRA BASIN							
1	DHARLA	KURIGRAM	27.66	26.50	24.28	24.26	-2	-224
2	TEESTA	DALIA	52.97	52.40	51.78	51.70	-8	-70
3	TEESTA	KAUNIA	30.52	30.00	27.75	27.75	0	-225
4	JAMUNESWARI	BADARGANJ	32.92	32.16	28.48	28.48	0	-368
5	GHAGOT	GAIBANDHA	22.81	21.70	18.80	18.78	-2	-292
6	KARATOA	CHAK RAHIMPUR	21.41	20.15	17.24	17.18	-6	-297
7	KARATOA	BOGRA	17.45	16.32	12.98	12.94	-4	-338
8	BRAHMAPUTRA	NOONKHAWA	28.10	27.25	23.07	23.02	-5	-423
9	BRAHMAPUTRA	CHILMARI	25.07	24.00	21.39	21.37	-2	-263
10	JAMUNA	BAHADURABAD	20.62	19.50	16.86	-	-	-
11	JAMUNA	SARIAKANDI	19.07	16.70	14.33	14.28	-5	-242
12	JAMUNA	SERAJGANJ	15.12	13.35	10.38	10.34	-4	-301
13	JAMUNA	ARICHA	10.76	9.40	6.60	6.57	-3	-283
14	GUR	SINGRA	13.53	12.65	11.76	11.74	-2	-91
15	ATRAI	BAGHABARI	12.45	10.40	8.41	8.39	-2	-201
16	DHALESWARI	ELASIN	12.32	11.40	9.99	9.97	-2	-143
17	OLD BRAHMAPUTRA	JAMALPUR	18.00	17.00	12.02	-	-	-
18	OLD BRAHMAPUTRA	MYMENSINGH	13.71	12.50	7.48	7.44	-4	-506
19	LAKHYA	LAKHPUR	8.70	5.80	4.51	-	-	-
20	BURIGANGA	DHAKA	7.58	6.00	3.45	3.45	0	-255
21	BALU	DEMRA	7.13	5.75	3.83	3.73	-10	-202
22	LAKHYA	NARAYANGANJ	6.93	5.50	3.79	3.76	-3	-174
23	TURAG	MIRPUR	8.35	5.94	4.04	3.99	-5	-195
24	TONGI KHAL	TONGI	7.84	6.08	4.50	4.49	-1	-159
25	KALIGANGA	TARAGHAT	10.39	8.38	5.54	5.50	-4	-288
26	DHALESWARI	JAGIR	9.73	8.23	5.81	5.77	-4	-246
27	DHALESWARI	REKABI BAZAR	7.66	5.18	3.20	3.33	+ 13	-185
28	BANSHI	NAYARHAT	8.39	7.32	4.52	4.51	-1	-280
	GANGES BASIN							
29	KARATOA	PANCHAGARH	72.65	70.75	66.97	66.96	-1	-379
30	PUNARBHABA	DINAJPUR	34.40	33.50	28.54	28.54	0	-496
31	ICH-JAMUNA	PHULBARI	-	29.95	25.93	25.96	+ 3	-399
32	TANGON	THAKURGAON	51.26	50.40	47.29	47.29	0	-311
33	UPPER ATRAI	BHUSIRBANDAR	41.10	39.62	36.39	36.39	0	-323
34	MOHANANDA	ROHANPUR	23.83	22.00	15.89	15.83	-6	-617
35	MOHANANDA	CHAPAI-NAWABGANJ	23.01	21.00	15.21	15.17	-4	-583
36	LITTLE JAMUNA	NAOGAON	16.20	15.24	12.43	12.42	-1	-282
37	ATRAI	MOHADEBPUR	19.89	18.59	13.80	13.79	-1	-480
38	GANGES	PANKHA	24.14	22.50	16.20	16.17	-3	-633
39	GANGES	RAJSHAHI	20.00	18.50	12.29	12.27	-2	-623
40	GANGES	HARDINGE BRIDGE	15.19	14.25	9.37	9.35	-2	-490
41	PADMA	GOALUNDO	10.21	8.65	6.51	6.52	+ 1	-213
42	PADMA	BHAGYAKUL	7.50	6.30	4.42	4.28	-14	-202
43	PADMA	SURESWAR	7.50	4.45	2.73	3.18	+ 45	-127
44	GORAI	GORAI RLY BRIDGE	13.65	12.75	7.89	-	-	-
45	GORAI	KAMARKHALI	9.48	8.20	4.29	4.28	-1	-392
46	ICHAMATI	SAKRA	4.69	3.96	2.40	-0.43	-283	-439
47	MATHABHANGA	CHUADANGA	12.67	12.04	6.19	6.18	-1	-586
48	MATHABHANGA	HATBOALIA	15.13	14.48	8.76	8.76	0	-572
49	KOBADAK	JHIKARGACHA	5.59	4.11	4.24	4.24	0	+ 13
50	KUMAR	FARIDPUR	8.76	7.50	4.06	4.03	-3	-347
51	ARIALKHAN	MADARIPUR	5.80	4.17	2.10	2.08	-2	-209
52	KIRTONKHOLA	BARISAL	-	2.55	-	-	-	-

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SL	RIVER	STATION NAME	RHWL (m)	D.L. (m)	WATER LEVEL 08-10-2015 9.00 AM (m)	WATER LEVEL 08-10-2015 3.00 PM (m)	+ Rise - Fall in cm	Above D.L. in cm
	MEGHNA BASIN							
53	SURMA	KANAIGHAT	15.26	13.20	9.26	9.40	+ 14	-380
54	SURMA	SYLHET	12.44	11.25	7.96	8.09	+ 13	-316
55	SURMA	SUNAMGANJ	9.75	8.25	6.48	6.46	-2	-179
56	KUSHIYARA	AMALSHID	18.28	15.85	12.01	12.34	+ 33	-351
57	KUSHIYARA	SHEOLA	14.60	13.50	10.59	10.83	+ 24	-267
58	KUSHIYARA	SHERPUR-SYLHET	9.68	9.00	7.41	7.41	0	-159
59	KUSHIYARA	MARKULI	8.51	8.50	7.08	7.08	0	-142
60	SARIGOWAIN	SARIGHAT	14.48	12.80	9.23	9.13	-10	-367
61	MANU	MANU RLY BR.	20.42	18.00	14.90	15.80	+ 90	-220
62	MANU	MOULVI BAZAR	13.25	11.75	8.45	8.47	+ 2	-328
63	KHOWAI	BALLAH	26.12	21.64	20.21	20.74	+ 53	-90
64	KHOWAI	HABIGANJ	12.00	9.50	6.48	6.46	-2	-304
65	DHALAI	KAMALGANJ	21.18	19.82	16.80	16.84	+ 4	-298
66	OLDSURMA	DERAI	7.75	7.00	6.13	6.12	-1	-88
67	BAULAI	KHALIAJURI	9.52	8.50	5.75	5.73	-2	-277
68	BHUGAI	NAKUAGAON	26.01	22.40	19.72	19.73	+ 1	-267
69	JADUKATA	LORERGARH	11.85	8.53	6.08	6.11	+ 3	-242
70	SOMESWARI	DURGAPUR	15.20	13.00	10.60	10.60	0	-240
71	KANGSHA	JARIAJANJAIL	13.37	9.75	8.32	8.30	-2	-145
72	TITAS	B. BARIA	6.50	5.50	4.53	4.51	-2	-99
73	MEGHNA	BHAIRAB BAZAR	7.78	6.25	4.45	4.43	-2	-182
74	MEGHNA	NARSINGDI	7.01	5.70	3.82	3.76	-6	-194
75	GUMTI	COMILLA	13.56	11.75	7.82	7.93	+ 11	-382
76	GUMTI	DEBIDDAR	-	8.50	5.13	5.18	+ 5	-332
77	MEGHNA	*CHANDPUR L.W.L.	4.92	4.00	2.46**	- **	-	-
		*CHANDPUR H.W.L.	5.35	-	2.84***	- ***	-	-
	SOUTH EASTERN HILL BASIN							
78	MUHURI	PARSHURAM	16.33	13.00	10.40	10.35	-5	-265
79	HALDA	NARAYAN HAT	19.30	15.25	12.27	12.30	+ 3	-295
80	HALDA	PANCHPUKURIA	12.54	9.50	4.32	4.03	-29	-547
81	SANGU	BANDARBAN	20.70	15.25	7.55	7.45	-10	-780
82	SANGU	DOHAZARI	9.05	7.00	2.30	2.50	+ 20	-450
83	MATAMUHURI	LAMA	15.46	12.25	7.54	7.76	+ 22	-449
84	MATAMUHURI	CHIRINGA	7.03	5.80	3.52	3.44	-8	-236
85	FENI	RAMGARH	21.42	17.37	14.75	14.80	+ 5	-257

NOTE: WATER LEVEL AT STATION ABOVE DANGER LEVEL UNDERLINED.

- DATA NOT AVAILABLE.

L.W.L.: Lowest Water Level.
RHWL: Recorded Highest Water Level.
D.L.: Danger Level.
* : Tidal Station
** : Low Water Level of the Previous Day
*** : High Water Level of the Previous Day

DUTY OFFICER,
FLOOD INFORMATION CENTER,
BWDB, DHAKA.

Appendix 2: Additional illustration to Chapter 3

Appendix 2 a: National weather forecast sample (Box 2.1 and table 2.1)

Table 2.1 National weather forecast indicating rainfall for last 24 hours (till 06 AM today) and maximum temperature of yesterday, minimum temperature of today

Name of Division	Name of Station	Rain fall (mm)	*Max.* Temp (°C)	Min. Temp (°C)	Name of Division	Name of Station	Rain fall (mm)	Max. Temp (°C)	Min. Temp (°C)
Dhaka	Dhaka	00	30.1	18.6	Khulna	Khulna	00	30.2	16.5
	Tangail	00	29.5	15.6		Mongla	00	30.5	17.5
	Faridpur	00	30.4	16.5		Satkhira	00	30.0	15.6
	Madaripur	00	30.0	15.8		Jessore	00	29.9	13.0
	Gopalgonj	00	29.2	15.0		Chuadanga	00	28.8	15.0
Mymensingh	Mymensingh	00	29.0	15.7		Kumarkhali	xx	28.5	15.6
	Netrokona	00	28.7	15.5	Barisal	Barisal	00	30.5	15.5
Rajshahi	Rajshahi	00	27.2	16.0		Patuakhali	00	30.9	16.5
	Ishurdi	00	28.3	15.0		Khepupara	00	31.2	16.3
	Bogra	00	30.2	15.3		Bhola	00	31.4	15.6
	Badalgachhi	00	27.6	15.3	Chittagong	Chittagong	00	30.6	18.5
	Tarash	00	29.6	15.8		Sandwip	00	31.6	16.1
Rangpur	Rangpur	00	28.0	12.4		Sitakunda	00	31.8	16.9
	Dinajpur	00	28.5	12.0		Rangamati	00	31.0	14.7
	Sayedpur Tetulia	00	28.6	12.1		Comilla	00	29.5	17.2
	Dimla	00	27.5	10.8		Chandpur	00	30.8	16.2
	Rajarhat	00	27.4	12.4		M.Court	00	29.8	17.0
	Rangpur	00	27.5	**10.5**		Feni	00	31.0	16.4
Sylhet	Sylhet	00	31.2	16.0		Hatiya	xx	30.8	16.6
	Srimangal	00	30.6	11.9		Cox's Bazar	00	**32.2**	19.5
						Kutubdia	00	29.1	18.5
						Teknaf	xx	31.4	13.4

Box 1: Example of national weather forecast for 24 hours

Date : 13-02-2017

Weather Forecast valid for 24 hours commencing 09 am today:

Synoptic Situation: Ridge of sub-continental high extends up to Bihar and adjoining area. Seasonal low lies over South Bay extending its trough to Northeast Bay.

Forecast: Weather may remain dry with temporary partly cloudy sky over the country.

Light fog is likely to occur at places over the country during late night till morning.

Temperature: Night temperature may fall slightly and day temperature may remain nearly unchanged over the country.

Wind direction and speed at Dhaka: North/Northeasterly, 06-08 kph.

RH at 06 A.M. of Dhaka : 65%

Today's sunset at Dhaka : 05-52 PM

Tomorrow's sunrise at Dhaka : 06-32 AM

Outlook for next 72 hrs : Little change.

Appendix-2b: Heavy rainfall warning

Box 2.3 Example of heavy rainfall warning

Due to active monsoon over Bangladesh heavy to very heavy rainfall is likely to occur at places over Rangpur, Rajshahi, Dhaka, khulna, Barisal , Chittagong and Sylhet divisions during next 24 hrs commencing 9:00 am today of 21 august, 2014.

Under the influence of heavy to very heavy rainfall landslide may occur at places over the hilly regions of Chittagong and Sylhet divisions

Appendix-2c: Flood Bulletin (see Appendix 1 b: Flood bulletin)

Appendix-2d: Weather & flood Information from BMD & FFWC through IVR system

Weather message for seafaring fishermen: Maritime ports of Chattogram, Cox's Bazar, Mongla and Payra have been advised to keep hoisted local cautionary signal number three. All fishing boats and trawlers over the North Bay have been advised to remain in shelter till further notice.

Inland river port warning: There will be temporary gusts of 45.60 km per hour over the Rajshahi, Rangpur, Pabna, Tangail, Mymensingh, Dhaka, Faridpur, Jessore, Kustia, Khulna, Barishal, Patuakhali, Noakahli, Kumillah, Chittagong and Cox's Bazar regions till 10 am tomorrow with showers and thundershowers. River ports in these areas have been asked to display warning signal number 1.

Daily divisional weather forecast: In many places in Dhaka, Rangpur, Barishal, Chittagong and Sylhet Divisions and in some places in Khulna and Rajshahi Divisions there may be light to moderate rain or thundershowers with temporary gusts. There may be moderate rainfall in some parts of the country. Day and night temperature may remain nearly unchanged over the country. This report also contains the last 24 hours maximum and minimum temperatures for each division in a table and presents the country's maximum and minimum recorded temperatures (and locations) for the previous day.

Flood information of FFWC: This includes tabular information of total observed, increasing and decreasing water levels, water levels crossing the danger level and water levels remaining unchanged for the number (54) of stations throughout the country as well as tabular information of water level variations and by how much the water level is likely to cross the danger level at each forecast station, river and district.

Appendix-2e: Example of disaster bulletin

BMD forecast of Marine warning and signals, inland river port warning and signals, daily divisional weather forecast.
Marine warning: There is no marine warning and no signal is to be hoisted;
Inland river port warning: There will be temporary gusts of 45.60 km per hour over the Rajshahi, Rangpur, Pabna, Tangail, Mymensingh, Dhaka, Faridpur, Jessore, Kustia, Khulna, Barishal, Patuakhali, Noakahli, Kumillah, Chittagong and Cox's Bazar regions till 10 am tomorrow with showers and thundershowers. River ports in these areas have been asked to display warning signal number 1.
Daily divisional weather forecast: In many places in the Dhaka, Rangpur, Barishal, Chittagong and Sylhet Divisions and in some places in the Khulna and Rajshahi Divisions, there may be light to moderate rain or thundershowers with temporary gusts. There may be moderate rainfall in some parts of the country. Day and night temperature may remain nearly unchanged over the country. The report also contains a table showing by divisions, the last 24 hours maximum and minimum temperatures and the country's maximum and minimum recorded temperatures and location for the previous day and where these were recorded .
Flood information of FFWC: This includes tabular information of total observed, increasing and decreasing water levels, water levels crossing the danger level and water levels remaining unchanged for the number (54) of stations throughout the country as well as tabular information about water level variations and how many cm water level crossing the danger level for each forecast station, river and district.
-The overview of the main river situation at a glance presents a qualitative future scenario of impending flood information for major rivers with a lead time of 24, 48 and 72 hours. The warning message is macro level flood information, mostly covering the district level and sometimes down to sub-district level. (See Appendix-3 for details)
- It also indicates significant rainfall recorded in the last 24 hours (in mm) from recording stations
Flood damage situation in Bangladesh: This contains information about flooding and flood damage in flood prone districts with details of the number of subdistricts, unions, villages, and farm households that have been submerged or flooded (broken down into districts and the measures put in place by the Ministry of Disaster Management and Relief to assist the victims. Example: Sirajgonj district: Due to heavy rains and upstream water, the water level of Jamuna and Atrai rivers has increased and is now flowing above the danger level. As many as 15,585 people from 200 villages in 34 riverside and char areas of five upazilas of the district have been affected due to rising river water. From the Ministry of Disaster Management and Relief, an allocation of 100 metric tonnes of rice and 270000 taka has been allocated for the assistance of the victims.

Appendix-2f: Example monthly forecast and advisories of the DAE

ভাদ্র মাসে কৃষকভাইদের করণীয়

আমন ধান

- এ সময় আমন ধান ক্ষেতের অন্তর্বর্তীকালীন যত্ন নিতে হবে।
- ক্ষেতে আগাছা জন্মালে তা পরিষ্কার করতে হবে।
- আগাছা পরিষ্কার করার পর ইউরিয়া সার উপরিপ্রয়োগ করতে হবে।
- আমন ধানের জন্য প্রতি হেক্টর জমিতে ২০০ কেজি ইউরিয়া সার প্রয়োজন হয়। এ সার তিন ভাগ করে প্রথম ভাগ চারা লাগানোর ১৫ থেকে ২০ দিন পর, দ্বিতীয় ভাগ ৩০ থেকে ৪০ দিন পর এবং তৃতীয় ভাগ ৫০ থেকে ৬০ দিন পর প্রয়োগ করতে হবে।
- নিচু জমি থেকে পানি নামতে দেরি হয়। পানি নেমে গেলে এসব জমিতে এখনও আমন ধান রোপণ করা যাবে। দেরিতে রোপণের জন্য বিআর ২২, বিআর ২৩, বিনাশাইল, নাইজারশাইল বা স্থানীয় উন্নত ধান বেশ উপযোগী। এ ক্ষেত্রে প্রতি হেক্টর জমিতে ১৭৫ কেজি ইউরিয়া, ১৩০ কেজি টিএসপি এবং ৬০ কেজি এমওপি সার প্রয়োজন। ইউরিয়া ছাড়া অন্য দুটি সার জমি তৈরি করার সময় প্রয়োগ করতে হবে। দেরিতে চারা রোপণের ক্ষেত্রে প্রতি গুছিতে ৫ থেকে ৭টি চারা দিয়ে ঘন করে রোপণ করতে হবে।
- আমন মৌসুমে মাজরা, পামরি, চুঙ্গি, গলমাছি পোকার আক্রমণ হতে পারে। এছাড়া খোলপড়া, পাতায় দাগ পড়া রোগ দেখা দিতে পারে। এক্ষেত্রে নিয়মিত জমি পরিদর্শন করে, জমিতে খুঁটি দিয়ে, আলোর ফাঁদ পেতে, হাতজাল দিয়ে পোকা নিয়ন্ত্রণ করতে হবে। তাছাড়া সঠিক বালাইনাশক সঠিক মাত্রায়, সঠিক নিয়মে, সঠিক সময় শেষ কৌশল হিসাবে ব্যবহার করতে হবে।

পাট

- বন্যায় তোষা পাটের বেশ ক্ষতি হয়। এতে ফলন যেমন কমে তেমনি বীজ উৎপাদনেরও সমস্যা সৃষ্টি হয়। এতে পরবর্তী মৌসুমে বীজ সঙ্কট দেখা দেয়। এ সমস্যা সমাধানে বিশেষ যত্নে ভাদ্রের শেষ পর্যন্ত দেশি পাট এবং আশ্বিনের মাঝামাঝি পর্যন্ত তোষা পাটের বীজ বোনা যায়। বন্যার পানি উঠে না এমন সুনিষ্কাশিত উঁচু জমিতে জো বুঝে প্রতি শতাংশে লাইনে বুনলে ১০ গ্রাম আর ছিটিয়ে বুনলে ১৬ গ্রাম বীজের প্রয়োজন হয়। জমি তৈরির সময় শেষ চাষে শতক প্রতি ৩০০ গ্রাম ইউরিয়া, ৬৫০ গ্রাম টিএসপি, ৮০ গ্রাম এমওপি সার দিতে হবে। পরে শতাংশপ্রতি ইউরিয়া ৩০০ গ্রাম করে দুই কিস্তিতে বীজ গজানোর ১৫ থেকে ২০ দিন পরপর জমিতে দিতে হবে।

আখ

- এ সময় আখ ফসলে লালপচা রোগ দেখা দিতে পারে। এক ধরনের ছত্রাকের আক্রমণে এ রোগ হয়। লালপচা রোগের আক্রমণ হলে আখের কাণ্ড পচে যায় এবং হলদে হয়ে শুকিয়ে যেতে থাকে। এজন্য আক্রান্ত আখ তুলে পুড়িয়ে ফেলতে হবে এবং জমিতে যাতে পানি না জমে সে দিকে খেয়াল রাখতে হবে। এছাড়া রোগমুক্ত বীজ বা শোধন করা বীজ ব্যবহার করলে অথবা রোগ প্রতিরোধী জাত চাষ করলে লালপচা রোগ নিয়ন্ত্রণে রাখা যায়।

তুলা

- ভাদ্র মাসের প্রথম দিকেই তুলার বীজ বপন কাজ শেষ করতে হবে। বৃষ্টির ফাঁকে জমির জো অবস্থা বুঝে ৩ থেকে ৪টি চাষ ও মই দিয়ে জমি তৈরি করে বিঘা প্রতি প্রায় ২ কেজি তুলা বীজ বপন করতে হয়।
- লাইন থেকে লাইনের দূরত্ব ৬০ থেকে ৯০ সেন্টিমিটার এবং বীজ থেকে বীজের দূরত্ব ৩০ থেকে ৪৫ সেন্টিমিটার বজায় রাখতে হয়।
- তুলার বীজ বপনের সময় খুব সীমিত। তাই হাতে সময় না থাকলে জমি চাষ না দিয়ে নিড়ানি বা আগাছানাশক প্রয়োগ করে জমি আগাছামুক্ত করে ডিবলিং পদ্ধতিতে বীজ বপন করা যায়। বীজ গজানোর পর কোদাল দিয়ে সারির মাঝখানের মাটি আলগা করে দিতে হবে।
- সমতল এলাকার জন্য সিবি–৯, সিবি–১২, হীরা হাইব্রিড রূপালী–১, ডিএম–২, ডিএম–৩ অথবা শুভ্র জাতের চাষ করতে পারেন।
- এছাড়া পার্বত্য চট্টগ্রাম অঞ্চলে পাহাড়ি তুলা–১ এবং পাহাড়ি তুলা–২ নামে উচ্চফলনশীল জাতের তুলা চাষ করতে পারেন।

Appendix 3: Additional illustration to Chapter 5

Appendix-3a: Monthly advisories of DAE

ভাদ্র মাসে কৃষকভাইদের করণীয়

আমন ধান

- এ সময় আমন ধান ক্ষেতের অন্তর্বর্তীকালীন যত্ন নিতে হবে।
- ক্ষেতে আগাছা জন্মালে তা পরিষ্কার করতে হবে।
- আগাছা পরিষ্কার করার পর ইউরিয়া সার উপরিপ্রয়োগ করতে হবে।
- আমন ধানের জন্য প্রতি হেক্টর জমিতে ২০০ কেজি ইউরিয়া সার প্রয়োজন হয়। এ সার তিন ভাগ করে প্রথম ভাগ চারা লাগানোর ১৫ থেকে ২০ দিন পর, দ্বিতীয় ভাগ ৩০ থেকে ৪০ দিন পর এবং তৃতীয় ভাগ ৫০ থেকে ৬০ দিন পর প্রয়োগ করতে হবে।
- নিচু জমি থেকে পানি নামতে দেরি হয়। পানি নেমে গেলে এসব জমিতে এখনও আমন ধান রোপণ করা যাবে। দেরিতে রোপণের জন্য বিআর ২২, বিআর ২৩, বিনাশাইল, নাইজারশাইল বা স্থানীয় উন্নত ধান বেশ উপযোগী। এ ক্ষেত্রে প্রতি হেক্টর জমিতে ১৭৫ কেজি ইউরিয়া, ১৩০ কেজি টিএসপি এবং ৬০ কেজি এমওপি সার প্রয়োজন। ইউরিয়া ছাড়া অন্য দুটি সার জমি তৈরি করার সময় প্রয়োগ করতে হবে। দেরিতে চারা রোপণের ক্ষেত্রে প্রতি গুছিতে ৫ থেকে ৭টি চারা দিয়ে ঘন করে রোপণ করতে হবে।
- আমন মৌসুমে মাজরা, পামরি, চুঙ্গি, গলমাছি পোকার আক্রমণ হতে পারে। এছাড়া খোলপড়া, পাতায় দাগ পড়া রোগ দেখা দিতে পারে। এক্ষেত্রে নিয়মিত জমি পরিদর্শন করে, জমিতে খুঁটি দিয়ে, আলোর ফাঁদ পেতে, হাতজাল দিয়ে পোকা নিয়ন্ত্রণ করতে হবে। তাছাড়া সঠিক বালাইনাশক সঠিক মাত্রায়, সঠিক নিয়মে, সঠিক সময় শেষ কৌশল হিসাবে ব্যবহার করতে হবে।

পাট

- বন্যায় তোষা পাটের বেশ ক্ষতি হয়। এতে ফলন যেমন কমে তেমনি বীজ উৎপাদনেরও সমস্যা সৃষ্টি হয়। এতে পরবর্তী মৌসুমে বীজ সঙ্কট দেখা দেয়। এ সমস্যা সমাধানে বিশেষ যত্নে ভাদ্রের শেষ পর্যন্ত দেশি পাট এবং আশ্বিনের মাঝামাঝি পর্যন্ত তোষা পাটের বীজ বোনা যায়। বন্যার পানি উঠে না এমন সুনিষ্কাশিত উঁচু জমিতে জো বুঝে প্রতি শতাংশে লাইনে বুনলে ১০ গ্রাম আর ছিটিয়ে বুনলে ১৬ গ্রাম বীজের প্রয়োজন হয়। জমি তৈরির সময় শেষ চাষে শতক প্রতি ৩০০ গ্রাম ইউরিয়া, ৬৫০ গ্রাম টিএসপি, ৮০ গ্রাম এমওপি সার দিতে হবে। পরে শতাংশপ্রতি ইউরিয়া ৩০০ গ্রাম করে দুই কিস্তিতে বীজ গজানোর ১৫ থেকে ২০ দিন পরপর জমিতে দিতে হবে।

আখ

- এ সময় আখ ফসলে লালপচা রোগ দেখা দিতে পারে। এক ধরনের ছত্রাকের আক্রমণে এ রোগ হয়। লালপচা রোগের আক্রমণ হলে আখের কাণ্ড পচে যায় এবং হলদে হয়ে শুকিয়ে যেতে থাকে। এজন্য আক্রান্ত আখ তুলে পুড়িয়ে ফেলতে হবে এবং জমিতে যাতে পানি না জমে সে দিকে খেয়াল রাখতে হবে। এছাড়া রোগমুক্ত বীজ বা শোধন করা বীজ ব্যবহার করলে অথবা রোগ প্রতিরোধী জাত চাষ করলে লালপচা রোগ নিয়ন্ত্রণে রাখা যায়।

তুলা

- ভাদ্র মাসের প্রথম দিকেই তুলার বীজ বপন কাজ শেষ করতে হবে। বৃষ্টির ফাঁকে জমির জো অবস্থা বুঝে ৩ থেকে ৪টি চাষ ও মই দিয়ে জমি তৈরি করে বিঘা প্রতি প্রায় ২ কেজি তুলা বীজ বপন করতে হয়।
- লাইন থেকে লাইনের দূরত্ব ৬০ থেকে ৯০ সেন্টিমিটার এবং বীজ থেকে বীজের দূরত্ব ৩০ থেকে ৪৫ সেন্টিমিটার বজায় রাখতে হয়।
- তুলার বীজ বপনের সময় খুব সীমিত। তাই হাতে সময় না থাকলে জমি চাষ না দিয়ে নিড়ানি বা আগাছানাশক প্রয়োগ করে জমি আগাছামুক্ত করে ডিবলিং পদ্ধতিতে বীজ বপন করা যায়। বীজ গজানোর পর কোদাল দিয়ে সারির মাঝখানের মাটি আলগা করে দিতে হবে।
- সমতল এলাকার জন্য সিবি-৯, সিবি-১২, হীরা হাইব্রিড রূপালী-১, ডিএম-২, ডিএম-৩ অথবা শুভ্র জাতের চাষ করতে পারেন।
- এছাড়া পার্বত্য চট্টগ্রাম অঞ্চলে পাহাড়ি তুলা-১ এবং পাহাড়ি তুলা-২ নামে উচ্চফলনশীল জাতের তুলা চাষ করতে পারেন।

Appendix 3b: Modules of the Integrated Farm Management Component – Farmers' Field School

Table 1 Outline of IFM Farmer Field School (FFS) in Jamalpur District

Module 1	Preparatory activities (4 sessions)
Module 2	Rice cultivation (14 sessions)
Module 3	Homestead gardening (7 sessions)
Module 4	Poultry rearing (4 sessions)
Module 5	Goat rearing (4 sessions)
Module 6	Cow rearing (5 sessions)
Module 7	Fish farming (5 sessions)
Module 8	Nutrition (3 sessions)
Module 9	Farmers' organizations and climate change issues (4 sessions)

Appendix-3b: Modules of Climate Farming School

Module session	Activities
Session 1	• What do we mean by weather and climate? Causes of climate change. • Agricultural problems in Bangladesh due to climate change. • Causes, timing and types of flood. • Activities to be done after flooding.
Session 2	• Impact of floods on ordinary people's lives and livelihoods. • What is the environment and the agricultural environment? • Measures to cope with adverse impact of climate change on agriculture. • The importance of adaptation on reducing agricultural losses and damage due to flooding. • Disaster risk reduction, mitigation and climate change adaptation. • Primary discussion on experiments related to adaptation strategies.
Session 3	• Discussion on one important local agricultural problem. • Making a crop calendar for a flood prone area. • What is soil? Classification, soil characteristics of a flood prone area; the importance of soil tests, collecting a soil sample for sending to the laboratory, recommendations about fertilizer use.
Session 4	• Beekeeping, mushroom and flower cultivation as alternative sources of income. • Discussion of one important local agricultural problem. • What is crop rotation? Cropping patterns to cope with a flood: intercropping, relay cropping and mixed cropping. • Discussion about fish farming on rice land in flood prone areas.
Session 5	• Discussion of one important local agricultural problem. • Importance of herbal pesticides for protecting the environment. • Agriculture for the whole year in flood prone areas. • Importance of planting trees in flood prone areas for ecological balance (road sides, homestead area, fallow land) and the selection of suitable plants.
Session 6	• Fertilizers and their classification. Ways of identifying the right fertilizer for farmers' needs. • What is organic fertilizer? Discussion on production techniques and the importance of organic fertilizer for improving soil health status. • Early flood warning systems, their effectiveness and limitations. • Qualities of good seed; germinability, the production and management of vegetable seedlings during floods.
Session 7	• Conservation and rearing beneficial insects and organisms to maintain an ecological balance. • Discussion of one important local agricultural problem. • Cultivation of suitable fruits and medicinal plants in flood prone areas. • Collection, identification and preservation of crop insects.
Session 8	• Organic pesticides and their importance in agriculture. • Discussion of one important local agricultural challenge. • Cultivation of floating vegetables and spices (ginger, turmeric, etc.).
Session 9	• Crop maturity determination, collection procedure and post-harvest operations. • Vegetables, fruit collecting, sorting and packaging for marketing. • Discussion of one important local agricultural challenge. • Cultivation of suitable year round vegetables in flood prone areas. • Preparation and caring of seedbeds (dry, *dapog* and floating) in emergency periods in flood prone areas.

Session 10	• Pest control through fertilizer and water management. • Planting and growing a mini nursery and managing it in flood prone areas. • Use of sex pheromone traps to manage harmful pests. • The importance of selecting suitable unconventional crops in flood prone areas.
Session 11	• Discussion of one important local agricultural problem. • Selection of crops based on soil type in flood prone areas. • Vegetable cultivation in homestead areas in flood prone areas.
Session 12	• The importance of, and production techniques for, green fertilizer for improving soil health status. • Cultivation of suitable relay crops in flood prone areas. • Selection of short growing oil crops and their management in flood prone areas. • Integrated farm management in flood prone areas.
Session 13	• Risks to, and the vulnerability of, women during flooding. • Producing seedlings in the homestead area. • Organic agriculture and its importance. • Selection of short growing pulse type crops and varieties and the management of these crops in flood prone areas. • Collection of, and preservation techniques for, crop seeds.
Session 14	• Annual planning of climate field school. • Discussion of one important local agricultural problem. • Production of animal feed and silage in flood prone areas. • Planting a mixed fruit garden in a flood prone area.
Session 15	• Field day - demonstration of the following topics I. Causes of climate change. II. Impact of climate change on agriculture and human life. III. Displaying different appropriate adaptation techniques for coping with climate change in a flood prone area. IV. Presentation of the results of the adaptation strategies implemented in the field. V. Public awareness through folk songs and role playing • Discussion meeting

Summary

Summary

Resource-poor rural households in Bangladesh are highly dependent upon agricultural production. Seasonal floods and unpredictable weather events pose serious challenges to agriculture, particularly in the regions along the main rivers. The development of weather, flood and climatic forecasts can potentially aid farmers to minimize the effect of floods and unpredictable weather events. However, the uptake and use of forecast information at local level are constrained by several factors including the nature of this information itself, in terms of timeliness, accuracy, reliability and accessibility, as well as limitations at the farm level, such as farmers' capacities to interpret and understand forecast information and use it effectively in their farming practices.

Previous studies on forecast information provide various explanations for the poor uptake of forecast information. These studies have largely neglected to investigate the interactions within and between the various organisations involved in the production, dissemination, communication, integration and use of forecast information. Such an analysis could lead to better understanding of the bottlenecks in the different steps/ processes involved in providing forecast information.

This thesis addresses the flow of forecast information along the entire chain from the collection of basic weather and hydrological data to the production of forecasts and their dissemination and use. The overall focus is on how different elements and processes in this information chain interact with each other and how this eventually shapes the usability of the information by farmers, how flood forecast information is integrated with other agricultural knowledge and information provided by different extension activities and how the opportunities and challenges concerning the use of forecast information vary across and within farming communities in different locations. These issues are investigated through a qualitative study, combining an analysis of the literature and documents as well as an analysis of data, collected through interviews, group discussion and participant observations. These methods are applied to the various organisations involved in the production and dissemination of flood forecasts and farmers and extension workers in three villages (Kulkandi, Pathorshi and Pirijpur) in Jamalpur district.

The objective of this dissertation is to explore and analyse the entire chain in which forecast information is produced, disseminated, accessed and integrated within agricultural extension activities, with a view to identifying the constraints and opportunities in effectively providing information to farmers.

To achieve this broad research objective, I formulated four research questions. They are:

(1) *How do the different organizations involved generate forecast information, what types of information are produced and why?*
(2) *What media and channels are used to disseminate forecast information to the local level, and how and to what extent is such information accessed by farmers in different communities?*
(3) *What are the existing farm management practices to deal with the flood and climatic risk among farmers operating in different agroecological conditions?*
(4) *How is forecast information integrated with other information as part of extension activities to generate recommendations for managing flood and climatic risks, and how are these valued by farmers?*

In the light of the existing literature, the introductory chapter (Chapter 1) provides an overview of the research background, problem formulation, and the prospects and challenges surrounding forecast information provision in Bangladesh. It also presents the research objectives, questions and the concepts used to understand and explain the entire chain in which forecast information is produced, disseminated, accessed and integrated in agricultural extension activities, and explains the relevance of the four empirical chapters, the research settings and the design and overall research methodology. This dissertation uses situated practices as an overarching concept to understand and explain how forecast information is given particular meanings that result from social interactions among actors and actants, including interactions with materials such as instruments, computer models, mobile phones, crops and other bio-materials within different settings of the organisations and villages that are studied.

In addition, key concepts from communication science are used to investigate and understand the dissemination of forecast information and access to such information at the local level. These concepts are helpful for understanding existing extension activities and recommendations and explaining how these are integrated with other knowledge and information to form the basis on which farmers take decisions.

This research for this dissertation used a case study design to generate an in-depth understanding of the forecast information chain. The data was collected from two types of empirical context. One was the village settings of Kulkandi, Pathorshi and Pirijpur, located in the Islampur sub-district of Jamalpur district, from which the experiences, perceptions and activities of farmers were studied. The other empirical context for data collection was the organisations involved in the production, dissemination and integration of forecast information. These are the Bangladesh Meteorological Department (BMD), the Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board (BWDB), and the Department of Agricultural Extension (DAE). Different units within these organisations were visited and individuals interviewed, after studying written materials, in print and online, issued by these organisations.

Chapter 2 shows that the histories of the three forecast producing organisations are quite different and that this has an effect on their operational procedures and work routines. Each organisation has different ways of data collection, uses different instruments for measurements and has different procedures for processing the collected data into weather and flood forecasts.
The institutionalized procedures and routines of these organisations have consequences for the exchange of information and other cooperation between them. As a result, the forecast information produced by the three organizations largely run parallel and with little coordination.
The findings of Chapter 2 also show that forecast information is mostly disseminated from a central level to the local level through hierarchical bureaucracies, using different media channels. Conventional media, such as radio, television and newspapers are used alongside digital channels such as the internet and mobile phone-based technology, particularly Short Message Services (SMS) and Interactive Voice Responses (IVR). SMS and IVR have been experimented with as part of pilot projects, and were only used by farmers in the project areas. Their use of such services declined quickly after the projects ended.
There were substantial variations in the media channels available across the villages and this meant that access to forecast information also varied considerably. It was found that the availability of media opportunities and the presence of extension agents and disaster management committees do not ensure farmers' access to forecast information. The functioning of technical equipment, internet connectivity, staff availability and commitment and transport facilities were all crucial in this respect, with malfunctioning equipment being a common cause for delays in disseminating forecast information.
Local administrators and extension officers are as dependent on technical facilities as farmers, and their administrative units also suffered from technical malfunctions. Limited coordination between disaster management committees at the upazila and union levels and an absence of government guidance regarding the responsibilities of government officials both reduced the timely distribution of forecast information at the local level.
Many farmers expressed the view that the features and qualities of forecast information are of limited value. Such information often arrives too late is and is often not connected to contextual advice and recommendations in relation to specific farm management practices.
Chapter 4 portrays farmers' existing crop and field management practices to deal with flood risks in the three communities. The chapter finds some clearly visible patterns within a diverse range of farm management practices. One example is the strategic use of elevated farmland. Access to even a small patch of land at a medium to higher elevation provides opportunities for growing seedlings that can then be planted in the main fields as soon as water in the flooded fields has receded. Farmers with larger plots on higher

ground strategically use these fields in combination with the lower fields that get flooded. Another pattern is the judicious use of crops and crop varieties in flood-prone fields. Sugar cane, for example, is a robust crop that can survive flooding. Yet, because sugar takes a long time to grow, it makes farmers dependent on a single crop for the whole year (as opposed to two or even three). Farmers' decisions about which crops and crop varieties to plant are largely informed by three criteria: growth duration, flood resistance and the value of the crop. The chapter also shows that farmers' decisions in one growing season have implications for the next growing season. Meteorological models, no matter how technically advanced, are of little help for such long-term strategizing.

Chapter 5 captures the extent to which extension workers are able to integrate forecast information into specific and usable recommendations as part of their extension activities and interactions with farmers. The chapter also explores farmers' appreciation of the DAE's activities. This forecast information is well linked to farming activities early in the growing cycle, for example for selecting varieties, managing seedbeds and soil fertility and crop protection measures. However, farmers expressed a desire for more time, and location, specific forecast information. Intensive group-based extension activities, such as farmer field schools, were generally by appreciated by the farmers, particularly as these activities create opportunities to observe and analyse a variety of field conditions and discuss these with other farmers and extension agents. However such activities are not structurally integrated within the extension programmes. They are generally *ad hoc* projects, financed by external donors and only a few farmer groups continued with group-based activities once these projects come to an end. In the absence of such project based activities, individual contacts between farmers and extension agents are the main way in which forecast information is integrated with other extension advice. However, the findings also show that such individual contacts do not occur as frequently as they should in all villages. An important finding is that resource-poor farmers, including all the farmers in the most remote village, which is also most vulnerable to floods, had the fewest interactions with agricultural extension agents.

Finally, the general discussion (Chapter 6) pulls together the main findings of the research from chapters 2 to 5, providing a synthesis that is linked with other studies, and formulating recommendations to improve the provision of forecast information. Based on the research findings in the different chapters, and in line with the analytical discussion, the thesis concludes that different organizational and institutional constrains relating to organizational mandates, histories and procedures, hierarchical forms of steering and communication, resource constraints and in-built discontinuities in activities and funding jointly contribute to sub-optimal collaboration and inhibit the exchange of knowledge and resources among those involved in the production, dissemination and integration of forecast information. This means that important feedback from local level stakeholders is overlooked, that there are significant delays in information provision and that there continue to be mismatches in terms of how providers go about disseminating and packaging forecast information to farmers and the everyday opportunities that farmers have to access and utilise such information.

In terms of the role of agricultural extension, the thesis concludes that conventional extension activities and recommendations play an important role in making forecast information usable, as they do effectively link forecast information to local knowledge and advice on farm management. Such integration is an important complement to traditional and novel ICT-based modes of disseminating forecast information.

Another core conclusion of this dissertation is that there are important differences within and between communities in terms of their specific agroecological contexts, the strategies and practices that farmers employ, the media channels to which farmers have access, the strength of linkages with agricultural extension workers and the capacities of communities to self-organize and fund group-based knowledge sharing activities.

The thesis concludes that, in order to address these constraints and opportunities, there is a need to establish and monitor new forms of collaboration, coordination and exchange in the forecast information system, as well as to explore and develop new public-private funding models that will help to foster the delivery of effective and relevant extension and forecast information services.

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About the author

About the Author

Mst. Sharmin Akter (Sharmin.agext@bau.edu.bd) was born and raised in Cantonment area in Bogura district of Bangladesh, where she attended elementary school. She did her higher secondary studies in another Cantonment area (Savar) of Dhaka division. Although, she grew up in army cantonment area, she gathered childhood memories from rural socio-cultural setting of her home district village of Gaibandha during her visits to her grandfather's house, which had several agricultural practises such as crop cultivation, livestock rearing and fishing by her neighbours and relatives.

She obtained a four year scholarship from the Rajshahi Education Board Fund and Sena Kalyan Sangstha, Bangladesh for her excellent academic achievements in Higher Secondary School Certificate (HSC) Examination in 2005. She completed her Bachelor of Science in Agriculture and Master of Science in Agricultural Extension Education from Bangladesh Agricultural University (BAU), Mymensingh. Sharmin obtained National Science and Technology (NST) fellowship, from Ministry of Science and Technology, Bangladesh in 2011 for conducting research titled: Vulnerability of Farm Households due to Drought: Evidence from Rajshahi District, during her Masters degree study. In 2012, she joined the Department of Agricultural Extension Education, BAU as a lecturer. In 2012 and 2013, she worked as field investigator of the Project: Management of Biodiversity using "Satoyama" model in the Teknaf Peninsula of Bangladesh and The Political Ecology of the Poverty and Deforestation in the Teknaf Peninsula with theJapanese research team of Kyushu University. Sharmin also participated in "Training of Teachers on Teaching Methods and Techniques" organized by "Modernization of Crop Science Education for Production of Quality Graduates at BAU (CP-2004)" as a sub-project of HEQEP-AIF, UGC at Faculty of Agriculture in 2013. In 2014, Sharmin started the PhD programme in Knowledge Technology and Innovation Group of Wageningen University and Research (WUR) as a PhD candidate, funded by the NUFFIC-NICHE-BGD-156 project, a collaboration between WUR and BAU.

She is life member of the Organization for Women in Science for the Developing World, Bangladesh Agricultural Extension Society (BAES), and the Bangladesh Society for Organic Farming and Safe Food (BSOFSF).

Sharmin is currently working as an Assistant Professor in the Department of Agricultural Extension Education of BAU. She is involved in different undergraduate courses such as: Fundamentals of Agricultural Extension, Data Collection and Report Writing, Extension for Agricultural Engineering, and Communication, as well as two master courses: Community Based Resource Management and Food Security and Poverty Reduction. Sharmin is also working as Co-Investigator of 'Capacity Development of the Farm Women on Nutrition Sensitive Household Agriculture Production Systems in BAUEC Working Areas' project funded by Bangladesh Agricultural University Research Systems (BAURES), BAU, Mymensingh. Additionally, since January, 2022

Sharmin is also working in Food and Agriculture Organization of the United Nations as an Agriculture Extension Education Instructional Designer of the 'Livestock and Dairy Development of Project' to develop a livestock farmer field school curriculum and a livestock extension manual and to revise the national livestock extension policy in Bangladesh. She also has a plan to develop a waste management centre at BAU in collaboration with different plastic industry, paper recycling industry, and organic waste collecting companies to recycle used products and to preserve the environment of BAU campus. She also wishes to develop an active baby day care center at BAU for ensuring a pleasant working environment for lady colleagues of BAU.

Mst. Sharmin Akter
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Professional Capacity Building Design and Implementation of Interdisciplinary Team Research Program on	International Centre for Development Oriented Research in Agriculture (ICRA)	2013	3.0
Competences for Integrated Agricultural Research	CDI	2014	1.0
Writing research proposal	KTI	2014	6.0
Participating in project related Thematic Session	WUR	2015	1.5
Participation and presentations in project related seminars and workshops	Interdisciplinary Institute for Food Security (IIFS), Bangladesh Agricultural University (BAU)	2015-2016	1.5
Fundamentals on GIS using ArcGIS	Dept. of Geography & Environment, Dhaka University	2016	3.0
B) General research related competences			
Research Methodology: From topic to proposal	WASS	2014	4.0
WASS Introduction course	WASS	2014	1.0
'Dissemination and Communication of Scientific Forecast Information and Advisory Services to Farming Communities on Jamalpur District, Bangladesh '	Tropentag, Bonn, Germany	2017	1.0
Information Literacy including Endnote	Wageningen UR Library	2014	0.6
YRM 60806:Qualitative Data Analysis: Procedures and Strategies	WUR	2014	3.0
Qualitative Data Analysis with Atlas.ti-a hands on practical	WASS	2014	1.0
Techniques for Writing and Presenting Scientific Paper	WGS	2014	1.2
Competencies Assessment for PhD	WGS	2014	0.3
The Essentials of Scientific Writing and Presenting	Wageningen in'to languages	2016	1.2
'Qualitative Research Methodology in Disaster Management: Application of Nvivo'	Disaster Research Training and Management Centre, University of Dhaka	2016	1.0
Research Ethics	WASS	2017	0.5
Scientific Writing	Wageningen in'to languages	2017	1.8

C) Career related competences/personal development			
Training on Gender, Agriculture and Rural Development	IIFS , BAU & CDI, WUR	2016	1.0
Data Management	Wageningen UR Library	2014	0.4
Reviewing a Scientific Paper	WGS	2017	0.1
PhD Workshop Carousel	WGS	2017	0.3
Scientific Publishing	WGS	2017	0.3
Publish for Impact	Wageningen UR Library	2017	0.1
Teaching in the BSc. Courses: - Extension Communication and Management - Agricultural Extension Education - Communications - Skills in Extension communication	BAU	2020	3.0
Review manuscript entitled- Problem Confrontation of Vegetable Growers in Production and Marketing of Vegetables: Evidence from Northern Part of Bangladesh	Journal of Agriculture Food and Environment	2021	1.0
BSAFE	United Nations Department of Safety and Security (UNDSS)	2021	0.1
Total			**38.9**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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