



# Climate-resilient agriculture in Bangladesh: **A value chain analysis of cotton**

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## EXECUTIVE SUMMARY

Climate change is an immediate concern in Bangladesh. The country's geophysical characteristics expose it to extreme events, and its economy relies on agriculture, which is highly climate-sensitive. Bangladesh continues to reduce poverty but still has a long way to go, as one out of every four Bangladeshi remains poor as of 2016 (World Bank, 2017). These factors imply that the smallest shocks or stresses can push the already socio-economically marginalised sections of the population further into poverty and deprivation. Meanwhile, rainfall patterns are already shifting, and the intensity of rainfall is projected to increase in the next few decades. Bangladesh has also been exhibiting increasing trends in annual mean temperatures. The situation will continue to worsen, indicating an urgent need to build the resilience of people and their livelihoods to climate change.

Global climate projections report declines in agricultural yields as one of the direct consequences of climate change. Paddy, the staple food grain of Bangladesh, is highly sensitive to temperature changes and will be adversely affected. Meanwhile, the agriculture sector plays a vital role in accelerating Bangladesh's economic growth. About 45.1% of the labour force is directly or indirectly dependent on agriculture. The sector also plays an important role in attaining food security and improving the quality of life of the increasing population, as well as creating employment. It is thus vital to ensure the agricultural system in place is profitable, sustainable and environmentally friendly. Measures to ensure this need to factor in the additional risks posed by climate change.

In this context, Action on Climate Today (ACT), a Department for International Development-funded initiative, in partnership with the International Centre for Climate Change and Development (ICCCAD), Bangladesh, has been supporting the Cotton Development Board (CDB) in enhancing the resilience of the value chain of cotton, an important emerging commercial crop in the country.

Bangladesh is the second largest readymade garments exporter in the world and one of the biggest importers of cotton. Current domestic production of cotton meets only 5% of the industry's demand and there thus exists significant scope to expand cotton production to bridge this gap. The cotton crop has certain features, such as a vertical tap root, that make it more resilient to high temperatures and salinity. Compared with paddy, it requires less water and therefore is more conducive to growth in the highlands. However, the crop is highly sensitive to changes in climate, especially shifts in rainfall patterns. Untimely rainfall during the flowering period drastically reduces the yield and quality of cotton. Cotton expansion is also at a nascent stage and tightly controlled at the processing and marketing stages. Existing bottlenecks across the value chain, along with climate change, pose problems for the wider uptake of cotton cultivation as well as for the livelihood security of cotton farmers.

The overall objective of this study was to map existing processes, benefits and constraints within the cotton value chain and the additional vulnerabilities posed by climate change. Based on these, this report suggests informed measures to address value chain bottlenecks and build the resilience of the crop and its farmers to the impending impacts of climate change. These measures can be taken by the government, community-based organizations, private sector entities and other stakeholders for replication, and could involve scaling up and enhancing the value share of small and marginal farmers and other vulnerable groups in the process. A value chain approach supports integrated climate risk management through better connection of producers to markets and increased economic returns to small farmers. Thus, it is an approach not just to building climate resilience but also to providing more effective support for agriculture generally.



To study the cotton value chain, we covered five cotton-growing districts in Bangladesh. These fall under two agro-ecological zones, in the northwest and southwest regions of the country. The core objective of the field visit was to understand the dynamics of cotton cultivation in the country as perceived by farmers, input dealers, processors – in this case the association of ginners – and the government to identify challenges, contradictions and opportunities. Details on pre-production, production and post-production activities were obtained. Rainfall and temperature data for the past 20 years (1998–2017) in the study areas was used to develop local-level climatic patterns to obtain a better understanding of how shifts caused by climate change have been affecting cotton cultivation in the region. Based on this assessment, we identified the following constraints and opportunities:

Opportunities:

- Bangladesh being one of the largest exporters of finished garments but the second largest importer of raw cotton, there is huge scope to increase domestic production of cotton.
- As cotton requires much less water than paddy, it is a viable option in highlands and drought-prone areas.
- Cotton has saline-tolerant properties, which make it beneficial for areas experiencing salt water intrusion.
- Economically, the crop is viable for small and marginal farmers.
- All by-products of cotton are useful. Cotton is used for textiles. The seed is used for vegetable oil. The seed residue serves as protein-rich food for livestock. The plant remnants are used as fuel wood, which is scarce in Bangladesh.

Constraints:

- Increasing temperatures have led to increased incidence of pests.
- Cotton flowers are highly sensitive to rainfall and therefore prone to destruction in cases of untimely rainfall.
- The cropping period for cotton is long, which lengthens the crop's exposure to climate variability and cuts down the annual crop bundle.
- There is a lack of information on weather predictions and variability, seed varieties and input materials, such that farmers cannot make informed decisions (as stated by farmers).
- There is no storage infrastructure available for farmers, which means cotton can be damaged by humidity and pests.
- The processing stage of the cotton value chain is weak, with very few ginners to buy and process cotton, which is a major obstacle to cotton expansion.
- Annually variable (both international and national) prices and little prior knowledge among farmers about pricing is another issue that limits cotton cultivation.
- The bargaining power of farmers is limited, and the region currently lacks a system by means of which farmers can share knowledge and collectively bargain for prices, input materials and information.
- The government's focus has been primarily on food security, so there is not enough financial and policy support for expanding cotton cultivation.
- Cotton is a labour-intensive crop and has a long cropping duration, which means it faces competition from short-duration commercial crops and plantations (mango) that require less effort.
- There is minimal participation of women in the cotton value chain.





The study's findings address general value chain issues, such as lack of information, market imperfections and the need to empower farmers, as well as climate-specific challenges for cotton, such as the cropping period, increasing pests and diseases and shifts in temperature and rainfall. The key recommendations are as follows:

- The first step towards climate-proofing the cotton value chain should be to conduct a climate vulnerability analysis in areas under cotton cultivation. The social and physical vulnerabilities identified through this analysis can help CDB make more informed strategic and policy decisions to expand cotton cultivation, secure the livelihoods of cotton farmers and make the value chain more resilient to climate change.
- Based on the challenges identified through this study and subsequent localised climate vulnerability analyses, a set of climate-resilient agro-economic practices need to be introduced across the value chain.
- While vulnerability assessments and the introduction of agro-economic practices are vital to enhance resilience, regular provision of information to farmers and other stakeholders across the value chain should go hand in hand with this. This will help ensure effective and large-scale uptake and localised knowledge-sharing on agricultural and adaptation practices.
- To ensure more equal relations between farmers and other stakeholders, cotton farmers' cooperatives should be created. This in turn will help ensure the flow of information and knowledge-sharing and increase collective bargaining power and access to financial and technical resources.
- Measures need to be taken to incentivise ginning such that there are more players at the processing stage of the value chain. This in turn will create better market opportunities for farmers and help with the expansion of cotton.
- The findings of this research need to be disseminated to other departments in the Ministry of Agriculture, which could use the ideas in their own agricultural domains.
- A core-group of individuals needs to be empowered to lead the climate change agenda within the Cotton Development Board in the form of a Technical Committee on Climate Change.



## PARTICIPATING ENTITIES

### Action on Climate Today

Action on Climate Today (ACT) is a Department for International Development (DFID)-supported technical assistance programme that works with national and subnational governments in South Asia to mainstream climate change resilience into sectoral plans, policies and budgets, with the aim of reducing people's vulnerability to climate change, reducing losses and damages owing to climate change impacts and ultimately minimising the impact of climate change on growth and development.

The programme provides technical assistance in the form of capacity-building, system enhancements, policy recommendations and decision support tools, as well as assistance in mobilising resources for adaptation. ACT has been operating in Afghanistan, India, Nepal and Pakistan since 2015, and in Bangladesh since 2017. The core objectives of the programme are to:

- Support the design and delivery of climate resilience;
- Promote investments for climate-compatible development;
- Build the climate change knowledge of decision-makers;
- Attract further climate change investment from the public and private sector.

### International Centre for Climate Change and Development

The International Centre for Climate Change and Development (ICCCAD) is a research and capacity-building organisation working on climate change and development in Bangladesh. The organisation's policy support programme provides support to the Government of Bangladesh in making informed and evidence-based decisions around pro-poor resilient development by leveraging learning, evidence and exchange on climate-responsive actions.

### Cotton Development Board, Bangladesh

Bangladesh has a long history of cotton and textile production. In medieval times, Bengal was famous for its production of muslin. The cotton required for the production of this was grown in the highlands around Dhaka, where most of the muslin handlooms were located. However, the production and trading of muslin gradually declined under British rule, ultimately resulting in closure of the industry by early 19th century.

Under Pakistani rule, efforts to produce cotton in this part of the country were limited. Before independence, the local textile industry's raw cotton requirement was met from the then West Pakistan. The importance of local cotton production was felt after Bangladesh's independence in 1971, when imports of raw cotton from Pakistan were suspended and Bangladesh's textile industry faced serious supply problems. In these circumstances, the Cotton Development Board (CDB) was established under the Ministry of Agriculture in 1972 to promote cotton production in the country. CDB started functioning in 1974/75 and started growing American Upland Cotton (*Gossypium hirsutum*) on an experimental basis. An extensive programme of Upland Cotton production was taken up in 1976/77 with the introduction of a new variety from the USA. Responsibility for cotton research was transferred from Bangladesh Agriculture Research Institute (BARI) to CDB in 1991.







# ACKNOWLEDGEMENTS

The climate-resilient value chain analysis of cotton began officially in the second half of 2018, but joint planning between ACT, CDB and ICCCAD occurred before this, in the first half of the year. We acknowledge financial support from UK Aid and its initiatives on green growth in the Global South. Dr Aditya Bahadur, Regional Programme Development Manager, ACT, has been one of the key players, designing the deliverables and the principles of engagement. At the same time, administrative guidelines were supplied by Dr. Cristina Rumbaitis del Rio (Regional Programme Manager, ACT) and Dr Saleemul Huq (Director, ICCCAD). The team is very much indebted to them.

This research initiative benefited immensely from the inputs of Mr Simon Croxton as technical lead. Simon trained the whole research team, supported it in data analysis and was always ready to backstop when needed. This research report would not have been able to attain its present quality without Simon's generous support. We also acknowledge all support colleagues in ACT and ICCCAD, who made this programme run by providing the right services at the right moment.

In this research, we collected data in two phases, first in May and then in November. In both the phases, data collection was outsourced to Consiglieri Private Limited (CPL). On both occasions, we had very little time to give notice to CPL. Nevertheless, CPL committed to the task without becoming overinvolved in bureaucracy and successfully completed the fieldwork. Having very efficient consultants like Mr Shibaji Roy, Mr Kamrul Hasan and Mr Aslam Parvez was a great privilege, and their insights in the field and inputs into the final report were extremely useful. The research team would like to express its most heartfelt gratitude to the CPL team.

This initiative would not have been possible without the high degree of cooperation, support and encouragement of the Cotton Development Board. Their enthusiasm, acumen and vision have enriched all elements of this report. Their commitment to making cotton production more resilient to the impacts of a changing climate is an exemplar of forward thinking action for adaptation.





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## LIST OF ACRONYMS

<b>ACT</b>	<i>Action on Climate Today</i>
<b>BARI</b>	<i>Bangladesh Agricultural Research Institute</i>
<b>BBS</b>	<i>Bangladesh Bureau of Statistics</i>
<b>BMD</b>	<i>Bangladesh Meteorological Department</i>
<b>BMDA</b>	<i>Barind Multipurpose Development Authority</i>
<b>CCC</b>	<i>Climate Change Cell</i>
<b>CDB</b>	<i>Cotton Development Board</i>
<b>CDMP</b>	<i>Comprehensive Disaster Management Programme</i>
<b>CPGD</b>	<i>Climate Proofing Growth and Development</i>
<b>CPL</b>	<i>Consiglieri Private Limited</i>
<b>CYMMIT</b>	<i>International Maize and Wheat Improvement Centre</i>
<b>DAE</b>	<i>Department of Agricultural Extension</i>
<b>DFID</b>	<i>Department for International Development</i>
<b>DAP</b>	<i>Diammonium Phosphate</i>
<b>FY</b>	<i>Fiscal Year</i>
<b>FYM</b>	<i>Farmyard Manure</i>
<b>GCM</b>	<i>General Circulation Model</i>
<b>GOB</b>	<i>Government of Bangladesh</i>
<b>ICCCAD</b>	<i>International Centre for Climate Change and Development</i>
<b>IFPRI</b>	<i>International Food Policy Research Institute</i>
<b>ITC</b>	<i>International Trade Centre</i>
<b>LT</b>	<i>Linear Trend Model</i>
<b>MFI</b>	<i>Microfinance Institution</i>
<b>MOEF</b>	<i>Ministry of Environment and Forest</i>
<b>MOP</b>	<i>Muriate of Potash</i>
<b>MT</b>	<i>Metric Tonne</i>
<b>NASA</b>	<i>National Aeronautics and Space Administration</i>
<b>NGO</b>	<i>Non-Government Organisation</i>
<b>PERSIANN</b>	<i>Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks</i>
<b>PRECIS</b>	<i>Providing Regional Climates for Impacts Studies</i>
<b>QT</b>	<i>Quadratic Trend Model</i>
<b>RMG</b>	<i>Ready-Made Garments</i>
<b>SDG</b>	<i>Sustainable Development Goal</i>
<b>SRDI</b>	<i>Soil Resource Development Institute</i>
<b>TRMM</b>	<i>Tropical Rainfall Measurement Mission</i>
<b>TSP</b>	<i>Triple Superphosphate</i>
<b>UNDP</b>	<i>United Nations Development Programme</i>
<b>UNEP</b>	<i>United Nations Environment Programme</i>



## 01

## INTRODUCTION



## 1.1 Climate-resilient value chain analysis for climate-proofing agriculture

The impacts of climate change are already being felt across the world, through rising temperatures, variability in rainfall, shifts in seasons, increasing salinity in coastal areas and increased intensity of extreme natural disasters. South Asia, which contains close to 25% of the world's population, is exceptionally vulnerable to climate change. Around half of the region's population is dependent on agriculture as the primary source of livelihood. Many parts of South Asia are likely to experience a decline in crop productivity unless there is a shift to different crop varieties and management practices. This in turn will not only adversely affect livelihoods of those dependent on it but also food security in the region, more so for the vulnerable and marginalised sections.

Shifts to more climate resilient crops are imperative to secure agriculture-based livelihoods. However, high sensitivity of agriculture to climate change implies that targeted interventions need to be adopted to proof entire value chains of crops rather than focusing simply on the pre-production or production levels. Value chains need to be seen as systems being affected by the changing climate and the existing bottlenecks across these need to be addressed. For doing so, an enabling environment is of utmost importance and entry points can be identified based on the context and the bottlenecks. These can range from policy and institutional changes and financial support and technical innovations to information and knowledge management.

ACT has worked with governments in five of its locations to identify climate resilient crops, analyse their value chains to identify gaps and recommend changes to bridge them. In 2017, ACT in partnership with ICCCAD began its engagement with the Ministry of Agriculture in Bangladesh and provided technical support in reviewing

<sup>1</sup>[http://www.acclimatise.uk.com/wp-content/uploads/2018/02/OPM\\_Agriculture\\_Pr2Final\\_WEB.pdf](http://www.acclimatise.uk.com/wp-content/uploads/2018/02/OPM_Agriculture_Pr2Final_WEB.pdf)





and incorporating climate change in their five-year National Agriculture Policy. The programme has been working with the Cotton Development Board (CDB) to conduct a value chain analysis of the cotton crop through the climate lens.

## 1.2 Objective and scope of the study

The overall objective of this study is to map existing processes, benefits and constraints within the cotton value chain and the additional vulnerabilities posed by climate change, and to suggest informed measures to build the resilience of the crop and its farmers to the impending impacts of climate change. These measures can be taken by the Government of Bangladesh (GOB), community-based organisations, private sector entities and other stakeholders for replication, and could involve scaling up and enhancing the value share of small and marginal farmers and other vulnerable groups in the process.

The recommendations emerging from this analysis have been collectively decided upon based on regular in-depth consultations with CDB and are based on the insights shared by farmers and other stakeholders across the crop's value chain.

This study is an analytical assessment of the cotton value chain with the following scope:

- Identification of the climate risks and climate-resilient features of cotton;
- Analysis of various processes and activities carried out at each stage in the value chain, including production, trading, storage, import, processing and value addition, to identify blockages and their causes;
- Investigation of the dynamics between various actors/players in the value chain, hierarchies, communication channels, associated risks and profit margins;
- Evaluation of the effectiveness of GOB policies and interventions in expanding cotton production, its value chain development and increasing its resilience to climate change.

The study presents focused, viable and sustainable policy recommendations and interventions for CDB to address climate vulnerabilities and improve and expand cotton production. The proposed interventions will also be helpful for donors and other development agencies in rolling out similar programmes/projects for other crops in the country.





## 02

## IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN BANGLADESH



### 2.1 Contribution of agriculture to the economy

Bangladesh is predominantly an agricultural country, with the sector playing a vital role in economic growth. About 45.1% of the labour force is directly or indirectly dependent on agriculture. The sector also plays an important role in food security, improving the quality of life of the country's increasing population and creating employment. It is therefore important that the systems involved are profitable, sustainable and environmentally friendly.

GOB has given the broad agriculture sector the highest priority, to ensure the country can be self-sufficient in food, in keeping with the goals set out in the Seventh Five Year Plan, the Sustainable Development Goals (SDGs) and the National Agriculture Policy. Over the past few years, there has been an increasing trend in food production. Preliminary estimates from the Bangladesh Bureau of Statistics (BBS) show that, in FY2016/17, food grain

production stood at around 388.14 lakh MT. In the same fiscal year, total internal procurement of food grains was 13.83 lakh MT, with total imports through the public and private sectors at 58.23 lakh MT (rice 1.33 lakh MT and wheat 56.90 lakh MT). In ongoing development assistance and productivity incentives, GOB is providing a 30% cash rebate on imports of agricultural produce and a 20% percent rebate on the electricity bills of agro-based industries and irrigation systems. Tk. 17,550 crore was targeted for disbursement as agricultural credit, against which Tk. 20,998 crore had been disbursed by June 2017 – 120% of the target. In order to scale up productivity, agricultural input subsidies have been increased, with coverage and availability of agricultural credit increased. Programmes have been launched to popularise the use of organic and balanced fertiliser to maintain soil fertility and productivity. In recognition of the importance of increased productivity, Tk. 6,000 crore was allocated in the revised budget of FY2016/17 in the form of subsidies on fertilisers and other agricultural inputs.







## 2.2 Climate Change Projections for Bangladesh

Located within the South Asian monsoon region, Bangladesh enjoys a warm, humid and tropical climate, influenced primarily by monsoon and partly by pre- and post-monsoon circulations. With the Bay of Bengal and the Indian Ocean to the south and large mountain ranges – the Himalayas and Arakan Mountains to the north and east, respectively – the country receives very high annual precipitation, most of which is concentrated during the monsoon season. There are four prominent climatic seasons in Bangladesh: winter (December–February), pre-monsoon (March–May), monsoon (June–September) and post-monsoon (October–November). Although the onset of the monsoon tends to vary from year to year, it generally (on average) starts during the first week of June and withdraws by the first week of October. Intense heat and consequent low-pressure systems over Punjab (in Pakistan and India) and the Upper Ganges draw in moisture-laden southwest trades to the Indian sub-continent, starting the main rainy period in Bangladesh. Besides the monsoon, easterly trade winds are also active in the country, providing warm and relatively drier circulation.

Analysis of precipitation data from 1961 to 2010 for 234 stations managed by the Bangladesh Water Development Board indicates that annual precipitation data in Bangladesh is essentially free of any significant change and trend (Mondal et al., 2013). Country-wide annual normal rainfall over a period of 30 years (1980–2009) is found to be 2,306 mm. Precipitation during 1960–1989 and 1970–1999 was 2,298 and 2,314 mm, respectively.

However, Mondal et al. (2013) note that, while all-country precipitation data remains trend-free, significant changes

in some regional annual rainfalls can be observed. The far northwest (Rangpur–Dinajpur) and southwest (Jessore–Khulna–Satkhira) regions exhibited increases in annual rainfall at 90% level of confidence, while the south-central and southeast regions (Faridpur–Comilla–Barisal) exhibited decreasing trends. Shahid (2010), using a different precipitation dataset, from 1958–2007 for 17 stations managed by the Bangladesh Meteorological Department (BMD), on the other hand, observed an increase in precipitation of 5.5 mm per year. Echoing Mondal et al., this study also reported a statistically significant increase in precipitation in the northwest and southwest regions.

Seasonal rainfall trends, when compared for three periods – 1960–1980, 1970–1999 and 1980–2009 – reveal that pre- and post-monsoon precipitations have increased whereas the monsoonal rainfall has decreased (Mondal et al., 2013). Winter rainfall also increased in the latter two periods relative to the first one. However, except for the pre-monsoon season, these precipitation trends are not statistically significant. Shahid (2010) also found an overall increasing trend in pre-monsoon rainfall. Stronger and more continuous winds from the Bay of Bengal during pre-monsoon months in recent years, as a result of increased sea surface temperatures (Khan et al., 2000), are postulated to be the cause of increased pre-monsoon rainfall in Bangladesh.

Models of climate change suggest higher than average monsoon rainfall in the future, with the findings of Agrawala et al. (2003) being reported in the key government publications. 1 summarises the modelling data that represents climate change scenarios for the country under three different timelines. The winter months – December, January, February – will become warmer and drier whereas the monsoon months – June, July, August – will become warmer and wetter.

**Table 1. Temperature and precipitation scenarios used in GOB documents**

Timeline	Mean temperature change (°C)			Mean precipitation change (%)			Sea level rise (cm)
	Annual	Winter	Monsoon	Annual	Winter	Monsoon	
2030	1.0	1.1	0.8	5	-2	6	14
2050	1.4	1.6	1.1	6	-5	8	32
2100	2.4	2.7	1.9	10	-10	12	88

Source: Agrawala et al. (2003); MOEF (2005).



Predicted changes in monthly distribution of rainfall, the number of rainy days and seasonal temperature for Khulna and Barisal divisions will have implications for people's lives and livelihoods. Increased monsoon rainfall may lead to frequent occurrence of high-intensity floods over the floodplains (Ahmed et al., 2015). Monsoon flood duration will be prolonged by a significant number of days, and inundation area and depth will increase (CCC, 2009). The reduction in rainfall during the drier months (November to March), coupled with increased surface desiccation, will heighten moisture stress and phonological drought, particularly in the western parts of the country (BCAS, RA & Approtech, 1994; Huq et al., 1996; Ahmed et al., 2015).

Mondal et al. (2013) reported that rainfalls in the months of May (13 mm/decade) and September (11 mm/decade) were found to be increasing (statistically significant). They also observed an increase in precipitation in the months of March and October and a decrease in the months of June and August, though these trends were not statistically significant. The study further observed that the number of rainy days was increasing in Bangladesh. Stations that showed statistically significant trends for increased rainy days and consecutive rainy days included Khulna and Satkhira, two of the project's six proposed target districts, with areas further along the coast indicating statistically non-significant changes. Both stations also exhibited a statistically significant decreasing trend of non-rainy days.

According to a study conducted by the Comprehensive Disaster Management Programme (CDMP) in 2013, Bangladesh has been exhibiting increasing trends in mean annual temperatures. Data from all 34 stations in Bangladesh suggests that the trend is 1.2°C (ibid.). This is in line with the results obtained by Shahid (2010), who analysed temperatures from 17 stations over the period 1958–2007 and observed an increase in the mean temperature by 0.097°C per decade.

Data from all 34 stations demonstrates a trend towards increasing temperature rates for the period 1980–2010 compared with 1948–2010 – that is, it is getting warmer quicker. It is evident that the annual trend in mean temperatures during the 1980–2010 period, at 2.4°C, was nearly twice the value computed using the data for the entire period (1948–2010). The CDMP study further noted that corresponding winter (December–February), pre-monsoon (March–May), monsoon (June–September) and post-monsoon (October–November) trends have been 1.2°C, 0.7°C, 1.2°C and 2.0°C, respectively. Shahid (2010) observed that, except in the northern areas, there

has been a significant increase in mean temperature in most parts of the country. The highest increase was observed in November, at a rate of 0.3°C per decade (ibid.). Seasonal analysis of temperature shows this is increasing significantly, but only in winter. Mean temperature has been increasing in the potential project areas. The mean temperature increase observed, although not statistically significant, is 0.09°C and 0.04°C per decade for Satkhira and Khulna stations, respectively (ibid.).

Several modelling exercises have noted a general increase in surface temperature, with higher rates of change during the drier periods (Ahmed and Alam, 1998; Agrawala et al., 2003; Mondal et al., 2013). Since the 1950s, a surface warming increase of approximately 0.74°C has been observed in Bangladesh, a trend that is increasing (Islam and Neelim, 2010). This is likely to reduce moisture from topsoil and exacerbate evaporation from plants and water bodies.

These trends are expected to continue in the future, as demonstrated by four general circulation models (GCMs) used to model temperature changes under the A1B scenario. Different data models show the maximum and minimum temperatures in Barisal and Khulna divisions as predicted by the four GCMs, with increases of between 1°C and 2°C by 2050. The PRECIS model (Providing Regional Climates for Impacts Studies) also predicts that annual maximum and minimum temperature will follow an increasing trend (CCC, 2009).

## 2.3 Implications for the Agriculture Sector

Bangladesh will be vulnerable to the potential impacts of global warming and sea level rise through immense effects on crops, soils, insects, weeds and diseases (UNEP, 2001). As discussed above, climate change is very visible in Bangladesh in terms of changes in seasonal weather patterns, such as rainfall regime shifts, dry spells, erratic rainfall, excessive heat and shorter winters, coupled with increases in the intensity and magnitude of extreme events, sea level rise, rising soil salinity and so on. All of these have had an impact on overall agricultural production in Bangladesh.

Temperature, which is one of the main factors involved in climate, is closely associated with agricultural production. Bangladesh's major crop, rice, which is tightly woven into the local culture, will be hugely affected by deviations in temperature. For example, a rice plant has nine growth

<sup>2</sup>IPCC Assessment Report 5





stages, with three of them distinct; every single stage is very sensitive to any deviation from its optimum heat. Different rice varieties in different physiological conditions will have different optimum heat sensitivities. Increases in temperature in combination with lower solar radiation cause sterility in the rice spikelet, and reduce the production of the aus, aman and boro high-yielding varieties in all seasons in Bangladesh (Bangladesh National Adaptation Programme of Action 2005).

Since variations in temperature dictate plants' growth, they will also modify rates of pollination and flower-blooming, seed distribution and so on, which will result in a decline in the production of rice, wheat, maize and other crops. Scientists predict about a 17% decline in overall rice production in Bangladesh, and a decline of as high as 61% in wheat production under 4°C changes in temperature. The biggest impact would be on wheat, followed by rice (aus variety). Basak et al. (2010) predict a 20% and 50% decline in boro rice production by 2050 and 2070, respectively.

The impacts of climate-induced salinity on agriculture-based livelihoods are significant and pose a tremendous risk to Bangladesh's agro-based economy. Local communities are experiencing direct damage to crops, decreasing freshwater fish stocks and income loss, which lead to increased vulnerability. This subsequently triggers and demands adaptive responses in livelihood choices and production patterns (Huq et al., 2015). The coastal belt is already experiencing reduced agricultural production as a result of a changing climate. A study conducted by the Soil Resource Development Institute (SRDI) in 2010 showed that over 1 million ha of cultivable land in the country were affected by salinity intrusion

caused by slow- and rapid-onset events. According to BBS in 2010, the net cultivated area in Satkhira decreased by about 7% between 1996 and 2008, and production of the principal rice crop in Satkhira decreased from about 0.3 million tons in 2008 to 0.2 million tons in 2010.

Climate change and global warming will be manifested through increase of extreme events in terms of both intensity and magnitude. Thus, occurrence of floods, droughts, tornadoes, cyclones, heat wave and hailstorms will be greater and more frequent than before. These events will have a direct impact in terms of physical damage to crops. Different regions will be affected differently by diverse extreme events.

Farmers in Bangladesh grow several crops on one piece of land, and they juggle with the different seasons to maximise the use of their land. Changes in climate patterns will break these crop patterns. For example, if changes in weather patterns delay the sowing of one crop, the farmer can expect a late harvest for that crop. Late harvesting of the earlier crop will delay land preparation and sowing for the next crop. It is very possible that farmers will have to give up one crop from their yearly crop bundle. This will have a significant impact on agro-household incomes at state level, since Bangladesh is an agro-economy-based developing country.

There is no doubt that climate change will badly affect Bangladesh's agriculture sector. Losses here will increase social problems, and also necessitate food imports, which will require the spending of hard currency. Therefore, there is an urgent need in Bangladesh to work on a strategy for climate-resilient agriculture at policy and planning level.



## 03

## EXISTING POLICY ENVIRONMENT



The main objectives of the National Agricultural Policy of 2018 are improved socioeconomic conditions by means of increased crop productivity and farmers' incomes, crop diversification, safe food production, nutrition security, efficient natural resource management, sustainable growth and creation of employment opportunities.

The policy mentions climate change-induced hazards such as drought, flood, salinity, waterlogging and extreme temperature as concerns for Bangladesh agriculture. It also notes that climate change will lead to crop disease outbreaks. The policy gives a particular focus to the issue of agriculture in the face of climate change.

One section of the Research and Development chapter in the policy has been dedicated to the development of climatic stress-tolerant seed and crop varieties. The Agricultural Environment and Natural Resources Management chapter has a section on Changed Climate and Agriculture.

The policy also identifies the following as major weaknesses in the agriculture section that require

attention: inadequate productivity of input materials; lack of capital; absence of environment/climate-smart technologies; limited agricultural marketing management; post-harvest losses; inadequate ventures to produce export quality products; limited agricultural credit; shortage of trained scientists and infrastructural facilities; poor active farmers' organisation; lack of coordination between research institutes and the Department of Agricultural Extension; slow rate of technology transfer; lack of diversification in agriculture; inadequacy of transportation and processing facilities; meagreness of private sector investment; use of agricultural lands for non-agricultural purposes; and declining soil fertility.

Paragraph 3.3.6 elucidates on the Development of Climate Change and Stress-Tolerant Varieties and Technologies and highlights the following aspects:

- Activities will be strengthened to assess the impacts of climate change on various crops and natural resources.
- Research activities will be expedited in the development of varieties and management technologies suitable for agriculture under climatic stresses such as salinity, flood, drought, submergence, cold and heat.
- Innovation of farming practices profitable in the context of climate change will be encouraged.
- Development of innovative natural resources management practices suitable in a hostile environment will be strengthened.
- Activities related to innovation of effective land use and fertiliser management technologies will be accelerated.
- Non-government organisations (NGOs) will be encouraged and provided support in the development of stress-tolerant cultivars, technologies and management practices.





# 04

## THE VALUE CHAIN APPROACH TO ENHANCING THE RESILIENCE OF COTTON TO CLIMATE CHANGE

### 4.1 Definition of Climate-Resilient Value Chain Analysis

The agricultural value chain is the whole range of goods and services necessary for an agricultural product to move from the farm to the final consumer. Successful agricultural value chains are both productive and sustainable; they conserve the environment and natural resource base and adapt to climate change, price fluctuations and consumer needs. This study looked specifically at the cotton value chain to identify factors that make it relatively resistant to climate impacts, and also identified existing bottlenecks across the value chain that reduce the viability or profitability of cotton and hence hinder the expansion of cotton cultivation.

A value chain approach supports integrated climate risk management through better connection of producers to markets and increased economic returns to small farmers. Thus, it is an approach not just to build climate resilience but also to provide more effective support to

agriculture generally. A value chain approach recognises the interdependency of actors involved in all stages of a value chain – from production to consumption – and guards against economic and climate change risks that threaten any part of this chain. It acknowledges that, when it comes to responding to the impacts of climate change, it is impossible to provide effective support unless the whole value chain is considered.

The impact of climate change on agriculture value chain is far-reaching. It goes beyond reduced yields and crop losses caused by extreme weather events such as floods, droughts and hailstorms. More extensively, climate change-induced catastrophes – which are becoming ever more frequent – can lead to the destruction of processing and transport infrastructure and even of supplies of seed for the next growing season. Thus, value chain analysis is extremely important in formulating a strategy and action plan for DFID's Climate Proofing Growth and Development (CPGD) programme.

Bangladesh is a hub for textile manufacturing and is the second largest importer of cotton in the world. However current domestic production of cotton meets only around

Figure 1 : Agricultural value chain approach







5% of demand, as Section 5 discusses in detail. Cotton is therefore an economically important crop and, when grown widely, will contribute significantly to foreign exchange savings. In this context, it is imperative to understand the existing blockages across its value chain and its vulnerability to climate change, to make it possible to minimise existing risks and sustainably expand production.

## 4.2 Methodology

### 4.2.1 Area of Study and Sample

To study the cotton value chain, we covered five cotton-growing districts in Bangladesh. These fall under two agro-ecological zones, namely the High Ganges Floodplain and the High Barind Tract, situated in the northwest and southwest parts of the country, respectively. The fieldwork was carried out in two phases over a period of six months. The first was shorter and focused primarily on piloting and gathering an in-depth understanding of the cotton value chain in the region. The second was intended to strategically analyse the issues that had surfaced during the first round.

The following interconnected steps were undertaken to carry out the study:

- Data collection and research;
- Identification of climatic risks and impact;
- Analysis of opportunities and constraints;
- Validation of findings with stakeholders; and
- Recommendations for future action.

The core objective of the fieldwork was to understand the dynamics of cotton cultivation in the country as perceived by farmers, input dealers, processors- in this case, the association of ginners and GOB, to identify challenges,

contradictions and opportunities. A total of 60 cotton farmers were interviewed across the study area, and 4 focus group discussions were held with around 75 farmers. In-depth interviews were conducted with input dealers, traders, wholesalers and processors for different crops of the cotton crop bundle. Interviews were also conducted with seed companies and bank stakeholders. For cotton specifically, focus group discussions were conducted with the association of ginners and CDB.

### 4.2.2 Methods

To ensure a comprehensive approach to analysing the cotton value chain, the study used a multi-step process with a combination of primary and secondary research. It used various methodological tools, such as a literature review, key informant interviews and focus group discussions, to identify challenges and limitations that restrict optimal performance across the value chain. Rainfall patterns over a decade in the region were also analysed to understand shifts and variability over time and to identify the implications of these for agriculture in the region.

The secondary data on cultivation, area, production, productivity, market and available infrastructure, etc., was collected from CDB, related web sites and available documents. Primary information and data were collected from farmer households, farmer associations/ organisations, traders, markets, etc. Special focus was given to value addition in different nodes of the value chain, identification of present status, associated constraints and detailed analysis of the production to consumption System.

Standard statistical tools such as averages, percentages and graphical presentations, etc., were used for analysis and interpretation and to infer conclusions to answer to the assessment objectives.

Table 2. Study area profile

Agro-ecological Zone	District	Sub-district
<b>First round of fieldwork</b>		
<b>High Barind Tract</b>	Rajshahi	Charghat
	Chapai Nawabganj	Chapai Nawabganj
		Nachole
<b>Second round of fieldwork</b>		
<b>High Ganges Floodplain</b>	Meherpur	Gangi, Meherpur
	Kushtia	Daulatpur
<b>High Barind Tract</b>	Chapai Nawabganj	Gomastpur
	Naogaon	Porsha, Sapahar
	Rajshahi	Godagari





# 05

## COTTON CULTIVATION IN BANGLADESH



Photo credit: ACT

This section primarily portrays the baseline scenario of cotton cultivation in Bangladesh with an emphasis on the value chain of cotton and the existing condition of cotton cultivators.

Bangladesh is the second largest ready-made garments (RMG) exporter in the world (Textile Today, 2018). Despite the global recession in 2007/08, the country's RMG exports have grown at a rate of 43.36% year on year to \$15.66 billion (CDB, 2014). Bangladesh now claims 4.8% of global RMG trade and the country's apparel exports are estimated to reach \$36 billion by 2020 (Berg et al., 2011). To meet the textile industry's demand, Bangladesh imports 4–4.2 million bales of raw cotton every year (CDB, 2014). Cotton grown in the country meets to close to 5% of this demand. CDB has been working towards bridging this gap through initiatives to expand cotton. According to CDB, in Bangladesh, about 5,00,000 ha of land are suitable for cotton production (ibid.). This includes highlands, drought-prone areas and coastal regions that remain fallow or are not viable for paddy cultivation, which is the dominant crop in the country.

Cotton has certain features, such as a vertical tap root, that make it more resilient to high temperatures and salinity (Jawdat et al., 2018). It requires less water than paddy and thus can grow more easily in the highlands.

However, it is highly sensitive to changes in climate, especially shifts in rainfall patterns. Untimely rainfall during the flowering period drastically reduces yield and quality. Cotton expansion is also at a nascent stage, and tightly controlled at the processing and marketing stages. Existing bottlenecks across the value chain, along with climate change, pose problems for the wider uptake of cotton cultivation as well as the livelihood security of cotton farmers.

### 5.1 Impact of Climate Change on Cotton Cultivation

Due to its vertical tap root, cotton is to some extent resilient to high temperatures, drought and salinity. Nevertheless, it is a climate-sensitive crop. Greenhouse gas emissions take place at different stages in the cotton value chain, although the amount is not significant (ITC, 2011). Thus, it both causes climate change and is being affected by the impacts of climate change. However, the extent to and ways in which climate change affect cotton cultivation depend on the geographical location.

Climate change will affect cotton cultivation through higher CO<sub>2</sub> levels, higher temperatures, lower humidity





and shortages in water availability (Gwimbi and Mundoga, 2010). With it being a C3 plant (a plant where the first product of photosynthesis is a three-carbon compound), elevated CO<sub>2</sub> levels in the atmosphere can bring positive impacts (Allen, 1991). Utilising the higher CO<sub>2</sub> levels, the plants can produce larger leaves, meaning a larger surface area for photosynthetic activities. This in turn results in a greater number of branches, leaves and bolls. However, higher vegetative growth can increase the demand for irrigation, fertilisers and pesticides (Kranthi, 2014). Increased concentration of CO<sub>2</sub> may increase the efficiency of water use, partially compensating for the stress caused by water scarcity (Mauney et al., 1994).

There are both positive and negative effects of temperature rise on cotton farming. Temperature has an influence on cotton growth and development. It determines the rate of node development, fruit production, photosynthesis and respiration (Hearn and Constable, 1984). A rise in the average daily temperature owing to climate change may result in better growth of cotton (Hebbar et al., 2013). On the other hand, climate change may increase the number and severity of hot days during the cotton season. Increased incidence of heat stress can damage plant tissue, resulting in parrot-beaked bolls, boll freeze and cavitation, which reduces the yield (Bange, 2007). Fibre lengths lower and micronaire values (a measure of the air permeability of compressed cotton fibres) increase if the temperature is high during boll filling. The negative impacts of hot condition on yield and quality are exacerbated if water stress occurs simultaneously (ibid.).

Cotton has several different stages of growth, with different water requirements. The young plants can endure water stress and continue to flower, but water stress that happens during the first 14 days after flowering may cause the cotton boll to fall off (Pace et al., 1999). A water deficit can also lead to a reduction in plant growth and fibre length, which leads to lower yields (Jamal et al.,

2014). The cotton crop is very sensitive to temperature. The proper temperature for bud formation is above 20°C but not more than 40°C during the daytime. It takes two months from flowering to bud formation (Hebbar et al., 2013). Strong and cold winds may harm the seedlings and the matured boll, causing it to open out and get covered with dust, which reduces the quality of the cotton fibre and thus its yields (Cetin and Basbag, 2010).

In a scenario of reduced water availability and higher atmospheric evaporative demand resulting from lower precipitation and relative humidity, it will be more challenging for the crop to transpire enough to keep the canopies cool. Thus, leaf temperature will go up, impairing photosynthesis and growth (Mauney et al., 1994). Again, increased evaporative demand in well-watered conditions may increase transpiration, thereby reducing water use efficiency. Precipitation during sowing to germination and vegetative growth is good for cotton, but during boll opening and harvesting it is detrimental (Chattopaddhay et al., 2008).

In a changing climate, an increase in rainfall intensity may become a problem for cotton farming. Although the water requirement during the flowering season is high, during harvesting the cotton fibre becomes highly sensitive to rain, which can cause flowers, buds and bolls to fall and be damaged. Too much rain in the last stage can also cause damage the quality and yield, since insect attacks, pests and diseases can be more frequent at this point (Shrivastava and Thakare, 2014). An increase in atmospheric CO<sub>2</sub> may also exacerbate the problem of pests and insect attacks (Zavala et al., 2017). For example, the leaf-eating cotton caterpillar *Spodoptera litura* eats 30% more leaves and lays more eggs under elevated CO<sub>2</sub> conditions. Higher temperatures create favourable condition for the survival and reproduction of cotton sap-sucking pests like whiteflies, thrips, aphids, mealybugs and many others, which cause serious yield losses in cotton (Bange and Constable, 2008).

**Table 3. Temperature requirement for cotton growth and development**

Growth Stage	Days	Cumulative Heat Units (Days Degree, DD16 = (°C max+°C min)/2 - 16)
Planting to emergence	4 to 9	10
Emergence to first square	27 to 38	435
Square to flower	20 to 25	735
Planting to first flower	60 to 70	1510
Flower to open ball	45 to 65	2360
Planting to harvest ready	130 to 160	4560

Source: CDB

<sup>3</sup>See <https://www.cabi.org/isc/datasheet/44520>





## 5.2 Climate Data Analysis of Two Study Areas

For this study, field data was collected from eight upazilas of five districts, which come broadly under two physiographic regions: the High Ganges Floodplain and the High Barind Tract. Kushtia and Meherpur districts are in the High Ganges Floodplain and are represented by the BMD station in Chuadanga. Rajshahi, Naogaon and Chapai Nawabganj districts are in the High Barind Tract, where Rajshahi BMD station has older data and Ishwardi BMD station is apparently new.

Since there are variations in rainfall data at a micro scale, we have used satellite data, which is available for the past 20 years (1998–2017). to develop local-level climatic patterns. We have used precipitation and temperature data from BMD weather stations and grid wise-satellite data from the Tropical Rainfall Measurement Mission (TRMM) and the Precipitation Estimation from Remotely Sensed Information Using Artificial Neural Networks (PERSIANN) system. Chuadanga and Rajshahi have been analysed using BMD data. Nachol and Porsha upazilas (in Chapai Nawabganj and Naogaon districts, respectively, of the High Barind Tract) do not have BMD stations, thus we use National Aeronautics and Space Administration (NASA) Satellite TRMM\_3B42\_daily data.

Hassan et al. (2017) analysed PERSIANN and TRMM daily data and compared it with observed data, finding that the satellite-derived rainfall data significantly matched the observed data. Chang et al. (2013) studied TRMM rainfall estimates for 10 typhoons that made landfall across Taiwan's coast between 2007 and 2010 and compared these with radar reflectivity maps. These two different sources of data also couple up quite well when the tropical cyclones are at the very moment of landfall. In this study,

we tried both the PERSIANN satellite data and the TRMM daily data and we found the TRMM data was more significant in this region.

### 5.2.1 Rainfall

One of the major objectives of this study is to identify the major climatic risks of cotton production in Bangladesh. Therefore, climatic analysis focused on three major phases of cotton production -

1. Plantation (July–August), represented as the monsoon season (June–September);
2. Flowering (October and November), often referred as the post-monsoon season;
3. Harvesting (December–March), represented as winter (December–February).

These three phases are further extended into six different stages of the cotton plant, in Table 6, which also gives water requirements for the different stages. As we see, water requirements very much follow a normal distribution curve, with water needs at a minimum at the beginning and the end and a gradual rise and fall in demand to and from the middle stage – when the first flower peak blooms – from the middle of September to the middle of November. Any delayed plantation would result in a delayed middle stage, which means the rainfall season would have ended and the cost of irrigation would increase. Delayed sowing could also be a result of environmental stress. For example, excessive rain between the middle of July and the middle of August could potentially lead to delayed plantation. Normally, cotton farmers prepare the land in late June and early July and plant the seeds in the middle of July. For seeds to germinate and plants to emerge, soil moisture is a necessity; however, seeds would rot in wet conditions.

**Table 4. General rainfall data in different study areas classified according to different stages of cotton farming (mm)**

Seasons	Regions			
	Kushtia	Rajshahi	Nachol	Porsha
Plantation (June to Sep) Average	1036.8 mm	978.6 mm	1135.2 mm	1166.4 mm
Flowering (Oct to Nov) Average	160.8 mm	130.7 mm	144.5 mm	176.4 mm
Harvesting (Dec to March) Average	63.2 mm	45.6 mm	38.6 mm	36.6 mm



Table 5. Cotton water requirements

Growth Stage	Water use (mm per day)	Days after Sowing	Duration of growth stage (days)	Water requirement (mm)
Planting to Emergence	low	0-7	7	Moist land, no rainfall required -No rainfall required
Emergence to First Square	3	7-30	23	69
Square to flower	6	30-55	25	150
Planting to first flower	9	55-110	55	495
Peak Bloom to Open Bolls	6	110-130	20	120
Open bolls to harvest	1	130-175	45	45

Source: CDB.

Overall rainfall is decreasing at rates of 0.0123, 0.20, 0.088 and 0.18 mm/year, respectively, in the High Ganges Floodplains (Kushtia) and the High Barind Tract (Rajshahi, Nachol, Porsha) (Table 6). Average annual rainfall is decreasing by 0.0123 mm per year in the Ganges River Floodplains (Chuadanga, Kushtia, Meherpur). In the post-monsoon season, it is decreasing by 0.053 mm at the 10th year and 0.054 mm at the 20th year. In winter, average rainfall is increasing by 0.01 mm/year.

The volume of rainfall during the cotton plantation period is dropping in all the study areas of the High Barind Tract. Our study also reveals that rainfall is increasing during the harvesting period only in Rajshahi. Data shows rainfall is steadily decreasing by 0.36 mm per year in the monsoon and increasing by 0.007 mm per year in winter in Rajshahi. In Nachol, annual rainfall is decreasing by 0.088 mm per year. The post-monsoon rainfall decrease is 0.14

mm/year. In winter, rainfall is increasing by 0.006 mm/year. In Porsha, average rainfall is decreasing by 0.18 mm/year. In the post-monsoon season, rainfall is decreasing by 0.26 mm/year and in winter it is decreasing by 0.006 mm/year.  $0^{\circ}\text{C}/\text{day}$  or  $0.002^{\circ}\text{C}/\text{year}$  or  $0.2^{\circ}\text{C}/100$  years.

To make things clearer, this study analysed dry spells in the monsoon (plantation) and wet spells in winter (harvesting). Annexes 2–5 present this analysis. The dry spells are more than four days without precipitation, and the dotted line shows their trend. These are generally decreasing in July and increasing in August. If this trend continues, it will be difficult for farmers to find a sowing phase in July, when they need moist land with no rainfall. Thus, sowing will likely move to August, when dry spells are increasing. However, wet spells in winter are decreasing, which favours harvesting.

Table 6. Average rainfall trends in different study areas classified according to different seasons

Region	Overall fitted model	Yearly Growth		Comment on Seasonal Growth rate				
		Rate (mm/year)	Comment	Pre-monsoon	Pre-monsoon	Post monsoon	Winter	Harvesting Season
Kushtia	LT	0.0123	D	D	I	D	I	D
Rajshahi	QT	0.20	D	I	D	D	I	I
Nachol	LT	0.088	D	D	D	D	I	D
Porsha	QT	0.18	D	D	D	D	D	D

Note: LT = Linear Trend Model; QT = Quadratic Trend Model; I = Increasing; D = Decreasing.





## 5.2.2 Temperature

Table 7. Temperature requirement for different stages of cotton farming (°C)

Regions	Seasons	Maximum	Minimum	Mean
High Ganges Floodplain	Plantation (June to September) Average	33.4	26.2	29.8
	Flowering (October to November) Average	31.1	20.6	25.8
	Harvesting (December to March) Average	28.0	14.1	21.1
High Barind Tract	Plantation (June to September) Average	33.5	26.2	29.9
	Flowering (October to November) Average	30.7	20.5	25.6
	Harvesting (December to March) Average	27.6	13.9	20.7

In temperature analysis, we consider maximum temperature and minimum temperature. Maximum temperature represents day temperature and minimum temp represents night temperature. Here, mean temperature is the average of maximum and minimum temperature. In this study, only the Linear Trend Model (LT) is used, because the LT, Quadratic Trend Model (QT) and Growth Curve Model results are almost equal.

and the minimum temperature is decreasing, at 1.10°C/100 years and 1.50°C/100 years, respectively. Both maximum and minimum temperatures (the mean temperature) during the cotton plantation period are rising, and the rate of increase is apparently higher in the High Barind Tract than in the High Ganges Floodplain. Similarly, temperatures are rising during the cotton harvesting season (December–March) in all the study

Table 8. Temperature growth rate in different study areas

Region	Overall fitted model	Yearly Growth		Comment on Seasonal Growth rate (°C/100years)			
		Rate (°C/100years)	Comment	Pre-monsoon	monsoon	Post monsoon	Winter
Kushtia/ Meherpur	LT	1.1(Max) 1.5(Min)	I D	3.4 (Mean) I	1.1 (Mean) I	7 (Mean) D	3.5 (Mean)I
Rajshahi/ Nachol/ Porsha	LT	2.8 (Mean)	D	5.8 (Mean) I	4.6 (Mean) I	1.4(Max) I 9.7(Min) D	0.2 (Mean) I

The maximum temperature in the High Ganges Floodplain (Chuadanga, Kushtia and Meherpur) is increasing at (2.88E-05\*365)°C/day or 0.011°C/year or 1.1°C/100 years and the minimum temperature is decreasing at (4.36E-05\*365)°C/day or 0.015°C/year or 1.5°C/100 years. In the post-monsoon season, the mean temperature is decreasing at (1.18E-03\*60) °C/day or 0.07°C/year or 7.0°C/100 years. In winter, the rate of decrease is (2.94E-04\*120)°C/day or 0.035°C/year or 3.5°C/100 years.

The overall changing mean temperature rate (both maximum and minimum) for the High Barind Tract (Rajshahi, Nachol and Porsha) is increasing at 2.8°C/100 years. However, in the High Ganges Floodplain, the maximum temperature (day temperature) is increasing

areas, though the rate of increase is higher in the High Ganges Floodplain.

Both maximum and minimum monsoon temperatures are increasing in the High Barind Tract. According to the projection, the increasing trend rate for the average temperature is (3.80E-04\*120)°C/day or 0.0460°C/year or 4.60°C/100 years. The overall mean temperature is decreasing in the post-monsoon season and increasing in the winter. In the post-monsoon season, the maximum temperature is increasing at (2.35E-04\*60)°C/day or 0.014°C/year or 1.4°C/100 years and the minimum temperature is decreasing at (1.62E-03\*60)°C/day or 0.097°C/year or 9.7°C/100 years. In winter, the increasing rate is (2.26E-05\*90)°C/day or 0.002°C/year or 0.2°C/100 years.



## 5.3 Crop Varieties and the Cotton Crop Bundle

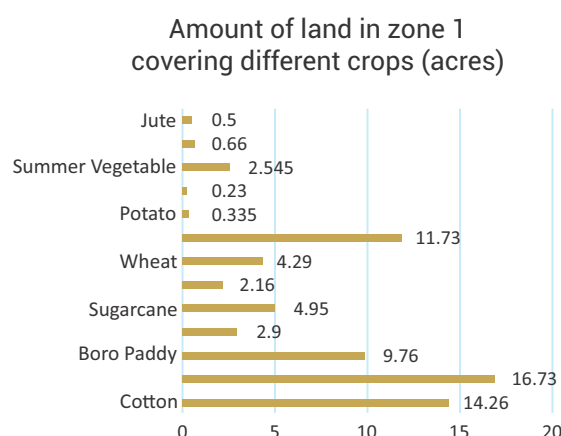
In our study area, cotton farmers grow several crops apart from cotton. Sometimes, they grow other crops on the same land where they cultivate cotton, and sometimes they use separate landholdings. When different crops are grown on the same land as cotton, they are considered as bundle crops of cotton. This section looks at the status of cropping varieties in the study region, the seasonal shift in the crop calendar over 10 years and the cotton crop bundle.

### 5.3.1 Status of Cropping Varieties

Study sites from the 1<sup>st</sup> fieldwork find cultivation practice of a variety of crops beside cotton, including aman and boro paddy, daal (pulse), sugarcane, wheat, jute, mango, vegetables, turmeric and mustard. Out of the total of 71.05 acres of all agricultural land studied, aman paddy grows on 16.73 acres, with cotton second highest, on 14.26 acres. Apart from this, daal grows on 11.73 acres and boro paddy on 9.76 acres, as Figure 2 shows.

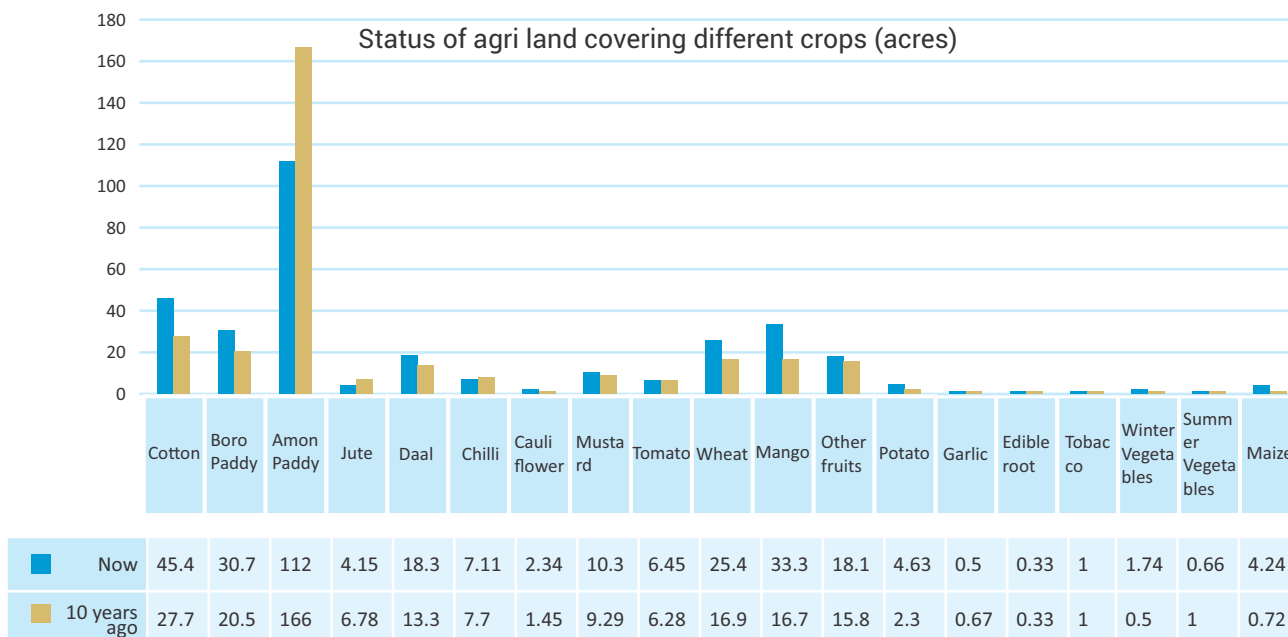
Figure 3 shows data from the 2<sup>nd</sup> fieldwork, where farmers grow boro, aman, jute, daal, chilli, cauliflower, mustard, tomato, wheat, potato, garlic, edible roots, tobacco, winter and summer vegetables, maize and other fruit as

Figure 2. Indexing of crop



well as cotton. After looking at the current and previous amount of cultivable land available for these crops, we found that the area under cultivation had significantly increased for almost all crops apart from paddy, jute and chilli. There has been a particularly noteworthy growth in cotton cultivation. Around 10 years ago, about 27.7 acres of land came under cotton cultivation; this area has now almost doubled. Farmers stated that this increase was the result mainly of the dedicated interventions, support and efforts of GOB officials from CDB.

Figure 3. Past and present agricultural practice in study sites of the 2<sup>nd</sup> fieldwork

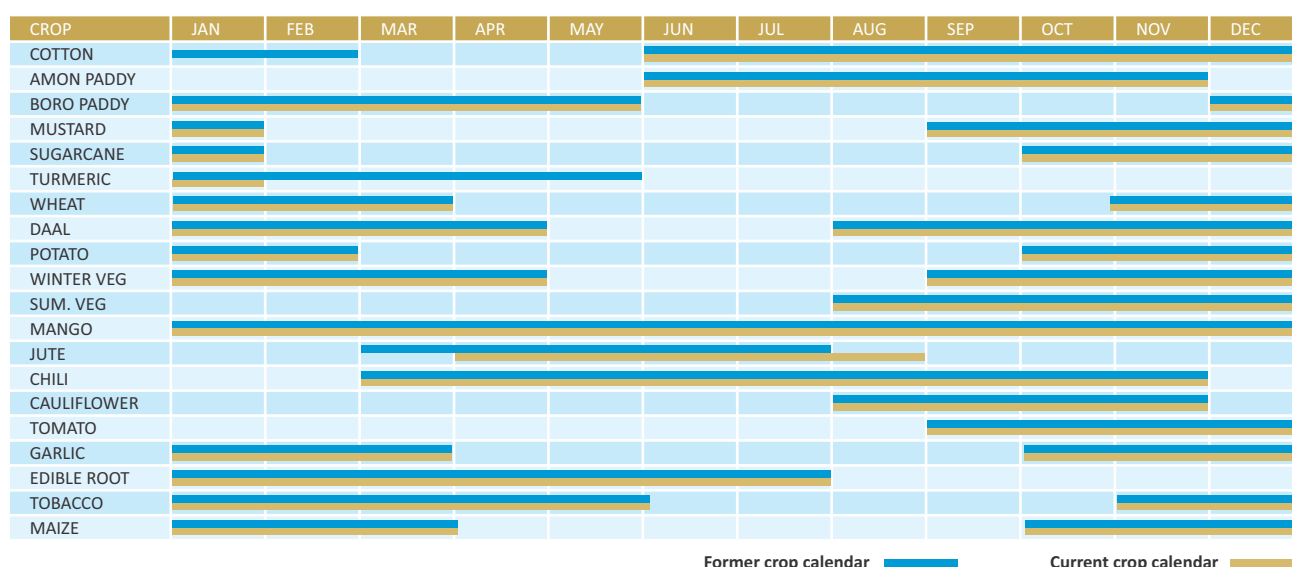




### 5.3.2 Shifts in the Cotton Crop Calendar Over 10 Years

The High Barind Tract is prone to dryness and less rainfall, but farmers said that the overall rainfall trend had changed over the previous 10 years, as mentioned also in Section 2. Past years have seen intense dryness on agricultural lands as a result of a lack of rainfall, but in the past two years rainfall has become more frequent. There have been fewer storms during the monsoon and long rainy days (for 15–16 days) during the monsoon have not been that common in recent years. These climatic variables are responsible for the shift that has occurred in the crop calendar for different crops within the past 10 years, as Table 9 shows.

Table 9. Shift in the crop calendar for different crops



Apart from this, shifting to hybrid seed from the unimproved local variety has also brought some changes in the seasonal calendar. The study revealed that cotton seed sowing requires soil that is a bit dry, and rain at the time of sowing is harmful to growth. Thus, changes in rainfall patterns significantly affect cotton cultivation. For example, one respondent said that one day of rain could postpone cotton planting for a week or so, and this has adverse impacts on cotton production.

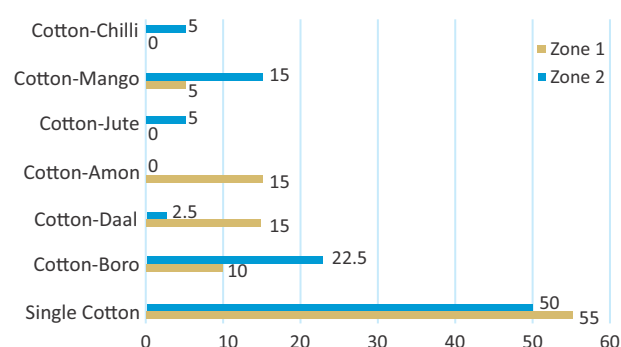
### 5.3.3 The Cotton Crop Bundle

Cotton is mostly grown as a mono crop in the study area. Almost 55% of respondent farmers from Zone 1 are involved in mono cropping. The other 45% grow cotton with other crops, such as boro paddy, daal, mango and aman paddy, as seen in Figure 4. The figure also shows that 15% of farmers interviewed grow cotton with aman paddy, 15% with daal, 10% with boro paddy and 5% with mango.

In the 2<sup>nd</sup> fieldwork, 50% of cotton farmers cultivate cotton as a single crop and grow nothing else on the land. Of the rest, 22.5% produce boro paddy with cotton, 5% each grow jute and chilli with cotton and 2.5% grow daal as bundle crops with cotton. On the other hand, 15% of cotton producers cultivate cotton in their mango orchards (mainly in Rajshahi, Chapai Nawabganj district) as an intercrop. The reason for intercropping, according to farmers, is that it helps increase the productivity of mango, which is the main crop. The pre-production and production processes for cotton such as fertilisation and manure application though not prioritised for mango, help enhance its productivity. Cotton production is also

profitable, thereby adding to the income derived from the land. Intercropping also increases diversity in the agricultural ecosystem, maintains the ecological balance, helps in the reduction of weeds, pests and diseases and enables the effective use of resources.

Figure 4. The cotton crop bundle in the study area (% of each crop)





## 5.4 The Cotton Value Chain

This section describes the baseline scenario across different stages of the cotton value chain in Bangladesh, including pre-production, production, processing and consumption.

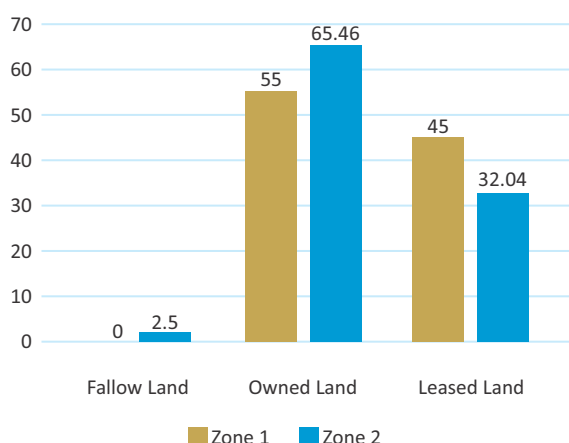
### 5.4.1 Pre-production

Pre-production plays a vital role in ensuring better productivity of cotton. This stage is sensitive to the status of the farmer's agricultural land, as well as the selection and arrangement of proper inputs like seeds, and their quality and variety, plant nutrients, plant protection materials, etc.

#### 5.4.1.1 Land Ownership Status

In Zone 1, 55% of all cotton farmer respondents grow cotton on land they own; the other 45% cultivate cotton on leased agricultural land (see Figure 5). In Zone 2, 65.46% of all cotton farmers cultivate cotton on their own land whereas only 32% grow cotton on leased land. Land ownership status has clear implications for farmers' choice of crops. Often, the owner of the land decides what crop is to be produced, and lease-taking cultivators have minimal influence on this decision-making. In addition to this, land ownership has a visible impact on farmers' access to credit. As per GOB's mandate, to access government loan schemes, farmers have to submit their land deeds and documents. Those who cultivate cotton on leased lands thus cannot access this facility and have to take loans from local moneylenders or NGOs at high interest rates, which ultimately minimises their profits.

Figure 5. Land ownership status of respondent cotton farmers (%)

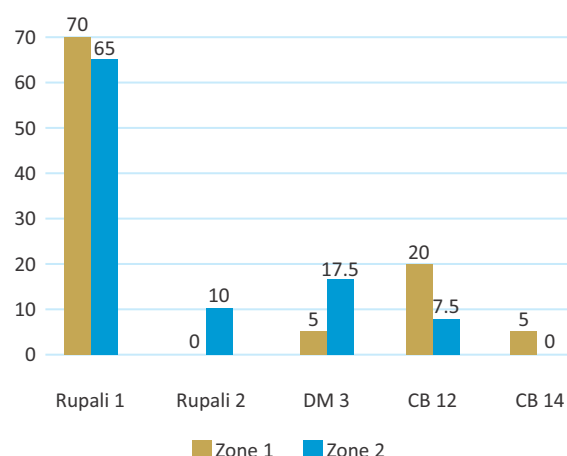


#### 5.4.1.2 Use of Seed Variety

Seeds represent the primary input that determines the yield and quality of a crop. Various other factors, such as resistance to pests and immunity to heat and water stresses, also depend on seed characteristics. Hence, selection of suitable cotton seed varieties is vital to ensure optimum production. The study revealed that farmers cultivating cotton in both study zones mainly preferred high-yielding hybrid varieties. The popular varieties grown by farmers are Rupali 1 and Rupali 2 provided by the seed company Supreme Seeds, and DM3 provided by Lalteer. Apart from hybrid varieties, farmers also use CB 12 and CB 14 local varieties. Among all these varieties, farmers preferred Rupali 1 (70% of farmers in Zone 1 and 65% of farmers in Zone 2). Apart from this, in Zone 1, 20% of farmers use CB 12 and 5% use CB 14 and DM3 variety. In Zone 2, 10% use Rupali 2, 17.5% use DM 3 and 7.5% use CB 12.

Farmers are mainly (95% of the total) dependent on CDB for arranging their cotton seeds. Farmers from the High Barind Tract area receive a significant amount of seeds free of cost from CDB through the latter's cotton-promoting programme in that area. Farmers in the other areas buy seeds from CDB at a fixed amount. For example, last year they purchased seeds from CDB at Tk. 2,350/kg. However, many farmers complained that during the past season they had purchased seeds at a higher rate but the seed quality was not up to mark. They claimed that almost 35–40% of the seeds remained unproductive when they sowed them, which causes them great loss.

Figure 6. Most used cotton seed varieties (%)







## 5.4.2 Production

Production comprises all the farm operations, from sowing to harvesting the crop. This section describes the current strategies adopted during the production stage in the study region.

### 5.4.2.1 Land Preparation

Various field operations are necessary before cotton seeds can be sown, to ensure optimum soil conditions and the health of the seedlings. Farmers in the study region said that cotton was a deep-rooted crop that needed fine tilling and a well-prepared field for successful germination and growth. To achieve this, they plough the field with deep ploughs and mechanised tractors and harrow with planking to make the soil loose, fine, level and pulverised. In this stage, they also remove all of the stubble from the previous crop that is left in the field. The study found that, to prepare 1 acre of land, 6 labourers per day are required, costing Tk. 300/person/day. Cultivating land using a tractor takes an additional Tk. 2,000–3,000 for each acre of land.

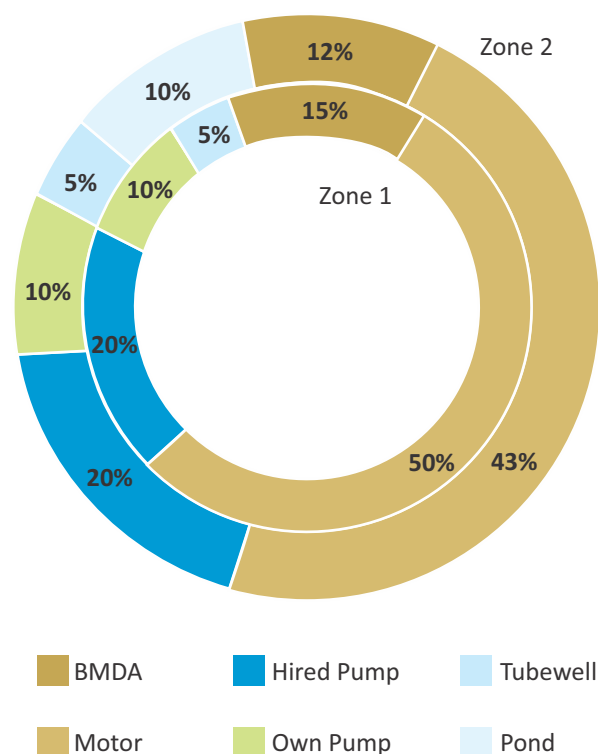
Figure 7. Cotton farmers busy preparing lands to sow cotton seeds



### 5.4.2.2 Seed Sowing

The quantity of the selected seed depends on the variety, soil fertility, climatic conditions and management of the crop. Ideally, farmers in the study area sow 1.5 kg of seeds per acre, which costs them Tk. 2,350/kg. The time of sowing has a strong influence on the quality of the mature cotton. If sowing is early or late, it adversely affects the fibre quality, mainly because of issues related to moisture. Farmers start sowing cotton seeds mainly from June. Before sowing, seeds are soaked in water for about 9–15 hours. After sowing, gap-filling is carried out, with cotton seedlings planted in those places where the seed has not germinated or is weak. Farmers also pull out the seedlings where there are too many of them, without damaging the roots. Sowing or transplanting cotton on 1 acre of land requires around 15 labourers per day, each costing Tk. 300/day.

Figure 8. Sources of irrigation used for cotton cultivation (%)



### 5.4.2.3 Irrigation

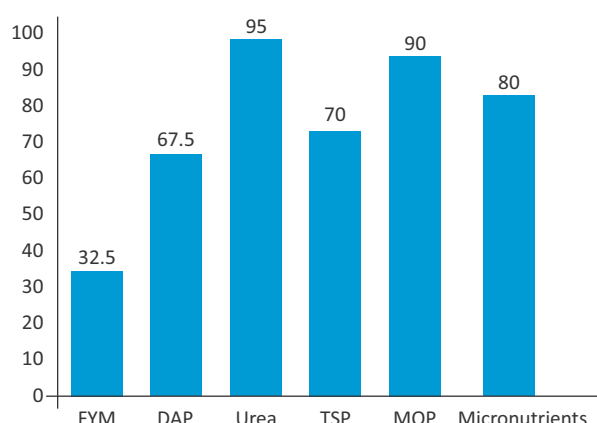
In our study region, almost all cotton cultivators are dependent on irrigation from different sources, since the soil in the area tends to be arid and has low soil moisture – Zone 1 more so than Zone 2. Some farmers have access to irrigation facilities provided by Barind Multipurpose Development Authority (BMDA) and most farmers use motors or pumps to irrigate their cotton farms. In Zone 1, 50% of the respondent farmers depend on motors for irrigation, 20% on hired pumps, 15% on BMDA, 10% on their own pumps and 5% on deep tube-wells, as Figure 8 shows. In Zone 2, 43% of cotton farmers use motors, 20% use hired pumps, 12% use water from BMDA, 10% use their own pumps and take water from nearby ponds and the remaining 5% use water from their own deep tube-wells. The farmers said that the groundwater level was falling by 2 to 3 feet every year, hence BMDA had stopped disseminating new deep pump facility from 2010.



#### 5.4.2.4 Fertilizer Management

Cotton farmers apply both organic and inorganic fertilisers. Figure 9 shows that almost 95% of all cotton farmers use urea, 90% use muriate of potash (MOP), 80% use micronutrients (like boron, zinc or gypsum), 70% use triple superphosphate (TSP), 67.5% use diammonium phosphate (DAP) and only 32.5% use organic farmyard manure (FYM).

Figure 9. Fertilisers used in cotton farming (%)



CDB helps the cotton farmers by providing required fertilisers on time and Farmers can pay CDB for pesticides and fertilisers after selling their final products. The study revealed that the cost of fertiliser was almost the same in both study zones, though the amount used varies a bit between the High Barind Tract and the High Ganges Floodplain. People in Zone 2 use more fertiliser than those in Zone 1. The field study shows that, in Zone 1, the total fertiliser cost is estimated at Tk. 2,500–3,000 for agricultural land of 0.33 acre; it comes to almost Tk. 3,000–4,000 for the same amount of land in Zone 2. This is because people in the High Barind Tract mainly grow cotton as an additional crop with mango and so are not willing to spend much on cotton fertiliser or pesticides, which may hurt their mango production.

Table 10 presents the amount and cost of fertiliser required for cotton cultivation on 0.33 acres (1 bigha in local terms).

#### 5.4.2.5 Pesticides Management

With different types of pests, often the tender leaves of cotton turn yellowish, the edges of the leaves are broken and start curling downwards, and the growth of cotton is retarded. But all of this can be controlled through the application of suitable pesticides. Farmers in the study zone mainly use Pegasus, Volume, Hot shot, Lipson, Etaph, etc. for pest management. CDB officers and local input dealers advise farmers on how to apply pesticides properly and also work on their safe handling. Pesticides cost farmers in Zone 2 almost Tk. 3,500 for 1 acre of land under cotton. In Zone 1, pesticides need to be sprayed under the cotton leave every 15–20 days when the plants are 20 days old, and each time the cost is Tk. 700 per acre.

#### 5.4.2.6 Weed Control

Among all agronomic factors, weed control is very important for a profitable yield. Weeds reduce the yield both directly and indirectly. Directly, they compete with cotton for space, water, light and nutrients. Indirectly, they give shelter to insects and grow casual organisms. Weed seeds usually stay dormant for a very long time and they germinate earlier than cotton; weeds have seedlings that grow faster, and they flower earlier, form seeds in abundance and scatter these before the maturity of cotton. Since cotton grows in the rainy season, it sees heavy infestation by weeds. In our study area, weed control is done manually, through enhancing the water-holding capacity of the soil and removing the weeds. Many weedicides, both pre-emergence and post-emergence, are available locally to make the process easier. CDB officers guide farmers on how and when to apply weedicides. It costs cotton farmers almost Tk. 1,000 to remove weeds for each acre of land.

Table 10. Fertiliser and pesticides used per 0.33 acres (1 bigha)

Name	Amount Used	Average Unit Rate
FYM	50-100 kg	Tk. 25/kg
MOP	50-60 kg	Tk. 15/kg
DAP	40-50 kg	Tk. 25/kg
TSP	30-40 kg	Tk. 30/kg
Urea	25-30 kg	Tk. 16/kg
Micronutrients (boron/zinc/gypsum)	30-40 kg	Tk. 100/kg





#### 5.4.2.7 Cotton Picking and Harvesting

Cotton maturity is not uniform in the study area, because the plants keep on flowering over an extended period. Because of this, harvesting is done in two to three phases. The first harvest is generally undertaken when half to two-thirds of the cotton plants are mature. Harvesting too early or too late can result in losses. Cotton is mostly picked manually in Bangladesh. Farmers told us that cotton picking mostly starts in late November, when the dew dries on the cotton plants. Lower bolls are picked first to reduce the contamination of cotton with leaves and dust. Farmers spend a significant amount on harvesting. Labourers are paid Tk. 7 per 1 kg of cotton harvested. As a result, in total, harvesting cotton costs around Tk. 4,500–5,000 per 1 acre of land.

#### 5.4.2.8 Cotton Yield

Hybrid varieties, scientific management of production and climatic conditions all have significant implications for the yield and quality of cotton flux and its lint in the study area. An average yield of around 40–45 maund (1 maund = 40 kg) per acre can be easily obtained in Meherpur, Kushtia district, whereas the average yield in Rajshahi, Chapai Nawabganj, is around 20–25 maund per acre. This is because in the latter area farmers often grow cotton as an intercrop with mango. Farmers also use cotton stalks as domestic fuel and some farmers sell them at the local market and receive an additional profit of Tk. 120/maund.

#### 5.4.2.9 Storage Facilities

Cotton is mostly stored at home in packages provided by CDB until the ginners come to the area to collect it. Almost 100% of respondent cotton farmers in both study zones store their cotton in their own house. There is no other storage facility for cotton in the local area. CDB informs farmers when and where the ginners will come to collect the harvest. The ginners collect cotton three to four times a season in Zone 1 and only once in Zone 2 (owing to lower production). They pay farmers in cash. Some farmers complained that often they did not have enough space in their house to store cotton and were forced to keep the harvest outside until the ginners came. As a result, the cotton becomes exposed to moisture (rain or dewdrops) and this degrades its quality.

#### 5.4.3 Processing

Processing comprises mainly the economic activities carried out for conservation and handling of agricultural production to make it usable as a good.

Cotton farmers in the study area directly sell to the ginners, with CDB officials acting as facilitators. Every year, the ginners' association fixes the price of cotton centrally with the active participation of farmers' representatives and CDB officers. After a day-long negotiation, they fix a cotton rate for a particular year based on the international market price at that time. If the international rate is high, the farmers receive a high price from the ginners; if the international rate is low, the farmers also receive a low price.

After buying the cotton from the farmers, the ginners separate the cotton fibre from the cotton seed using mechanised ginning machines. The freshly picked cotton is pressed into large modules. The first step in the ginning process is when the cotton is vacuumed into tubes that carry it to a dryer to reduce moisture and improve the fibre quality. Then it runs through cleaning equipment to remove leaf trash, sticks and other foreign matter. The cotton gin mechanically separates the fibres from the seed and turns it into ginned cotton, also called lint. This is pressed into large bales and transported to the textile mill. The cotton seed is delivered to a seed storage area, where it will remain until it is loaded into trucks and transported to a cotton seed oil mill, or it goes directly for livestock feed.

Cotton cultivators have almost no access to marketing and processing facilities. This is because they are interested only in producing cotton; for marketing and processing they rely on the private ginners. As noted earlier, ginners collect cotton from farmers three or four times a season. The revenue is delivered to the farmers through CDB mostly as cash in hand two to three days after collection. After purchasing, ginners carry out both processing and marketing, with interventions from CDB. Farmers are not usually allowed to take part in these phases.

### 5.5 Facilities and Farmer's Satisfaction across the Value Chain

This section focuses mainly on existing infrastructural facilities for cotton farmers in the study area as well as their satisfaction level with these across the entire cotton value chain.

#### 5.5.1 Access to Credit

Cotton farmers access credit from different sources. In Zone 1, 40% of respondent farmers obtain credit from different NGOs working on microcredit, 25% have access to CDB, 15% receive credit from different microfinance

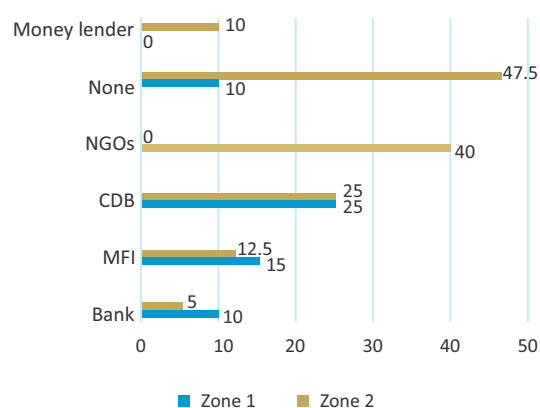


institutions (MFIs), 10% depend on banks and the remaining 10% have no access to credit. In contrast, in Zone 2, most cotton farmers (47.5%) cannot access credit at all. Only 25% receive credit from CDB, 12.5% from MFIs, 10% from local moneylenders and 5% from banks (Figure 10).

Farmers avoid government banks for agricultural loans because of the difficult and lengthy process involved and the huge paperwork requirement. Moreover, banks do not provide credit to poor farmers. Accessing credit from NGOs is less challenging. Farmers can take loans from NGOs any time and for any purpose besides agricultural activities. ASA, BRAC and TMSS are the most used NGOs in the study area for microcredit by cotton cultivators. However, the interest rate is very high, so most farmers prefer to access credit from CDB, which offers a 4.5% flat interest rate. CDB also provides seeds and other inputs on loan, which farmers can pay back after selling their products.

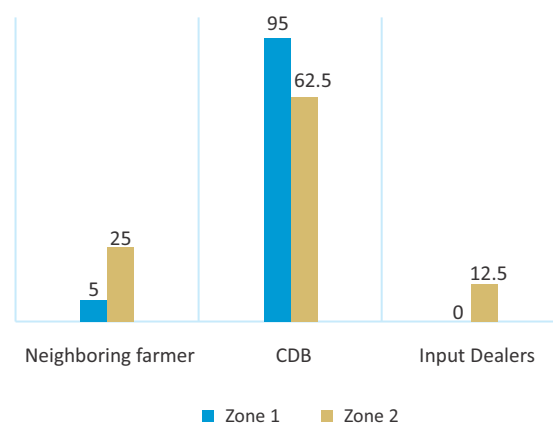
### 5.5.2 Access to Information Service

Figure 10: Access to credit service for cotton farmers



Access to information helps farmers make appropriate decisions in adopting sustainable and climate-resilient agriculture practices. In Zone 1, cotton producers are exposed to agricultural information from two main sources, with 95% using CDB (and the rest using neighbouring farmers) (see Figure 11). Meanwhile, 62.5% cotton farmers in Zone 2 use CDB, 25% use neighbouring farmers and 12.5% use local input dealers. This difference between Zone 1 and Zone 2 exists primarily because cotton has been grown in Zone 2 for much longer, whereas it is a relatively new crop in Zone 1.

Figure 11. Different sources of information for cotton farmers (%)



Local NGOs do not offer technical knowledge, training or information related to crop cultivation. It is CDB that is mainly responsible for providing these services. CDB extension officers visit cotton farmers frequently and provide information on fertiliser application, pesticide selection procedures and usage, appropriate seed collection times, the right ways and times to produce and harvest cotton, etc. Input dealers also visit farmers through CDB to promote new seed varieties or advanced fertilisers. Farmers obtain weather-related information from either the television or the radio, but this is generic information such 'There will be scattered rainfall in the northern parts of the country this upcoming week.' This does not really help the cotton cultivators.

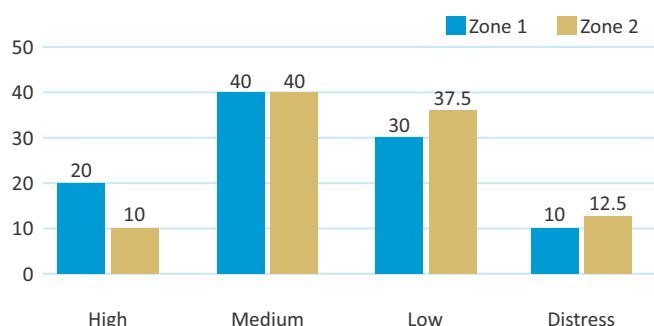
### 5.5.3 Price Satisfaction Level

As mentioned earlier, a national-level syndicate of CDB officials, ginners and farmer representatives fix the price of cotton, in line with the international rate. It is mainly ginners who control the pricing system. CDB facilitates the negotiation between farmers and ginners but the small group of farmers may not always represent farmers across the income and landholding scales. Prior consultations with the wider cotton farming community are also limited. As a result, a kind of monopoly exists, and this means the ginners' association has no accountability to farmers and no transparency. This has reduced the satisfaction level of the cotton cultivators. In both zones, around 40% of cotton farmers have a medium level of satisfaction. In Zone 1, 30% are less satisfied and 10% have resorted to distress sales. In Zone 2, 37.5% are less satisfied and 12.5% have resorted to distress sales. Only 20% of farmers in Zone 1 and 10% in Zone 2 are highly satisfied with the price ginners fetch.





Figure 12. Price satisfaction level of cotton farmers (%)



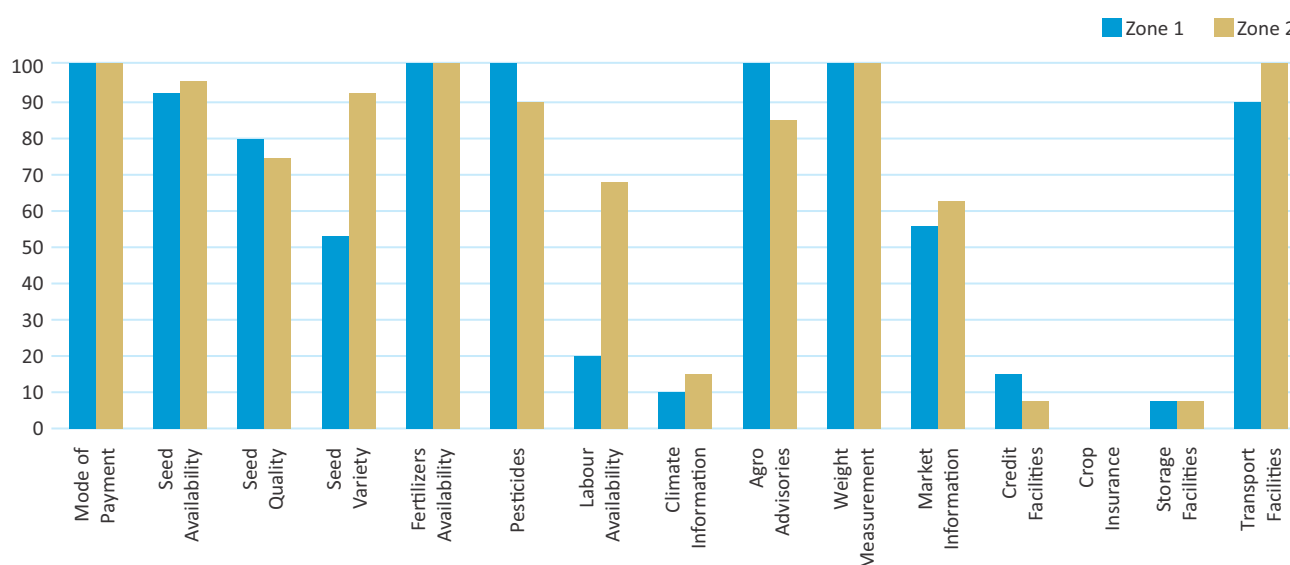
### 5.5.4 Level of Satisfaction for Different Facilities

The study analysed the level of satisfaction of the cotton farmers on different indicators. All farmers in both study areas are satisfied with the mode of payment (cheque), weight measurement (standard dimension framework developed by CDB), transport facilities and availability and quality of fertilisers and pesticides.

In Zone 1, 90% of cotton cultivators are contented with transportation facilities, 95% with seed availability, 80% with seed quality and 55% with market information and seed variety. In Zone 2, 100% are satisfied with transport facilities, as ginneries collect cotton from their doorsteps, 97.5% with seed availability, 92.5% with seed variety, 75% with seed quality and 62.5% with market information. Explaining their dissatisfaction with seeds, some farmers claimed they had to depend on CDB, and hybrid seeds come from abroad, which sometimes creates a scarcity of quality seeds. Others said that the germination rate was not satisfactory, and should be around 75–80%. Farmers raised the issue of the relatively long timespan required for cotton cropping. One of their hopes is to have access to new seed varieties that can be harvested within a shorter period.

Apart from seeds, cotton farmers claimed that their main constraints related to labour unavailability and lack of knowledge on the cotton marketing process. Only 20% of respondents in Zone 1 (67.5% in Zone 2) were satisfied with labour availability. They said the labour supply was low in their area because of the high rate of migration to the divisional city or capital. Instead of working on farms, labourers prefer to work in the market or at the nearby brick kiln. This creates labour scarcity during the peak season

Figure 13. Satisfaction level of cotton farmers (%)





and during the harvest. As a result, farmers need to pay more for labour.

Besides this, farmers are very dissatisfied (only 15% in Zone 1 and 7% in Zone 2) with credit facilities. As seen above, farmers often cannot access government facilities, and the high interest rate NGOs set causes them problems. Meanwhile, only 10–15% of cotton farmers are happy with their access to climate information. They do not get information in advance, which means their crops often get damaged. On a different note, cotton farmers cannot access crop insurance, which makes them more vulnerable when their cotton crops are destroyed.

In addition to this, only 5% of cotton farmers are satisfied with storage facilities. This is because there are no such facilities available in the study area and they have to store their final product at home. The ginner comes only three or four times a season, which means the quality and weight of their cotton degrades and they will receive a lower price.

## 5.6 Role of Women across the Value Chain

Our study also tried to incorporate gender perspectives and to identify the role of women across the entire value chain.

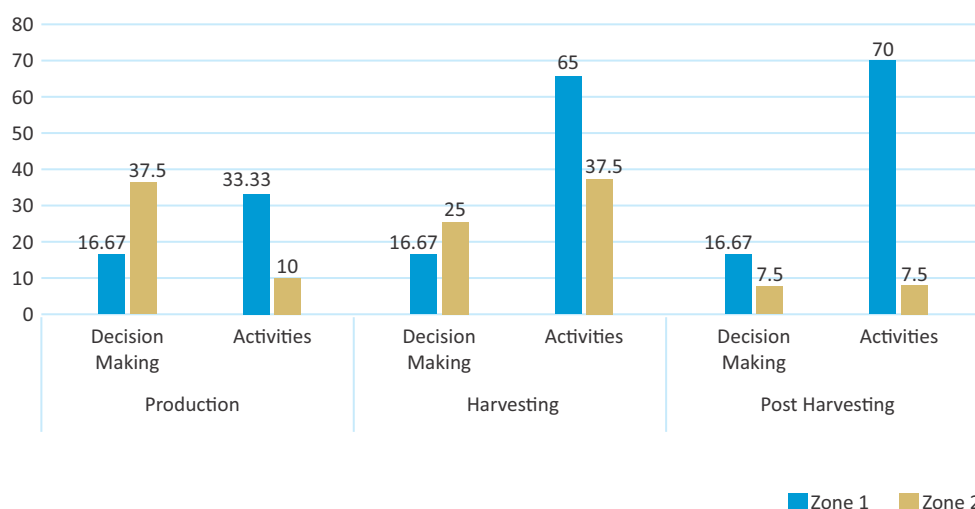
Men perform most activities related to cotton cultivation. Male workers are hired mostly for fertiliser application, land preparation and other intensive labour. Women are mainly

involved in harvesting and post-harvesting activities. In Zone 1, women perform approximately 65% of harvesting activities and 70% of post-harvest activities. Figure 14 also shows that, in the production phase of cotton cultivation, only 16.67% of women interviewed take part in decision-making activities and 33.33% in production activities.

In Zone 2, the level of participation is much lower than in Zone 1. Here, only 10% of women interviewed are involved in production activities, 37.5% in harvesting activities and 7.5% in post-harvesting marketing activities. Farmers said women were usually not involved because of religious factors, and they felt it was a shame and disgrace for them if women worked outside the home. But young cotton farmers do not adhere so much to these social and religious norms and they consider women's opinions and contributions to decision-making on agricultural activities.

In Zone 1, hired labourers, both men and women, mainly come from the local ethnic community (Santal). Labourers often migrate to nearby urban areas in search of better job opportunities and this has created an intense labour crisis in the area. The Santal have relatively less opportunity to migrate and do not usually occupy their own lands. These two factors mean they are often forced to be involved in agricultural activities as labourers. However, there is quite a noticeable wage difference between male and female agricultural workers. Male labourers earn Tk. 350–500 a day whereas female labourers earn only Tk. 200–250 a day.

Figure 14. Women's participation across the value chain (%)







## 5.7 Economic Viability of Cotton Cultivation

The major cost elements in cotton cultivation are land preparation, seed sowing, irrigation, fertiliser, pesticide,

weedicide, harvesting, threshing and their relative labour charges (Table 11).

Table 11 shows that the price of cotton inputs is considerable. Apart from this, the amount of profit cotton farmers receive varies from area to area and within the same area, as reflected in Table 12.

**Table 11. Cost-benefit estimation of cotton in the study region**

Cost Variables	Cost Parameters	Quantity of Inputs (Amount per bigha)	Unit Rate/Input (Tk.)	Total Cost (Tk.)
<b>Various operations and labour cost</b>				
Land preparation	Labour Cost	3	300	900
	Tractor Cost	3	300	900
Seed sowing	Labour Cost	6	300	1,800
Irrigation	Labour Cost	3	250	750
Cost of machine	Diesel/electricity cost			1,000
Fertiliser management	Labour Cost	6	300	1,800
Pesticide management	Labour Cost	5	300	1,500
Weeding	Labour cost	4	300	1,200
Harvesting	Labour cost	10	250	2,500
Threshing	Labour cost	4	250	1,000
<b>Total agricultural operations cost (C1)</b>			<b>13,350</b>	
<b>Input Cost</b>				
Seed		0.5 kg	2,350	1,175
FYM		50 kg	20	1,000
DAP		50 kg	25	1,250
Urea		60 kg	15	900
TSP		50 kg	32	1,600
MOP		50 kg	15	
Micronutrients		20 kg	100	2,000
Pesticides		0.5 litre	3,000	1,500
Weedicides		2 litre	250	500
<b>Total input cost (C2)</b>			<b>9,925</b>	
<b>Total cost of cotton (C= C1+C2)</b>			<b>23,275</b>	
<b>Revenue Cost</b>				
Cotton selling price		500 kg	60	30,000
By product (stalks) selling price		500 kg	3	1,500
<b>Total revenue for cotton (R)</b>			<b>31,500</b>	
<b>Profit/loss calculation</b>				
<b>Total net profit for cotton (C-R)</b>			<b>8,225</b>	

Note: Profitability is calculated based on quantitative data from the field survey of cotton cultivators for 2017 only, and it varies from area to area, as discussed below. Here, only the standard value reported by most farmers in the field survey is used. Each cost and revenue is calculated for 1 bigha (0.33 acre) of cotton land.





Table 12. Estimated profit/loss of cotton farmers in different regions of Bangladesh (%)

		Rajshahi	Naogaon	Chapai Nawabganj	Kushtia	Meherpur
Farmers making a net profit		80	100	60	80	86.67
Farmers making a net loss		20	0	40	20	13.33
Total farmers		100	100	100	100	100
Range of profit	Tk. 0–15,000/year	50	60	66.67	0	7.69
	Tk. 15,001–30,000/year	25	20	16.67	0	23.08
	Tk. 30,001–45,000/year	25	20	16.67	75	15.38
	Tk. 45,001–60,000/year	0	0	0	25	30.77
	Tk. 60,001+/year	0	0	0	0	23.08

The study finds that cotton farming is profitable for 80% of farmers in Rajshahi district. However, for 50%, the profit is under Tk. 15,001/year per acre of land. The highest level of net profit accrued in Rajshahi is in the range Tk. 30,001–45,000. No farmer in Naogaon faces a net loss. However, overall profitability is lower here than in Rajshahi: 60% of farmers have a net annual profit under Tk. 15,000 per acre, and the highest net profit in this district does not exceed Tk. 45,000 per acre.

In Chapai Nawabganj, 40% of farmers face a net loss annually – the highest rate among all the districts visited. Among those who make a profit, 66.67% earn less than Tk. 15,000/year per acre. No farmers make a net profit above Tk. 45,000/year per acre. Lower profitability in this district can be attributed to a lower yield per acre. Those who make a higher profit sell cotton in the local bedding shops at a price much higher than the ginners' association price. However, this mode of cotton trade is unlikely to be sustainable in the long run. The higher profit also results from using school children during harvesting at a very low wage rate compared with that of a grown-up worker.

In Kushtia, 80% of farmers make a net profit. All of them earn a minimum of Tk. 30,000/year from an acre, with Tk. 60,000/year the ceiling. In Meherpur, 86.67% of farmers make a profit, with only 7% of them making less than Tk.

15,000/year; 30.77% earn between Tk. 45,001 and Tk. 60,000/year and 23% earn above Tk. 60,000. 100% of the farmers in this study who make a profit above Tk. 60,000/year from each acre of land are from this district.

To summarise, cotton farming is less profitable in Rajshahi, Naogaon and Chapai Nawabganj, demonstrated by the fact that 50%, 60% and 66.67% of farmers, respectively, earn a profit in the range of Tk. 0–15,000/year per acre, and none cross Tk. 45,000/year. This is mainly because cotton is not the main crop here: most respondent farmers in these areas only cultivate cotton as an intercrop with mango. They are not willing to cultivate cotton in vast open spaces as they think it will not grow well on their drought-prone highlands. They do not use pesticides, fertilisers or weedicides on their cotton plants as they fear that this may harm their mango buds. This means their cotton is of lower quality and quantity and, as a result, they receive comparatively less profit.

On the other hand, 100% of farmers in Kushtia and 69.23% of those in Meherpur make a profit above Tk. 30,000/year, which means these two districts are more profitable. Also, all of those earning more than Tk. 45,000/year per acre are concentrated in these two districts. Meherpur contains 100% of the farmers who earn above Tk. 60,000/year from each acre under cotton.





# 06

## RISKS ACROSS THE COTTON VALUE CHAIN

### 6.1 Climate Risks

- **Rainfall variability:** Bangladesh is one of the most vulnerable countries in the world to climate change, and is often labelled 'climate change ground zero' because of its susceptibility to extreme events and abrupt changes. Rainfall data also shows that, in all our local study areas, rainfall patterns are changing. Winters are becoming drier and monsoons are becoming gradually more wet. Rainfall variability could result in delays in sowing, loss of seeds, rising irrigation costs, favourable conditions for pests, fungi and other microorganisms, production losses, poor quality harvests, loss of storage and many other adverse impacts.
- **Increasing occurrence of drought conditions:** Rainfall data shows that, overall, rainfall is decreasing in the post-monsoon season and winter, with dry spells also increasing in frequency, particularly in August and September. At the same time, agricultural intensification means farmers are pumping out groundwater for irrigation. The water table is dropping, which is leading to scarcity when water is most needed – when cotton plants are flowering. The situation is particularly challenging in Porsha, the driest part of the High Barind Tract. This is not only increasing irrigation costs but also affecting cotton production.
- **Long cropping period:** Cotton is a long-duration crop, with a planting to harvest readiness time of 130–160 days, and is also very much reliant on the temperature. Planting generally begins in the middle of July but can continue until the middle of August. Harvesting begins in December and continues until March. In this eight-month cropping period, cotton often becomes susceptible to changing climatic conditions. A shorter cropping period would mean more resilience to variability.
- **Lack of information:** Farmers do not have adequate information on weather variability and predictions. For example, an advance warning of rain in July and August would help them make better decisions on sowing. Similarly, early information on winter rain would make them better prepared for harvesting and post-harvesting storage.
- **Increasing temperatures:** Increased temperatures and moisture favour the growth of certain pests and fungi. During the second field visit, farmers in Kushtia pointed out attacks of fungi that spoil cotton bolls before they burst out. This is one of the unseen risk farmers need to be prepared for. Bolom, sucking bug, secede, white fly, mealybugs and red cotton bug are common pests.
- **Lack of storage infrastructure and humidity:** Late collection because of a shortage of ginneries, as well as a lack of storage, causes damage to post-harvest cotton. A relatively wet winter will increase this risk of post-harvest losses.

### 6.2 Value Chain Bottlenecks

- **Long cropping period:** Cotton is a long-duration crop, and cotton farmers often engage their land under mono cropping. This means that, in a yearly crop cycle, they can grow only one other crop with a short cropping period. Therefore, cotton needs to be profitable enough to compensate for any profit margin from multi-cultivable land. Alternatively, a reasonable investment is needed to develop shorter-duration cotton.
- **Lack of information:** Seed and input supply services are very much top-down. At present, the most popular seed supplies come from private corporations, which import seeds from abroad, especially from China, with



farmers not consulted on their experiences with seeds that they have previously used, as part of the selection process. The second most popular seed varieties come from the CDB lab. Farmers need to have their experiences and expectations reflected in the choice of both imported seed varieties and input materials from private corporations, as well as in CDB research and innovation.

- **Lack of market opportunities:** Cotton markets are currently monopolised. A cartel of private ginners settles the price with the farmers, with CDB playing a vital role at the negotiation table. Although farmers always have physical representation in this process, the existing social hierarchical system means this certainly does not give them enough bargaining power. More ginners in the field and the empowerment of cotton farmers would potentially expand market opportunities.
- **Price variability:** Cotton prices fluctuate with the global market and are settled every year in an open discussion between ginners and farmers with facilitation by CDB. However, in practice, farmers usually have weak bargaining power. Last year, the price was settled at Tk. 2,400 per maund and farmers could make profit on this price. A few years ago, the price was down at Tk. 1,900 per maund and farmers could not even cover their input costs. In the following year, the amount of cotton farmers and the size of cotton fields had shrunk significantly. This price variability is one of the most challenging issues, recognised by every single stakeholder in cotton farming.
- **Crowding out by other crops:** Cotton is still a marginal crop and is generally grown on marginal and abandoned lands. Cotton has the unique characteristic of being able to survive in challenging environments, in saline and drought-prone areas and on high slopes.

The High Barind Tract is relatively dry, with water scarcity often an obstacle to agricultural production. Climate data shows the area is becoming drier, particularly the higher lands, far from the water table. When cotton cultivation evolved, people were encouraged to use abandoned lands.

The High Ganges Floodplain has always had enough water and the only motivation for farming cotton has been to upgrade the profit margin of cotton-growers.

In both areas under study, new crops are emerging that are less labour-intensive, have enough corporate assistance and higher profit margins (tobacco in the High Ganges Flood Plain and tobacco in the High Barind Tract). To encourage an increase in cotton farming, there will be a need to motivate farmers and to put in place incentives so that cotton fields are not colonised by new crops.

- **Minimal participation of women in decision-making and cultivation processes:** Ensuring women's power, agency and inclusion in the agriculture sector has always been a challenge in Bangladesh. The main constraint to women's empowerment lies in their participation in the different spheres of life. Rules, norms, gender relations, social and cultural perception, personal and household endowment and attitudes and so on all together represent factors in women's participation. In Nachol and Porsha, women take part in cotton-picking on top of their domestic roles, though they have no other roles in terms of ownership, decision-making and income-earning. Other areas seem very strict about applying the concept of purdah. Lying the concept of purdah. en's 'purdah'.





# 07

## OPPORTUNITIES AND CONSTRAINTS

### Opportunities

- Bangladesh being one of the largest exporters of finished garments but the second largest importer of raw cotton, there is a huge scope for increasing domestic production of cotton to bridge this gap (Textile Today, 2018).
- As cotton requires much less water than paddy, it is a viable option in highlands and drought-prone areas (CDB, 2014)
- Cotton has saline-tolerant properties, which makes it beneficial for areas experiencing salt water intrusion (Ahmad et al., 2002).
- Economically, the crop is viable for small and marginal farmers as the returns are much better.
- All by-products of cotton are useful. Cotton is used for textiles. The seed is used for vegetable oil. The seed residue serves as protein-rich food for livestock. The plant remnants are used as fuel wood, which is scarce in Bangladesh.

### Constraints

- Cotton flowers are highly sensitive to rainfall and therefore prone to destruction in case of untimely rainfall (Whitaker et al., 2018).
- Increasing temperatures have led to increased incidence of pests.
- The cropping period of cotton is long, which lengthens its exposure to climate variability and cuts down the annual crop bundle (CDB, 2014).
- There is a lack of information on weather predictions and variability, seed varieties and input materials such that farmers cannot make informed decisions (as stated by the farmers).
- There is no storage infrastructure available for farmers, which leads to damage to cotton owing to humidity and pests.
- The processing stage of the cotton value chain is weak, with very few ginners to buy and process cotton, which is a major hurdle for cotton expansion.
- Annually variable (both international and national) prices and little prior knowledge among farmers about pricing is another issue that limits cotton cultivation.
- The bargaining power of farmers is limited, and the region currently lacks a system by means of which farmers can share knowledge and collectively bargain for prices, input materials and information.
- GOB's focus has been primarily on food security, thus there is not enough financial and policy support for expanding cotton cultivation.
- Cotton is a labour-intensive crop and has a long cropping duration, which means it faces competition from short-duration commercial crops and plantations (mango) that require less effort.
- There is minimal participation of women in the cotton value chain.



## 08

## KEY RECOMMENDATIONS



As seen in the previous section, the huge gap between demand for raw cotton in Bangladesh and its domestic production indicates a need to expand the area under cotton cultivation and improve its productivity. In this context, this study set out to identify bottlenecks across the existing cotton value chain to its expansion across the country. Recognising the adverse impacts that climate change will have on agriculture, the study also assessed localised climatic shifts and implications for the cotton value chain. This section draws on the findings to elaborate a set of recommendations to help CDB address gaps and blockages in the cotton value chain and enhance its resilience to climate change. These thus address general value chain issues such as lack of information, market imperfections and the need for empowerment of farmers as well as climate-specific challenges for cotton, such as the cropping period, increasing pests and

diseases and shifts in temperature and rainfall. The recommendations are listed in the order they need to be prioritised and implemented.

### 8.1 Undertake climate risk assessment in all cotton-growing areas

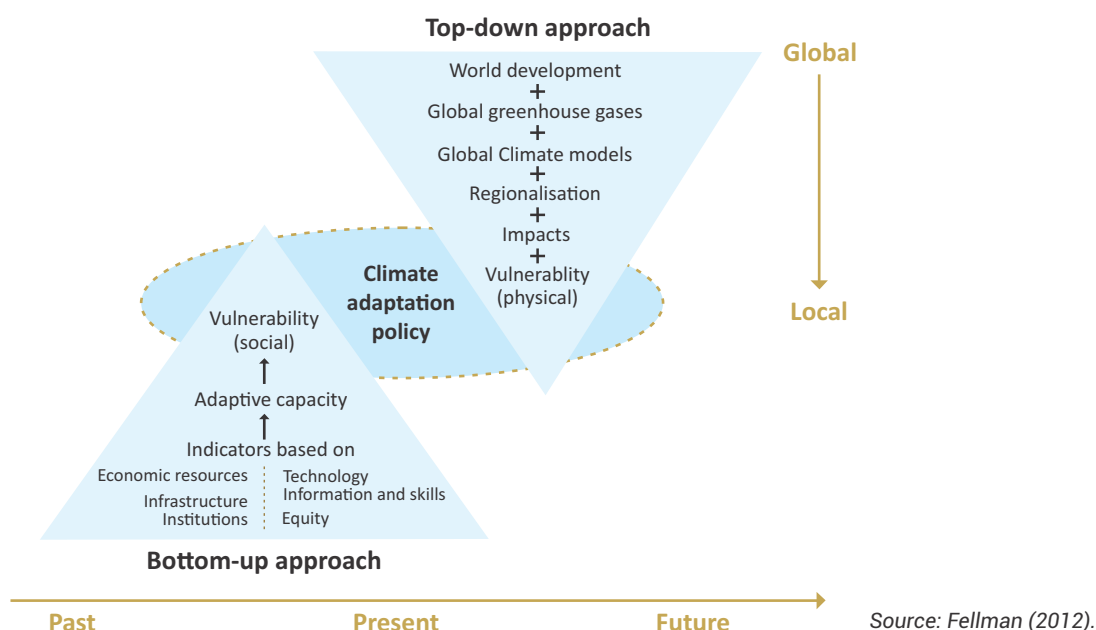
The first step towards climate-proofing the cotton value chain should be to conduct a climate vulnerability analysis in cotton cultivation areas. Analysis of social and physical vulnerabilities can help CDB make more informed strategic and policy decisions to expand cotton cultivation, secure the livelihoods of cotton farmers and make the value chain more resilient to climate change.







Figure 15. Top-down and bottom-up approaches to climate adaptation policy



The data we have from interviews, focus group discussions and climate models at national and regional scales unanimously supports the fact that the climate is changing. This means seasonal rainfall patterns, moisture, amount of sunlight, yearly and diurnal temperature characteristics and myriad climatic components will tend to have ever-evolving new features in the days to come. This will have an impact on cotton cultivation. For example, increased rain in July and August will delay cotton farm sowing, which will eventually affect production. In our fieldwork, both farmers and other stakeholders, including CDB, recognised the impact of climate change on cotton production. However, there has been no formal climate risk assessment in cotton-growing areas. We propose a climate vulnerability analysis, comprising a mix of bottom-up and top-down approaches, to evaluate social and physical vulnerabilities. This would give CDB more confidence to make informed strategic and policy decisions and help cotton flourish as a climate-resilient crop in Bangladesh.

Rapid vulnerability assessments are based on participatory rural appraisal techniques, which involves direct on-farm observations, key informant interviews with farmers and local experts, secondary data, transect walks and crop and climate calendars. This tool is very efficient in developing an understanding of the vulnerability of farming systems at a local level, which will allow for more informed cropping decisions. CDB and cotton farmers are using this approach in an informal way. For example, CDB extension officers are interacting with

cotton farmers to understand existing challenges and feeding information back into CDB's future research agenda and development planning. However, the current research focus is very much centred around genetic engineering and other lab-based work. As this research revealed, issues around input suppliers, markets, storage and so on are equally important, and need to be unpacked and addressed through formalising rapid vulnerability assessments as routine work in cotton development planning.

Alongside rapid vulnerability assessments, CDB could collaborate with BMD to make larger-scale (sub-regional) climate change projections and analyse how these will affect cotton production in the long run. What and who could be affected? How seriously? By when? What level of confidence do we have that the impacts will occur? Where are the strengths, weaknesses, opportunities and threats across the value chain? Answering these questions would help CDB sketch out adaptation and mitigation plans as well as future trajectories for cotton growth in Bangladesh.

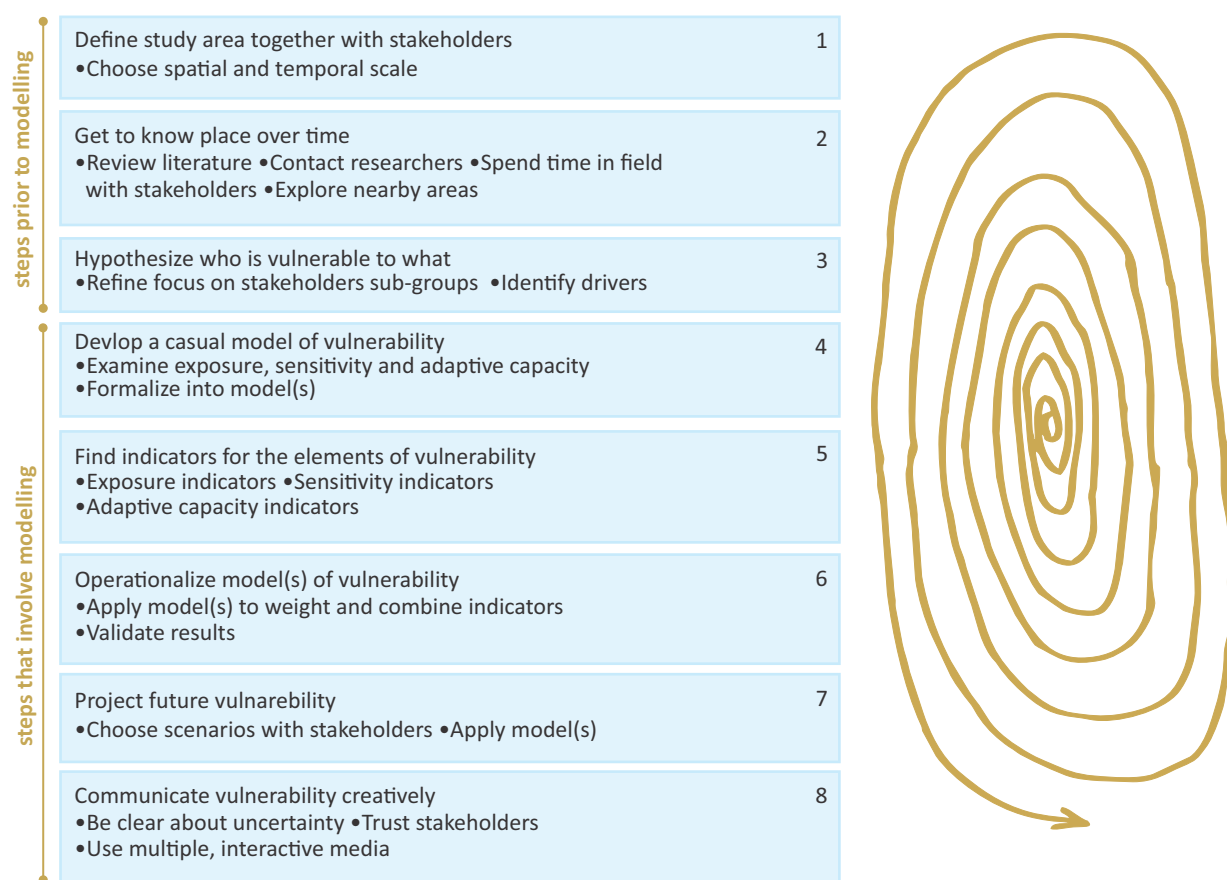
The above-mentioned climate risk assessments should be combined to approach the issue exhaustively. However, in the case of lack of resources, priority should be given to localised rapid assessments, which will allow effective local-level planning.

This research proposes a sequential spiral vulnerability assessment methodology, whereby social and physical





Figure 16. An eight-step method for vulnerability assessment



Source: Bousquet et al. (2015)

vulnerability assessments are conducted simultaneously, since they are often characterised by overlaps and iterations in real life. The model suggests two main steps: 1) steps prior to modelling and 2) steps involved in the modelling. In the first step, BMD may play an important role, since it is already collaborating with the Bangladesh Department of Agriculture Extension (DAE), the International Maize and Wheat Improvement Centre (CYMMIT), the International Food Policy Research Institute (IFPRI), Practical Action and others to develop scenarios for the weather–agriculture nexus, and relevant implementing organisations are disseminating weather information to farmers at local level. CDB could take the initiative to develop a partnership with BMD to obtain cotton production-related climatic information.

In the second step, CDB and ICCCAD, which already have an open memorandum of understanding, could work jointly on providing training facilities to their extension

officers and local farmers. At the same time, CDB could also partner with relevant service providers to disseminate real-time weather information to farmers through modern communication technologies, such as m-agri (mobile-based agriculture information services).

The detailed steps of this assessment model are illustrated in Figure 16, and Schröter et al. (2005) and Fischer et al. (2002) are two key references. The value of this stakeholder-driven vulnerability assessment model goes beyond guiding further scientific inquiry, as it factors in differential social and economic vulnerabilities. Such direct engagement with stakeholders is a beneficial exercise for decision-makers as well as communities, as it enhances knowledge-sharing, specifically the sharing of localised and nuanced knowledge. The learnings derived from these assessments help increase awareness among communities and, most importantly, lend salience and credibility to subsequent interventions.

<sup>4</sup> See <https://www.gsma.com/mobilefordevelopment/magri/>





## 8.2 Develop Climate-Resilient Agronomic Packages

Based on the challenges identified in this study and subsequent localised climate vulnerability analyses, a set of climate-resilient agro-economic practices need to be introduced across the value chain. These practices will help address existing social and economic vulnerabilities and improve the resilience of the value chain to climate change. Specifically, new or existing seed varieties that have a shorter cropping duration and are viable for specific climatic conditions in which they are grown are needed. Pests and crop diseases need to be regularly monitored and necessary measures to tackle these undertaken. Most importantly, the climate data indicate a need for climate-smart irrigation and the use of inputs such as organic manure and fertilisers to optimise sustainable resource use.

- One of the major issues identified in this research is the long duration of cotton cropping; it appears to be extremely important to make this crop duration shorter, at a maximum six month. A farmer who is not growing cotton can often intensify agricultural land use and grow three crops on the same land, thus achieving a better income and more food security. Besides, because of the very nature of changing climatic conditions, shorter-duration crops are likely to be more resilient through reduced exposure to climatic variability. Addressing this would help encourage farmers to adopt cotton cultivation at a larger scale.
- CDB is already investing resources in lab-based research to innovate new varieties. It is also trying to bring in short-duration cotton varieties from India and Turkey. One of the major challenges is their suitability to Bangladeshi climatic conditions. CDB is also trying to increase the number of scientists who will invest the majority of their time in breeding short-duration varieties of cotton. Currently, CDB has 18 scientists and is in the process of recruiting another 30. It is extremely important that CDB understand the changing climate pattern and focus on synchronising different growth phases of cotton with the evolving conditions. For example, now the cotton harvesting phase is longer and cotton is picked in three phases. If

innovative varieties have two picking seasons, instead of three, this could reduce the risk of losses from the emerging wet spells in February and March.

- Along these lines, seed varieties also need to be suitable for the local micro-environmental conditions (e.g. drought, salinity, slopes). Varieties do not necessarily have to be new; existing varieties can be screened to identify the most suitable for the different contexts.
- Changing climatic features will expose cotton farming to new and upgraded sets of pests, fungi and other microorganisms. Increased CO<sub>2</sub> in the atmosphere will increase the appetite and fertility of leaf-eating caterpillars. Similarly, increased temperatures will facilitate favourable survival conditions for whiteflies, thrips, aphids, mealybugs and many other pests (Bange and Constable, 2008). It is very important that input service providers are ready to supply materials to match these changes. CDB could put in place a very specific research agenda in its annual plan to generate new knowledge on ever-evolving pest threats in a changing climate. At the same time, CDB could also tap into its existing international knowledge networks to keep updated on climate change-induced changing patterns of pests and pest control in other regions. This area needs regular monitoring and research so that farmers are updated on emerging pest threats and remedies. It is equally important to disseminate information to private dealers so they can also deliver appropriate pesticides to farmers.
- Our climate data analysis demonstrates that the weather is changing and posing a major challenge to cotton farmers in terms of water scarcity: 1) rainfall in September and October is declining; 2) dry spells of over four days are gradually increasing in number; and 3) the water table is dropping. Therefore, CDB needs to upscale its advocacy on climate-smart irrigation practices, which include 1) increasing the use of organic fertilisers and other organic materials to increase the moisture conservation capacity of the soil significantly; and 2) using water sprinklers instead of general irrigation to markedly reduce the use of irrigation water.



## 8.3 Provide Information Services

While vulnerability assessments and the introduction of agro-economic practices are vital to enhance resilience, regular provision of information on the same to farmers and other stakeholders across the value chain should go hand in hand with this. This will help ensure effective and large-scale uptake and localised knowledge-sharing on agricultural and adaptation practices. Such information ranges from timely weather predictions and warnings to minimise crop losses, to price allocation and market opportunities. CDB extension workers can be an effective means of disseminating such information and therefore their capacity should be built in this regard.

- Farmers have come into cotton farming through very careful handholding from CDB. CDB extension officers are extremely capable and easily reachable, as they regularly visit farmers in their locations. Farmers receive many very important pieces of advice from the officers, on seeds, pests, plant care, fertilisers, diseases and so on. However, the main cause of losses was said to be weather-induced. Had farmers had advance weather warning, their losses could easily have been avoided or recovered from. And BMD is very capable of providing an 11-day weather forecast with a 93% precision level. CDB could take the initiative to partner with BMD and could consider developing a mechanism to disseminate and communicate information to farmers. As mentioned earlier, BMD is already working with DAE, CYMMIT, IFPRI and Practical Action on climate insurance and weather data-related issues. It provides necessary weather data to its partner organisations, which disseminate this to local people using m-agri or in-vitro maturation technology. Hence, the BMD platform represents a great opportunity to communicate with local cotton farmers.
- Climate change is a new domain of activity for CDB. CDB could consider building the capacity of its extension officers on the basics of climate change and its relevance to the future of cotton farming. ICCCAD and CDB have already signed a memorandum of understanding, under which they have agreed to conduct collaborative research and facilitate capacity-building training on climate change; ICCCAD will work to enhance the capacity of CDB's extension officers. Extension officers then can transfer their knowledge to farmers, so they are aware and mentally prepared to deal with climate change adversities in cotton farming.

- Development of an efficient information management system is important, whereby top-down information flows and bottom-up feedback loops ensure dissemination, absorption and use of information on climate change, pests, diseases, insects, microorganisms, markets and so on.

## 8.4 Establish Cotton Farmers' Cooperatives

To ensure more equal relations between farmers and other stakeholders, cotton farmers' cooperatives should be created. Cotton production is at a nascent stage and information on input materials, weather patterns and their impact on cotton cultivation, pricing and market opportunities is not yet adequate. The processing stage is also tightly controlled by a handful of ginners. This, coupled with lack of awareness, has considerably reduced farmers' bargaining power. The cumbersome process involved in accessing credit is exacerbating the situation. In this context, farmers' cooperatives can help ensure the flow of information, enable knowledge-sharing and increase collective bargaining power and access to financial and technical resources.

This study identifies farmers as the least powerful group among all the stakeholders in the cotton value chain. They are less powerful because they are poor, have limited access to information and services and do not have an active role in decision-making across the value chain. Inclusive and representative farmers' cooperatives are hence important to ensure farmers have a collective voice and role in decision-making not just at the pre-production and production levels but across the entire value chain. Proactive engagement of farmers' cooperatives across the value chain will not only enhance their bargaining power but also help plug their localised knowledge and experiences into improving value chain practices.

Farmers' cooperatives find mention in the new National Agriculture Policy (2018–2023), which states that GOB will provide support to cooperatives of small and marginal farmers, smallholder producers and entrepreneurs. The policy also states that the government will help these groups take out loans, mechanise agricultural processes and encourage cooperative marketing to ensure fair prices. CDB can mobilise resources through this strategy to facilitate the formation of cotton farmers' cooperatives, which will benefit them in the following ways:

- Farmers saving groups can be used to access shared resources, such as storage, transport and machinery.





- Farmers will have a platform to share knowledge and information on different cotton farming-related issues.
- Cooperatives can leverage cotton farmers' institutional affiliations, access to finance and banking services, making collective purchases and building individual and organisational capacities.
- Cooperatives can give farmers stronger bargaining power with ginners.

CDB could affiliate with the Department of Cooperatives under the Ministry of Local Government, Rural Development and Co-operatives to explore its specialised services in supporting cotton farmers' cooperative formation.

## 8.5 Create a More Equal Market for The Cotton Crop

The existing control of a handful of ginners over cotton processing has led to an imperfect market situation and is proving a substantial blockage in the value chain. Measures need to be taken to incentivise ginning such that there are more players at the processing stage. This in turn will create better market opportunities for farmers and help with the expansion of cotton.

From discussions with multiple farmers across the two sites where research was conducted, it was evident that ginners have an undue influence on the price farmers receive. This is because there are a small number of ginners in Bangladesh who are well networked and therefore can indulge in oligopolistic trade practices to artificially depreciate the price offered for raw materials. While CDB plays a helpful role and speaks on behalf of farmers to ensure prices are just and reflect the price of inputs and labour, the ginners remain the dominant party in negotiations as they are limited in number and aligned in their negotiation stances. A few ginners also delay collection, which in turn leads to damage to cotton. To create a more equal market for the cotton crop we suggest that:

- A charter is consultatively drawn up between the ginners' association and GOB on fair trade practices, to which both sides agree.
- Incentives are provided through favourable taxation and other fiscal instruments to enable additional entities to enter the market as ginners.
- Farmers' representatives and cooperatives (when they are formed) are provided an equal voice in price negotiations that are hosted by CDB.

- Data is collected and shared regularly on input prices in Bangladesh and on global cotton prices to enable better benchmarking and price comparison.
- Forward thinking intermediary users such as cotton mills are enlisted in a programme to ensure fair trade practices, using similar accreditation and branding techniques as have been used for cocoa and coffee globally (e.g. Fair Trade).

## 8.6 Establish a Technical Committee on Climate Change within the Cotton Development Board

Executing the five preceding recommendations will require managerial oversight and administrative will. Therefore, a core-group of individuals needs to be empowered to lead the climate change agenda within the Cotton Development Board in the form of a Technical Committee on Climate Change. The Committee should be chaired by the Executive Director of the Cotton Development Board and should include three other individuals that have an understanding of the impacts of climate change on cotton production in Bangladesh. The Committee will be charged with executing the recommendations of this report, mainstreaming climate change in the work of the CDB, undertaking more research, analysis and information gathering on the impacts of climate change on cotton and leading all activities to ensure that the cotton crop in Bangladesh is able to withstand the impacts of a changing climate.

Therefore, while the terms of reference for the Committee should be determined by the members themselves, it should be focused on the following five priorities:

- Develop an actionable roadmap for executing recommendations listed in this report
- Mainstream climate change across the policies, plans, programmes and projects of the Cotton Development Board
- Expand the climate resilient value chain analysis of the cotton crop beyond the two regions covered by this report
- Collect, collate and disseminate the latest information on the implications of climate change on the cotton crop amongst key stakeholders
- Act as the nodal mechanism for catalyzing and executing actions for enhancing the resilience of the cotton crop in Bangladesh



## 09

## WAY FORWARD

This final section presents 'next steps' aimed at actioning and operationalising the key recommendations provided in Section 8.

## 9.1 Prioritising Action

Section 8 presents recommendations in a prioritised order. Three broad criteria were used to carry out this prioritisation: 1) time (whether impacts can be achieved over the short, medium and longer term); 2) effort (a combination of the person power and finance required); and 3) likely impacts (from high to low). The schema in Figure 17 illustrates the prioritisation used.

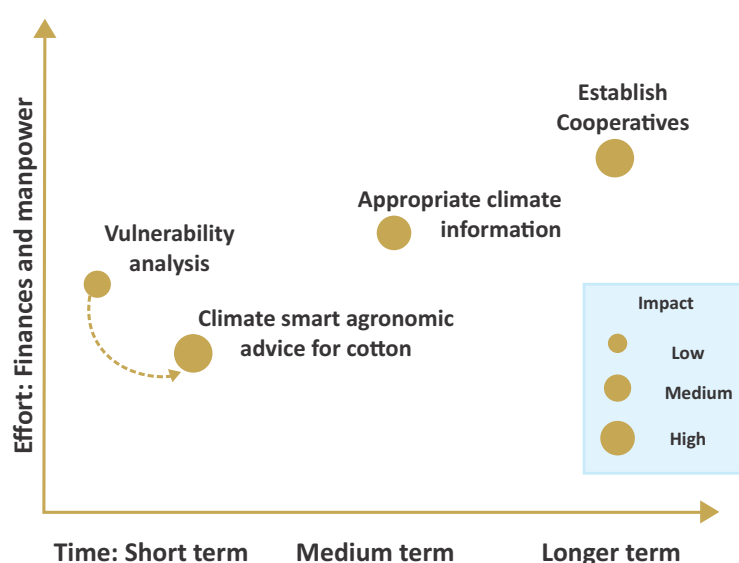
There is a sequencing issue associated with the prioritisation. The climate vulnerability analysis has to be undertaken first, to provide the evidence required to produce 'climate-smart' agronomic advice relevant at sub-regional level, for cotton farmers (i.e. updating existing agronomic advice on cotton cultivation, to include ways to respond effectively to changes in weather and climate).

The agronomic advice will have a higher impact on cotton production than vulnerability analysis on its own. However, the two activities are linked, and high impact is achieved in the cotton sector once the findings of the climate vulnerability analysis (which will provide information relevant also to other crops and livestock systems) are translated into specific, updated advice for cotton cultivation.

CDB should then develop a detailed action plan, with the following components:<sup>5</sup>

1. Specific: Objectives need to be clear and detailed.
2. Measurable: Results need to be measurable.
3. Agreement: All key stakeholders need to be consulted and the development of the action plan needs to be inclusive.
4. Realistic: Strategic actions should be selected keeping available resources in mind.
5. Time-specific: Deadlines for achieving each stage should be set.

Figure 17: Example of prioritising schema



<sup>5</sup>[http://www.gp-training.net/training/communication\\_skills/mentoring/smart.htm](http://www.gp-training.net/training/communication_skills/mentoring/smart.htm)







There are numerous templates available for the preparation of such plans. CDB could use the one below as a starting point.

Third, it is crucial to map all the key stakeholders and then include all relevant organisations and individuals in decision-making processes. Change processes that are

Goal						
Strategic action required	Person/department responsible	Start date	Finish date	Resources required	Potential risk	Objectives

## 9.2 Securing Leadership and Participation

Securing and determining leadership for the entire enterprise of enhancing the resilience of the cotton crop is vital.

First, it is important to secure the backing of a high-level GOB official who could act as a champion. This can be done by identifying individuals who are influential and exposing them to the benefits of engaging with this agenda. These could range from exposure on the world stage (e.g. through potentially presenting insights from this work at international conferences), the opportunity of aligning themselves with salient frameworks (e.g. SDG 13 on climate change) or a higher profile within their own organisation for pushing an innovative agenda. Champions are vital to ensure the success of all kinds of innovative change processes and, as climate change is a relatively new issue within the domain of cotton production in Bangladesh, it will be important to ensure this agenda receives the backing it deserves. Influential champions can exert a positive influence on processes of change by strategically convening stakeholders who are key to the success of an initiative, resolving differences between parties, providing guidance on navigating policy and bureaucratic hurdles to the operational team and lending credibility/legitimacy to innovative actions.

Second, as mentioned earlier in this section, all actions need to be assigned to a responsible entity to ensure success. It is crucial to keep in mind that the responsibility should ideally be assigned to a 'designation' (e.g. director, extension services) as opposed to an individual, to avoid any lapses as a result of transfers, retirements, reassignments and resignations. It is also important to ensure leadership on and responsibility for strategic actions are distributed, so no single functionary is burdened with a disproportionate amount of work.

inclusive and participatory have a higher chance of succeeding than those that are closed or mired in opacity. There are a large number of approaches to stakeholder mapping. These could be predicated on determining 'core' stakeholders (e.g. CDB team), 'direct' stakeholders (e.g. BMD, DAE, farmers) and 'indirect' stakeholders (e.g. ginners, garment manufacturers). Otherwise, stakeholders could be mapped based on whether stakeholders need to be satisfied, managed closely, monitored or kept informed. Essentially, multiple approaches for stakeholder mapping are available and the team can select any one to do this rigorously.

Fourth, ensuring the comprehensive engagement of all stakeholders identified through the mapping is particularly vital in the initial stages of an initiative, after which actions can be disaggregated and distributed among stakeholders and mechanisms for regular check-ins/reviews. To the extent possible, it is vital to ensure cotton farmers and/or their representatives are included in key decisions on enhancing the resilience of the cotton crop. This will lead to actions being more impactful and ensure any unintended consequences have greater visibility.

## 9.3 Ensuring Sustainability

Along with prioritising action and securing leadership/participation, it is vital to ensure that the sustainability of this initiative is ensured, by enshrining it in an official policy document of CDB and associated departments. Policy documents could include annual plans, multi-year work programmes, five-year plans and action plans. It is important to keep in mind that the National Agriculture Policy 2018 clearly underlines the importance of pursuing climate-resilient agriculture. This policy directive needs to be combined with findings from this report to channel this directive and reflect it in different, derivative policy instruments to ensure sustainability.

<sup>58</sup> [http://www.gp-training.net/training/communication\\_skills/mentoring/smart.htm](http://www.gp-training.net/training/communication_skills/mentoring/smart.htm)





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## ANNEXURE 1: Climate Vulnerability Analysis

Climate change has significant implications for agriculture and the food security, from household level to national level. Therefore, it is vital to understand the climate risks associated with any agricultural investment. The point of departure for investments seeking to integrate responses to climate change is assessing the climate risks. To identify and understand how climate change impacts crops, livestock, water, and the livelihoods of the agrarian communities— Climate change Vulnerability Assessment (CVAs) are used widely. CVAs also lay the groundwork for planning and designing agricultural investment projects.

The primary objective of the CVAs is raising awareness of the consequences of climate change. However, the in-depth CVAs try to identify the nexus among climate change impacts, vulnerabilities and adaptation to as well as mitigation of it.

The first step of the CVAs is analysis of the climate change risks under the assumption of 'no adaptation efforts', for example, what would be the yield loss of paddy in a projected scenario of lesser rainfall in the drought prone Barind tract of the north-western Bangladesh in absence of irrigation facility and no drought tolerant variety is used. In order to do an effective analysis, and assessment of 'autonomous adaptation', meaning, expected spontaneous response to the changed climatic scenario, is done. Shifting of the sowing or harvesting time to avoid adverse weather can be an example of it. CVAs then find out the residual effects of climate change assuming that autonomous adaptation is in place.

To get a clearer picture of the nature of vulnerabilities CVAs attempt to find the answers to questions like— the effects will be on whom and what, how serious will it be, by when, and what the likelihood of occurring that is.

Then comes finding ways to ameliorate the impacts of climate change. CVAs do so by focusing mainly on the identification of adaptation options. As we are talking about agriculture which besides being impacted by climate change also causes it, mitigation should also be taken into account where possible. Checking the development policies and plans to see the degree to which adaptation as well as mitigation options are embedded into those should also be a part of the CVAs.

Policies may both thwart and enable technology choices. As there is linkage between them, CVAs seek to identify policy and technical opportunities and constraints while exploring adaptation and mitigation options. In doing so, the effectiveness of the options, their costs of implementation and feasibility, co-benefits and if there is any possibility to have negative implications for other systems are important factors to take into account.

Purposes of doing a CVA can be diverse. For example, it could be for the policymakers or for the public, for a local level planning or for a national one, for agriculture sector or for fisheries sector. It could be for making an adaptation policy or a mitigation policy. Also, it could be for formulating a hundred-year mega plan like the Bangladesh Delta Plan 2100 or for a plan with shorter timeframe like the upcoming Eighth Five Year Plan (2021-25). Depending on its point of focus, an exhaustive CVA design demands considering some finer aspects, like, what the CVA, whom the assessment it is for, if it is supporting a broader policy, expected outputs, sectors, timeframes, geographic scope.

CVAs aim at exploring various future scenarios. In order to do so, modelled climate change projections are blended with baseline socio-economic scenarios. For example, a CVA may want to see the plausible impacts of a worst-case climate scenario given a high population growth and accompanied by economic boom. A vital thing to remember during assessment of the adaptation options is to use a broad spectrum of projected future climatic scenarios— from the best to the worst— even if the associated probability is very low. This is for avoiding biased results and marking the frontiers of probable climatic risks.





CVAs adopt two major types of approaches—1) Impact Frameworks and 2) Adaptation Frameworks.

The first ones are top-down approaches dependent on scenario-based climate models, focusing larger geographical scale and longer-term effects of climate change. Starting from global circulation models Impact Frameworks downscale the biophysical impacts and physical vulnerabilities to local level. Use of longer timeframe is because the major GHG carbon-dioxide resides in the atmosphere for a very long time. Another reason behind looking at the long-term effects is to inform the policymakers of the potential consequences of unswerving GHG emission. These approaches are useful for assessing the long-term climate risks.

The second kind of approaches are called Adaptation Frameworks. Contrary to the earlier ones they use a bottom-up approach. Focusing on social vulnerabilities, these start with local level perceptions, skills and resources. Geographic scope of the Adaptation Frameworks is usually smaller compared to the Impact Frameworks and rely mostly on qualitative method of data collection. This kind of approaches help understand the recent past and plan for the short to medium-term.

Timeframe of the most agricultural investments are short. Therefore, bottom-up approaches to CVAs are the most appropriate for providing useful insights to plan investments in the agriculture sector.



## ANNEXURE 2: Tropical Rainfall Measuring Mission

The best performance in our study area is observed using TRMM data ( $r=0.68$ ) but PERSIANN showed poor correlation with the rain-gauge data ( $r=0.55$ ). The loss of more localised convectional rainfall is possible, which makes sense of the differences between rain-gauge and satellite data. Islam et al. (2010) show a similar distribution between TRMM estimates of monthly, seasonal and annual rainfall with the rain-gauge data and find the correlation coefficient of these two datasets to be 0.71.

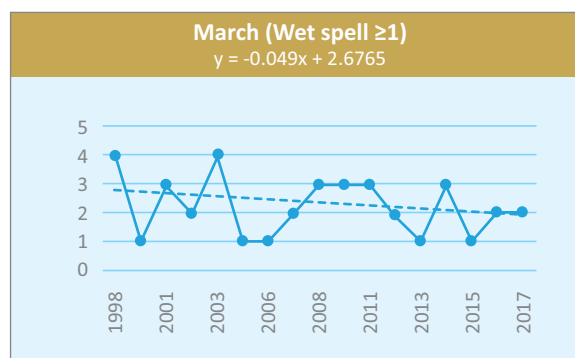
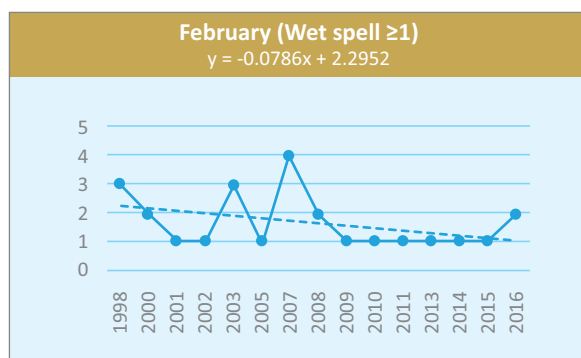
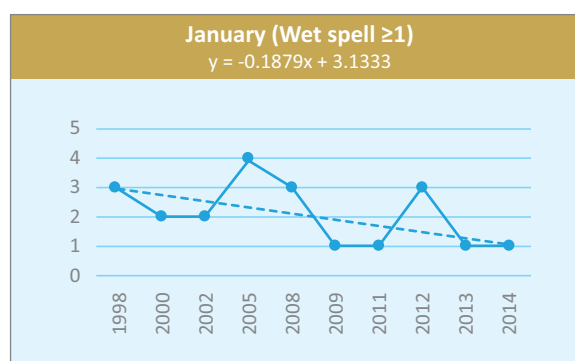
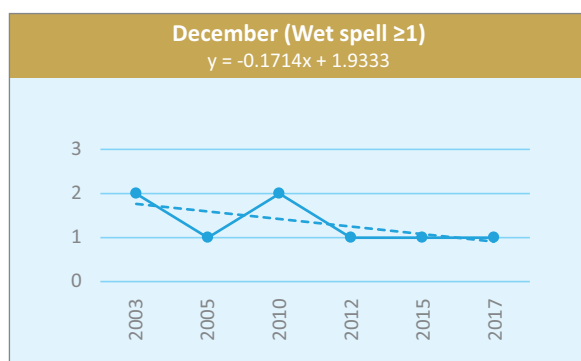
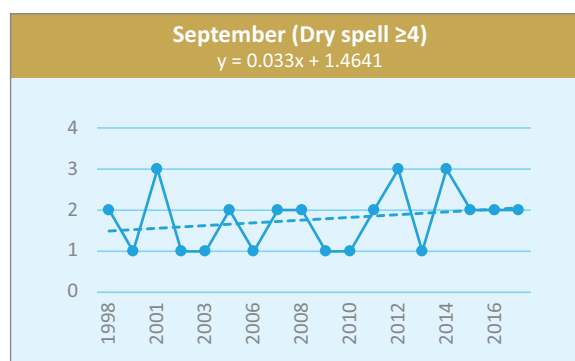
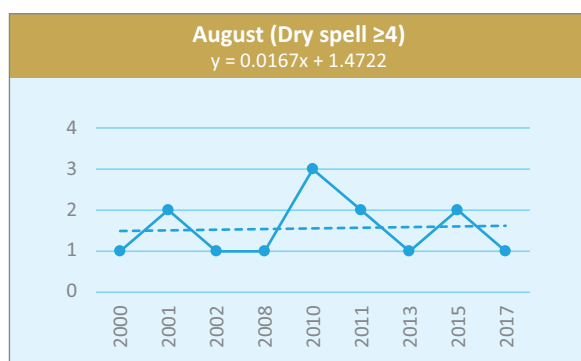
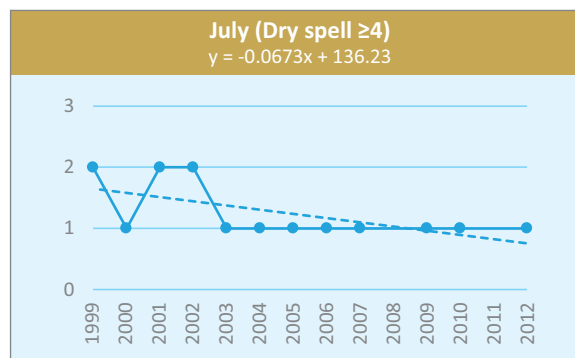
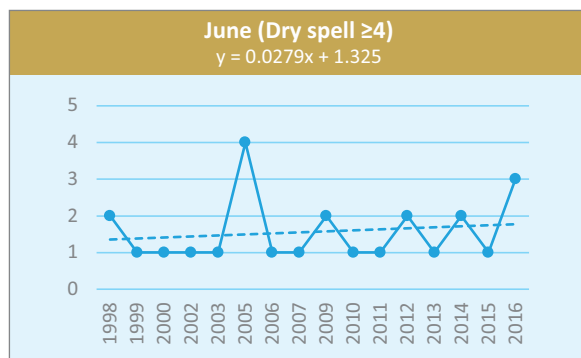
### **Background of TRMM**

- Data Set Short Name: TRMM\_3B42\_daily
- Data Set Long Name: Daily TRMM and Others Rainfall Estimate (3B42 V7 derived)
- Data Set Version: 7
- Data Set Creator: Tropical Rainfall Measurement Mission Project (TRMM)
- Data Set Publisher: Goddard Space Flight Center Distributed Active Archive Center (GSFC DAAC)
- Platform: Tropical Rainfall Measuring Mission
- Sensor(s): Advanced Microwave Scanning Radiometer, Advanced Microwave Sounding Unit-A, Advanced Microwave Sounding Unit-B, TRMM Precipitation Radar, Special Sensor Microwave Imager/Sounder, TRMM Microwave Imager, Visible and Infrared Spin Scan Radiometer (GMS Series), Visible and Infrared Spin Scan Radiometer (METEOSAT Series)
- Horizontal Resolution: 0.25 x 0.25 degree
- Vertical Resolution: Surface
- Temporal Resolution: Daily
- Temporal Coverage: 1997-12-31 – present
- Parameters: PRECIPITATION RATE
- Data Source: <https://giovanni.gsfc.nasa.gov/giovanni>





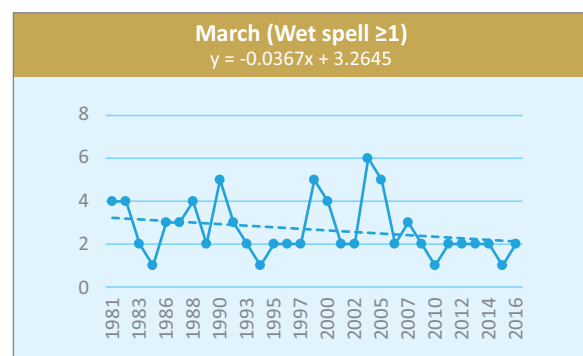
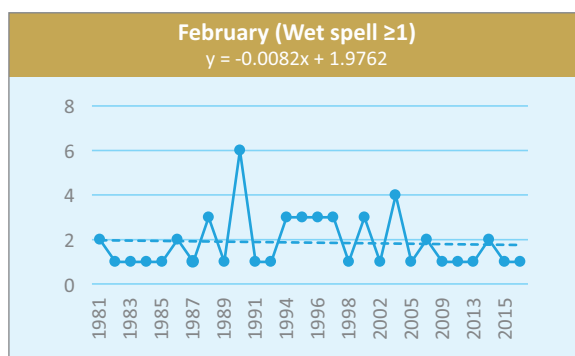
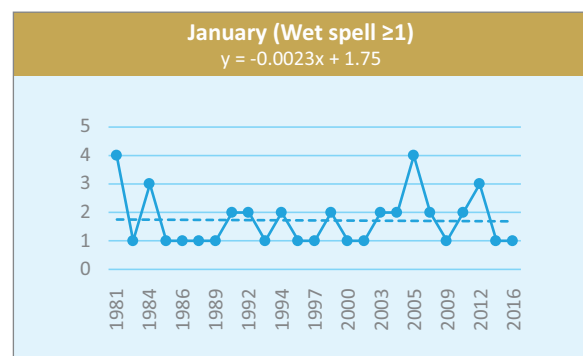
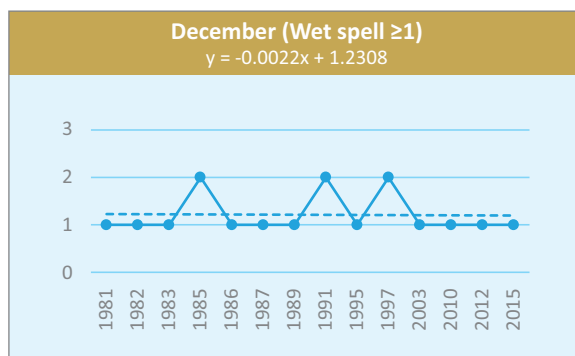
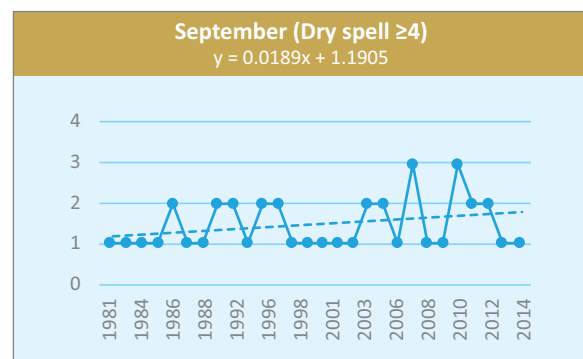
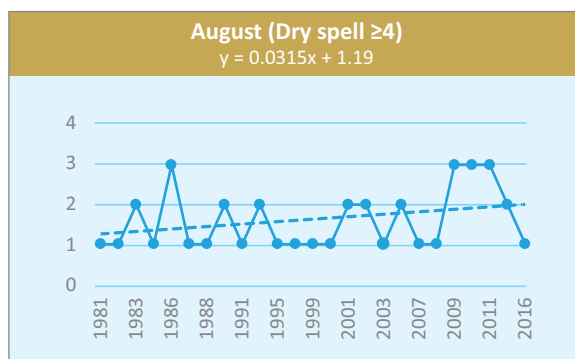
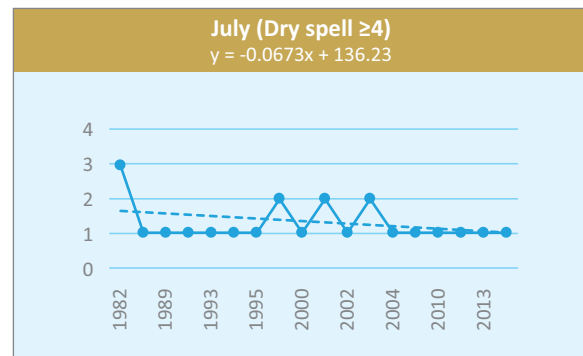
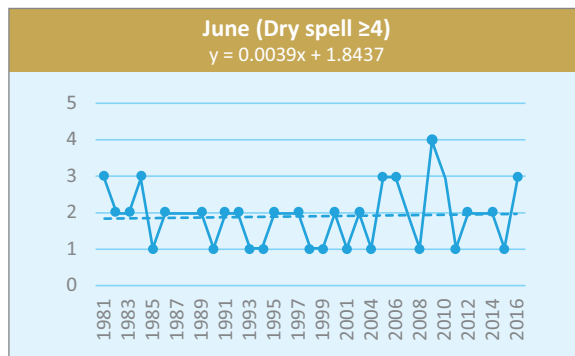
## ANNEXURE 3: Dry and wet spells in high Ganges floodplain (Kustia and Meherpur)





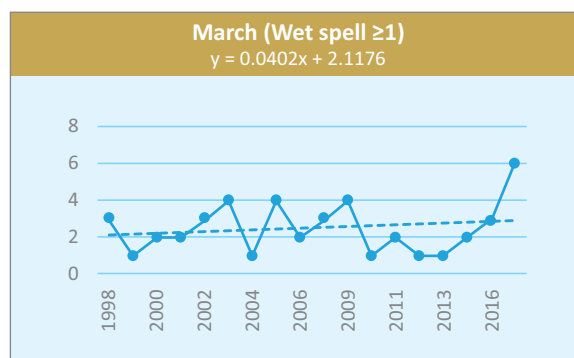
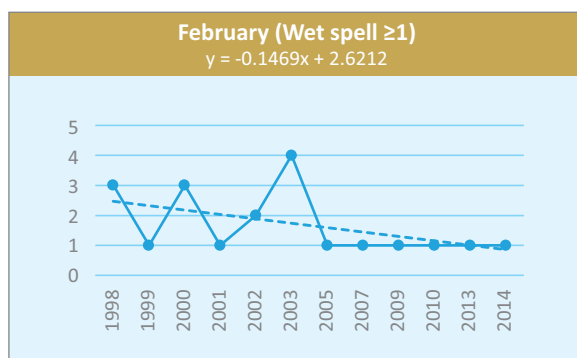
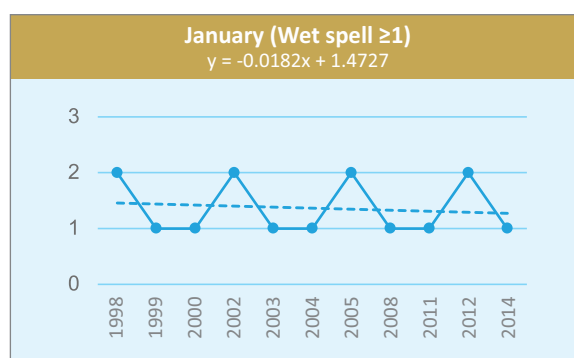
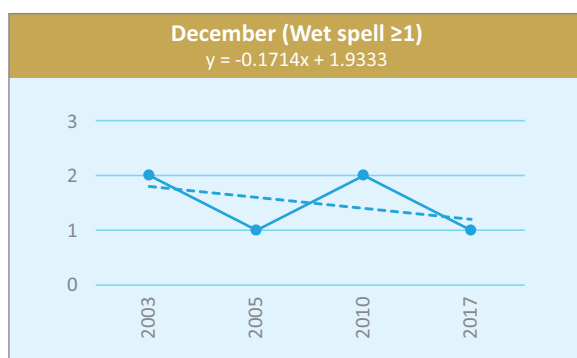
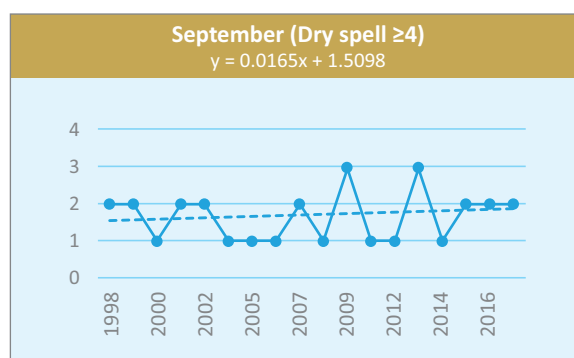
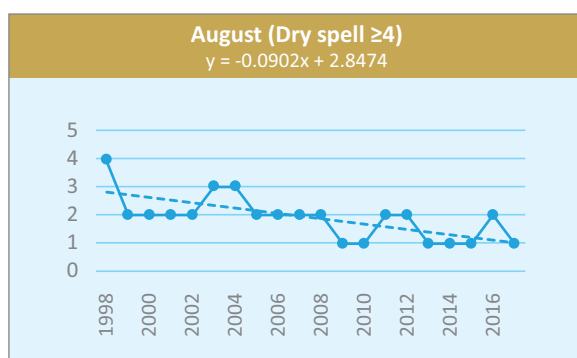
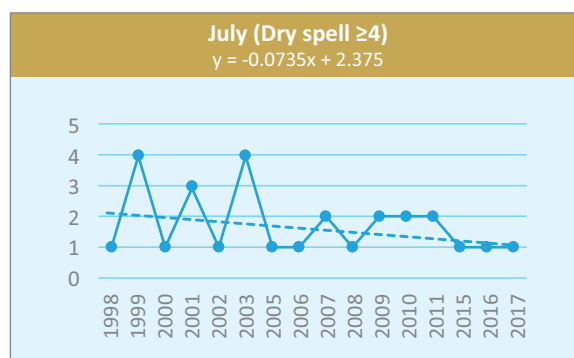
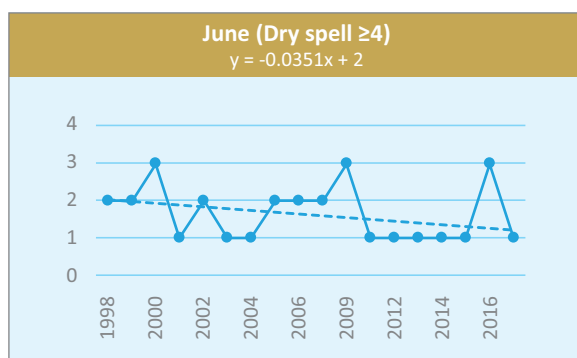


## ANNEXURE 4: Dry and wet spells in high barind tract (Rajshahi)



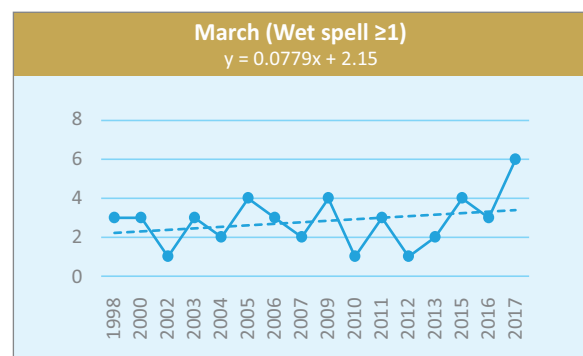
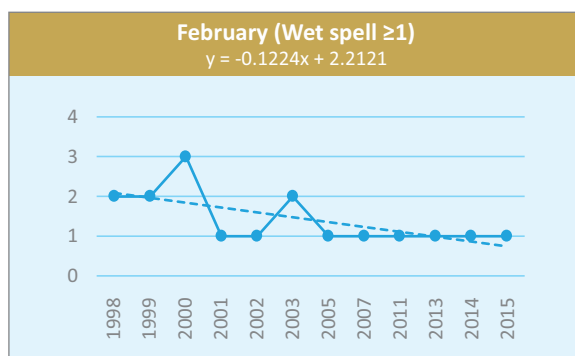
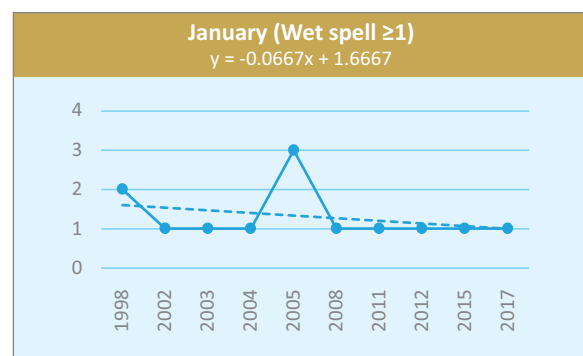
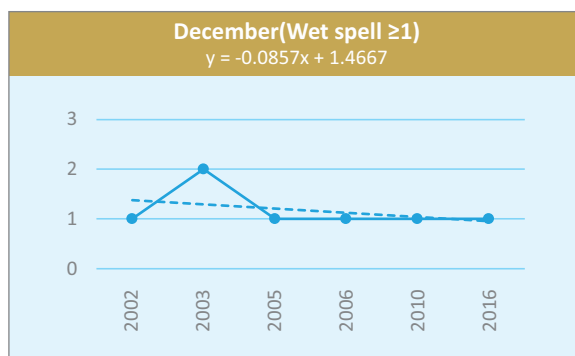
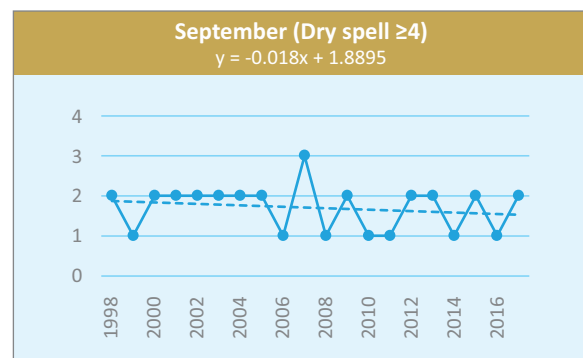
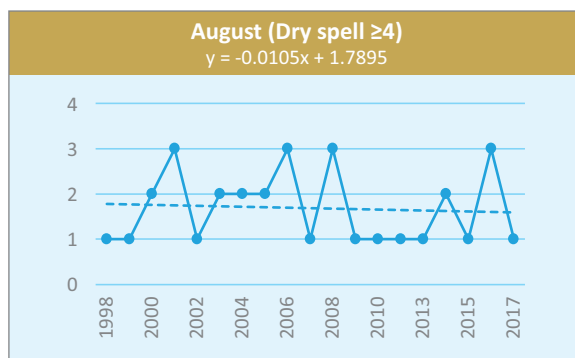
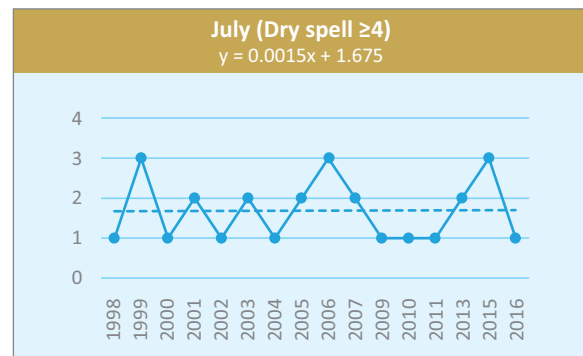
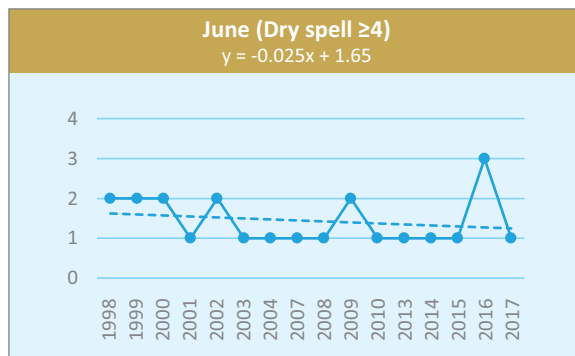


## ANNEXURE 5: Dry and wet spells in high barind tract (Nachol)





## ANNEXURE 6: Dry and wet spells in high barind tract (Porsha)










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