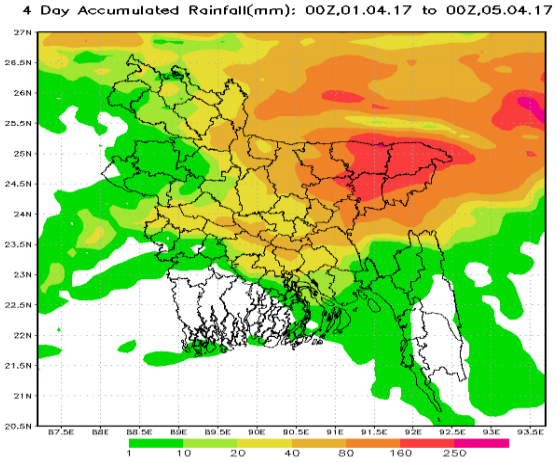
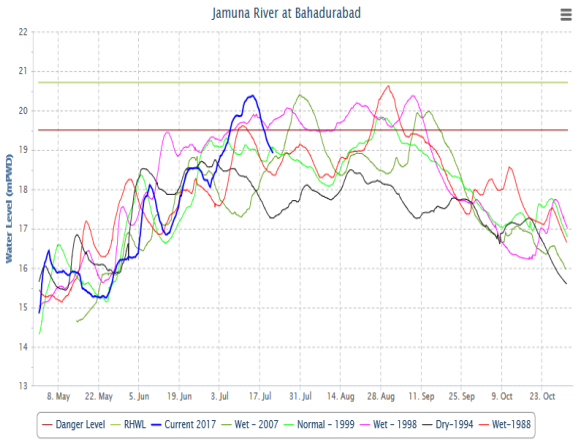
ANNUAL FLOOD REPORT 2017





FLOOD FORECASTING & WARNING CENTER

PROCESSING & FLOOD FORECASTING CIRCLE

BANGLADESH WATER DEVELOPMENT BOARD

TABLE OF CONTENTS

TABLE OF CONTENTS 2
LIST OF TABLES 3
LIST OF FIGURE 5
PREFACE 7
EXECUTIVE SUMMARY 9
LIST OF ABBREVIATIONS 10
CHAPTER 1: INTRODUCTION 12
1.1. THE PHYSICAL SETTING 12
1.2. THE RIVER SYSTEM 12
1.3. ACTIVITIES OF FFWC 14
1.4. OPERATIONAL STAGES BEFORE FORECAST MODEL RUN 15
1.5. NATURE AND CAUSES OF FLOODING 16
1.5.1. Causative Factors 16
1.5.2. Statistics of Flooding 17
CHAPTER 2 : RAINFALL SITUATION 19
2.1 MAY 19
2.2 JUNE 21
2.3 JULY 22
2.4 AUGUST 23
2.5 SEPTEMBER 24
2.6 OCTOBER 25
CHAPTER 3: RIVER SITUATION 33
3.1 THE BRAHMAPUTRA BASIN 33
3.2 THE GANGES BASIN 37
3.3 THE MEGHNA BASIN 40
3.4 THE SOUTH EASTERN HILL BASIN 44
3.5 PEAK AND RECORDED HIGHEST WATER LEVELS 45
CHAPTER 4: FORECAST EVALUATION, 2017 70
4.1 GENERAL 70
4.2 EVALUATION CRITERIA OF FORECAST PERFORMANCE 71
4.2.1. Mean Absolute Error (MAE) 71
4.2.2. Co-efficient of Determination, r^2 71
4.3 PRE-DEFINED SCALES TO EVALUATE FORECAST PERFORMANCE 72
4.4 DETERMINISTIC FORECAST STATISTICS AND PERFORMANCE, 2017 72
CHAPTER 5 : INUNDATION STATUS 83
CHAPTER 6: RESEARCH AND DEVELOPMENT 93
6.1 Flash Flood Forecast for North East Part 93
CHAPTER 7: PATTERN AND MAGNITUDE OF 2017 FLOODS 94
7.1 Early Flood in North East Region 94
7.2 Flood in North-West region 98
7.3 Flood in Assam 101
CHAPTER 8: CONCLUSION 102
ANNEX-1 104
ANNEX-2 105
ANNEX-3 106
ANNEX-4 107
ANNEX-5 108

LIST OF TABLES

TABLE 1.1 :YEAR-WISE FLOOD AFFECTED AREA IN BANGLADESH.....18
TABLE 2.1: RAINFALL STATISTICS FOR THE MONSOON 2017 OVER THE FOUR BASINS 19
TABLE 2.2 : SUMMARY OF THE RAINFALL SITUATION DURING THE MONTH OF MAY-2017.....20
TABLE 2.3: SUMMARY OF THE RAINFALL SITUATION DURING THE MONTH OF JUNE -2017 21
TABLE 2.4: SUMMARY OF THE RAINFALL SITUATION DURING THE MONTH OF JULY-2017 22
TABLE 2.5: SUMMARY OF THE RAINFALL SITUATION DURING THE MONTH OF AUGUST-2017.....24
TABLE 2.6: SUMMARY OF THE RAINFALL SITUATION DURING THE MONTH OF SEPTEMBER-2017.....25
TABLE 2.7: SUMMARY OF RAINFALL FOR THE MONTH OF OCTOBER-2017...26
TABLE 3.1 : COMPARISON OF WATER LEVEL (IN MPWD) OF 2017 AND HISTORICAL EVENTS OF 1988 & 1998 OF SOME IMPORTANT STATIONS IN THE BRAHMAPUTRA BASIN. 36
TABLE 3.2 : COMPARISON OF WATER LEVEL (IN MPWD) OF 2017 AND HISTORICAL EVENTS OF 1988 & 1998 OF SOME IMPORTANT STATIONS IN GANGES BASIN. 39
TABLE 3.3: COMPARISON OF WATER LEVEL (IN MPWD) OF 2017 AND HISTORICAL EVENTS OF 1988 & 1998 OF SOME IMPORTANT STATIONS IN MEGHNA BASIN. 43
TABLE 3.4 : COMPARISON OF WATER LEVEL OF 2017 (IN MPWD) AND HISTORICAL EVENTS OF 1988 AND 1998 OF SOME IMPORTANT STATION IN SOUTH EASTERN HILL BASIN. 45
TABLE 3.5: RECORDED PEAK WATER LEVEL (IN MPWD) WITH DATES DURING THE MONSOON-2017.....45
TABLE 3.6: RECORDED HISTORICAL HIGHEST WATER LEVELS (IN MPWD) WITH DATES 48
51
59
TABLE 4.1 : SCALES USED FOR PERFORMANCE EVALUATION.....72
TABLE 4.2: STATISTICS FOR 24-HOURS FORECAST PERFORMANCE (YEAR, 2017) 73
TABLE 4.3: STATISTICS FOR 48-HOURS FORECAST PERFORMANCE (YEAR, 2017) 74
TABLE 4.4: STATISTICS FOR 72-HOURS FORECAST PERFORMANCE (YEAR, 2017) 75
TABLE 4.5: STATISTICS FOR 96-HOURS FORECAST PERFORMANCE (YEAR, 2017) 76
TABLE 4.6: STATISTICS FOR 120-HOURS FORECAST PERFORMANCE (YEAR, 2017) 77

TABLE 7.1 : RECORDED RAINFALL MEGHALAYA AND BARAK BASIN DURING 29/03/2017 TO 05/04/2017 (RAINFALL IN MM) 94

TABLE 7.2: RECORDED RAINFALL IN MAJOR STATIONS IN THE NORTH EAST REGION DURING 29/03/2017 TO 05/04/2017 (RAINFALL IN MM) 94
TABLE 7.3: RECORDED RAINFALL MEGHALAYA AND BARAK BASIN DURING 17/04/2017 TO 27/04/2017 (RAINFALL IN MM) 95
TABLE 7.4: RECORDED RAINFALL IN MAJOR STATIONS IN THE NORTH EAST REGION DURING 17/04/2017 TO 27/04/2017 (RAINFALL IN MM) 95
TABLE 7.5: RAINFALL OF MAJOR STATIONS IN THE NORTH EAST REGION IN APRIL 2017 (RAINFALL IN MM) 95
TABLE7.6: RISE OF WATER LEVEL IN MAJOR RIVERS BETWEEN 27/03/2017 TO 02/04/2017 96
TABLE 7.7: ACTUAL RAINFALL DURING MAY TO SEPTEMBER, 2017 98
TABLE 7.8: ACTIVITY OF MONSOON DURING 7 AUGUST TO 14 AUGUST, 2017 98
TABLE 7.9: RAINFALL EVENTS IN NORTH-WEST REGION 99
TABLE 7.10: RAINFALL EVENTS IN THE UPPER CATCHMENT OF TEESTA-DHARLA-DUDKUMAR 99
TABLE 7.11: RAINFALL EVENTS IN ASSAM 99
TABLE 7.12: DAYS OF WATER LEVEL ABOVE DANGER LEVELS AT MAJOR RIVERS IN THE NORTH 100
TABLE 7.13: SEVERE FLOOD AT SEVERAL PLACES 100

LIST OF FIGURE

FIGURE 1 : BASIN MAP OF BANGLADESH WITH WATER LEVEL GAUGE STATIONS 11
FIGURE 2.1 : ISOHYET OF ACTUAL RAINFALL (MAY-2017) 27
FIGURE 2.2 : ISOHYET OF ACTUAL RAINFALL (JUNE 2017) 28
FIGURE 2.3 : ISOHYETS OF ACTUAL RAINFALL (JULY-2017) 29
FIGURE 2.4 : ISOHYET OF ACTUAL RAINFALL (AUGUST-2017) 30
FIGURE 2.5 : ISOHYETS OF ACTUAL RAINFALL (SEPTEMBER-2017) 31
FIGURE 2.6 : ISOHYET OF ACTUAL RAINFALL (OCTOBER-2017) 32
FIGURE 3.1: COMPARISON OF HYDROGRAPH ON DHARLA AT KURIGRAM 49
FIGURE 3.2: COMPARISON OF HYDROGRAPH ON TEESTA AT DALIA 49
FIGURE 3.3: COMPARISON OF HYDROGRAPH ON GHAGOT AT GAIBANDHA 49
FIGURE 3.4: COMPARISON OF HYDROGRAPH ON UPPER KARATOA AT PANCHAGARH 50
FIGURE 3.5: COMPARISON OF HYDROGRAPH ON TANGON AT THAKURGAON 50
FIGURE 3.6: COMPARISON OF HYDROGRAPH ON C. JAMUNESWARI AT BADARGANJ 50
FIGURE 3.7: COMPARISON OF HYDROGRAPH ON PUNARBHABA AT DINAJPUR 51
FIGURE 3.8: COMPARISON OF HYDROGRAPH ON ATRAI AT MOHADEVPUR 51
FIGURE 3.9: COMPARISON OF HYDROGRAPH ON BRAHMAPUTRA AT NOONKHAWA 52
FIGURE 3.10: COMPARISON OF HYDROGRAPH ON BRAHMAPUTRA AT BAHADURABAD 52
FIGURE 3.12: COMPARISON OF HYDROGRAPH ON JAMUNA AT ARICHA 53
FIGURE 3.13: COMPARISON OF HYDROGRAPH ON ATRAI AT BAGHABARI 54
FIGURE 3.14 : COMPARISON OF HYDROGRAPH ON BURIGANGA AT DHAKA (MILBARAK) 54
FIGURE 3.15: COMPARISON OF HYDROGRAPH ON LAKHYA AT NARAYANGONJ 55
FIGURE 3.16 : COMPARISON OF HYDROGRAPH ON TURAG AT MIRPUR 55
FIGURE 3.17: COMPARISON OF HYDROGRAPH ON GANGES AT PANKHA 56
FIGURE 3.18: COMPARISON OF HYDROGRAPH ON GANGES AT RAJSHAHI 56
FIGURE 3.19: COMPARISON OF HYDROGRAPH ON GANGES AT HARDINGE BRIDGE 57
FIGURE 3.20: COMPARISON OF HYDROGRAPH ON PADMA AT GOALONDO 57
FIGURE 3.21: COMPARISON OF HYDROGRAPH ON PADMA AT BHAGYAKUL 58
FIGURE 3.22: COMPARISON OF HYDROGRAPH ON GORAI AT GORAI RAILWAY BRIDGE 58
FIGURE 3.23: COMPARISON OF HYDROGRAPH ON KOBODAK AT JHIKARGACHA 59
FIGURE 3.24: COMPARISON OF HYDROGRAPH ON SURMA AT KANAIGHAT 59
FIGURE 3.25: COMPARISON OF HYDROGRAPH ON SURMA AT SYLHET 60
FIGURE 3.26: COMPARISON OF HYDROGRAPH ON SURMA AT SUNAMGANJ 60
FIGURE 3.27: COMPARISON OF HYDROGRAPH ON KUSHIYARA AT AMALSHID 61
FIGURE 3.28: COMPARISON OF HYDROGRAPH ON KUSHIYARA AT SHEOLA 61
FIGURE 3.29: COMPARISON OF HYDROGRAPH ON KUSHIYARA AT SHERPUR 62
FIGURE 3.30: COMPARISON OF HYDROGRAPH ON MANU AT MANU RAIL BRIDGE 62
FIGURE 3.31: COMPARISON OF HYDROGRAPH ON KHOWAI AT HABIGANJ 63

FIGURE 3.32: COMPARISON OF HYDROGRAPH ON BHUGAI AT NAKUAGAON ... 63
FIGURE 3.33: COMPARISON OF HYDROGRAPH ON JADUKATA AT LORERGARH64
FIGURE 3.34: COMPARISON OF HYDROGRAPH ON SOMESWARI AT DURGAPUR ... 64
FIGURE 3.35: COMPARISON OF HYDROGRAPH ON KANGSHA AT JARIAJANJAIL ... 65
FIGURE 3.36: COMPARISON OF HYDROGRAPH ON UPPER MEGHNA AT BHAIRAB BAZAR ... 66
FIGURE 3.37: COMPARISON OF HYDROGRAPH ON MUHURI AT PARSHURAM.... 66
FIGURE 3.38 : COMPARISON OF HYDROGRAPH ON HALDA AT NARAYANHAT . 67
FIGURE 3.39: COMPARISON OF HYDROGRAPH ON SANGU AT BANDARBAN..... 67
FIGURE 3.40: COMPARISON OF HYDROGRAPH ON SANGU AT DOHAZARI 68
FIGURE 3.41: COMPARISON OF HYDROGRAPH ON MATAMUHURI AT LAMA 68
FIGURE 3.42: COMPARISON OF HYDROGRAPH ON MATAMUHURI AT CHIRINGA ... 69
FIGURE 3.43: COMPARISON OF HYDROGRAPH ON FENI AT RAMGARH 69
FIGURE 4.1 : 24-HRS FORECAST EVALUATION (YEAR, 2017)..... 78
FIGURE 4.2 : 48-HRS FORECAST EVALUATION (YEAR, 2017)..... 79
FIGURE 4.3 : 72-HRS FORECAST EVALUATION (YEAR, 2017)..... 80
FIGURE 4.4 : 96-HRS FORECAST EVALUATION (YEAR, 2017)..... 81
FIGURE 4.5 : 120-HRS FORECAST EVALUATION (YEAR, 2017)..... 82
FIGURE 5.1: COMPARISON OF FFWC FLOOD INUNDATION MAP (16TH AUGUST 2017) WITH SENITNEL-1 BASED INUNDATION MAP (BETWEEN 12TH -22ND AUGUST 2017) ... 86
FIGURE 5.2: FLOOD INUNDATION MAP OF BANGLADESH (ON 16 AUGUST 2017) ... 87
FIGURE 5.3 : FLOOD INUNDATION MAP OF BANGLADESH (24HR FORECAST BASED ON 16 AUGUST 2017)..... 88
FIGURE 5.4: FLOOD INUNDATION MAP OF BANGLADESH (48HR FORECAST BASED ON 16 AUGUST 2017)..... 89
FIGURE 5.5: FLOOD INUNDATION MAP OF BANGLADESH (72HR FORECAST BASED ON 16 AUGUST 2017)..... 90
FIGURE 5.6 : FLOOD INUNDATION MAP OF BANGLADESH (96HR FORECAST BASED ON 16 AUGUST 2017)..... 91
FIGURE 5.7 : FLOOD INUNDATION MAP OF BANGLADESH (120HR FORECAST BASED ON 16 AUGUST 2017)..... 92
FIGURE 6.1: FLASH FLOOD WEB PORTAL 93
FIGURE 7.1 : HYDROGRAPH OF SURMA RIVER AT SYLHET 96
FIGURE 7.2: HYDROGRAPH OF SURMA RIVER AT SUNAMGANJ..... 97
FIGURE 7.3: HYDROGRAPH OF JADUKATA RIVER AT LORERGARH..... 97
FIGURE 7.4: NEWS CLIP FROM THE DAILY ANANDABAZAR (INDIA)..... 101

PREFACE

Bangladesh is the part of world's most dynamic hydrological and the biggest active delta system. The topography, location and outfall of the three great rivers shapes the annual hydrological cycle of the land. Too much and too little water in a hydrological cycle is the annual phenomenon. Regular monsoon event is the flood, the depth and duration of inundation are the deciding factors whether it affecting beneficially or adversely. Monsoon inflow along with rainfall historically shapes the civilization, development, environment, ecology and the economy of the country. Extreme events of flood adversely affect the development, economy, food security, poverty and almost every sector. In flood management, Bangladesh has been taken structural and non-structural measures. One of the main non-structural measures is the flood forecasting and warning.

As stated in the BWDB Act-2000, Flood Forecasting in Bangladesh is the mandate and responsibility of Bangladesh Water Development Board (BWDB) and Flood Forecasting and Warning Center (FFWC) is being carried out this. The FFWC was established in 1972 and is fully operative in the flood season, from April to October every year, following the Standing Orders for Disaster (SOD) of the Government of Bangladesh. The FFWC is acting as the focal point on flood forecasting and warning services in co-ordination with other ministries and agencies like BMD, DDM, DAE etc during the monsoon for flood disaster mitigation and management.

The objectives of flood forecasting and warning services are to enable and persuade people, community, agencies and organizations to be prepared for the flood and take necessary actions to increase safety and reduce or protect damages of lives and properties. Its goal is to alert the agencies, departments, communities and people to enhance their preparedness and to motivate vulnerable communities to undertake preparedness and protective measures.

The professionals of FFWC gratefully acknowledge the valuable advice and leadership of Director General, BWDB for his interest, continuous drive and suggestion. The valuable suggestions and encouragement provided by the ADG (Planning), Chief Engineer, Hydrology and Superintending Engineer, Processing & Flood Forecasting Circle, Hydrology, BWDB to improve the quality of works of the center.

The services of Flood Information Centers (FICs) established at the Division Offices of BWDB, Gauge Reader's, Wireless operators, local communities and other support service providers are gratefully acknowledged. The FFWC is also grateful to the print and electronic news media and those who helped in disseminating the flood information and warning messages during flood 2017. A number of NGOs have been working in different areas for dissemination of the flood warning message generated by the FFWC at community and grass root level (Union and Village), this enables flood preparedness at local level.

FFWC is providing the following services

- Daily flood bulletin for 90 water level monitoring stations on major rivers and 59 rainfall measurement stations throughout the country
- Observed rainfall map
- Deterministic flood forecast lead time extended from 3-days to 5-days
- Structure based forecast for 3 BWDB projects and Dhaka-Mawa Highway
- Model based flood inundation map on current day along with forecast inundation maps for next five days
- Upgraded/updated, easy to operate, interactive and more user friendly web-site with flood warning message both in Bangla and English
- Flood warning dissemination through toll free Interactive Voice Response (IVR) method using mobile phone (number 1090)

FFWC is primarily disseminating its forecast products through website and feedback from different stakeholder is essential for its improvement. FFWC is trying to develop further the process and system to cope-up with the technological and computational development. One of the main struggle and demand is to increase flood forecasting and warning lead time and location specific flood forecast.

The FFWC hopes that this report might be a point of interest to the planners, designers, administrators, working in the water sector, disaster managers/fighters and various activities of formulating measures for flood mitigation/management in Bangladesh. The FFWC warmly welcomes comments and suggestions; these would certainly improve the services, activities and output of the FFWC in the coming days.

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Executive Summary

The characteristics of flood of 2017 is a representative of severe one in terms of duration and magnitude. During the monsoon 2017, while the flood was a severe one, duration was medium in the north (along the Brahmaputra-Jamuna River). Several rivers in the Brahmaputra basin exceeded their historical record in August. The country also faced severe flash flood in very early April in the North East region and landslide in June at many places in the South East hilly region. Duration of flooding in the central part (along the Padma river) was medium and moderate in magnitude. Duration of flooding in some rivers like Kushiyara was longer in the monsoon period. As a whole, the monsoon 2017 was a moderate to severe flood year in Bangladesh.

The country as a whole received just around 1.20% less rainfall than normal during the monsoon-2017 (May to October), which can be considered as normal rainfall for the monsoon. During the season, the Brahmaputra basin received 17.90% less rainfall, while the Ganges, Meghna and South Eastern Hill basins received 1.79%, 0.78% and 4.25% more rainfall than normal respectively. Except the South Eastern Hill basin, all the basins recorded more rainfall than their respective monthly normal in August, 2017. Based on percentage, basin wise monthly less (-) or more (+) rainfall than the normal are presented in the following table.

Month	Brahmaputra basin	Ganges basin	Meghna basin	South East Hill basin
May	-18.00%	-21.82%	-26.23%	-43.11%
June	-39.82%	-20.88%	15.03%	20.94%
July	-21.97%	26.37%	-22.91%	29.43%
August	10.57%	5.45%	44.74%	-20.58%
September	-30.07%	-28.49%	-0.55%	19.83%
October	27.62%	90.45%	46.12%	-3.67%

[BWDB Data 2017]

Professionals of the FFWC have been fully dedicated and committed to generate and disseminate flood forecasting and warning services on daily basis during the monsoon.

During the monsoon-2017, maximum flooded area was 42% of the whole country (62,000 sq-km approximately).

List of Abbreviations

ADG	Additional Director General
ADPC	Asian Disaster Preparedness Centre
BWDB	Bangladesh Water development Board
BMD	Bangladesh Meteorological Department
CB	Cell Broadcast
CDMP	Comprehensive Disaster Management Programme
CEGIS	Centre for Environmental Geographical Information Services
CFAB	Climate Forecast Application Bangladesh
CARE	Cooperative for American Relief Everywhere
CFAN	Climate Forecast Application Network
DG	Director General
DL	Danger Level
DDM	Department of Disaster Management
DHI	Danish Hydraulic Institute
ECMWF	European Centre for Medium-Range Weather Forecasts
DEM	Digital Elevation Model
DAE	Department of Agriculture Extension
FFWC	Flood Forecasting and Warning Centre
GM	General Model
GBM	Ganges Brahmaputra Meghna
IWM	Institute of Water Modelling
IVR	Interactive Voice Response
MAE	Mean Absolute Error
MoFDM	Ministry of Food and Disaster Management
MoWR	Ministry of Food Water Resources
NGO	Non-Government Organization
MSL	Mean Sea Level
RHWL	Recorded Highest Water Level
RIMES	Regional Integrated Multi-hazard Early Warning System
SOD	Standing Order on Disaster
SSB	Single Site Band
SPARRSO	Space Research and Remote Sensing Organization
UNDP	United Nations Development Porgramme
USAID	United States Agency for International Development
WL	Water Level

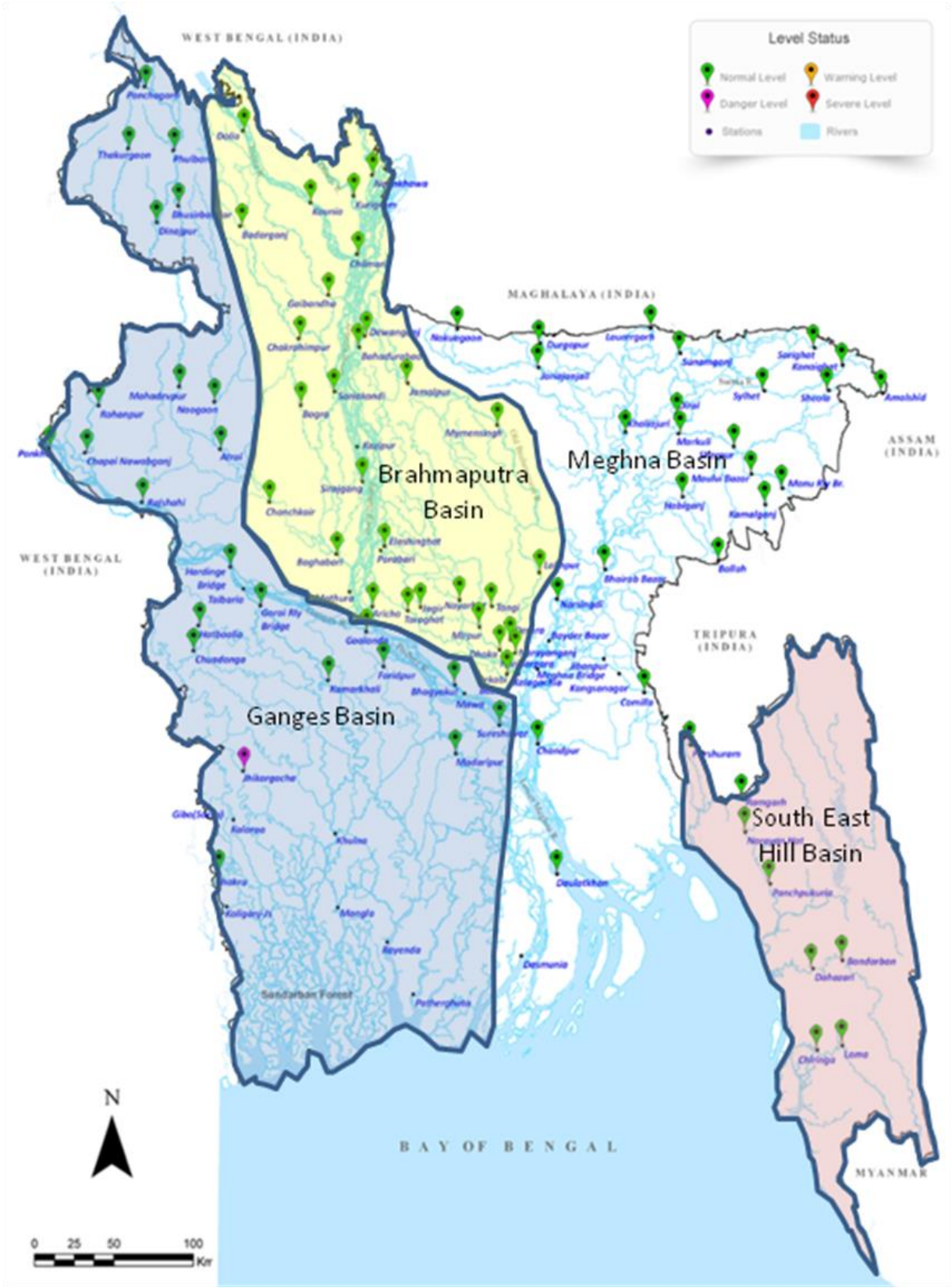


Figure 1 : Basin Map of Bangladesh with Water Level Gauge Stations

CHAPTER 1: INTRODUCTION

1.1. THE PHYSICAL SETTING

Bangladesh lies approximately between 20°30' and 26°40' north latitude and 88°03' and 92°40' east longitude. It is one of the biggest active deltas in the world with an area of about 1,47,570 sq-km. The country is under sub-tropical monsoon climate, annual average precipitation is 2,300 mm, varying from 1,200 mm in the north-west to over 5,000 mm in the north-east. India borders the country in west, north and most part of east. The Bay of Bengal is in the south, Myanmar borders part of the south-eastern area. It has 405 rivers including 57 transboundary rivers, among them 54 originated from India including three major rivers the Ganges, the Brahmaputra and the Meghna (*Ref. Bangladesher Nod Nodi, BWDB, August 2011*). Three rivers originated from Myanmar. Monsoon flood inundation of about 20% to 25% area of the country is assumed beneficial for crops, ecology and environment. But flood more than that causing direct and indirect damages and considerable inconveniences to the population.

The country is mostly flat with few hills in the southeast and the northeast part. Generally ground slopes of the country extend from the north to the south and the elevation ranging from 60 meters to one meter above Mean Sea Level (MSL) at the Northwest boundary of the country and at the coastal areas in the south. The land in the west of the Brahmaputra is higher than the eastern part. Several large depressions have been formed, particularly in greater Mymensingh, Sylhet, Sunamgonj and part of Pabna-Rajshahi districts. The country consists of the flood plains of the Ganges, the Brahmaputra and the Meghna rivers and their numerous tributaries and distributaries. The Ganges and the Brahmaputra join together at Aricha-Goalundo and is known as the Padma River. The river Meghna joining the Padma near Chandpur flows to the Bay of Bengal as the Meghna River.

1.2. THE RIVER SYSTEM

The Ganges, Brahmaputra and Meghna river systems together, drain the huge runoff generated from large area with the highest rainfall areas in the world. Their total catchment area is approximately 1.6 million sq-km of which only about 7.5% lies in Bangladesh and the rest, 92.5% lies outside the territory. It is assumed that an average flow of 1,009,000 Million cubic meters passes through these river systems during the monsoon season. Most of the rivers are characterized by having sandy bottoms, flat slopes, substantial meandering, banks susceptible to erosion and channel shifting. The river system of Bangladesh is one of the most extensive in the world, and the Ganges and the Brahmaputra are amongst the largest rivers on earth in terms of catchment size, river length and discharge.

The Brahmaputra (Jamuna) river above Bahadurabad has a length of approximately 2,900 km and a catchment area about 5,83,000 sq-km. Started from the glaciers in the

northernmost range of the Himalayas and flows east far above half its length across the Tibetan plateau. In the complex mountain terrain bordering north-east India and China it bends through a series of gorges and is joined by a number of major tributaries, e.g., the Dihang and the Luhit before entering its broad valley section in Assam. This stretch is about 720 km long to the border of Bangladesh and throughout most of this, the course is braided. This braided channel is continued to the confluence with the Ganges.

Within Bangladesh, the Brahmaputra receives four major Right Bank tributaries - the Dudkumar, the Dharla, the Teesta and the Hurasagar. The first three are flashy rivers, rising in steep catchments on the southern side of the Himalayan between Darjeeling and Bhutan. The Hurasagar River is the outlet to the Karatoya-Atrai river system, which comprises much of the internal drainage of northwest of Bangladesh.

The Old Brahmaputra is the main left-bank distributaries of the Brahmaputra river presently known as the Jamuna. The shift of river course appears to have been taken place after a major earthquake and catastrophic flood in 1787. It is now a high flow spill river contributing largely to flood, as in the Dhaleswari, and their behavior is highly dependent on the variations of siltation at their entries.

Total length of the Ganges River is about 2,600 km to its confluence with the Brahmaputra -Jamuna at Aricha-Goalondo and a catchment area of approximately 9,07,000 sq-km. Started from the high western Himalayans glaciers, the Ganges has a short mountain course of about 160 km. From there it flows south easterly in a vast plain with major tributaries from the southern Himalayans in Nepal and smaller rivers from the central Indian Plateau to the south. With deep-water channel with numerous bar formations (chars), the Ganges is not braided. After its confluence with the Jamuna at Goalondo, the river, known as the Padma, flows in a wide and straight. At Chandpur, the Padma is joined to the Meghna from where it flows to the sea with tidal influence.

The Meghna system originates in the hills of Shillong and Meghalaya of India. The main source is the Barak River, which has a considerable catchment in the ridge and valley terrain of eastern Assam bordering Myanmar. On reaching the border with Bangladesh at Amalshid in Sylhet district, it bifurcates into Surma and the Kushiyara rivers. The Surma, flowing on the north of the Sylhet basin receives Right Bank tributaries from Khasia and Jaintia Hills of Shillong. These are steep, highly flashy rivers, originating in one of the wettest area of the world, the average annual rainfall at Cherrapunji at Meghalay being about 11,755 mm. The Kushiyara receives left bank tributaries from the Tripura Hills, the principal ones being the Manu. Also, flashy in nature with less elevations and rainfall of Tripura makes these rivers less violent than the northern streams.

Between the Surma and Kushiyara, there are many internal draining depressions (haors), meandering flood channels and abandoned river courses, which are widely flooded every monsoon season. The two rivers rejoined at Markuli and flow via Bhairab as the Meghna to join the Padma at Chandpur. The major tributaries of any size outside the Sylhet basin

are the Gumti and the Khowai River, which rises in Tripura and other hilly streams from Meghalaya and Assam of India to join the Meghna.

The streams of the southeast region are all short and of a flashy nature, rising in the Chittagong Hill Tracts or adjacent parts of eastern India. The main streams are the Muhuri, Halda, Sangu, Matamuhuri, etc.

1.3. ACTIVITIES OF FFWC

The importance of the flood forecasting and warning is recognized as a vital non-structural measures to aid the mitigating the loss of lives, crops and properties caused by the annual flood occurrence. The Flood Forecasting and Warning Centre, under the Directorate of Processing and Flood Forecasting Circle, Hydrology, BWDB takes hydrological monitoring data of 90 representative water level stations and 59 rainfall stations throughout the country. The principal outputs are the daily statistical bulletin of floods, river situation, a descriptive flood bulletin, forecast for 24, 48, 72, 96 and 120 hours at 54 monitoring points on the major rivers, special flood report along with different graphical and statistical presentation during the monsoon season. The Centre is also involved in preparation of flood status report at national level, weekly bulletin during dry season bulletin, monthly and annual flood reports. The Centre is responsible as a focal point in respect of flood from the month of April to November as per Government order for generating flood forecast & warning that are issued with the flood bulletin and also provide support services to DDM other relevant organization.

OUTPUTS of the FFWC

- **Rainfall distribution/surface Map.**
- **Daily Flood Bulletin & River situation summary**
- **Forecast bulletin & Hydrograph**
- **Warning message**
- **River situation map**
- **Special outlook**
- **Press briefing**
- **Structure based flood forecast**
- **Flood inundation map**
- **Comparison Hydrographs for various years**

Step by step development has been made in the flood forecasting and warning services in Bangladesh, started from 1972. Before 1990, forecast for six locations viz. Bahadurabad, Serajgonj, Aricha, Goalondo, Bhagyakul and Hardinge Bridge on the Padma – Brahmaputra –Jamuna river system were issued by Co-axial correlation, Gauge to Gauge relation and Muskingum-Cunge Routing Model. After the devastating flood of 1987 and catastrophic flood of 1988, it was deeply realized that the forecast formulation should be introduced in the process of river modelling. In view of the above, the simulation model MIKE11 developed by Danish Hydraulic Institute (DHI) was installed at FFWC and a special version of MIKE11 FF conceptual Hydrodynamic model is in operation for forecast formulation.

The General Model (GM) developed under MIKE11 was adapted to real time operation in which boundary extended near to the Indian border on all main rivers. A supermodel now is in operational at FFWC covering entire flood affected area of Bangladesh, except coastal zone, the southern part. The Supermodel covers about 82,000 km^2 of entire country, except the coastal zone of the country. The area covered under the supermodel is divided into 107 numbers of sub-catchments. It includes 195 river branches, 207 link channels, 40 Broad Crested Weirs. The total river length modeled is about 7300 km. Model operation and data base management is being done with a well-managed server based (Widows 2000) LAN–Operating System installed with desk top PCs at the FFWC.

Flood Forecasting & Warning Services: Brief History

1972 - FFWC Established under BWDB
- Real Time Flood Monitoring at 10 Stations/Points along the Brahmaputra, Ganges and Padma rivers
- Flood Forecast (FF) with few hours lead time at 6 points by Gauge Correlation along Brahmaputra and Padma rivers

1992 - MIKE11-FF Model Introduced
- FF with one day lead time at 16 points/locations

1995-96 - MIKE11 Super Model with GIS
- FF at 30 locations with lead time upto 2-days

2000-04 - Strengthening FFWS
- Expansion of FF areas coverage
- Flood monitoring covers entire country
- Improved accuracy and extend Lead Time upto 3-days
- Improved dissemination

2005-07 - Probabilistic medium range FF with lead time upto 10-days initiated at 18 points/locations

2007-09 - Further extension of FFWS
- Mike 11 Super Model with GIS introduced with flood ma generation facility
- FF at 38 locations on 21 Rivers upto 3-days Lead Time
- Flood Inundation Mapping
- Improvement of probabilistic medium range FF upto 10-days at 18 points

From 2012 - Strengthening and Improvement of FFWS
- FF at 54 locations on 29 rivers with Extended Lead Time upto 5-days
- Structure based FF for 4-selected projects upto 5-days lead time
- Improved and more user friendly web-site with Bangla language
- IVR system for dissemination based on mobile phone introduced
- Improved LAN and display.

1.4. OPERATIONAL STAGES BEFORE FORECAST MODEL RUN

Data Collection: The real time hydrological data (90 WL stations and 59 rainfall stations) is collected by SSB wireless, fixed & mobile telephone from the BWDB hydrological network. WL for non-tidal stations are collected five times daily at 3 hourly intervals during day time from 6:00 AM to 6:00 PM, and for tidal stations collected hourly. Rainfall is collected daily period beginning at 9 AM. The data collections at FFWC are

usually completed within 9.30 A.M. using mobile sms. Limited WL, rainfall and forecasts of upper catchments from Indian stations are also collected through internet, e-mail, and from BMD.

Essential Information's: Estimation of WL at the model boundaries and rainfall for the catchments are required input to the model upto the time of Forecast (24, 48, 72, 96 & 120hrs). For the rainfall estimation, satellite images from NOAA and IMD is used. In addition a dedicated land line radar link with BMD (Bangladesh Meteorological Department) provided frequent (five minutes interval) rainfall information.

Forecast Calculation: Collected/observed WL and rainfall data are given input to the computer database and checked. The WL and rainfall estimation has to be prepared. During monsoon (June to October) WL of few stations of upper catchments of Ganges, Brahmaputra, Teesta, Dharala and Barak rives has been received since 2010 from CWC India through e-mail. The basis for WL estimation is considering trend Hydrograph extrapolated upto the period of forecast from previous few days data, response characteristics of rivers, effect of rainfall on WL and Indian available WL & forecasts data. Rainfall estimation based on previous 2-day's rainfall and analysis of information collected. After input required data and boundary-estimated data to the model, model run started. It takes about 30 to 40 minutes time to complete the calculations.

Daily forecast bulletin is prepared upto 5 days for important locations and region-wise flood warning messages. The bulletins are disseminated to more than 600 recipients including different ministries, offices (central & district level), individuals, print & electronic news media, development partners, research organizations, NGO's etc. including President's & Prime Minister's Secretariat. Whenever, the forecast river stage cross the DL, the concern field offices and limited key officials are informed through mobile SMS. Interactive Voice Response (IVR) through mobile has been initiated since July 2011 through Teletalk. Now, all the mobile operators have started the IVR since 2015.

The flood forecast is intended to alert the people of the locality about the predicted WL of floodwater 3-days ahead of its occurrence. An accurate forecast would be one where the forecast level and corresponding observed level at the stipulated time are within a small range of variation.

Mode of Dissemination

- E-mail
- Website
- Media, print & electronic
- Telephone, Mobile, Fax
- Hard/print copy
- Lobby display
- (IVR) through mobile (no 1090)

1.5. NATURE AND CAUSES OF FLOODING

1.5.1. Causative Factors

There are for climatic distinct seasons(i) Winter November to February (ii) Premonsoon March to May, (iii) Monsoon June to September (iv) Post monsoon. Over 80% of the

rainfall occurs during the monsoon or rainy season also known as flood season. The normal annual rainfall of the country varies approximately from 1,200 mm in the west to over 5,000 mm in the east. Long periods of steady rainfall persisting over several days are common during the monsoon, but sometimes local high intensity rainfall of short duration also occurs.

Floods in Bangladesh occur for number of reasons. The main causes are excessive precipitation, low topography and flat slope of the country; but others include:

- *The geographic location and climatic pattern:* Bangladesh is located at the foot of the highest mountain range in the world, the Himalayas, which is also the highest precipitation zone in the world. This rainfall is caused by the influence of the south-west monsoon. Cherapunji, highest rainfall in the world, is located a few kilometers north east of the Bangladesh border
- *The confluence of three major rivers, the Ganges, the Brahmaputra and the Meghna:* the runoff from their vast catchment (about 1.72 million km²) passes through a small area, only 8% of these catchments lie within Bangladesh. During the monsoon season the amount of water entering Bangladesh from upstream is greater than the capacity of the rivers to discharge in to the sea.
- *Bangladesh is a land of rivers:* there are about 310 major and minor rivers in the country. The total annual runoff of surface water flowing through the rivers of Bangladesh is about 12,000 billion cubic meters.
- *Man-made environment:* the construction of embankments in the upstream catchments reduces the capacity of the flood plains to store water. The unplanned and unregulated construction of roads and highways in the flood plain without adequate opening creates obstructions to flow.
- *The influence of tides and cyclones*: the frequent development of low pressure areas and storm surges in the Bay of Bengal can impede drainage. The severity of flooding is greatest when the peak floods of the major rivers coincide with these effects.
- *Long term environmental changes:* climate changes could influence the frequency and magnitude of flooding. A higher sea level will inhibit the drainage from the rivers to the sea and increase the impact of tidal surges. Deforestation in hilly catchments causes more rapid and higher runoff, and hence more intense flooding.

The springtides of the Bay of Bengal retard the drainage of floodwater into the sea and locally increase monsoon flooding. A rise of MSL at times during the monsoon period due to effect of monsoon winds also adversely affect the drainage and raise the flood level along the coastal belt.

1.5.2. Statistics of Flooding

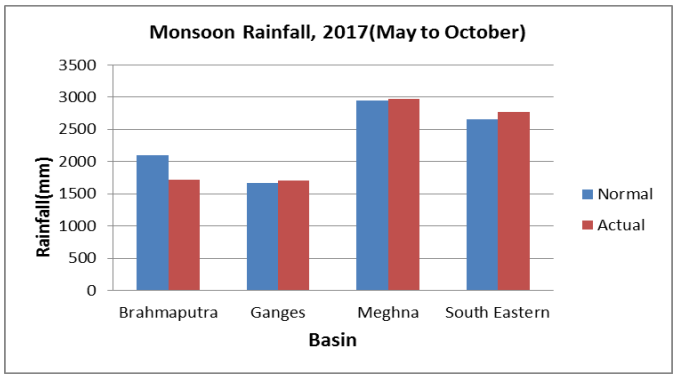
Many parts of the Asia during monsoon frequently suffer from severe floods. Some parts of India and Bangladesh experience floods almost every year with considerable damage.

The floods of 1954, 1955, 1974, 1987, 1988, 1998, 2004 and 2007 all caused enormous damages to properties and considerable loss of life. The floods of 1987, 1988 1998, 2004 and 2007 flood caused heavy damage. During monsoon 2017, the flood was a moderate to severe one which stayed up to medium duration in the Brahmaputra and Ganges basins, but for an extensively long period in the Meghna basin. Flood in the South Eastern Hill basin stayed for short period however inflicted damages. During monsoon-2017, 42% of the country got flood affected which corresponded to 35 nos. of flood affected districts (part of full, on the low-lying areas) namely: Kurigram, Rangpur, Lalmonirhat, Nilphamari, Gaibandha, Bogra, Sirajganj, Tangail, Jamalpur, Natore, Pabna, Manikganj, Narayanganj, Rajbari, Faridpur, Manikganj, Munshiganj, Shariatpur, Panchagarh, Thakurgaon, Dinajpur, Naogaon, Chapai Nawabganj, Jessore, Sylhet, Sunamganj, Netrokona, Brahmanbaria, Habiganj, Moulvibazar, Sherpur, Chittagong, Bandarban, Cox's Bazar and Feni. Percent of total area of Bangladesh affected by the flood are available since 1954 is presented in Table 1.1.

Table 1.1 :Year-wise Flood Affected Area in Bangladesh

Year	Flood Affected area		Year	Flood affected area		Year	Flood affected area	
	Sq-Km	**%**		**Sq-Km**	**%**		**Sq-Km**	**%**
1954	36,800	25	1977	12,500	8	2000	35,700	24
1955	50,500	34	1978	10,800	7	2001	4,000	2.8
1956	35,400	24	1980	33,000	22	2002	15,000	10
1960	28,400	19	1982	3,140	2	2003	21,500	14
1961	28,800	20	1983	11,100	7.5	2004	55,000	38
1962	37,200	25	1984	28,200	19	2005	17,850	12
1963	43,100	29	1985	11,400	8	2006	16,175	11
1964	31,000	21	1986	6,600	4	**2007**	**62,300**	**42**
1965	28,400	19	1987	57,300	39	2008	33,655	23
1966	33,400	23	**1988**	**89,970**	**61**	2009	28,593	19
1967	25,700	17	1989	6,100	4	2010	26,530	18
1968	37,200	25	1990	3,500	2.4	2011	29,800	20
1969	41,400	28	1991	28,600	19	2012	17,700	12
1970	42,400	29	1992	2,000	1.4	2013	15,650	10.6
1971	36,300	25	1993	28,742	20	2014	36,895	25
1972	20,800	14	1994	419	0.2	2015	47,200	32
1973	29,800	20	1995	32,000	22	2016	48,675	33
1974	52,600	36	1996	35,800	24	**2017**	**61,979**	**42**
1975	16,600	11	**1998**	**1,00,250**	**68**			
1976	28,300	19	1999	32,000	22			

CHAPTER 2 : RAINFALL SITUATION



During the monsoon-2017 (May to October), the country experienced as a whole only 1.18 % less rainfall than normal which can be considered as normal rainfall situation in the monsoon period in Bangladesh. The Brahmaputra basin received 17.90% less rainfall, while the Ganges, Meghna and South Eastern Hill basins received 1.79%, 0.78% and 4.25% more rainfall than the normal values respectively, in the year of 2017. Comparison of the country basin average of normal and actual rainfall for the monsoon-2017 (May to October) is presented in the bar chart. Considering monthly value, all the basins have been recorded less rainfall than their respective normal during May-October period except the South-Eastern Hill Region. The monthly normal and actual rainfall of all the basins and the country average are shown in Table 2.1.

Table 2.1: Rainfall statistics for the monsoon 2017 over the four Basins

Month	Brahmaputra Basin(mm)		Ganges Basin(mm)		Meghna Basin(mm)		South Eastern Hill Basin(mm)		Monsoon average (mm)	
	Nor	Act	Nor	Act	Nor	Act	Nor	Act	Normal	Actual
May	315.4	255.86	191.8	148.09	491	329.04	290.4	154.70		
June	433.5	255.88	327	251.54	621	687.74	599.8	691.38		
July	496.1	378.4	397.8	498.81	650.5	487.39	728.5	898.62		
Aug	339.7	383.13	337.8	356.18	537.9	778.53	536.9	426.41	2317.03	2289.80
Sept	353.4	247.15	298.7	201.15	449.2	400.09	317.9	422.14		
Oct	155.6	198.58	120.1	247.3	194.7	284.45	183.4	176.64		
Total	2093.7	1719	1673.2	1703.07	2944.3	2967.24	2656.9	2769.89		
%More/ Less	17.90% Less		1.79% More		0.78% More		4.25% More		1.18% Less	

Rainfall situation of the country for the monsoon-2017 (May to October) is described in the following sections.

2.1 MAY

The country as a whole, experienced rainfall less than normal during the month of May 2017. The basins, namely the Brahmaputra, the Ganges, the Meghna and

Important Rainfall Information for May-2017

Monthly Maximum at Sheola: 694 mm

1 day maximum at Bandarban: 206.0 mm

10 day maximum at Sheola: 450.0 mm

the South-Eastern Hill received 18.00%, 21.82%, 26.23% and 43.11% less rainfall respectively than their monthly normal rainfall.

Table 2.2 : **Summary of the rainfall situation during the month of May-2017**

Basin:	**Brahmaputra**	**Ganges**	**Meghna**	**South Eastern Hill**
No of Stations:	13	18	17	11
Average Rainfall (mm) of the basin:	255.86	148.09	329.04	154.70
%More(+)/Less(-) than the Normal:	-18.00%	-21.82%	-26.23%	-43.11%
Number of Stations above Normal Rainfall:	5	5	2	2
Highest 1-day Maximum Rainfall with Stations:	Chilmari	Jessore	Sunamganj	Bandarban
	126 mm	68.5 mm	106 mm	206 mm
Number of Rain Fed Flood* Stations:	3	0	7	1

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

In Brahmaputra basin, out of 13 rainfall monitoring stations, all the stations except Kurigram, Dalia,Rangpur, Chilmari and Bogra received less rainfall than their normal. The Basin received 18.00% less rainfall than their normal during the month May-2017.

In Ganges basin, out of 18 rainfall monitoring stations, all the stations except Panchagarh, Naogaon, Mohadevpur, Rajshahi, Khulna received less rainfall than their normal value of the month May 2017. The basin as a whole received 21.82% less rainfall than the normal during the month of May-2017.

In the Meghna basin, out of 17 rainfall monitoring stations, all the stations except Sylhet and Sheola received more rainfall than their normal value of the month. The Basin received 26.23% less rainfall than their monthly normal during the month of May-2017 .

Summary of the rainfall situation of the country is presented in Table 2.2. Considering 10-day maximum rainfall of 300 mm as a rain-fed flood index, as many as 11 stations were crossed the threshold value in this month.

During the period of May 2017, all the 90 water level monitoring points flowed below their respective danger levels.

The Isohyet of the actual rainfall of the month of May-2017 is shown in the Figures 2.1.

2.2 JUNE

Important Rainfall Information for June, 2017

Maximum, at Narayanhat : 1062.5 mm

One day maximum, Bandarban : 332 mm

The country, as a whole, experienced rainfall less than normal during the month, June 2017. Among the four basins of the country, the Brahmaputra basin, the Ganges basin received 39.82%, and 20.88% less rainfall respectively while the Meghna basin and the South Eastern Hill basins received 15.03% and 20.94% more rainfall than their respective monthly normal rainfall during the month of June 2017.

The summary of the rainfall situation for June 2017 is shown in the Table 2.3.

Table 2.3: Summary of the rainfall situation during the month of June -2017

Basin:	Brahmaputra	Ganges	Meghna	South Eastern Hill
No of Stations:	13	18	17	11
Average Rainfall (mm) of the basin:	255.88	251.54	687.74	691.38
%More(+)/Less(-) than the Normal:	-39.82%	-20.88%	+15.03%	+20.94%
Number of Stations above Normal Rainfall:	3	6	10	7
Highest 1-day Maximum Rainfall with Stations:	Mymensingh 127.5 mm	Khulna 180 mm	Chandpur 226 mm	Bandarban 332 mm
Number of Rain Fed Flood* Stations:	2	1	11	10

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

In Brahmaputra basin, out of 13 rainfall monitoring stations, three stations namely Dalia, Mymensing and Dhaka were recorded more rainfall than the monthly normal. The Basin received 39.82% less rainfall than their normal during the month June-2017.

6 out of 18 monitoring stations in the Ganges Basin were recorded rainfall above their monthly normal. One day maximum rainfall of 159.8 mm was recorded at Jessore. Ten day consecutive maximum rainfall of 349.8mm was recorded at Barguna. The Basin received 20.88% less rainfall than their monthly normal rainfall during the month of June 2017.

In the Meghna basin, out of 17 rainfall monitoring stations, 10 stations were recorded more rainfall than the normal. One day maximum of 226 mm at Chandpur and the 10-day consecutive maximum rainfall of 557 mm at Sylhet was recorded in the month of June 2017. The Meghna basin as a whole received 15.03% more rainfall than the normal rainfall during the month of June-2017.

In the South Eastern Hill basin, Out of 11 rainfall monitoring stations 7 stations received more rainfall than their normal rainfall for the month of June-2017. One day maximum of 332 mm was recorded at Bandarban and the 10-day consecutive maximum rainfall of 729.3 mm was also recorded at Teknaf. The basin as a whole recorded 20.94% more rainfall than the normal rainfall during the month of June-2017.

Summary of the rainfall situation of the country is presented in the Table 2.3. Out of total 59 rainfall monitoring stations under FFWC system in the country, at 24 stations/points recorded 10-day consecutive rainfall more than 300mm. The maximum 1-day rainfall of 332mm at Bandarban and the 10-day consecutive maximum rainfall of 729.2mm was recorded at Teknaf.

The Isohyet of the actual rainfall of the month of June-2017 are shown in the Figure 2.2.

2.3 JULY

Important Rainfall Information for July 2017

Monthly Maximum at Lama: 1567.5 mm

1 day maximum at lama: 273.00 mm

The country, as a whole, experienced rainfall more than normal during the month of July 2017 due to more rainfall in the Ganges basin and the South Eastern Hill Basin. The Brahmaputra and the Meghna basins received 21.97% and 22.91% less rainfall while the Ganges and South Eastern Hill Basin received 26.37% and 29.43% more rainfall respectively than their respective monthly normal values.

The summary of the rainfall situation of the country during the month of July 2016 is shown in the Table 2.4.

Table 2.4: Summary of the rainfall situation during the month of July-2017

Basin:	**Brahmaputra**	**Ganges**	**Meghna**	**South Eastern Hill**
No of Stations:	13	18	17	11
%More(+)/Less(-) than the Normal:	**-21.97%**	**+26.37%**	**-22.91%**	**+29.43%**
Number of Stations above Normal Rainfall:	3	14	4	8
Highest 1-day Maximum Rainfall with Stations:	Tangail **170 mm**	Faridpur **169 mm**	Durgapur **200.8 mm**	Lama **273 mm**
Number of Rain Fed Flood* Stations:	2	9	6	10
Name of Rain Fed Flood* Stations:	Dalia, Tangail	Panchagarh, Bhagykul, Barguna, Jessore	Sylhet, Sunamganj Durgapur, Lorergarh,	Chittagong, Cox's Bazar, Teknaf, Noakhali,Lama

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

In Brahmaputra basin, all the stations received less rainfall than their normal rainfall except Dhaka, Tangail and Bogra stations. The Basin received **21.97%** less rainfall than their normal during the month July 2017. Monthly 1-day maximum rainfall of 170mm and 10-day max of 330mm was recorded at Tangail. Total rainfall of Dhaka in July 2017 was recorded as 649 mm, which was above the normal rainfall of Dhaka.

In Ganges basin, 14 of 18 stations received more rainfall than their normal. The basin as a whole received **26.36%** more rainfall than its normal during the month of July-2017. One day maximum rainfall of **169** mm at Faridpur and 10-day consecutive maximum rainfall of **672** mm was recorded at Barguna.

In Meghna basin, 13 stations were recorded less rainfall than their normal value of the month. The Basin recorded **22.91%** less rainfall than their normal during the month of July 2017. One day maximum rainfall of 200.8 mm and 10-day consecutive maximum rainfall of 531 mm were recorded at Durgapur.

In South Eastern Hill basin, 8 stations received more rainfall than their normal rainfall. The basin as a whole received 29.43% more rainfall than its normal rainfall during the month of July 2017. One day maximum rainfall of 273 mm and 10-day consecutive maximum rainfall of 882.5 mm was recorded at lama. This rainfall caused water logging and local flood at the area.

Summary of the country's rainfall situation is presented in Table 2.4. Total 27 stations recorded more than 300 mm rainfall for 10-day period. Maximum 10-day and 1-day maximum rainfall recorded at Lama of 882.5 mm and 273 mm. Rain fed flood situation developed at Dalia, Tangail, Panchagarh, Barguna, Jessore, Lorergarh, Sunamganj Jariajanjail, Comilla, Chandpur, Chittagong, Cox's Bazar, Teknaf and in some other places.

A map with isohyets of the actual rainfall of July-2017 is shown in the Figure 2.3.

2.4 AUGUST

Important Rainfall Information for August 2017
Maximum at Sunamganj: 1534 mm
One day maximum at Chandpur: 255.2 mm

The country, as a whole, experienced rainfall more than normal during the month of August 2017. The three hydrological basins Brahmaputra, Ganges and Meghna received more rainfall than their respective monthly normal rainfall during the month of August, 2017. The Brahmaputra, the Ganges and the Meghna received 10.57%, 5.45%, and 44.74% more rainfall and the South Eastern Hill basin received 20.58% less rainfall than their respective normal rainfall of the month. Table 2.5 represents the summary of rainfall situation all through the country.

Table 2.5: Summary of the rainfall situation during the month of August-2017

Basin:	Brahmaputra	Ganges	Meghna	South Eastern Hill
No of Stations:	13	18	17	11
Basin average rainfall at August, 2017(mm):	383.13	356.18	778.53	426.41
%More(+)/Less(-) than Normal:	+10.57%	5.45%	+44.74%	-20.58%
No. of Stations above Normal Rainfall:	6	7	11	3
Highest 1-day Maximum Rainfall Stations:	Dalia	Panchagarh	Chandpur	Lama
	(186 mm)	(209 mm)	(255.2 mm)	(181 mm)
No of Rain Fed Flood* Stations:	2	2	8	7

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

The above table shows that 6 out of 13 rainfall station in the Brahmaputra basin, 7 out of 18 rainfall stations in the Ganges basin; 11 out of 17 rainfall stations in the Meghna basin and 3 out 11 stations in South Eastern Hill the basin received more rainfall than their monthly normal rainfall. Among all monitoring stations, Chandpur in the Meghna Basin has the daily highest rainfall recorded station.

The Table 2.5 shows that 2 stations in Brahmaputra basin, 2 stations in Ganges basin, 8 stations in the Meghna Basin and 7 stations in the South Eastern Hill basin received more than 300 mm rainfall in consecutive 10-day period. It may be mentioned that 300 mm or more rainfall in consecutive 10-day period may cause rain fed flood in the locality.

The Isohyet of the actual rainfall of the month of August-2017 is shown in the Figure 2.4.

2.5 SEPTEMBER

Important Rainfall Information for September 2017
Maximum at Durgapur : 662 mm
1-day maximum at Madaripur : 175.1 mm
10-day maximum at Kanaighat : 381 mm

The country, as a whole, experienced less rainfall than normal during the month of September-2017. Among the four hydrological basins, the Brahmaputra, the Ganges and the Meghna basin received 30.07 %, 28.49% and 0.55% less rainfall and the South-Eastern Hill Basin received 19.83% more rainfall in the month of September 2017. Table 2.1 represents the summary of rainfall situation all through the country.

Table 2.6: Summary of the rainfall situation during the month of September-2017

Basin:	Brahmaputra	Ganges	Meghna	South Eastern Hill
No of Stations:	13	18	17	11
Basin average rainfall at September,2017(mm):	247.15	201.15	400.09	422.14
%More(+)/Less(-) than Normal:	-30.07	-28.49	-0.55	19.83
No. of Stations above Normal Rainfall:	1	4	10	9
Highest 1-day Maximum Rainfall Stations:	Jamalpur (118 mm)	Madaripur (175.1mm)	Durgapur (159 mm)	Ramgarh (122.2 mm)
No of Rain Fed Flood*Stations:	0	0	5	0

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

The above table shows that 1 out of 13 stations in the Brahmaputra, 4 out of 18 stations in the Ganges basin, 10 out of 17 stations in the Meghna and 9 out of 11 stations in South Eastern Hill the basin received more rainfall than their monthly normal rainfall. Among all monitoring stations, Durgapur in the Meghna basin is the monthly highest (662mm) rainfall recipient station.

The table also shows that 5 stations in the Meghna basin received more than 300 mm rainfall in 10-day period. As a result, some parts of Sylhet, Sunamganj, Netrokona were affected by rain feed flood during the month of September 2017. It is to be mentioned here that 300 mm or more rainfall in 10-Day period may cause rain fed flood.

The Isohyet of actual rainfall for September-2017 is shown in the Figure 2.5.

2.6 OCTOBER

Important Rainfall Information for October 2017

Monthly Maximum at Patuakhali: 453.1 mm

1 day maximum at Barisal: 226 mm

10 day maximum at Sunamganj: 374 mm

The country, as a whole, experienced rainfall more than normal during the month of October 2017. The Brahmaputra, the Ganges and the Meghna basins received 27.62%, 90.45%, and 46.12% more rainfall respectively, while South Eastern Hill Basin received 3.67% less rainfall than their monthly normal rainfall.

Table 2.7: Summary of Rainfall for the month of October-2017

Basin:	Brahmaputra	Ganges	Meghna	South Eastern Hill
No of Stations:	13	18	17	11
Average Rainfall (mm) of the basin:	198.57	247.3	284.49	176.6
%More(+)/Less(-) than the Normal:	+27.62 %	+90.45%	+46.12%	-3.67 %
Number of Stations above Normal Rainfall:	8	11	10	5
Highest 1-day Maximum Rainfall with Stations:	Tangail 180 mm	Barisal 226 mm	Chandpur 128.3 mm	Noakhali 177.5 mm
Number of Rain Fed Flood* Stations:	1	0	2	0

*300 mm or more rainfall in consecutive 10 days impedes the drainage are likely to cause rain fed flood in the area.

In Brahmaputra basin, out of 13 rainfall monitoring stations, 8 stations recorded more rainfall than the normal and The Basin received 27.62% more rainfall than their normal during the month October 2017. Highest 1 day maximum rainfall of 180 mm was recorded at Tangail.

In Ganges basin, out of 18 rainfall monitoring stations, 11 stations recorded more rainfall than the normal rainfall of the month. The basin as a whole received 90.45% more rainfall than the normal during the month of October-2017.

In the Meghna basin, out of 17 rainfall monitoring stations, all stations except Satkhira were recorded more rainfall than the normal value of the month. The Basin received 46.12% more rainfall than their monthly normal during the month of October-2017.

In the South Eastern Hill basin, out of 11 rainfall monitoring stations 5 stations were recorded more rainfall than their normal rainfall. The Basin as a whole recorded 3.67% less rainfall than the normal rainfall during the month October-2017.

A map with the Isohyet of actual rainfall for the month of October-2017 is shown in the Figure 2.6.

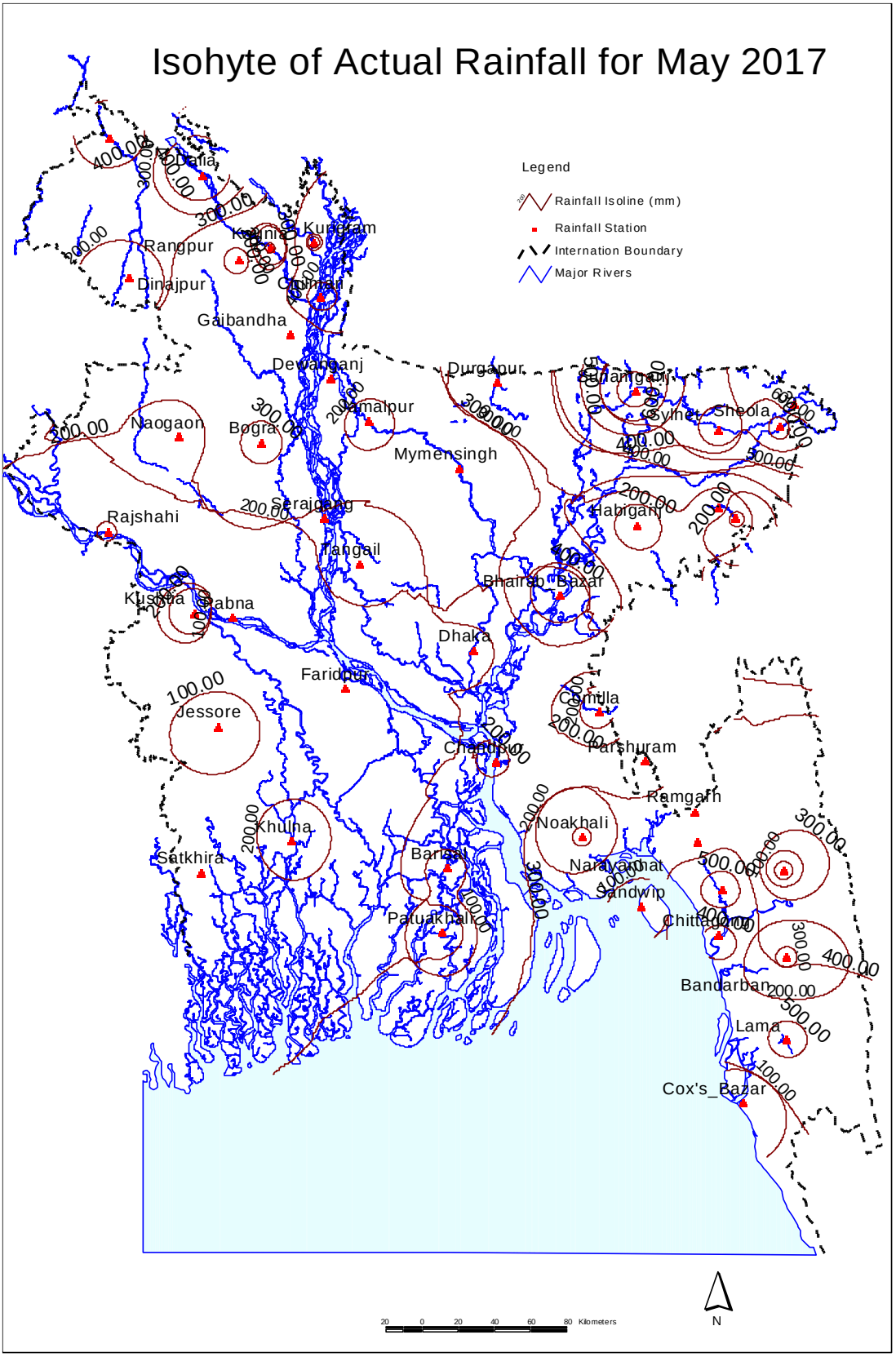


Figure 2.1 : Isohyet of Actual Rainfall (May-2017)

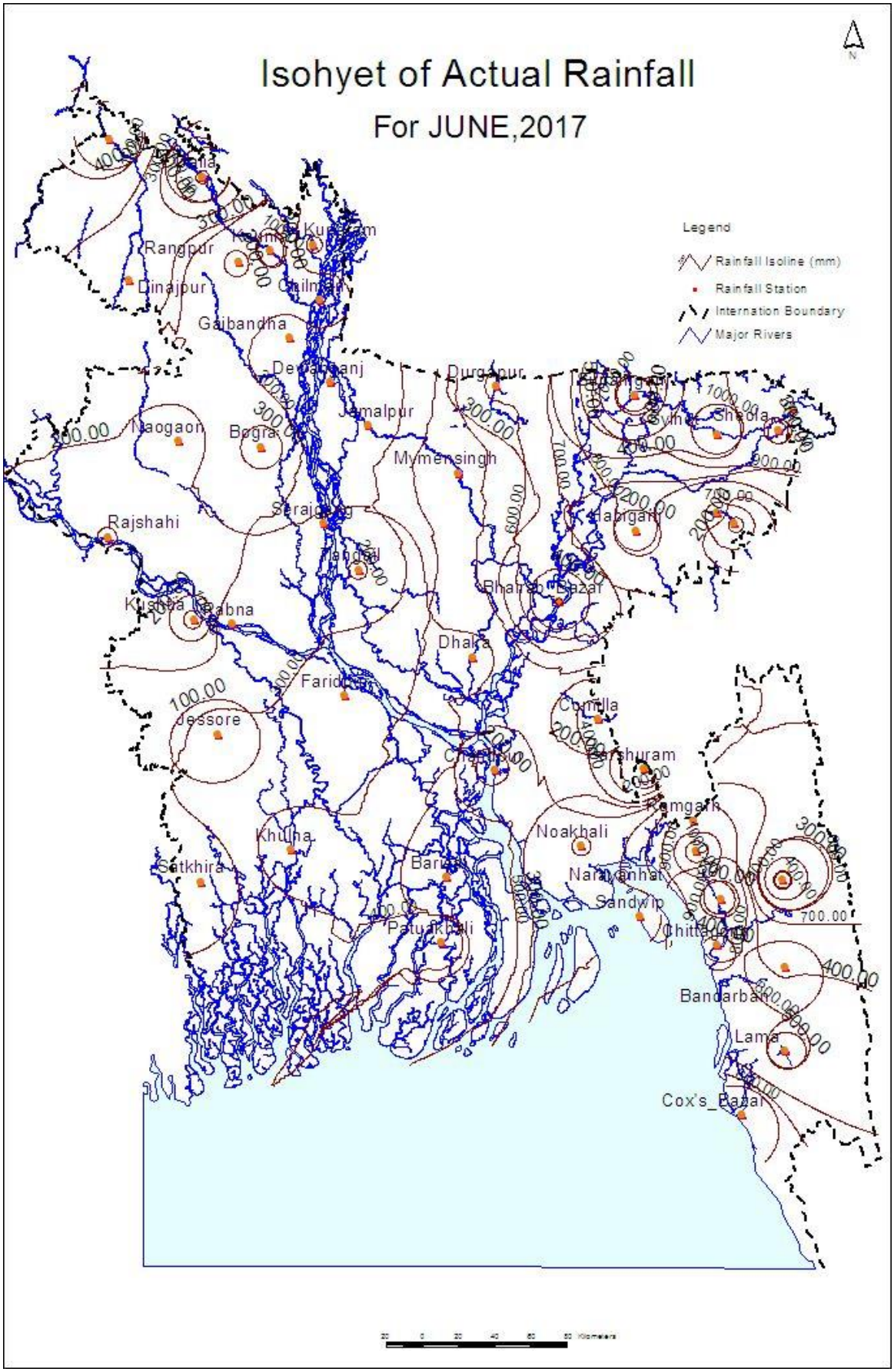


Figure 2.2 : Isohyet of Actual Rainfall (June 2017)

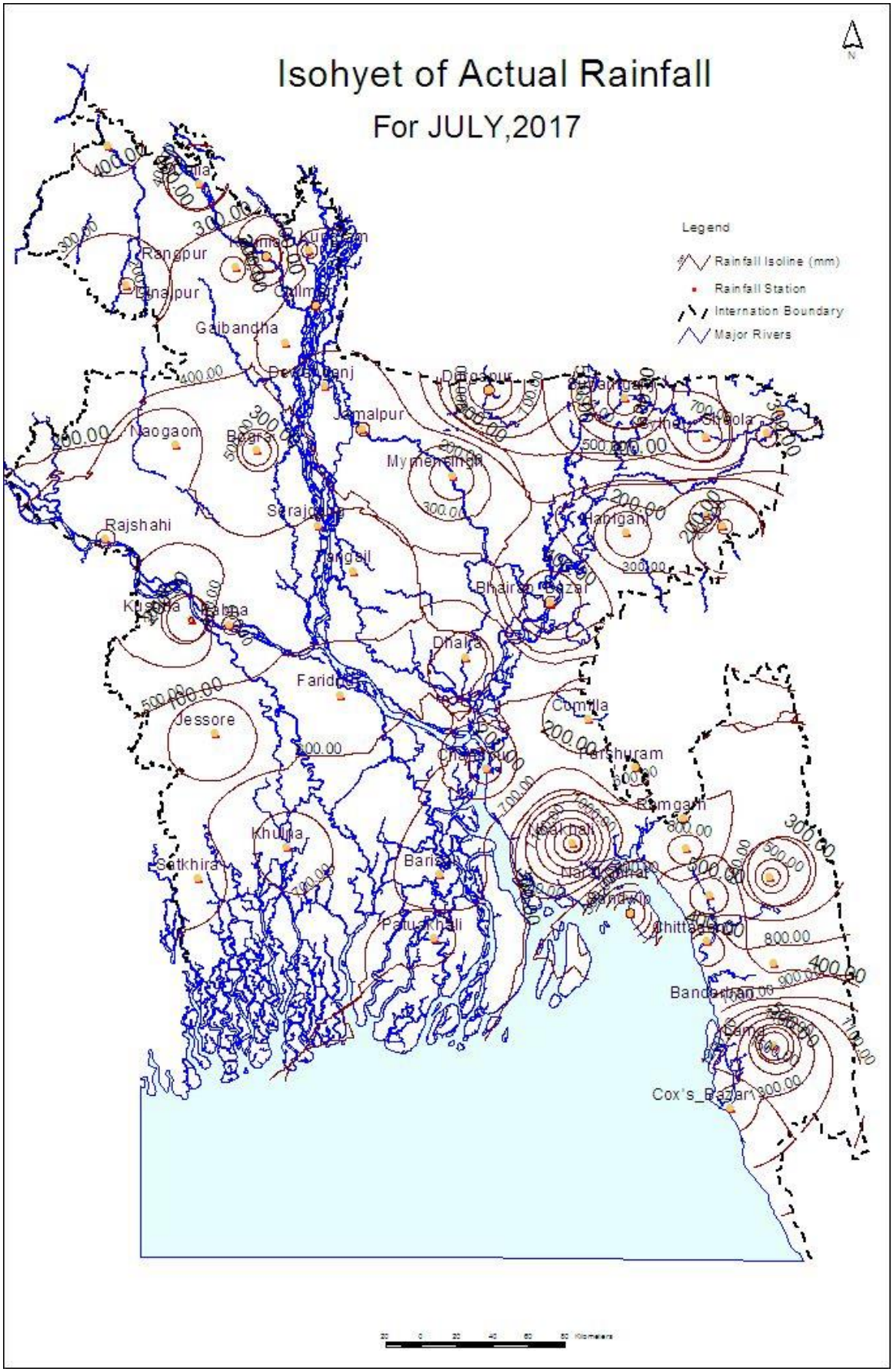


Figure 2.3 : Isohyets of Actual Rainfall (July-2017)

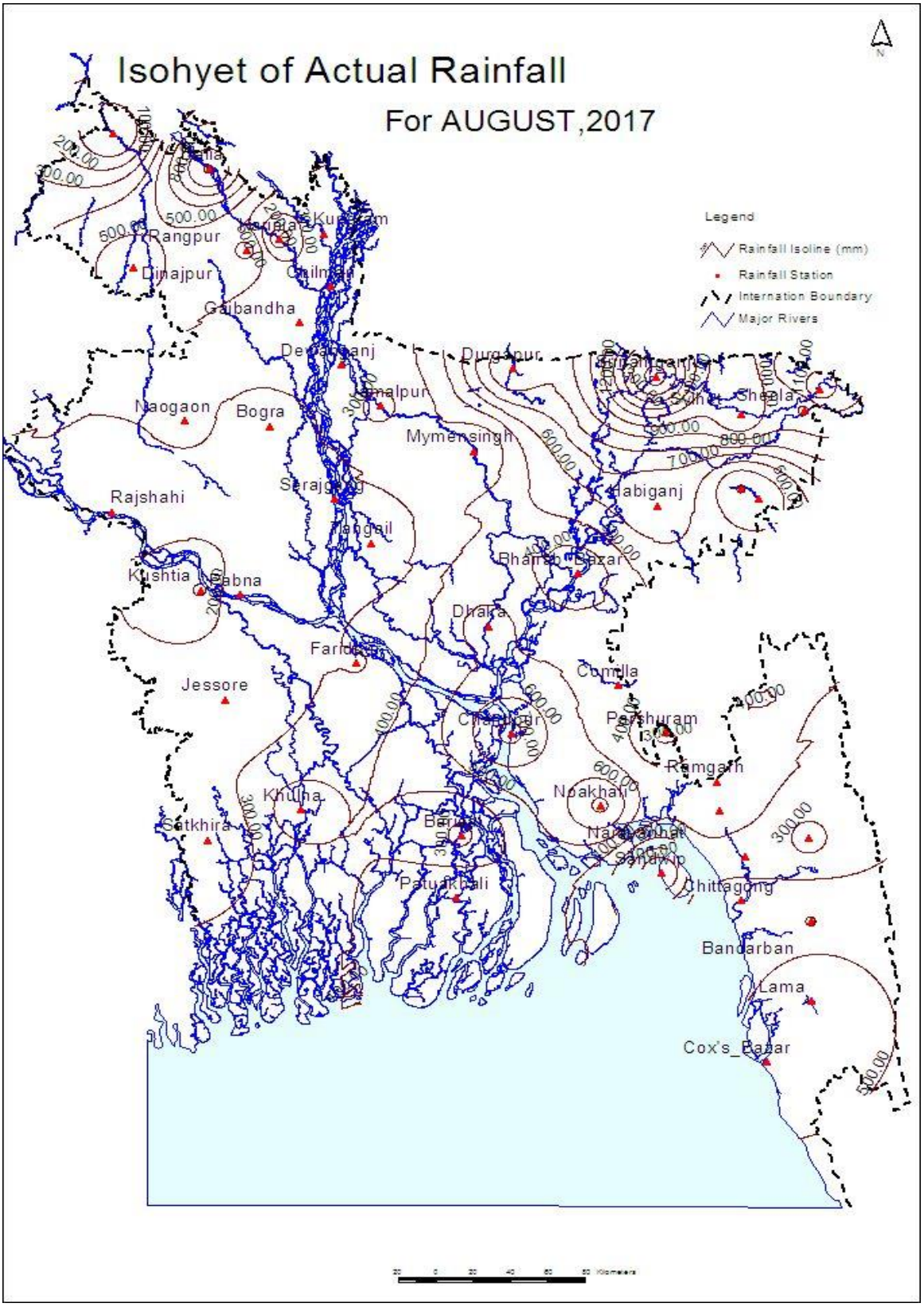


Figure 2.4 : Isohyet of Actual Rainfall (August-2017)

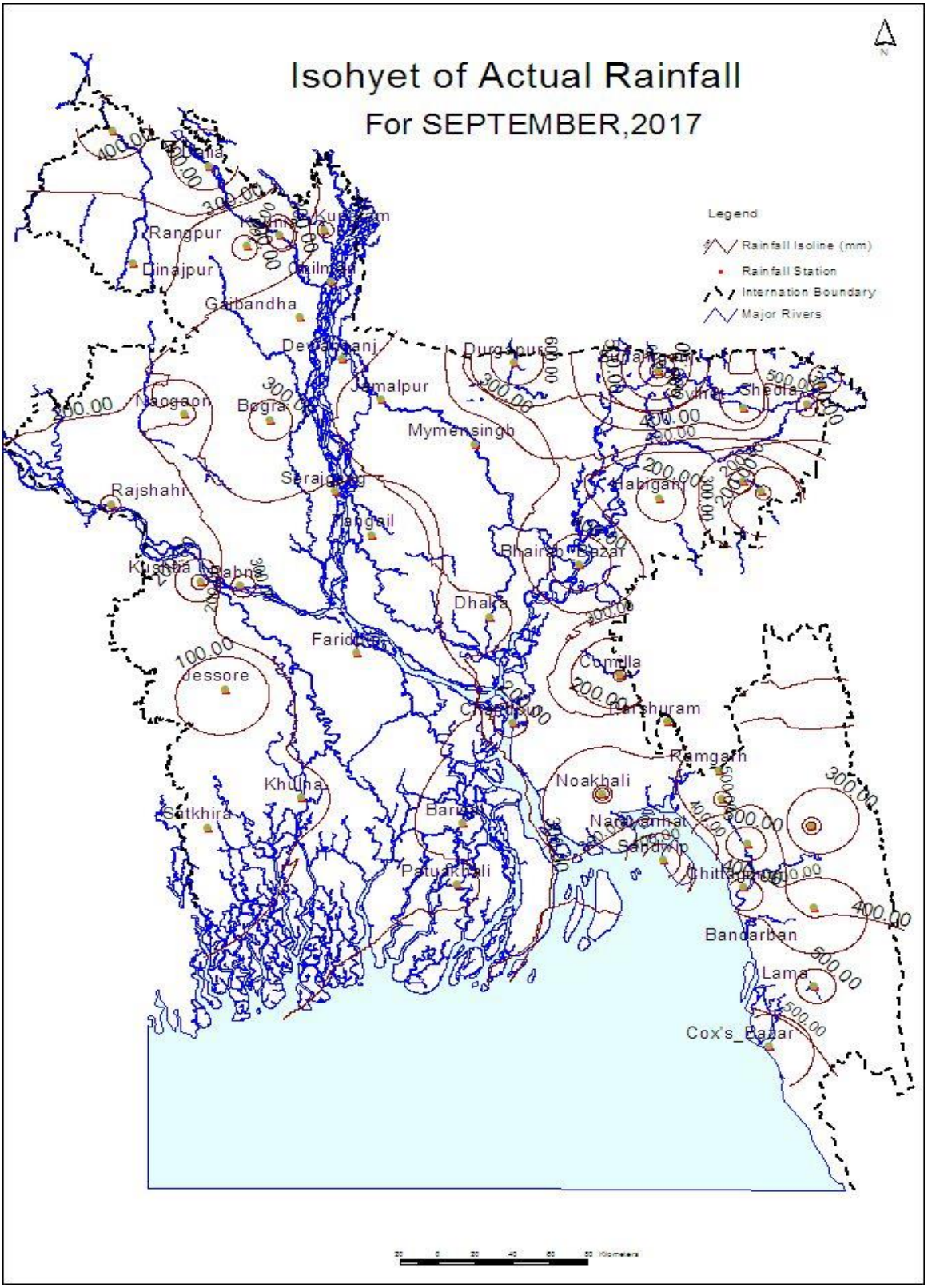


Figure 2.5 : Isohyets of Actual Rainfall (September-2017)

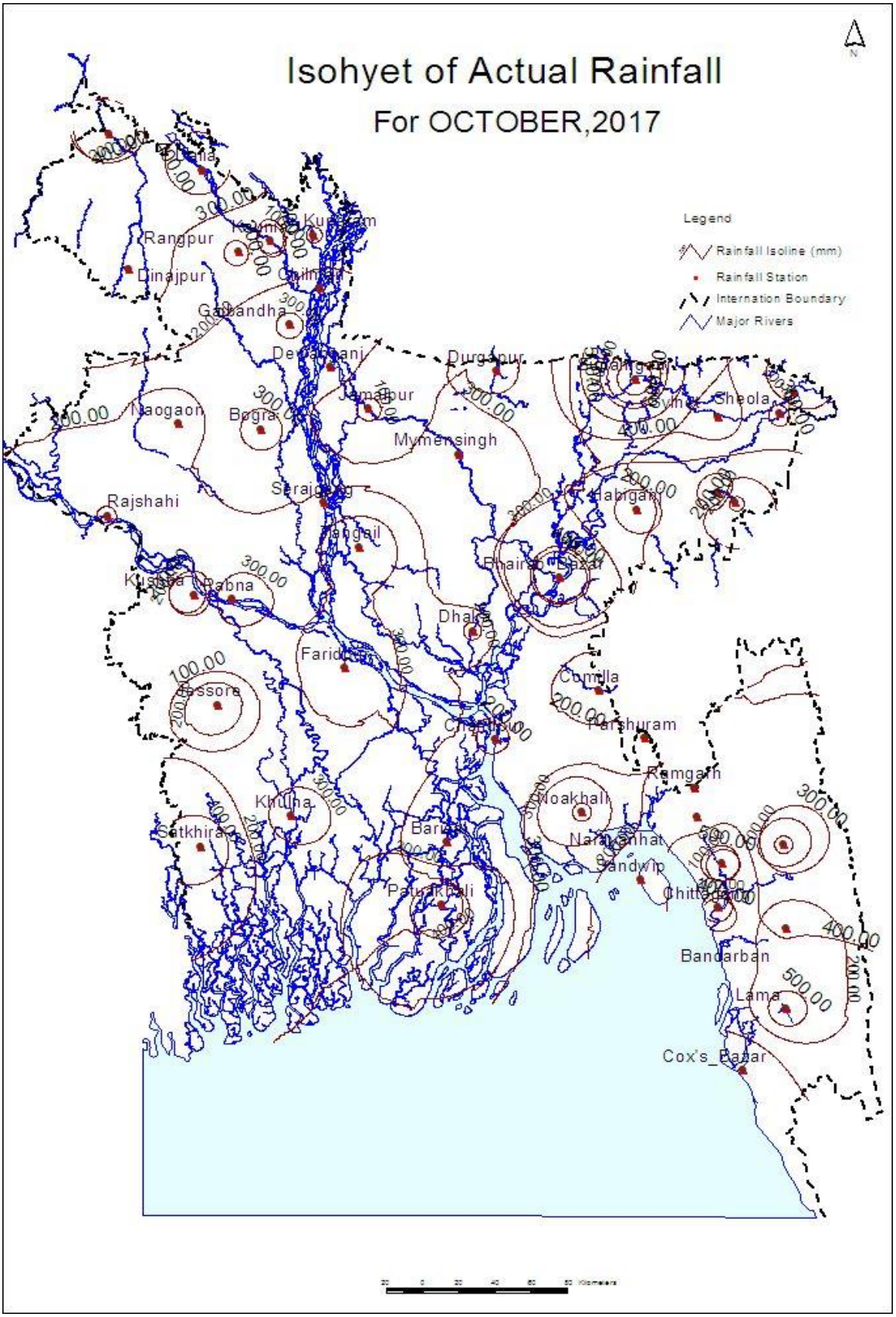


Figure 2.6 : Isohyet of Actual Rainfall (October-2017)

CHAPTER 3:RIVER SITUATION

During the monsoon 2017, the flood was a moderate to severe one which stayed for medium duration in the Brahmaputra and Ganges basins, but for a prolonged duration in the Meghna basin. Flood in the South Eastern Hill basin however was of short duration. The Brahmaputra basin first experienced the monsoon flood from the first week and the Ganges basin from the second week of July, while the Meghna basin from the first week of June, 2017. Rise of water level was recorded in the upper portion of Ganges Basin in mid of August. Basin wise WL situation is described in the following sections.

3.1 THE BRAHMAPUTRA BASIN

Out of 30 Water Level (WL) monitoring stations in this basin, at 22 stations, river WL crossed their respective Danger Levels (DL). Water Level of Brahamaputra Basin started rising from the fourth week of June 2017, for the first time in the monsoon, and caused a medium duration of flood for this basin. In this monsoon Brahmaputra basin had experienced several peaks with two majors, one in July while another in August, which caused flood in this country in 2017. This flood situation lasted for around 30 days for the basin. As a result, low-lying areas of Kurigram, Lalminiorhat, Gaibandha, Bogra, Rangpur, Serajgonj and Jamalpur districts were mostly flooded for short to medium duration. A comparative statement of WL for current year 2017 and historical events of 1988 and 1998 for the Brahmaputra Basin is shown in the Table 3.1. The details of the river situation in this basin are described in the following sections:

The Dharla at Kurigram

The WL of Dharla river at Kurigram registered its monsoon peak during the monsoon 2017, in 2nd week of August. It crossed the DL two times during the monsoon-2017 at the 2nd week of July and then again 2nd week of August and flowed above DL for total 12 days. WL at Kurigram attained peak of 27.84 mPWD on 13th August which was 134 cm above the DL (26.50 m).

The Teesta at Dalia and Kaunia

The Teesta river is flashy in nature. The WL of river Teesta showed several peaks during the monsoon both at Dalia and Kaunia. At Dalia, WL crossed its DL mark for 4 times during the monsoon, highest peak on 13th August with a WL of of 53.05 mPWD, which was 65 cm above its DL (52.40m). At Dalia, it flowed above DL for 6 days throughout the monsoon period. At Kaunia, WL of the river Teesta did not cross the DL during the mosoon-2017, attained the peak of 29.95 mPWD on 13th August of July which was 5 cm below the DL(30.0m) at this point.

The Jamuneswari at Badargonj

The Jamuneswari at Badargonj crossed the DL for a single time in monsoon-2017 and attained the peak of 33.61 mPWD (DL 32.16m) on 15th August. During the whole monsoon this station flowed above DL for 8 days.

The Ghagot at Gaibandha

The WL of Ghagot river at Gaibandha crossed the DL(21.70m) for 2 times during the monsoon-2017. It attained peak water level 22.55 mPWD on 15th August which was 85 cm above DL (21.70m). During the whole monsoon, this station flowed above DL for 15 days.

The Karatoa at Chakrahimpur and Bogra

The WL of Karatoa river at Chakrahimpur crossed the DL for 2 times but at Bogra it did not cross DL during the monsoon-2017. At Chakrahimpur, the Karatoa reached peak water level 20.40 mPWD on 16th August and flowed 25 cm above the DL(20.15m). During the whole monsoon, this station flowed above DL for 10 days. At Bogra point, the Karatoa river did not cross its respective Danger Level with a peak flow of 15.04 mPWD on 27th August which was 128 cm below the respective DL(16.32mPWD).

The Brahmaputra at Noonkhawa and Chilmari

The river Brahmaputra at Noonkhawa and Chilmari observed sharp rise and fall at several times. At Noonkhawa, the WL of the Brahmaputra river attained the peak of 27.39mPWD on 15th August, which was 14cm above the respective DL (27.25mPWD) at this point. Water level flowed above danger level for 3 days.

Brahmaputra at Chilmari flowed above its DL(24.00 m) from the middle of 2nd week of July 2017 (10th July) and continued till 16th July for 7 days & it also crossed the danger level again from the end of 2nd week of August (13th August) and continued till 19th August for 7 days. At Chilmari, the Brahmaputra reached peak water level 24.87 mPWD on 15th August and flowed 87 cm above the DL(24.00m). The Brahmaputra at Chilmari flowed above its DL for 14 days in 2017 monsoon.

The Jamuna at Bahadurabad, Sariakandi, Serajgonj and Aricha

The WL of river Jamuna at Bahadurabad, Sariakandi, Serajgonj & Aricha demonstrated similar trends like Brahmaputra at Noonkhawa and Chilmari. At Bahadurabad the Jamuna flowed above DL for 25 days with the peak of 20.84 mPWD on 16th August, which is 134cm above the DL(19.50m) at this point. At this point Jamuna crossed its DL on 6th July and continued till 18th July for 13 days, then again crossed the DL on 12th August and continued till 23rd August for 12 days. At Sariakandi, the Jamuna crossed the respective DL twice in this monsoon like Bahadurabad station. At first it crossed the DL on 7th July and continued till 18th July for 12 days. Again, it crossed DL on 12th August and flowed above the DL for till 23th August for 12 days. It flowed above for total 24 days, with a peak of 17.96 mPWD on 16th August which was 126 cm above the DL (16.70 m). At Serajgonj, the Jamuna flowed thrice above DL from 7th July to 19th July for 13 days and 12th August to 28th August for 17 days and finally 11th September to 13th September for 3 days with a monsoon peak of 14.87 mPWD, on 16th August which is 152 cm above the DL(13.35m). At Serajgonj, the Jamuna flowed above DL(13.35m) for 33 days during the whole monsoon of 2017.

At Aricha, the WL of the Jamuna river crossed the DL on 14th August and continued till 25th August for 12 days and the peak WL recorded was 10.16 mPWD on 18th

August,which was 76 cm above the DL(9.40m). At this station, the water level remained above DL for 12 days during the whole monsoon of 2017.

The Gur at Singra

The WL of river Atrai at Baghabari flowed above DL for 24 days from 14th August to 6th September 2017, with the peak of 13.67 mPWD on 22nd August, which is 102 cm above the DL(12.65m) at this point.

The Atrai at Baghabari

The WL of river Atrai at Baghabari flowed twice above DL(10.40m) from 13th July to 18th July for 6 days and 14th August to 29th August for 16 days with the peak of 11.50 mPWD on 18th August which is 110 cm above the DL(10.40m) at this point. The WL of river Atrai at Baghabari flowed above DL for 22 days in total during the whole monsoon of 2017.

The Dhaleswari at Elashin

The WL of river Dhaleswari at Elashin flowed above DL twice from 8th July to 20th July and 13th august to 30th August with the peak of 12.52 mPWD on 18th August, which is 112 cm above the DL(11.40m) at this point. The WL of river Dhaleswari at Elashin flowed above DL for 31 days in total during the whole monsoon of 2017.

The Old Brahmaputra at Jamalpur and Mymensingh

The WL of the Old Brahmaputra river at Jamalpur and Mymensingh showed rise and fall during the monsoon. At Jamalpur, the water level crossed the DL(17.00m) on 18th August for 1 day with the recorded peak WL of 17.01 mPWD which is 1cm above the DL at this point (DL 17.0m). At Mymensingh, the WL remained below the DL(12.50m) during the whole monsoon. The peak WL recorded was 12.03 mPWD on 21st August, which was 47cm below the DL (12.5m) at this point.

The Lakhya at Lakhpur and Narayanganj

The Lakhya river at Lakhpur flowed above DL for 22 days from 14th August to 4th September. It attained its monsoon peak of 6.77 mPWD 23rd August, which was 97cm above the DL (DL 5.8m). Lakhya River at Narayanganj first crossed its DL(5.5 m) at 19th August and flowed above danger level for 10 days in total with several intermittent rise and fall. It attained its monsoon peak of 5.74 mPWD 22nd August, which 24cm above the DL (5.5m).

The Rivers around Dhaka

Stations near or around Dhaka city like Buriganga at Dhaka and the Turag at Mirpur attained the peak of the monsoon during the July and August in this year. All the river around Dhaka city flow Flowed below their respective DLs except Tongi Khal at Tongi. The Buriganga at Dhaka and the Balu at Demra recorded their highest peak of 5.22 mPWD (DL 6.0m) on 24th August, 5.65m (DL 5.75m) on 23rd August respectively. The Turag at Mirpur did not cross its respective DL and flowed with a peak of 5.88 mPWD on 24th August which is only 6 cm below the DL (5.94 mPWD). The water level of Tongi

Khal at Tongi flowed above DL(6.08m) only for 2 days starting from 28th August.The peak WL recorded at this station was 6.10m on 28th August.

The Kaliganga at Taraghat

The WL of Kaliganga river at Taraghat showed a trend similar to that of the Buriganga at Dhaka. The river at this station flowed above the DL from 17th August to 30th August for 14 days with a peak of 9.34 mPWD on 20th August which was 94 cm above its DL(8.40 m).

Comparative hydrographs for the year of 2017, 1998 & 1988 of few stations of the Brahmaputra basin are shown in Figures 3.1 – 3.13.

Table 3.1 : Comparison of Water Level (in mPWD) of 2017 and Historical Events of 1988 & 1998 of Some Important Stations in the Brahmaputra Basin.

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger level		
					2017	1998	1988	2017	98	88
1	Dharla	Kurigram	27.66*	26.50	27.84	27.22	27.25	12	30	16
2	Teesta	Dalia	52.97*	52.40	53.05	52.20	52.89	6	-	8
3	Teesta	Kaunia	30.52	30.00	29.95	29.91	30.43	NA	-	38
4	Jamuneswari	Badarganj	33.12*	32.16	33.61	33.00	32.80	8	6	5
5	Ghagot	Gaibandha	22.81	21.70	22.55	22.30	22.20	15	51	17
6	Karatoa	Chakrahimpur	21.41	20.15	20.40	20.86		10		
7	Karatoa	Bogra	17.45	16.32	15.04	15.57		NA		
8	Brahmaputra	Noonkhawa	28.10	27.25	27.39	27.35	NA	3	-	NA
9	Brahmaputra	Chilmari	25.07	24.00	24.87	24.77	25.04	14	22	15
10	Jamuna	Fulchari	-	-	21.03	-		-	-	-
11	Jamuna	Bahadurabad	20.71*	19.50	20.84	20.37	20.62	25	66	27
12	Jamuna	Sariakandi	19.07	16.70	17.96			24		
13	Jamuna	Kazipur	-	15.24	16.80			29		
14	Jamuna	Serajgonj	15.12	13.35	14.87	14.76	15.12	33	48	44
15	Jamuna	Aricha	10.76	9.40	10.16	10.76	10.58	12	68	31
16	Gur	Singra	13.53*	12.65	13.67			24		
17	Atrai	Baghabari	12.45	10.40	11.50			22		
18	Dhaleswari	Elasin	12.80	11.40	12.52			31		
19	Old Br.putra	Jamalpur	18.00	17.00	17.01	17.47	17.83	1	31	8
20	Old Br.putra	Mymensingh	13.71	12.50	12.03	13.04	13.69	NA	33	10
21	Lakhya	Lakhpur	8.70	5.80	6.77			22		
22	Buriganga	Dhaka	7.58	6.00	5.22	7.24	7.58	NA	57	23
23	Balu	Demra	7.13	5.75	5.65			NA		
24	Lakhya	Narayangonj	6.93	5.50	5.74	6.93	6.71	10	71	36
25	Turag	Mirpur	8.35	5.94	5.88	7.97	NA	NA	70	NA
26	Tongi Khal	Tongi	7.84	6.08	6.10	7.54	NA	2	66	NA

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger level		
					2017	1998	1988	2017	98	88
27	Kaliganga	Taraghat	10.39	8.38	9.34			14		
28	Dhaleswari	Jagir	9.73	8.23	9.00			13		
29	Dhaleswari	Rekabi Bazar	7.66	5.18	5.07			NA		
30	Banshi	Nayarhat	8.39	7.32	5.93			NA		

(* Stations were recorded higher than previous highest water level during 2017 flood)

3.2 THE GANGES BASIN

In this basin out of 25 WL monitoring stations, 16 stations exceeded their respective DLs during monsoon 2017. The stations which flowed above DL for relatively longer time are: the Padma at Goalondo and Bhagyakul for 20 days, at Sureswar for 13 days and the Kobadak River at Jhikargacha for 29 days. In the Central part, some places in low lying areas of Rajbari, Faridpur, Manikganj, Munshiganj and Shariatpur districts were mostly affected. The Norhtern part of the basin comprising Panchagarh, Thakurgaon, Dinajpur, Naogaon and C. Nawabganj districts were also affected by flooding this year. The details of the river WL situation in this basin are described below:

The Karatoa at Panchagarh

The Karatoa river at Panchgarh showed a sharp rise and fall during the monsoon and crossed the DL only once on 12th August for 1 day with a peak flow of 70.81 mPWD at 12th August, which was 6 cm below the respective DL (70.75 m)

The Punarbhaba at Dinajpur

The water level of river Punarbhaba at Dinajpur showed rise and fall during the monsoon and crossed the DL on 12th August and continued till 15th August for a span of 4 days. The peak WL recorded was 34.30 mPWD on 13th August, which was 80 cm above its DL (33.50m).

The Tangon at Thakurgaon

The Tangon river is flashy in nature and showed various small peaks during the monsoon. It crossed its respective Danger Level once on 11th August and flowed above danger level for 3 days with highest peak of 51.30 mPWD on 12th August, which was 90 cm above the Danger level (50.40 m).

The Upper Atrai at Bhusirbandar and Atrai at Modevpur

The WL of river Upper Atrai at Bhusirbandar also showed similar trend of Punarbhaba and flowed above the DL from 12th August to 14th August for 3 days. It had a peak value of WL 40.35 mPWD on 13th August, which was 73 cm above the DL(39.62m). The Atrai at Mohadevpur also flowed above the DL from 13th August to 19th August for 7 days with peak of 19.38 mPWD on 16th August which is 79 cm above the DL(18.59m).

The Mohananda at Chapai-Nawabgonj

This river showed a gradual rise and fall in water level throughout the monsoon. It attained its peak of 21.16 m on 22nd August, which was 10cm below its DL (DL21.00m) at Chapai-Nawabgonj. The Mohananda at Chapai-Nawabgonj flowed above the DL for 6 days from 20th August to 25th August.

The Little Jamuna at Naogaon

The Little Jamuna river at Naogaon flowed above its danger level from 13th August to 25th August for 13 days and it attained its peak 16.06 mPWD on 17th August which was 82 cm above the Danger level (15.24 m).

The Ganges/Padma at Pankha, Rajshahi and at Hardinge Bridge

The Ganges River at Pankha showed a gradual rise in July as well as in mid of August but did not cross the respective DL. At Pankha the peak water level recorded was 21.48 mPWD on 22th August, which was only 102 cm below the DL (22.50m) at this point. At Rajshahi, the Ganges showed nearly similar trend as at Pankha and also flowed below its respective DL. It attained its peak of 17.54 mPWD on 21st August, which was 96 cm below its DL (DL18.50m) at Rajshahi. At Hardinge Bridge, water level did not cross the respective Danger Level and it attained its peak of 13.85 mPWD on 21st August which was 40 cm below its DL (14.25m) at this point.

The Ganges/ Padma at Goalundo

At Goalondo river,WL flowed above the DL twice from 14th July to 17th July for 4 days and 14th August to 29th August for 16 days. The WL of the river Padma at Goalondo attained its yearly peak of 9.71 mPWD on the 18th August which was 106 cm above its DL (8.65 m) at this point.

The Padma at Bhagyakul and Sureswar

The river Padma has tidal influence at this point. At Bhagyakul, the WL of river Padma flowed above the DL from 14th July to 17th for 4 days and 14th August to 29th August for 16 days. The WL of the river attained its highest yearly peak water level of 6.81 mPWD on 18th August which was 51 cm above the DL (6.30m) at Bhagyakul. The Padma at Sureswar crossed the DL for 12 days during the whole monsoon. At Sureswar point, the WL crossed the DL from 17th August to 28th August for 12 days. The WL of the river attained its highest yearly peak water level of 5.04 mPWD on 20th August which was 19 cm above the DL (4.45m) at Sureswar.

The Gorai at Gorai Railway Bridge and Kamarkhali

The WL of river Gorai at Gorai Railway Bridge and Kamarkhali showed steady rise and fall during July-August period during the monsoon in 2017. The WL of river Gorai did not cross the DL at Gorai Railway Bridge. The WL of the river attained its highest yearly peak of 12.21 mPWD on 21st August, which was 54cm below the DL (12.75m) at Gorai Rail Bridge. Gorai river at Kamarkhali first crossed the DL on 20th August and flowed above DL for 3 days during the whole monsoon. The WL of the river attained its highest

yearly peak of 8.24 mPWD on 21st August, which was 4cm above the DL (8.20m) at Kamarkhali station.

The Arialkhan at Madaripur

At Madaripur, the WL of the river Arialkhan showed similar trend of rise and fall of the river Padma. The WL of Arialkhan at Madaripur flowed below the DL throughout the monsoon. The WL attained its highest peak of 3.89 m on 22nd August, which was 28 cm below the DL (4.17m) at Madaripur.

Kobodak at Jhikorgacha

Water Level at Jikorgaha was above DL from 13th July to 15th July, 24th July to 9th August,15th August,17th August and and finally 21st October to 27th October and drainage congestion is the main reasons to proong the flooding sitaution . At Jhikorgacha, the WL flowed above the DL for 29 days in total with a peak of 4.65 mPWD on 27th July which was 119cm above the DL(4.11m) at this point.

Comparative hydrographs for few important stations for the year of 2017, 2007 & 2004 of the Ganges basin are shown in figures 3.14 to 3.20.

Table 3.2 : Comparison of Water Level (in mPWD) of 2017 and Historical Events of 1988 & 1998 of Some Important Stations in Ganges Basin.

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger Level		
					2017	1998	1988	2017	98	88
1	Karatoa	Panchgarh	72.65	70.75	70.81			1		
2	Punarbhaba	Dinajpur	34.40	33.50	34.30	34.09	34.25	4	3	4
3	Ich-Jamuna	Phulbari	-	29.95	30.12			3		
4	Tangon	Thakurgaon	51.26*	50.40	51.30			3		
5	Upper Atrai	Bhusirbandar	41.10	39.62	40.35			3		
6	Mohananda	Rohanpur	23.83	22.00	22.70			14		
7	Mohananda	Chapai-Nawabganj	23.01	21.00	21.16			6		
8	Little Jamuna	Naogaon	16.20	15.24	16.06			13		
9	Atrai	Mohadebpur	19.89	18.59	19.38			7		
10	Ganges	Pankha	24.14	22.50	21.48	24.14	NA	NA	66	NA
11	Ganges	Rajshahi	20.00	18.50	17.54	19.68	19.00	NA	28	24
12	Ganges	Hardinge Bridge	15.19	14.25	13.85	15.19	14.87	NA	27	23
13	Padma	Goalundo	10.21	8.50	9.71	10.21	9.83	20	68	41
14	Padma	Bhagyakul	7.50	6.00	6.81	7.50	7.43	20	72	47
15	Padma	Sureswar	7.50	4.45	5.04			13		
16	Gorai	Gorai Rail Bridge	13.65	12.75	12.21	13.45	13.65	NA	25	25
17	Gorai	Kamarkhali	9.48	8.20	8.24	NA	NA	3	NA	NA

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger Level		
					2017	1998	1988	2017	98	88
18	Ichamati	Sakra	4.69	3.96	3.67			NA		
19	Mathabhanga	Chuadanga	12.67	12.04	8.67			NA		
20	Mathabhanga	Hatboalia	15.13	14.48	10.62			NA		
21	Kobodak	Jhikorgacha	5.59	4.11	4.65	NA	NA	29	NA	NA
22	Kumar	Faridpur	8.76	7.50	5.22			NA		
23	Arialkhan	Madaripur	5.80	4.17	3.89	NA	NA	NA	NA	NA
24	Kirtonkhola	Barisal	-	2.55	2.69			1		
25	Pashure	Khulna	3.46*	3.04	3.48			31		

(* Stations were recorded higher than previous highest water level during 2017 flood)

3.3 THE MEGHNA BASIN

Most of the rivers of this basin entered from the hilly catchment of India (Barak basin, Tripua and Meghalaya) and are flashy in nature. Out of 26 WL monitoring stations in the Meghna basin, 18 stations flowed above their respective DLs, which are Surma River at Kanaighat, Sylhet and Sunamganj, Kushyara River at Amalshid, Sheola and Sherpur, Sarigowain river at Sarighat, Khowai river at Habigonj and Ballah, Bhugai river at Nakuagaon, Jadukata river at Lorergarh, Someswari river at Durgapur, Kangsha River at Jariajanjail and Titas river at Brahmanbaria for 2 days to 92 days. As a result, floods of short to prolonged duration were experienced in the districts of Sylhet, Sunamgonj, Habiganj, Moulvi Bazar, Netrokona, Sherpur and Brahmanbaria during the monsoon 2017.

Comparative statement of WL and days flowed above the DL for 2017 and historical events of 1998 and 1988 for this basin for selected stations are shown in Table 3.3.

The Surma at Kanaighat

Water Level in the Surma river started to rise from mid of April and it showed rapid rise and fall in several times. FFWC monitors 3 stations on the Surma River.

As a flashy river, WL of the river Surma at Kanaighat in Sylhet district crossed the DL several times from April to September. First it flowed above its DL at Kanaighat from 1st April to 6th April for 6 days,then 3rd June to 20th July for 44 days and finally from 4th August to 16th September for 42 days.The Surma at Kanaighat was above DL for 92 days in total during the whole monsoon. . It attained its highest peak of 14.51 mPWD on 10th September which was 131cm above the DL (13.20 m).

Surma at Sylhet

The WL of river Surma at Sylhet showed similar trend like Kanaighat. The Surma at Sylhet flowed above its danger level from 2 April to 4 April for 3 days, on 29th June and finally from 12 August to 18 August for 7 days. It attained the monsoon peak WL of 11.70 mPWD on 15th August which was 45 cm above its DL (11.25m).

The Surma at Sunamgonj

The Surma at Sumangnaj showed rapid rise and fall in different period of the monsoon. The WL of the river Surma at Sunamgonj first crossed the DL on 17th June and continued till 22nd June for 4 days. It again flowed above DL from 4th July to 5th July for 2 days and finally from 11th August to 19th August for 9 days. The Surma at Sunamgonj was above DL for 15 days in total during the whole monsoon. The WL of Surma at Sunamgonj recorded its highest peak of 9.19 mPWD on 14th August which was 94 cm above its DL (8.25m).

The Kushiyara at Amalshid, Sheola and Sherpur

The Kushiyara river at Amalshid, Sheola and Sherpur (Sylhet district) observed similar rise and fall trend throughout the monsoon 2017. At Amalshid water level of Kushiyara crossed the DL for several times including 3rd April to 5th April, 3rd June to 20th July, 6th August to 16th September. The Kushiyara at Amalshid flowed above the DL for 76 days in total during the whole monsoon. At Amalshid, Kushiyara attained the peak flow of 17.34 mPWD on 28th June which was 149 cm above the DL (15.85 mPWD).

At Sheola, it also crossed the DL several times. It flowed above DL from different span of periods like from 2nd April to 6th April, 3rd June to 16th June ,19th June to 22nd July and finally from 6th August to 17th September. This station was above DL for 88 days in total during the whole monsoon. It attained its highest peak of 14.57 mPWD on 28th June which was 107 cm above its DL (13.50 m).

At Sherpur the river flowed similar trend like Sheola. It first crossed the DL 6th April. This station was above DL for a number of spans like from 4th June to 9th June, 13th June to 24th July and finally from 13th August to 13th September. It flowed above its DL for 76 days in total during the whole monsoon. It attained its highest peak of 9.45 mPWD on 20th June which was 45 cm above its DL (9.00 m)

The Sarigowain at Sarighat

As the flashy river the Sarighat on Saigowain river in Sylhet district showed several peaks during the monsoon 2017 and crossed the respective DL for 6 times.

This station first crossed the DL on 2nd April and continued till 4th April for 3 days. It was above DL for 9 days in total during the whole monsoon. It attained monsoon highest peak of 13.60 mPWD on 12th August which was 80 cm above its DL (12.80 m).

The Manu at Manu Railway Bridge and Moulvi Bazar

As a flashy river, the WL of the river Manu at Manu Railway Bridge and at Moulvibazar observed several sharp peaks during the monsoon-2017. The WL of Manu river at Manu Railway Bridge crossed the DL 3 times. It first crossed the DL on 2nd June and was above DL for 6 days throughout the whole monsoon.The WL at Manu Railway Bridge had a peak flow of 19.05 mPWD on 5th June which was 105 cm above the DL(18.0 m).

At Moulvibazar the WL of Manu crossed the DL several times. It first crossed the DL on 2nd June with 11 days in total above the DL during the whole monsoon. It attained its

highest peak of 12.56 mPWD on 5th June which was 81 cm above its DL(11.75m) at this point.

The Khowai at Habigonj and Ballah

The Khowai at Habigonj as well as Ballah showed several peaks during the monsoon 2017. The Khowai at Habiganj first crossed the DL on 6th April with total 18 days above DL throughout the monsoon. The WL recorded as its yearly highest peak was 12.3 mPWD on 20th June which was 280 cm above its DL (9.50 m).

The Khowai at Habigonj crossed the DL a number of times. It first crossed the DL on 30th March and was above DL for 34 days from March to October. The highest peak was 24.02 mPWD which attained on 20th June which was 238 cm above the DL(21.64 m).

The Dhalai at Kamalgonj

The Dhalai at Kamalgonj also crossed the DL a number of times. It first crossed the DL on 5th April and was above DL for 9 days in total from April to October. The highest peak was 20.45 mPWD which attained on 4th June which was 63 cm above the DL(19.82 m).

The Bhugai at Nakuagaon

As flashy river the Bhugai at Nakuagaon in Sherpur district recorded sharp rise & fall with several peaks in August and September. It flowed above its DL for only 3 days during monsoon 2017. It first crossed the DL on 12th August. It attained monsoon highest peak of 24.86 mPWD on 12th August which was 246 cm above its DL (22.40m) at this point.

The Jadukata at Lorergarh

Like other flashy rivers in the North-east region, the Jadukata showed several peaks during the monsoon 2017. It crossed its DL for three times in July,August and September. First it crossed the DL on 1st July with 5 days in total above the DL in this monsoon. It attained monsoon highest peak of 10.57 mPWD on 11th August which was 204 cm above its DL (8.53 m).

The Someswari at Durgapur

As the flashy river the Durgapur in Netrokona district, showed rise and fall during the monsoon 2017 crossed its DL three times as the Jadukata in Lorergarh. It first crossed the DL on 4th July for one day only.It was above DL for 5 days It attained monsoon highest peak of 14.45 mPWD on 12th August which was 145 cm above its DL (13.0 m).

The Kangsha at Jariajanjail

As flashy river the Kangsha at Jariajanjail in Netrokona district showed rise and fall during the monsoon-2017. It crossed the DL several times and remained above DL for total 82 days during the whole season. It first crossed its DL on 18th June, 2017. It attained its yearly highest peak of 11.59 mPWD on 13th August which was 181 cm above its DL (9.75m).

The Titas at Brahmanbaria

The Titas River at B. Baria point flowed at above its DL for 30 days from 15th August to 15th September with monsoon peak of 6.01 mPWD on 25th August which was 51 cm above its DL (5.5 m) at this point.

Comparative hydrographs for few stations the year of 2017, 2007 & 2004 of rivers of the Meghna basin are shown in figures 3.21 to 3.36.

Table 3.3: Comparison of Water Level (in mPWD) of 2017 and Historical Events of 1988 & 1998 of Some Important Stations in Meghna Basin.

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger level		
					2017	1998	1988	17	98	88
1	Surma	Kanaighat	15.26	13.20	14.51	15.00	15.10	92	73	75
2	Surma	Sylhet	12.44	11.25	11.70	11.72	11.95	11	14	21
3	Surma	Sunamgonj	9.75	8.25	9.19	8.90	9.03	15	56	62
4	Kushiyara	Amalshid	18.28	15.85	17.34	17.60	17.50	76	54	65
5	Kushiyara	Sheola	14.60	13.50	14.57	14.14	14.09	88	37	80
6	Kushiyara	Sherpur	9.68	9.00	9.45	NA	NA	76	NA	NA
7	Kushiyara	Markuli	8.51	8.50	8.0			NA		
8	Sarigowain	Sarighat	14.48	12.80	13.60			9		
9	Manu	Manu RB	20.42	18.0	19.05	18.63	18.95	6	6	66
10	Manu	Moulvi Bazar	13.25	11.75	12.56	11.68	13.01	11	-	25
11	Khowai	Ballah	26.12	21.64	24.02			34		
12	Khowai	Habiganj	12.00*	9.50	12.30	11.44	11.06	18	8	14
13	Dhalai	Kamalganj	21.18	19.82	20.45			9		
14	Old Surma	Derai	7.75	7.00	7.48			37		
15	Baulai	Khaliajuri	9.52	8.50	7.39					
16	Bhugai	Nakuagaon	26.01	22.40	24.86			3		
17	Jadukata	Lorergarh	11.85	8.53	10.57			5		
18	Someswari	Durgapur	15.58	13.00	14.45			5		
19	Kangsha	Jariajanjail	13.37	9.75	11.59	NA	NA	82	NA	NA
20	Titas	B.Baria	6.50	5.50	6.01			30		
21	Upper Meghna	Bhairab Bazar	7.78	6.25	6.05	7.33	7.66	NA	68	68
22	Meghna	Narsingdi	7.01	5.70	5.32			NA		
23	Meghna	Meghna Bridge	-	5.03	4.95			NA		
24	Gumti	Comilla	13.56	11.75	11.78	12.79	11.80	1	17	17
25	Gumti	Debiddar	-	8.50	8.67			2		
26	Meghna	Chandpur	5.35		4.59					

(* Stations were recorded higher than previous highest water level during 2017 flood)

3.4 THE SOUTH EASTERN HILL BASIN

The South Eastern Hill basin is constituted with the basin areas of the hilly rivers like the Muhuri, the Halda, the Sangu, the Matamuhuri and the Feni in the South Eastern Part of the country and most of the rivers show similar behavior during monsoon flood. The WL of the monitoring rivers except Feni crossed their respective DLs several times throughout the monsoon-2017. Due to flashy nature, multiple short duration floods occurred at some places of Chittagong, Feni, Bandarban, Cox's Bazar during the monsoon 2017. The details of WL of different river are described in following sections. A comparative statement of water level and days flowed above the DLs for the monsoon-2017 and historical events of 1998 and 1988 for this basin are shown in the Table 3.4.

The Muhuri at Parshuram

The Muhuri river in Feni, Noakhali district is a flashy which flowed above the DL from 20th July to 21st July, on 22nd August and finally from 21st October to 22nd October for 5 days in total during the whole monsoon. It attained its highest peak 15.2 mPWD on 21st July which was 220 cm above its DL (13.00 m).

The Halda at Narayanhat

As it is a flashy river, the WL of the river Halda (a flashy river) at Narayanhat under Hathazari upzilla also showed several peaks during this monsoon. It first crossed DL on 2nd June and was above DL for 11 days in total from June to September during the monsoon. It attained its peak of 16.85 mPWD on 13th June which was 110 cm above the DL(15.25 m) at Narayanhat.

The Halda at Panchpukuria

The Halda at Panchpukuria first crossed the DL on 13th June for only 2 days during the whole monsoon. It attained its highest peak of 9.70 mPWD on 14th June which was 20 cm above its DL (9.50 m).

The Sangu at Bandarban and Dohazari

The Sangu is also a flashy river which showed several peaks during flood period. The river crossed the DL at Bandarban twice in this monsoon-2017. It first crossed the DL on 13th june and then was above DL from 4th July to 5th July.In total,this station was above DL for 3 days. The peak recorded was 16.60 mPWD on 13th June which was 135 cm above its DL (15.25m). At Dohazari also the Sangu was above DL for 3 days with 1st crossing of danger mark on 3rd June. At Dohazari the highest peak was recorded 7.79 mPWD on 4th June which was 79 cm above its danger mark (7.00 m) at this point.

The Matamuhuri at Lama and Chiringa

The river observed several peaks in the monsoon-2017 like Sangu River. At Lama, the Matamuhuri River crossed the DL 3 times with 1st crossing on 12th June. It was above DL for 5 days in total during the whole monsoon. At Lama the peak recorded was 13.79 mPWD on 4th July which was 154cm above its DL (12.25m). The Matamuhuri at Chiringa crossed the DL 4 times during the monsoon. At Chiringa station the matamuhuri

river was above DL from 12th June to 13th June,3rd July to 6th July, 23rd July to 25th July and on 12th August. It was above DL for 10 days in total during the whole monsoon. At Chiringa the peak recorded was 7.32 mPWD on 4th July which was 157 cm above its DL (5.75m).

The Feni at Ramgarh

The WL of river Feni at this point observed several peaks and flowed below its DL during the monsoon-2017. The highest peak WL attained by the river was 16.20 m on 24th July which was 117 cm below its DL (17.37m) at this point.

Table 3.4 : Comparison of Water Level of 2017 (in mPWD) and Historical Events of 1988 and 1998 of Some Important Station in South Eastern Hill Basin.

Sl. No	River	Station	Previously Recorded Maximum	Danger Level	Peak of the year			Days above Danger level		
					2017	98	88	2017	98	88
1	Muhuri	Parshuram	16.33	13.00	15.20	14.60	12.42	5	9	48
2	Halda	Narayanhat	19.30	15.25	16.85	16.57	NA	11	21	NA
3	Halda	Panchpukuria	12.54	9.50	9.70	10.44	10.05	2	4	6
4	Sangu	Bandarban	20.70	15.25	16.60	15.25	16.80	3	1	3
5	Sangu	Dohazari	9.05	7.00	7.79	7.42	NA	3	2	NA
6	Matamuhuri	Lama	15.46	12.25	13.79	13.05	12.18	5	2	-
7	Matamuhuri	Chiringa	7.03*	5.75	7.32	6.85	NA	10	5	NA
8	Feni	Ramgarh	21.42	17.37	16.20	17.50	NA	NA	1	NA
9	Karnaphuli	Chittagong	-	4.57						

Comparative hydrographs for the year of 2015, 2007 and 2004 of few stations of the South Eastern Hill Basin are shown in Figures 3.37 to 3.42.

3.5 PEAK AND RECORDED HIGHEST WATER LEVELS

The peak water level of all the water level monitoring stations under FFWC with the date during the monsoon 2017 and date of exceedance of previously recorded highest are shown in the following tables.

Table 3.5: Recorded Peak Water Level (in mPWD) with Dates during the Monsoon-2017

SL No	River name	Station	Peak WL-2017	Date
	BRAHMAPUTRA BASIN			
1	DHARLA	KURIGRAM	27.84	13/08/17
2	TEESTA	DALIA	53.05	13/08/17
3	TEESTA	KAUNIA	29.95	13/08/17
4	JAMUNESWARI	BADARGANJ	33.61	15/08/17
5	GHAGOT	GAIBANDHA	22.55	15/08/17
6	KARATOA	CHAK RAHIMPUR	20.40	16/08/17
7	KARATOA	BOGRA	15.04	27/08/17
8	BRAHMAPUTRA	NOONKHAWA	27.39	15/08/17
9	BRAHMAPUTRA	CHILMARI	24.87	15/08/17
10	JAMUNA	BAHADURABAD	20.84	16/08/17
11	JAMUNA	SARIAKANDI	17.96	16/08/17

SL No	River name	Station	Peak WL-2017	Date
12	JAMUNA	SERAJGONJ	14.87	16/08/17
13	JAMUNA	ARICHA	10.16	18/08/17
14	GUR	SINGRA	13.67	22/08/17
15	ATRAI	BAGHABARI	11.50	18/08/17
16	DHALESWARI	ELASIN	12.52	18/08/17
17	OLD BRAHMAPUTRA	JAMALPUR	17.01	18/08/17
18	OLD BRAHMAPUTRA	MYMENSINGH	12.03	21/08/17
19	LAKHYA	LAKHPUR	6.77	23/08/17
20	BURIGANGA	DHAKA	5.22	24/08/17
21	BALU	DEMRA	5.65	23/08/17
22	LAKHYA	NARAYANGONJ	5.74	22/08/17
23	TURAG	MIRPUR	5.88	24/08/17
24	TONGI KHAL	TONGI	6.10	28/08/17
25	KALIGANGA	TARAGHAT	9.34	20/08/17
26	DHALESWARI	JAGIR	9.0	22/08/17
27	DHALESWARI	REKABI BAZAR	5.07	23/08/17
28	BANSHI	NAYARHAT	5.93	11/09/17
GANGES BASIN				
29	KARATOA	PANCHAGARH	70.81	12/08/17
30	PUNARBHABA	DINAJPUR	34.30	13/08/17
31	ICH-JAMUNA	PHULBARI	30.12	15/08/17
32	TANGON	THAKURGAON	51.30	12/08/17
33	UPPER ATRAI	BHUSIRBANDAR	40.35	13/08/17
34	MOHANANDA	ROHANPUR	22.7	23/08/17
35	MOHANANDA	CHAPAI-NAWABGANJ	21.16	22/08/17
36	LITTLE JAMUNA	NAOGAON	16.06	17/08/17
37	ATRAI	MOHADEBPUR	19.38	16/08/17
38	GANGES	PANKHA	21.48	22/08/17
39	GANGES	RAJSHAHI	17.54	21/08/17
40	GANGES	HARDINGE BRIDGE	13.85	21/08/17
41	PADMA	GOALONDO	9.71	18/08/17
42	PADMA	BHAGYAKUL	6.81	18/08/17
43	PADMA	SURESWAR	5.04	20/08/17
44	GORAI	GORAI RAIL BRIDGE	12.21	21/08/17
45	GORAI	KAMARKHALI	8.24	21/08/17
46	ICHAMATI	SAKRA	3.67	10/06/17
47	MATHABHANGA	CHUADANGA	8.67	24/08/17
48	MATHABHANGA	HATBOALIA	10.62	23/08/17
49	KOBADAK	JHIKARGACHA	4.65	27/07/17
50	KUMAR	FARIDPUR	5.22	23/08/17
51	ARIALKHAN	MADARIPUR	3.89	22/08/17
52	KIRTONKHOLA	BARISAL	2.69	21/10/17
MEGHNA BASIN				
53	SURMA	KANAIGHAT	14.51	10/09/17
54	SURMA	SYLHET	11.7	15/08/17
55	SURMA	SUNAMGONJ	9.19	14/08/17
56	KUSHIYARA	AMALSHID	17.34	28/06/17
57	KUSHIYARA	SHEOLA	14.57	28/06/17
58	KUSHIYARA	SHERPUR	9.45	20/06/17
59	KUSHIYARA	MARKULI	8.0	20/06/17
60	SARIGOWAIN	SARIGHAT	13.60	12/08/17
61	MANU	MANU RAILY BRIDGE	19.05	05/06/17
62	MANU	MOULVI BAZAR	12.56	05/06/17
63	KHOWAI	BALLAH	24.02	20/06/17

SL No	River name	Station	Peak WL-2017	Date
64	KHOWAI	HABIGANJ	12.30	20/06/17
65	DHALAI	KAMALGONJ	20.45	04/06/17
66	OLD SURMA	DERAI	7.48	20/08/17
67	BAULAI	KHALIAJURI	7.39	16/08/17
68	BHUGAI	NAKUAGAON	24.86	12/08/17
69	JADUKATA	LORERGARH	10.57	11/08/17
70	SOMESWARI	DURGAPUR	14.45	12/08/17
71	KANGSHA	JARIAJANJAIL	11.59	13/08/17
72	TITAS	B. BARIA	6.01	25/08/17
73	MEGHNA	BHAIRAB BAZAR	6.05	24/08/17
74	MEGHNA	NARSINGDI	5.32	23/08/17
75	GUMTI	COMILLA	11.78	23/10/17
76	GUMTI	DEBIDDAR	8.67	24/10/17
77	MEGHNA	CHANDPUR	4.59	21/08/17
	SOUTH EASTERN HILL BASIN			
78	MUHURI	PARSHURAM	15.20	21/07/17
79	HALDA	NARAYAN HAT	16.85	13/06/17
80	HALDA	PANCHPUKURIA	9.70	14/06/17
81	SANGU	BANDARBAN	16.60	13/06/17
82	SANGU	DOHAZARI	7.79	04/06/17
83	MATAMUHURI	LAMA	13.79	04/07/17
84	MATAMUHURI	CHIRINGA	7.32	04/07/17
85	FENI	RAMGARH	16.20	24/07/17

Table 3.6: Recorded Historical Highest Water Levels (in mPWD) with Dates

Sl. No.	River	Station	Danger Level	Recorded highest WL before 2017 flood (date)	WL (Date) Exceeding previous Highest WL
1	Dharla	Kurigram	26.50	27.66 (14.07.96)	**27.84(13.08.17)**
2	Teesta	Dalia	52.40	52.97 (29.07.72)	**53.05(13.08.17)**
3	Teesta	Kaunia	30.00	30.52 (06.01.68)	-
4	Jamuneswari	Badarganj	32.16	33.12 (06.09.98)	**33.61 (15.08.17)**
5	Brahmaputra	Noonkhawa	27.25	28.10	-
6	Brahmaputra	Chilmari	24.00	25.07 (23.08.62)	-
7	Jamuna	Bahadurabad	19.50	20.62 (30.08.88)	**20.84 (16.08.17)**
8	Jamuna	Serajgonj	13.35	15.12 (30.08.88)	-
9	Jamuna	Aricha	9. 40	10.76 (02.09.88)	-
10	Dhaleswari	Elasin	11.40	12.80 (31.07.16)	-
11	Old Brhamaputra	Jamalpur	17.00	18.00 (31.07.54)	-
12	Old Brhamaputra	Mymensingh	12.50	13.71(01.09.88)	-
13	Buriganga	Dhaka	6.00	7.58 (04.09.68)	-
14	Lakhya	Narayangonj	5.50	6.93 (10.09.98)	-
15	Turag	Mirpur	5.94	8.35 (10.09.88)	-
16	Tongi Khal	Tongi	6.08	7.84 (01.09.62)	-
17	Kaliganga	Taraghat	8.38	10.37(02.09.88)	-
18	Punarbhaba	Dinajpur	33.50	34.40	-
19	Tangon	Thakurgaon	50.40	51.26 (13.08.87)	**51.30 (12.08.17)**
20	Gur	Singra	12.65	13.53	**13.67 (22.08.17)**
21	Padma	Pankha	21.50	24.14 (07.09.97)	-
22	Padma	Rajshahi	18.50	20.00(13.09.1910)	-
23	Padma	H. Bridge	14.25	15.19 (10.09.98)	-
24	Padma	Goalundo	8.50	10.21 (03.08.08)	-
25	Padma	Bhagyakul	6.00	7.58	-
26	Gorai	Gorai Rly Br	12.75	13.65 (02.09.98)	-
27	Surma	Kanaighat	13.20	15.58(26.06.12)	-
28	Surma	Sylhet	11.25	12.44 (19.07.04)	-
29	Surma	Sunamgonj	8.25	9.75 (20.07.04)	-
30	Kushiyara	Amalshid	15.85	18.28 (08.06.74)	-
31	Kushiyara	Sheola	13.50	14.60 (09.09.08)	-
32	Manu	Manu Rly Br	18.00	20.42 (23.05.02)	-
33	Manu	Moulvi Bazar	11.75	13.25 (08.06.93)	-
34	Khowai	Habiganj	9.50	12.00 (18.06.07)	-
35	Someswari	Durgapur	13.00	15.58 (28.07.07)	-
36	Upper Meghna	Bhairab Bazar	6.25	7.78 (24.07.04)	-
37	Gumti	Comilla	11.75	13.56 (23.07.93)	-
38	Muhuri	Parshuram	13.00	16.33 (13.09.04)	-
39	Halda	Narayanhat	15.25	19.30 (13.08.99)	-
40	Halda	Panchpukuria	7.00	12.54(27.06.03)	-
41	Sangu	Bandarban	15.25	20.7 (12.07.97)	-
42	Sangu	Dohazari	5.75	9.05	-
43	Matamuhuri	Lama	12.25	15.46 (12.08.99)	-
44	Matamuhuri	Chiringa	5.75	7.03 (10.07.97)	**7.32 (04.07.17)**
45	Feni	Ramgarh	17.37	21.42 (11.07.68)	-

WL - Water Level

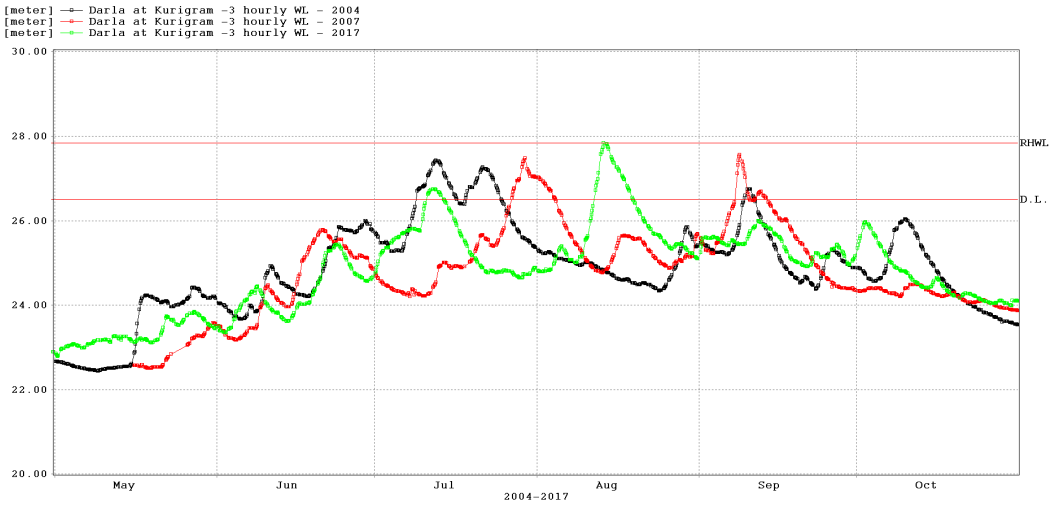


Figure 3.1: Comparison of Hydrograph on Dharla at Kurigram

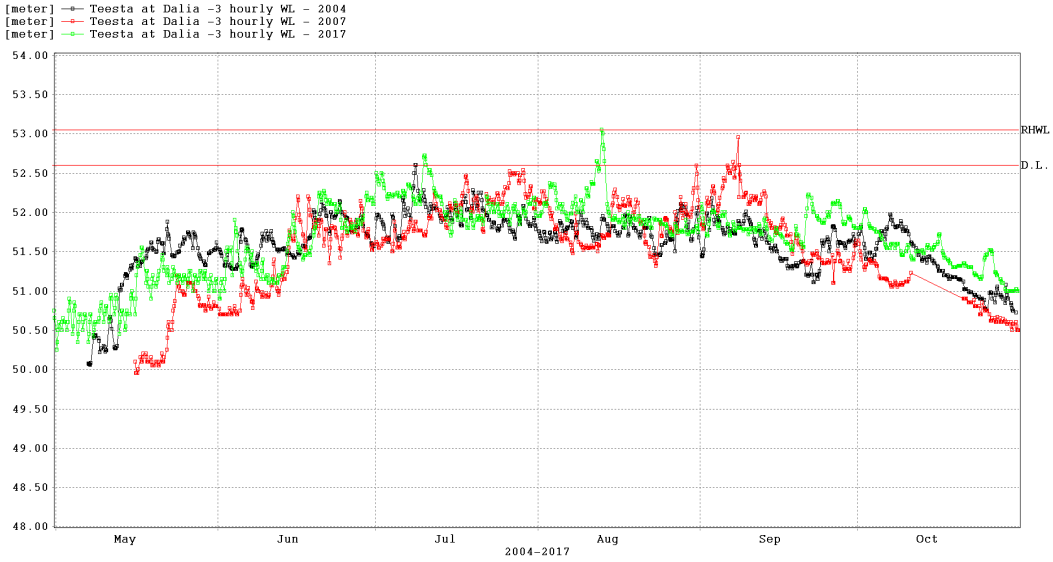


Figure 3.2: Comparison of Hydrograph on Teesta at Dalia

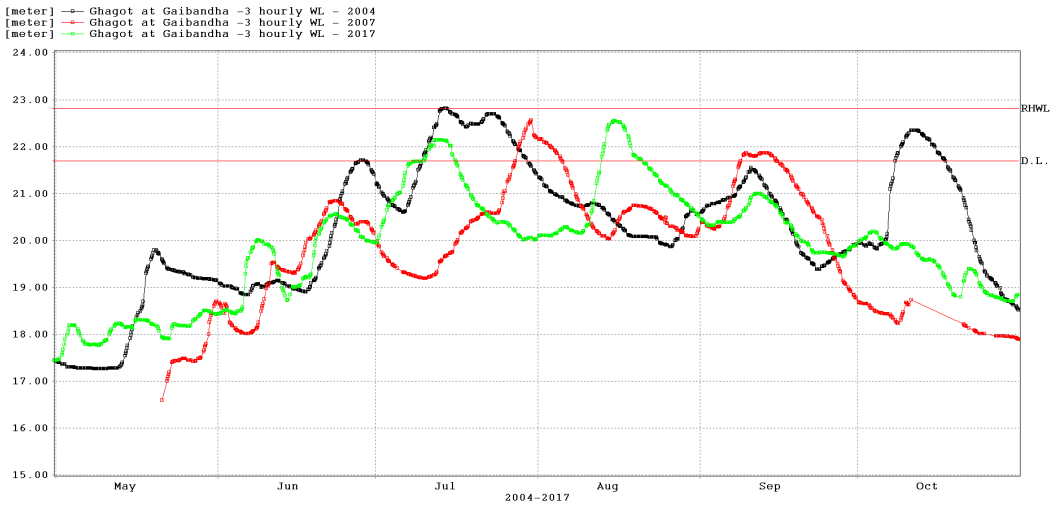


Figure 3.3: Comparison of Hydrograph on Ghagot at Gaibandha

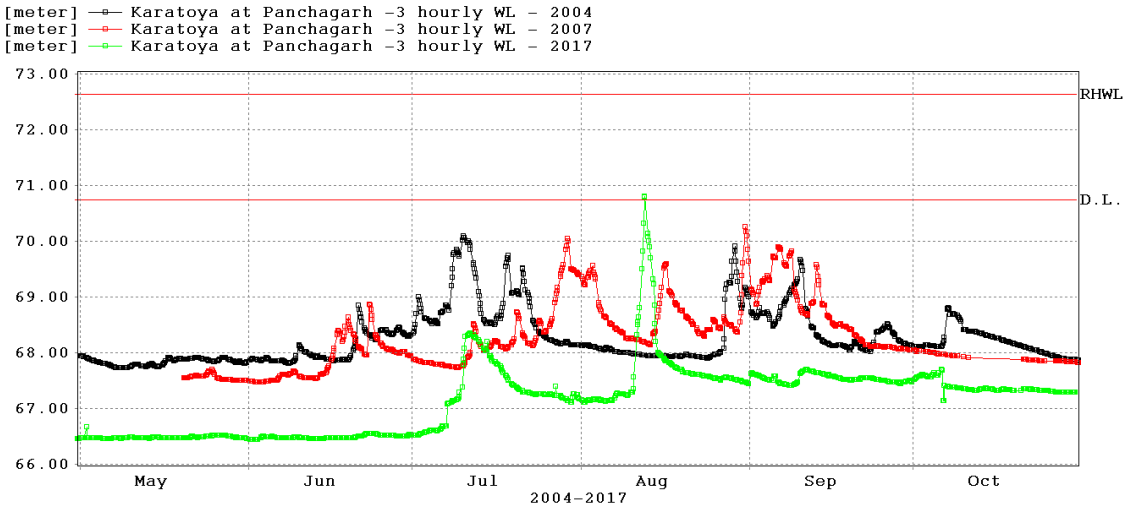


Figure 3.4: Comparison of Hydrograph on Upper Karatoa at Panchagarh

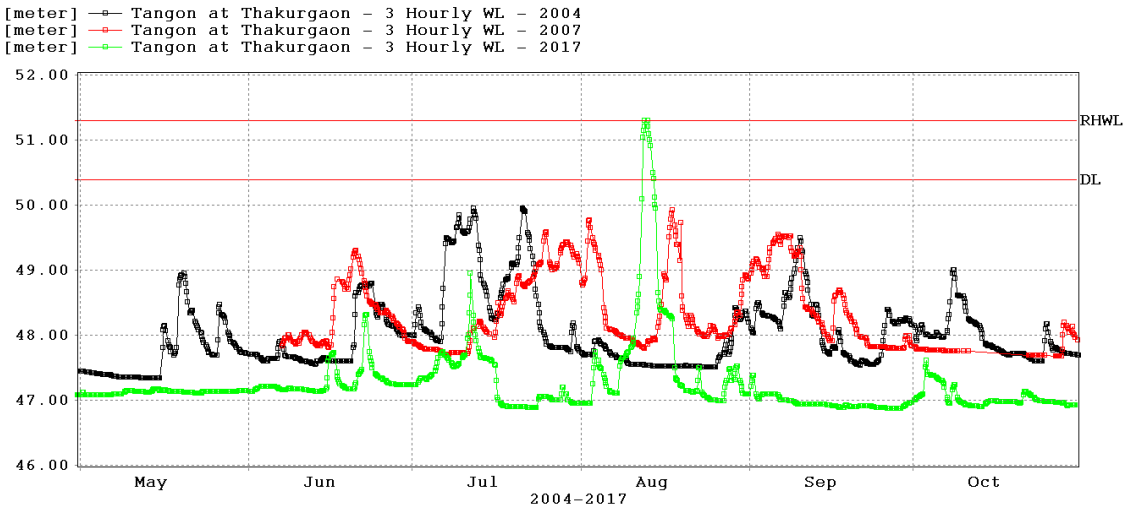


Figure 3.5: Comparison of Hydrograph on Tangon at Thakurgaon

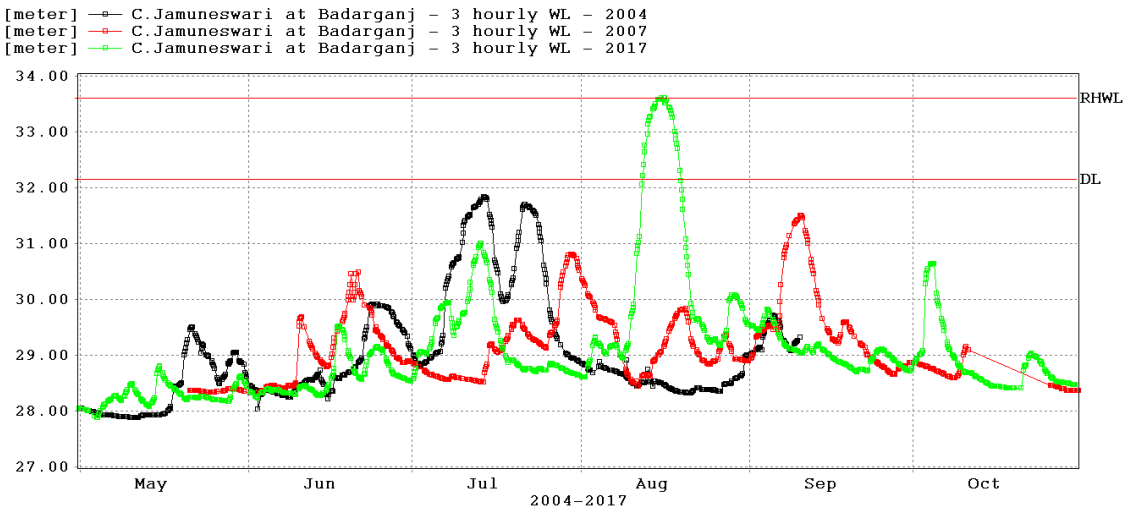


Figure 3.6: Comparison of Hydrograph on C. Jamuneswari at Badarganj

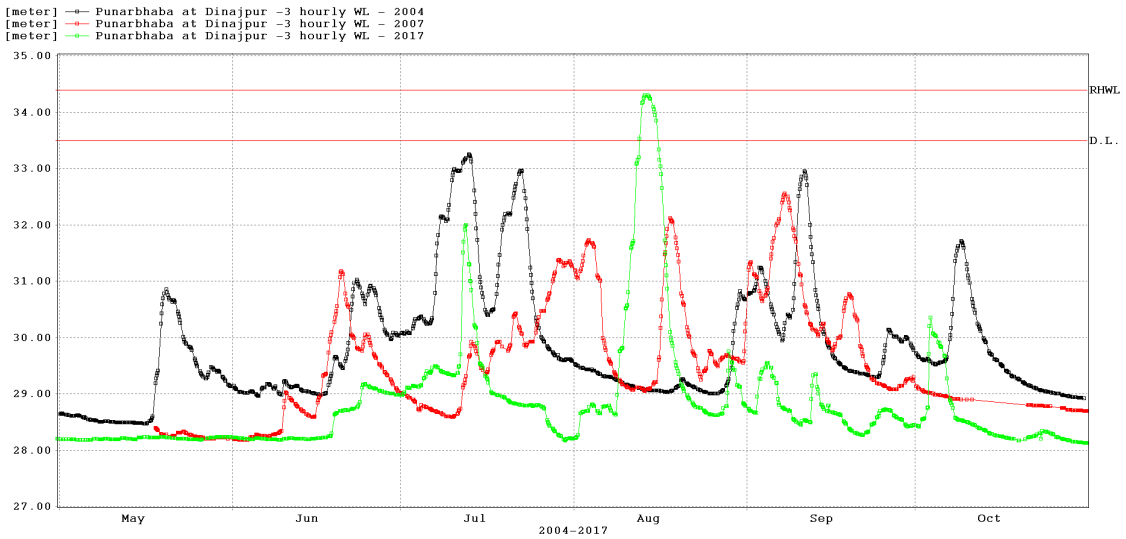


Figure 3.7: Comparison of Hydrograph on Punarbhaba at Dinajpur

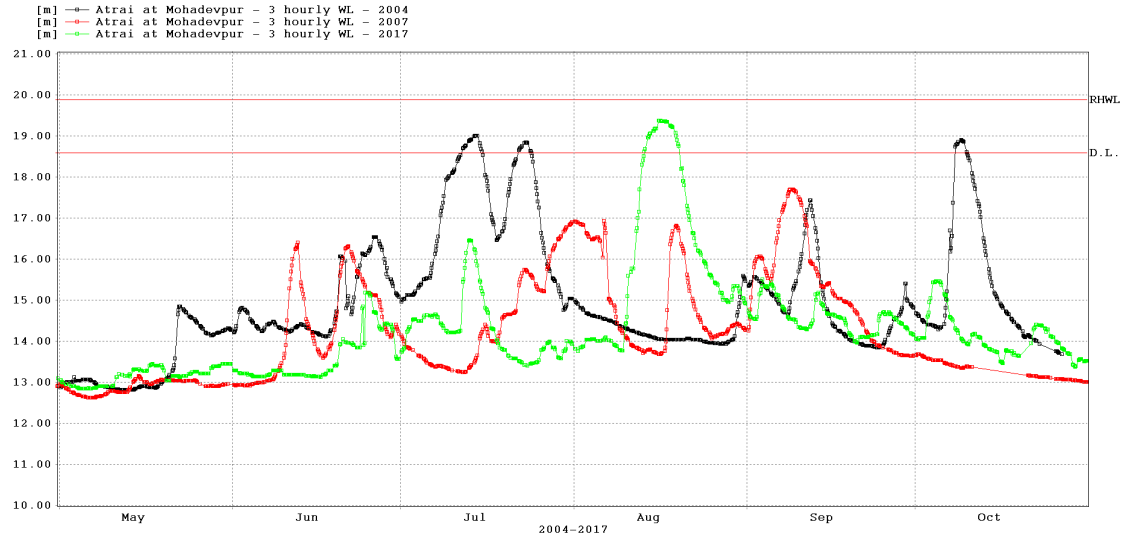


Figure 3.8: Comparison of Hydrograph on Atrai at Mohadevpur

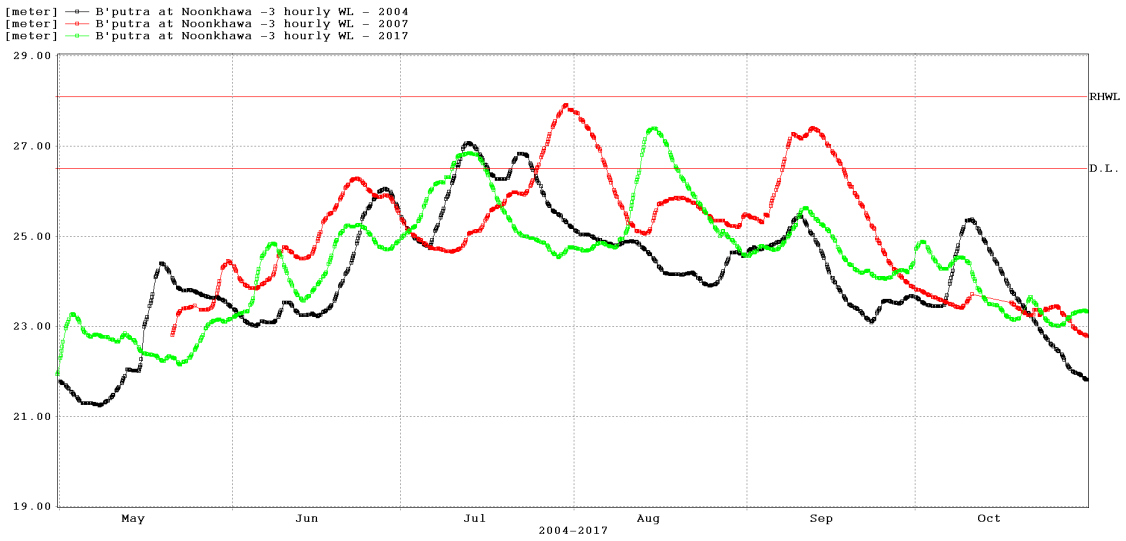


Figure 3.9: Comparison of Hydrograph on Brahmaputra at Noonkhawa

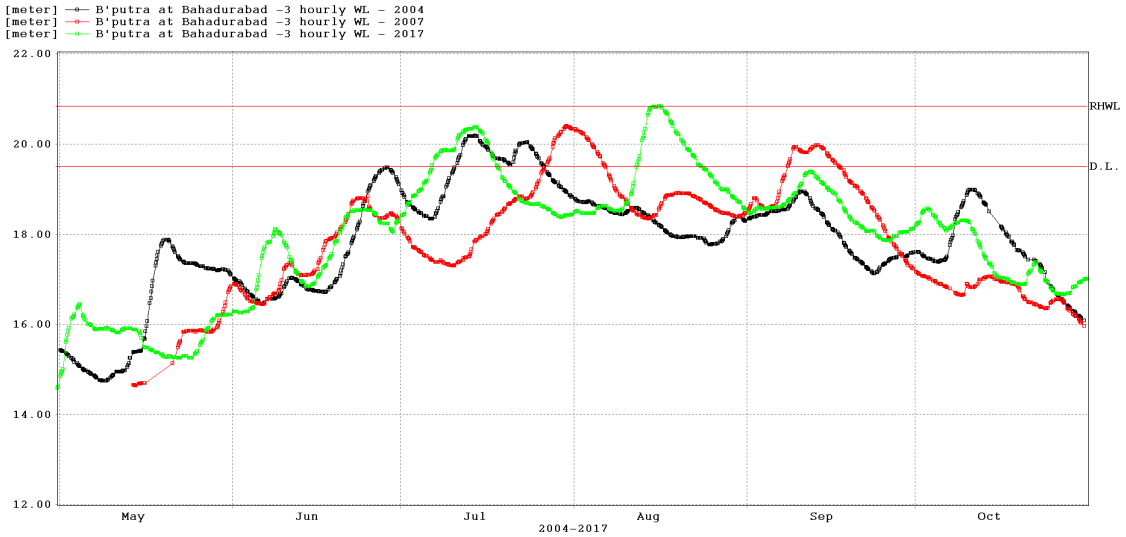


Figure 3.10: Comparison of Hydrograph on Brahmaputra at Bahadurabad

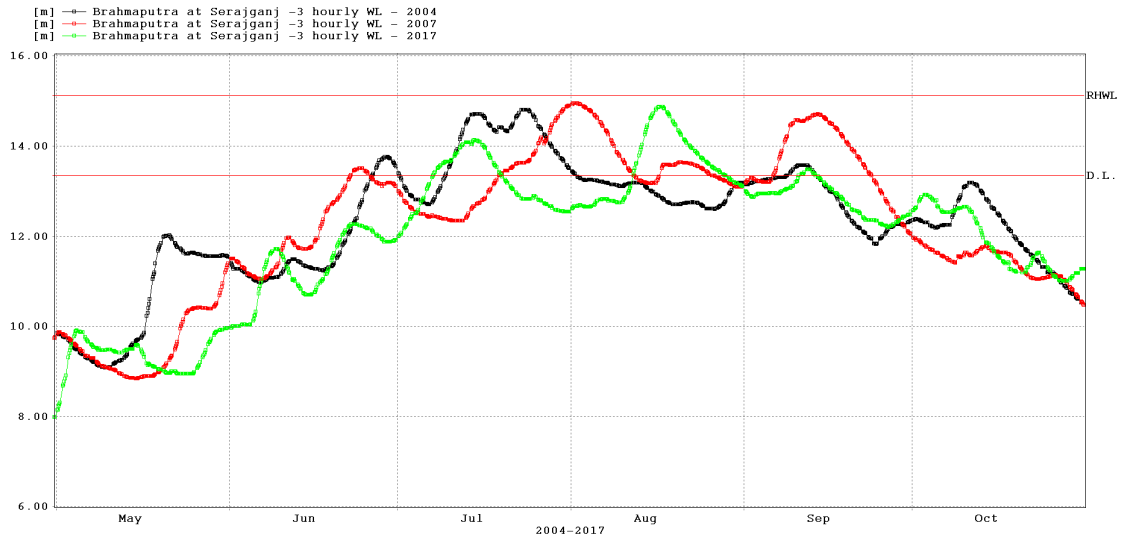


Figure 3.11: Comparison of Hydrograph on Jamuna at Serajgonj

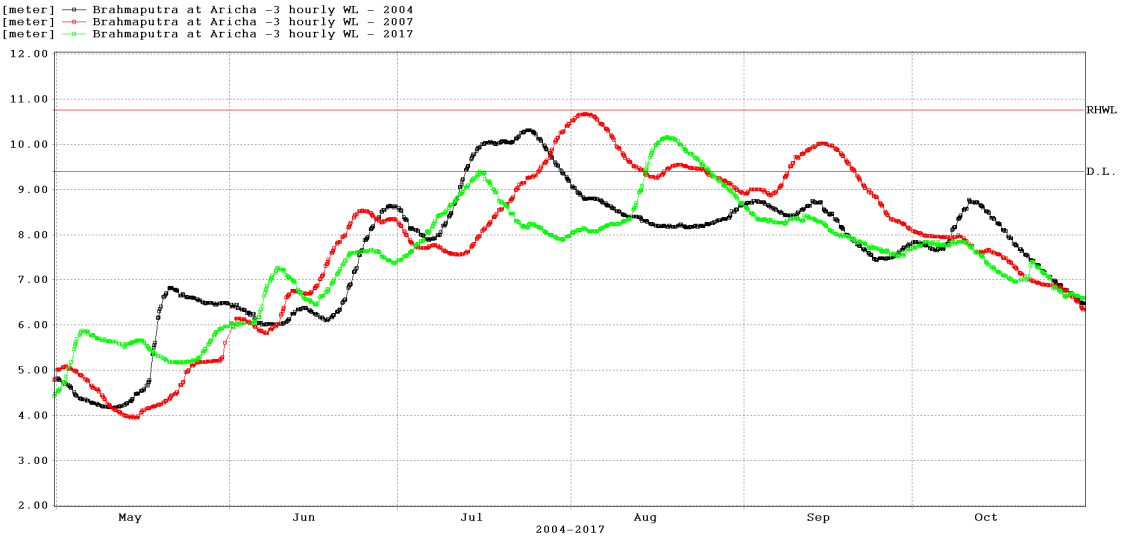


Figure 3.12: Comparison of Hydrograph on Jamuna at Aricha

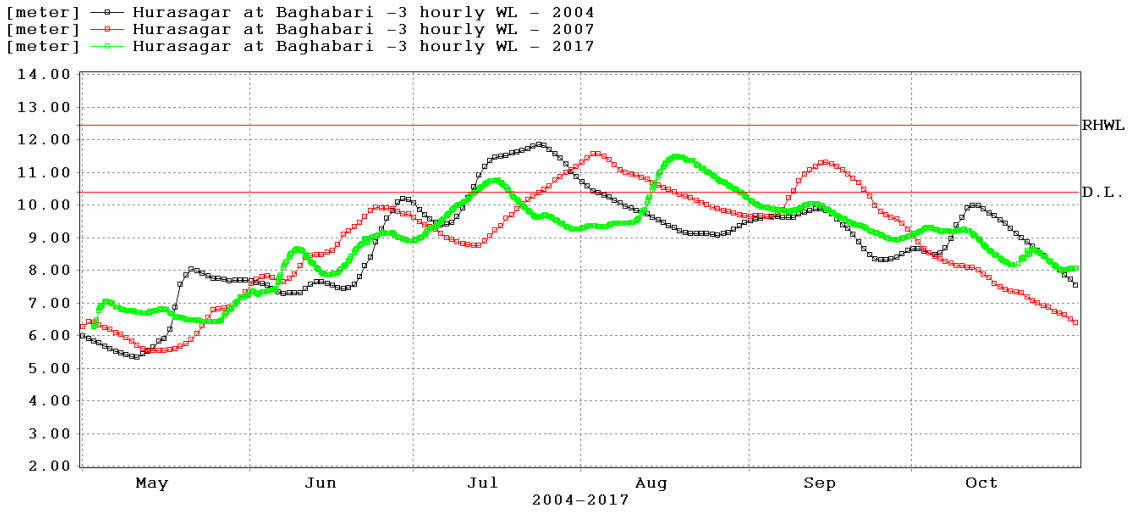


Figure 3.13: Comparison of Hydrograph on Atrai at Baghabari

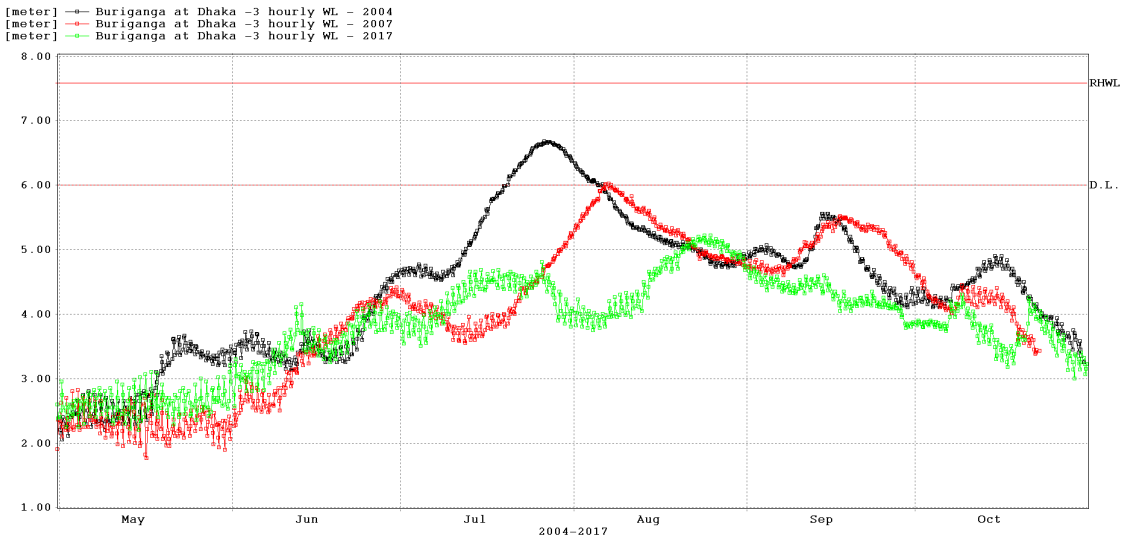


Figure 3.14 : Comparison of Hydrograph on Buriganga at Dhaka (Milbarak)

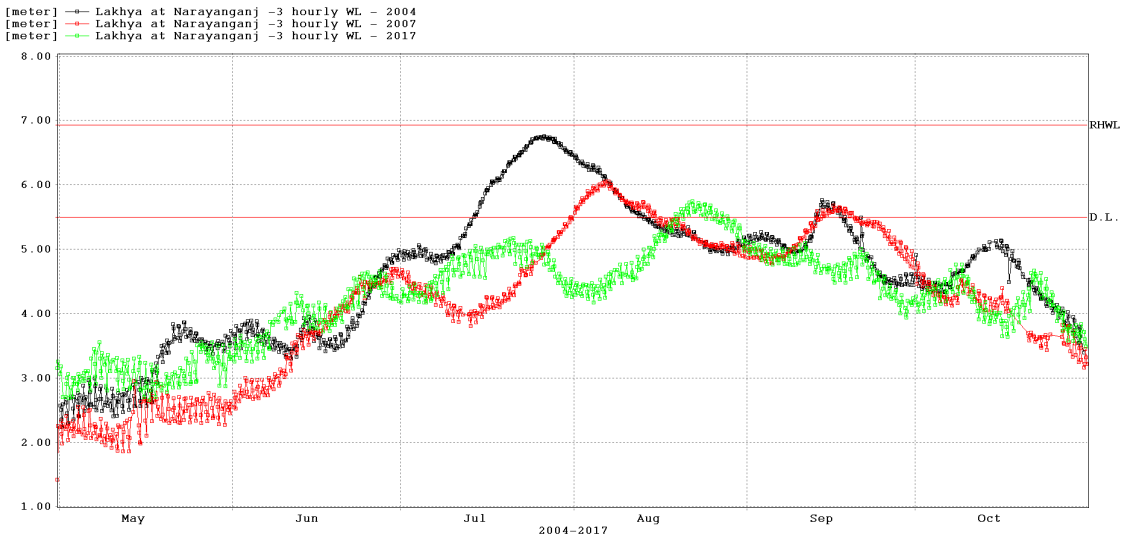


Figure 3.15: Comparison of Hydrograph on Lakhya at Narayangonj

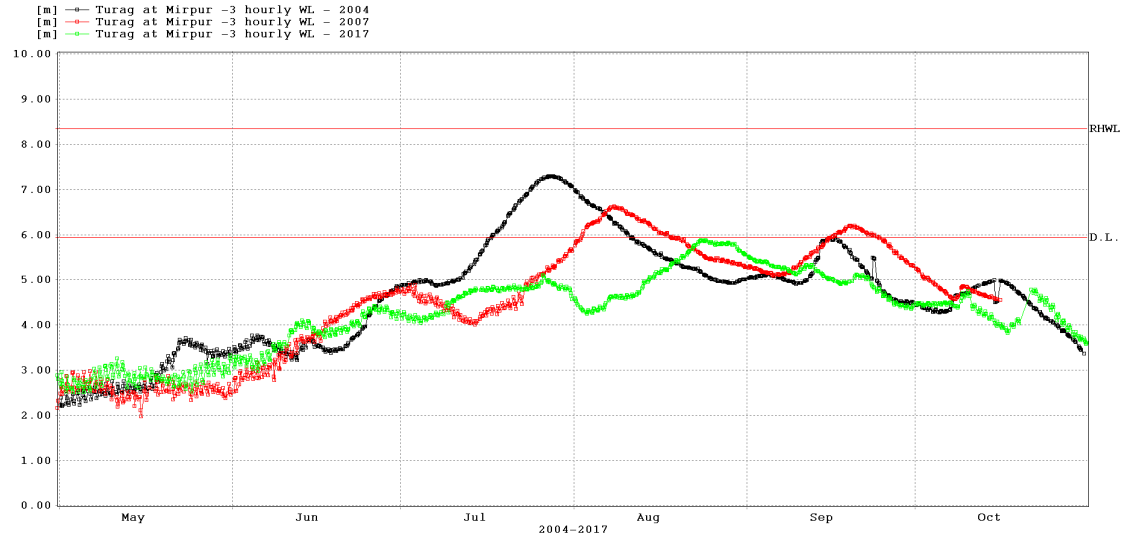


Figure 3.16 : Comparison of Hydrograph on Turag at Mirpur

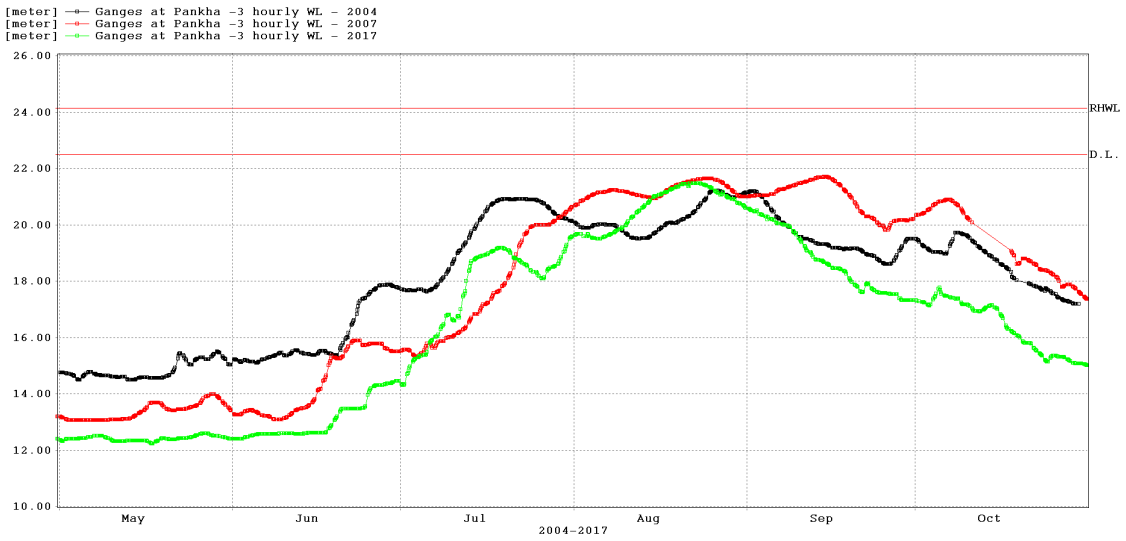


Figure 3.17: Comparison of Hydrograph on Ganges at Pankha

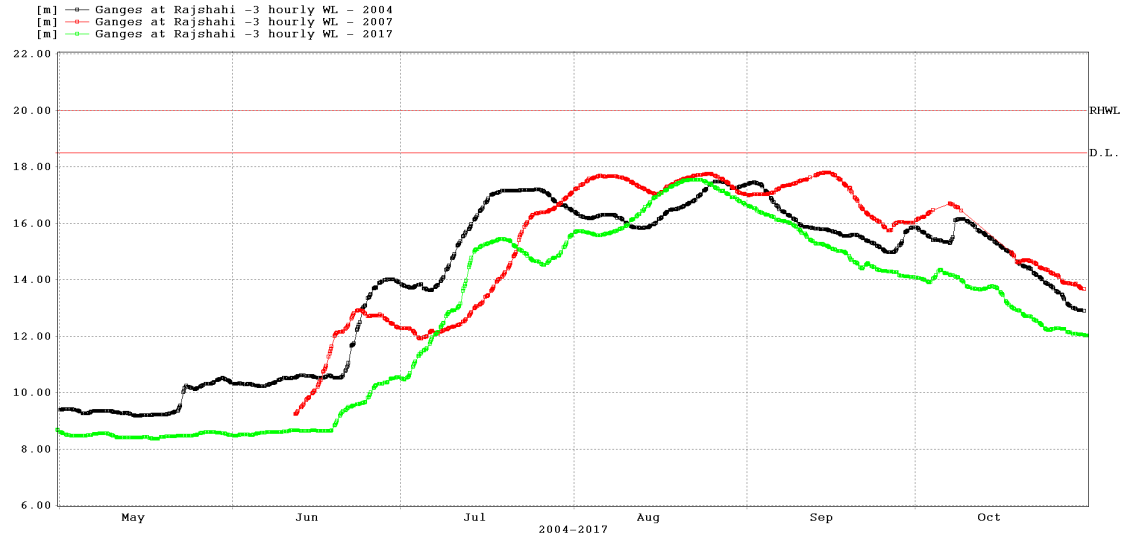


Figure 3.18: Comparison of Hydrograph on Ganges at Rajshahi

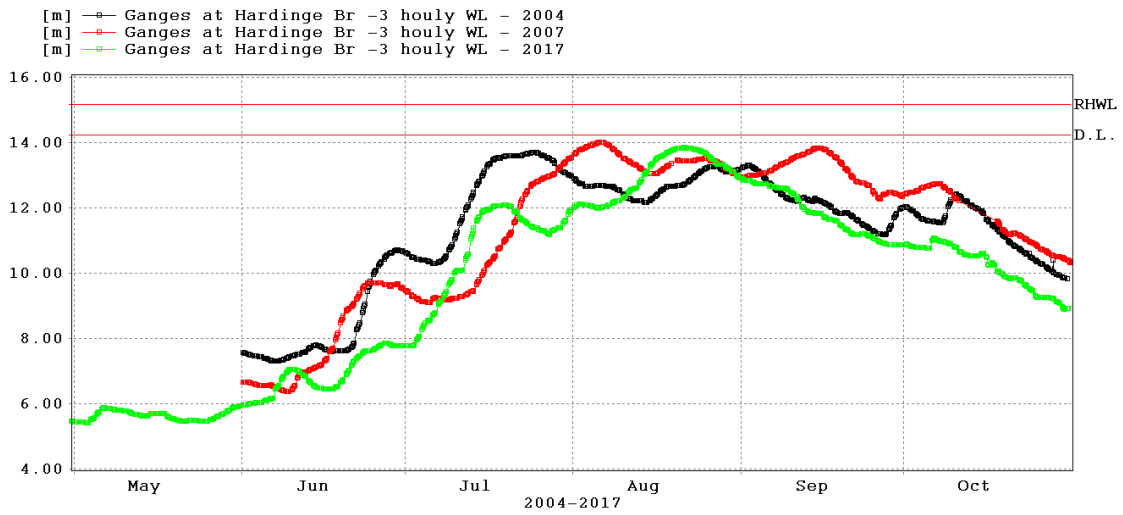


Figure 3.19: Comparison of Hydrograph on Ganges at Hardinge Bridge

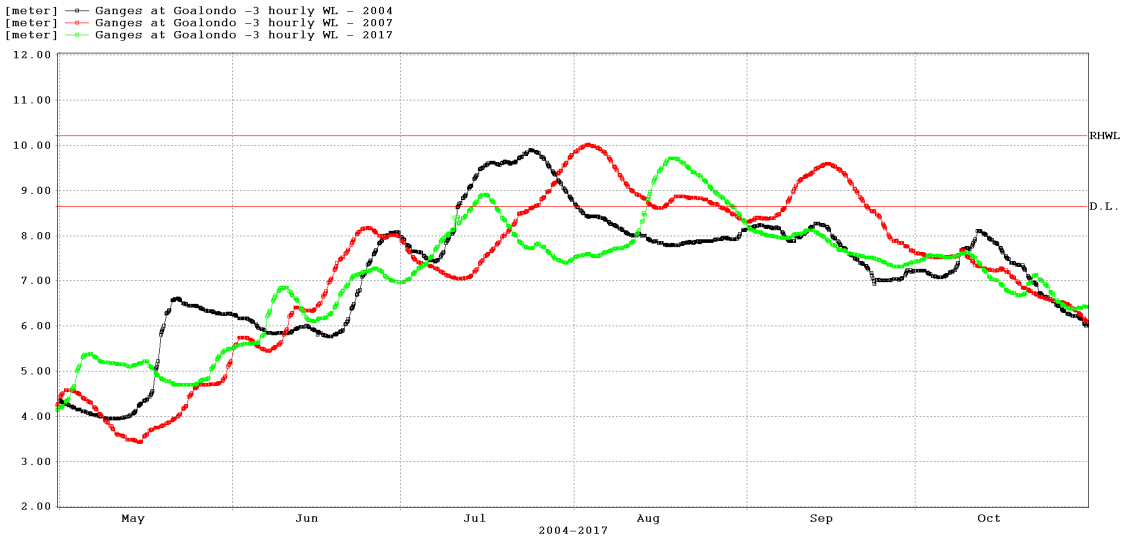


Figure 3.20: Comparison of Hydrograph on Padma at Goalondo

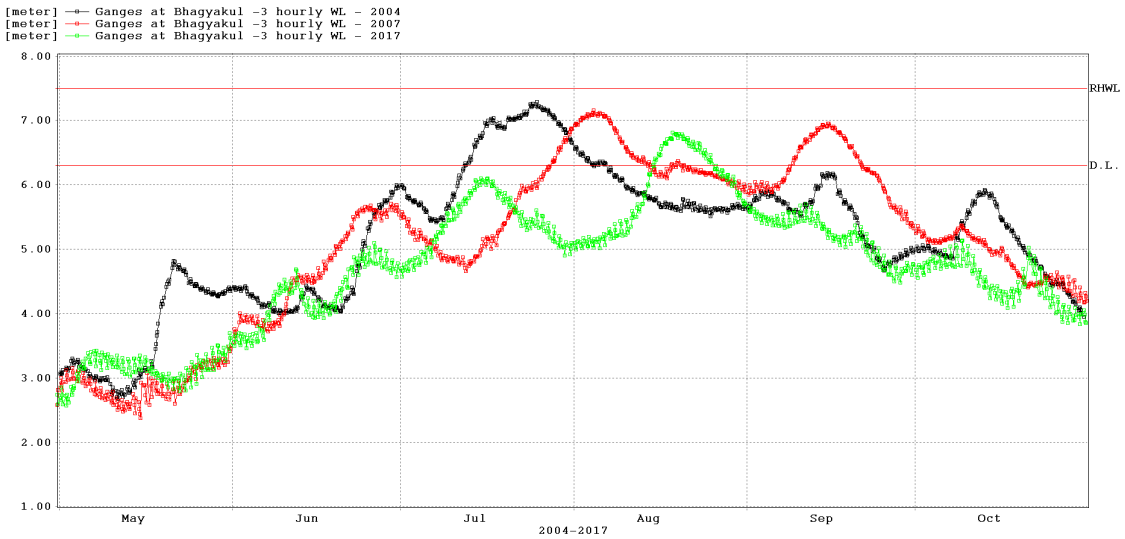


Figure 3.21: Comparison of Hydrograph on Padma at Bhagyakul

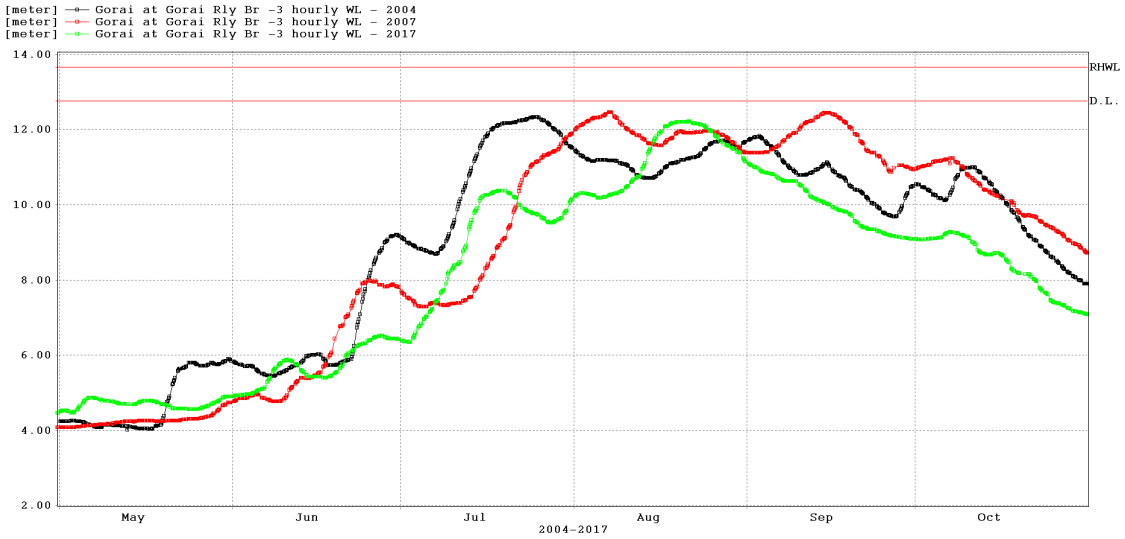


Figure 3.22: Comparison of Hydrograph on Gorai at Gorai Railway Bridge

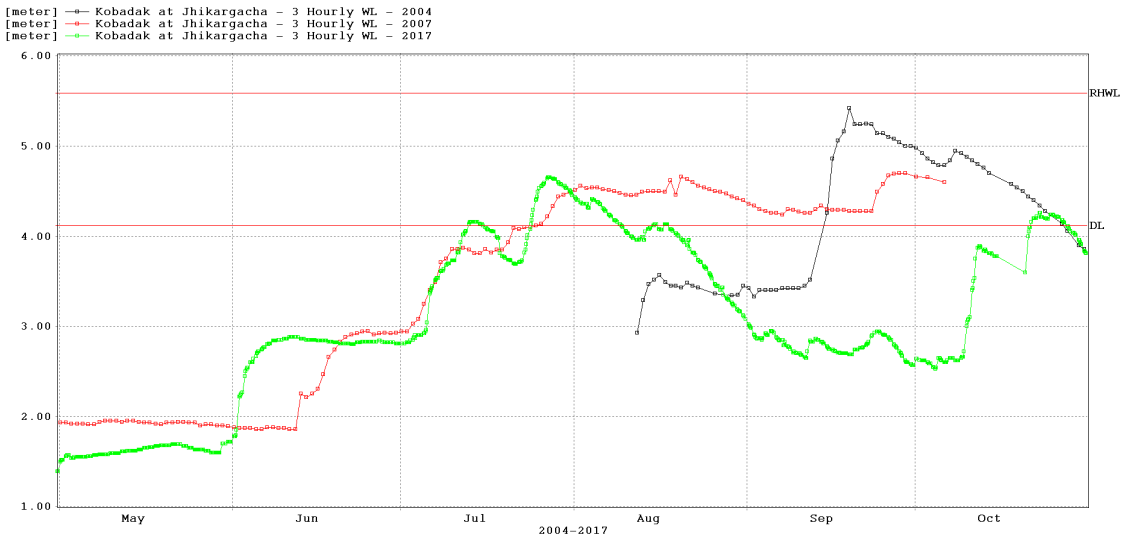


Figure 3.23: Comparison of Hydrograph on Kobodak at Jhikargacha

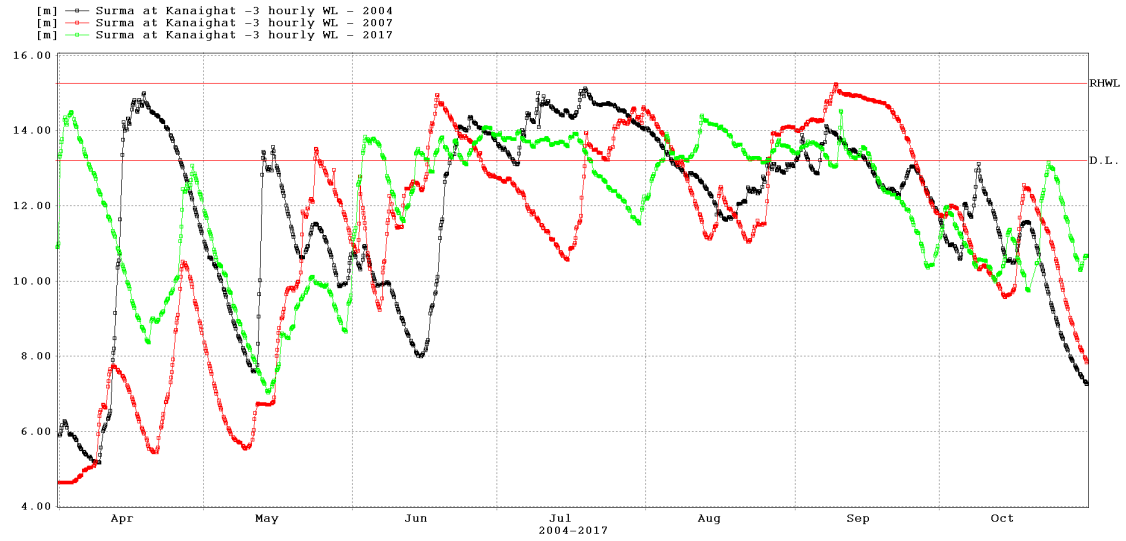


Figure 3.24: Comparison of Hydrograph on Surma at Kanaighat

Figure 3.25: Comparison of Hydrograph on Surma at Sylhet

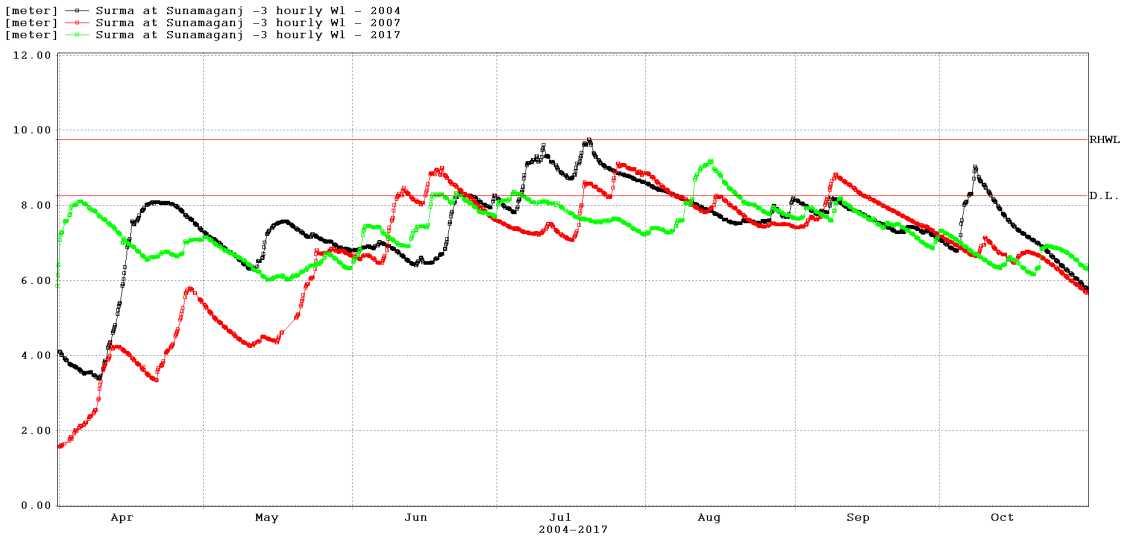


Figure 3.26: Comparison of Hydrograph on Surma at Sunamganj

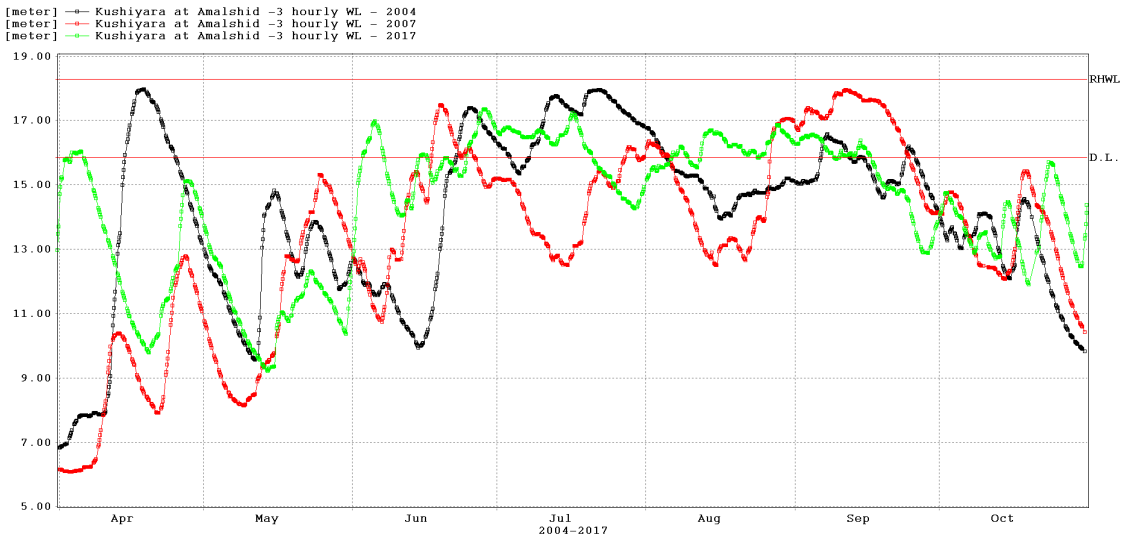


Figure 3.27: Comparison of Hydrograph on Kushiyara at Amalshid

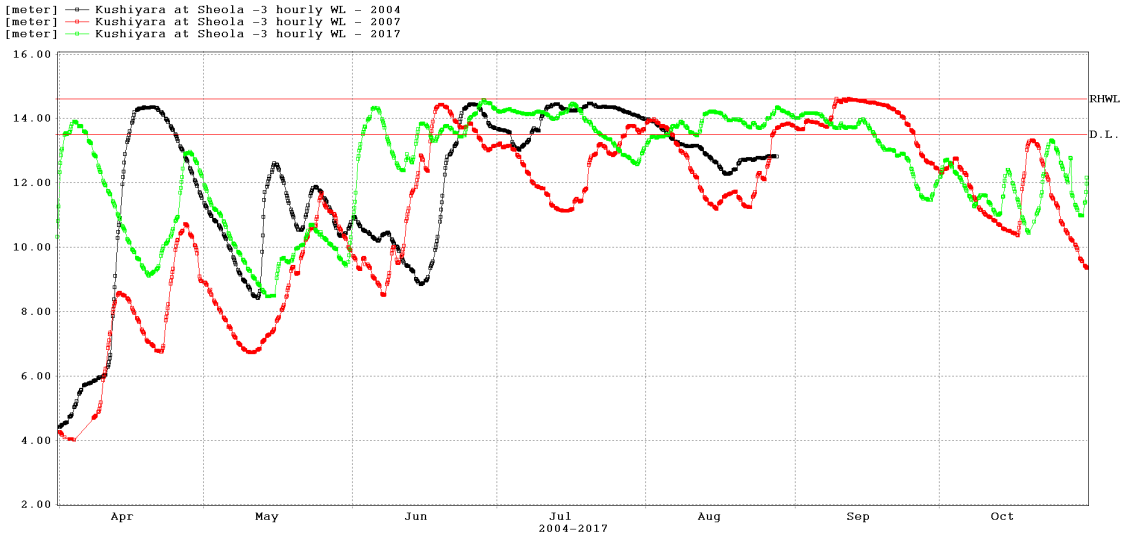


Figure 3.28: Comparison of Hydrograph on Kushiyara at Sheola

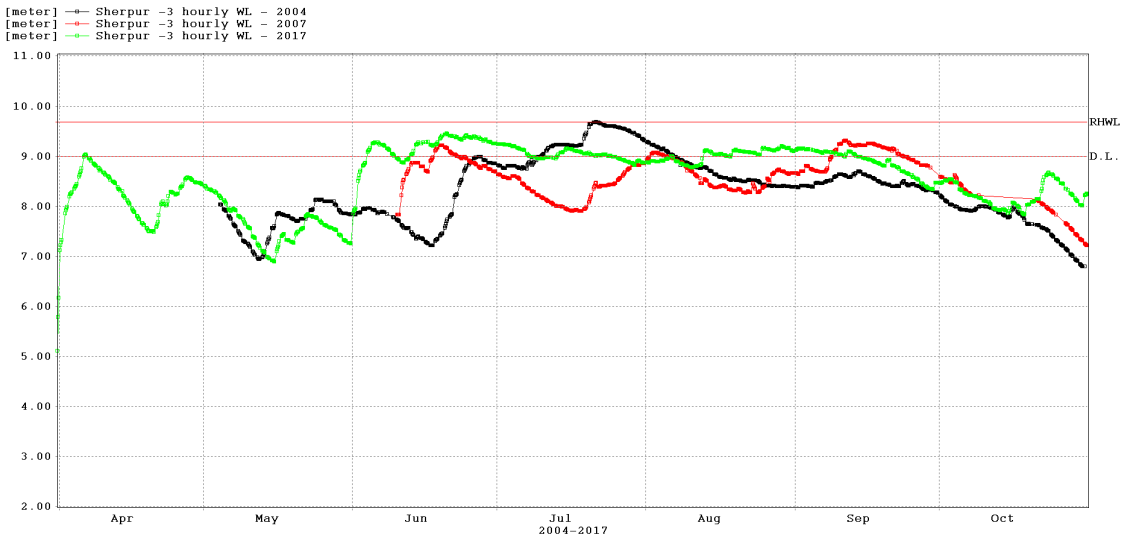


Figure 3.29: Comparison of Hydrograph on Kushiyara at Sherpur

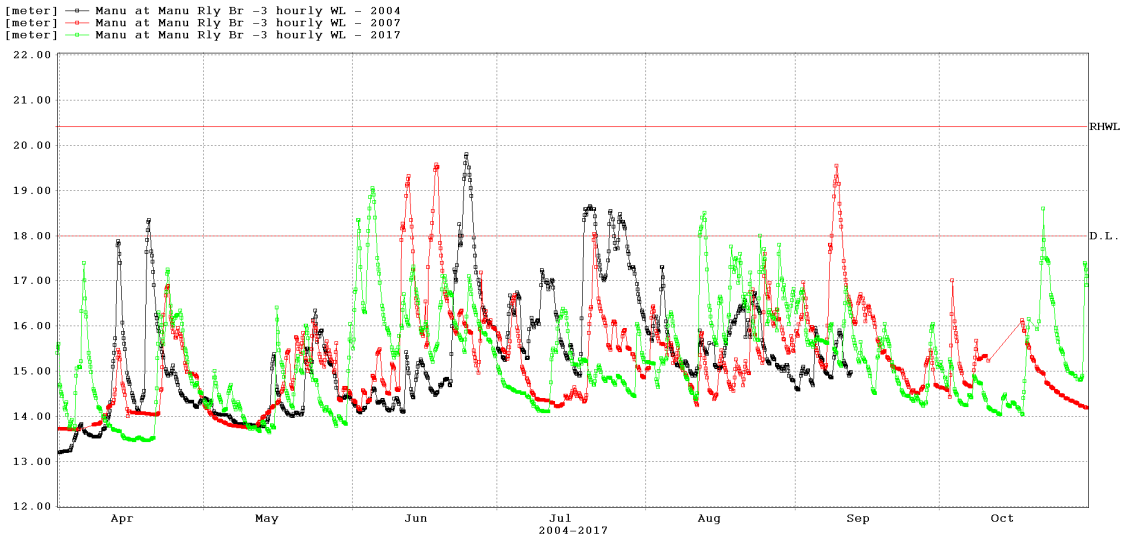


Figure 3.30: Comparison of Hydrograph on Manu at Manu Rail Bridge

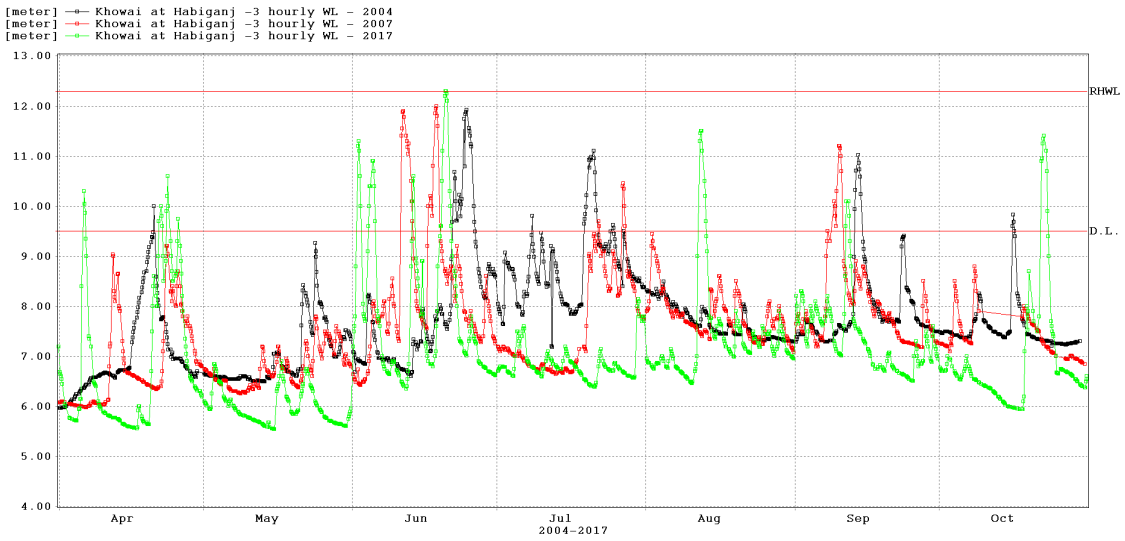


Figure 3.31: Comparison of Hydrograph on Khowai at Habiganj

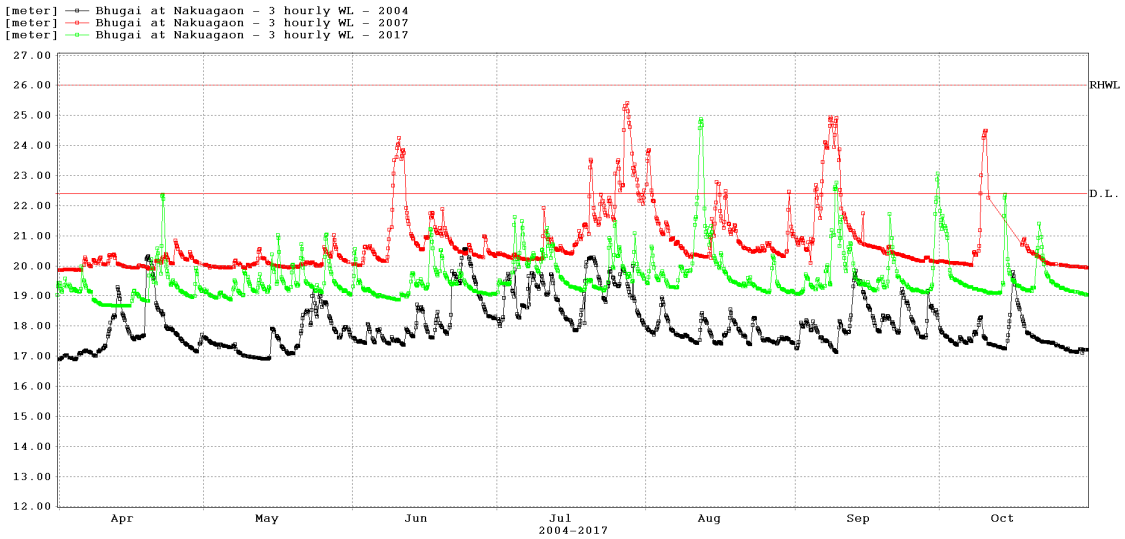


Figure 3.32: Comparison of Hydrograph on Bhugai at Nakuagaon

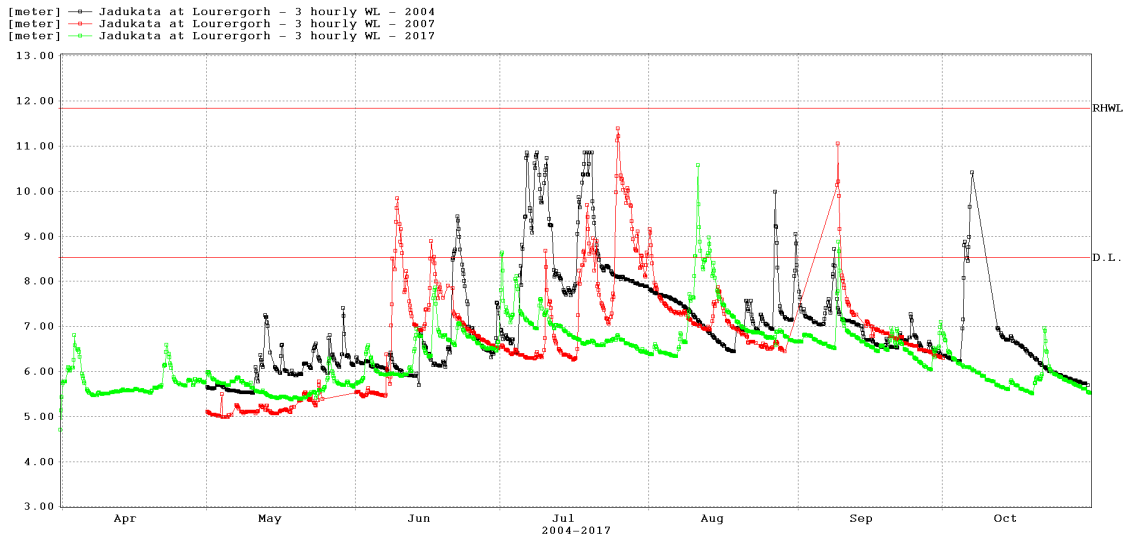


Figure 3.33: Comparison of Hydrograph on Jadukata at Lorergarh

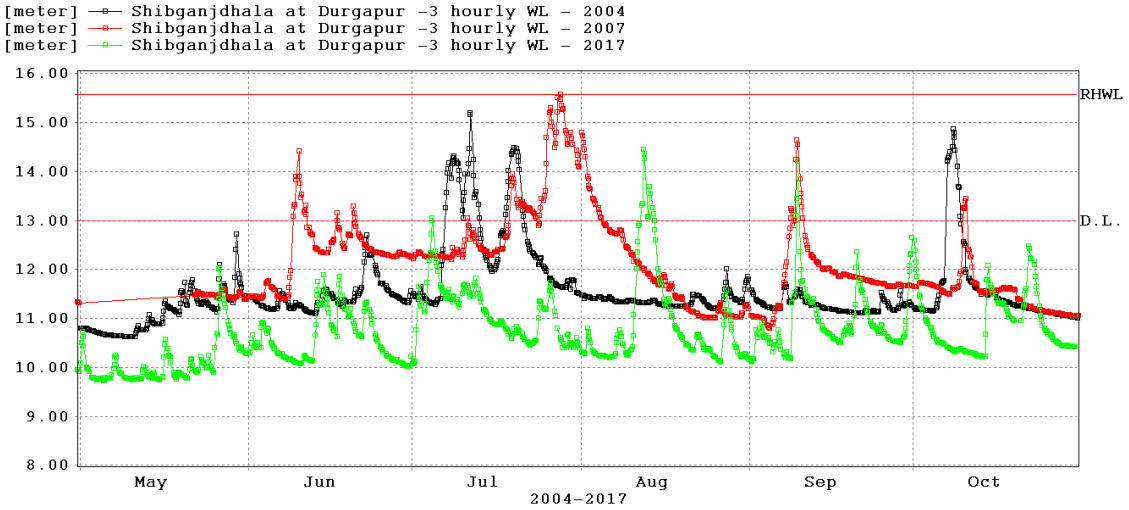


Figure 3.34: Comparison of Hydrograph on Someswari at Durgapur

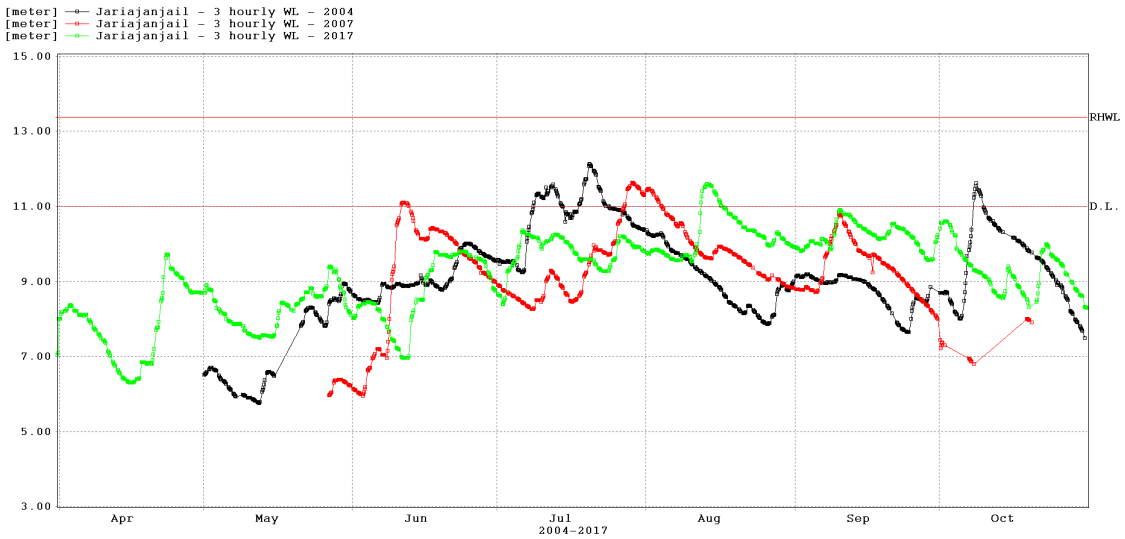


Figure 3.35: Comparison of Hydrograph on Kangsha at Jariajanjail

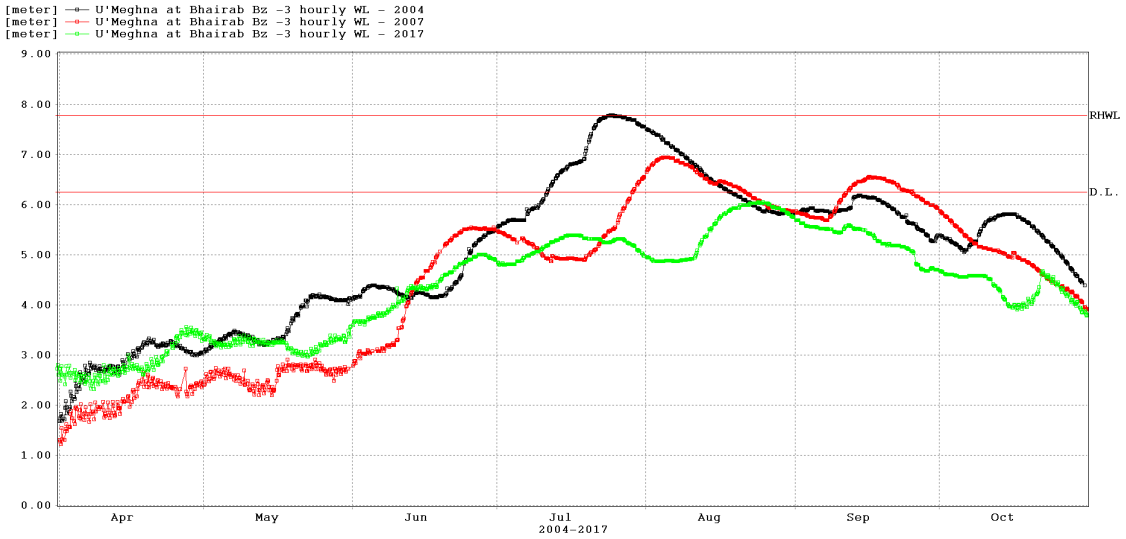


Figure 3.36: Comparison of Hydrograph on Upper Meghna at Bhairab Bazar

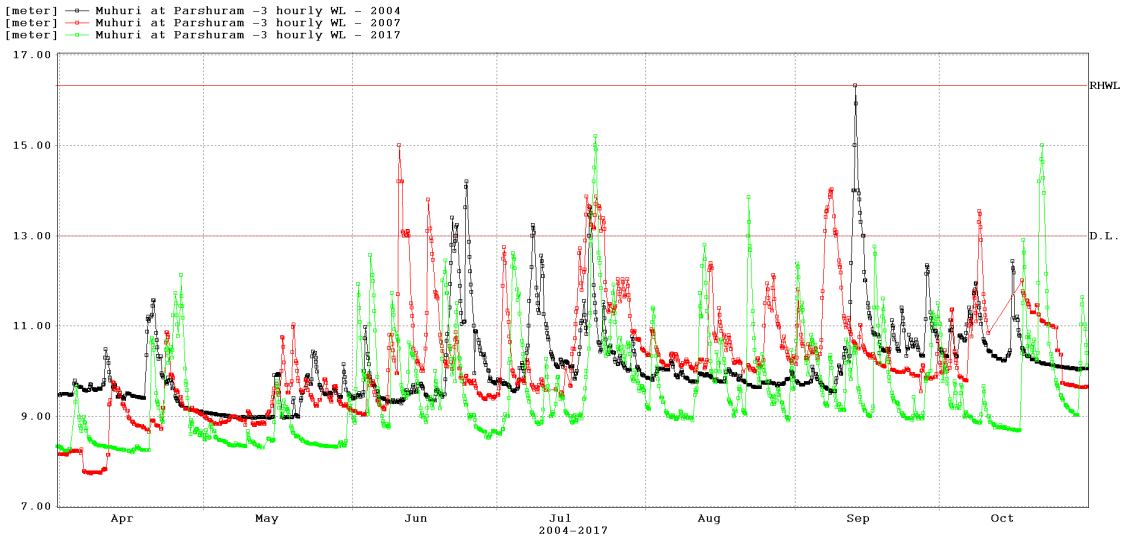


Figure 3.37: Comparison of Hydrograph on Muhuri at Parshuram

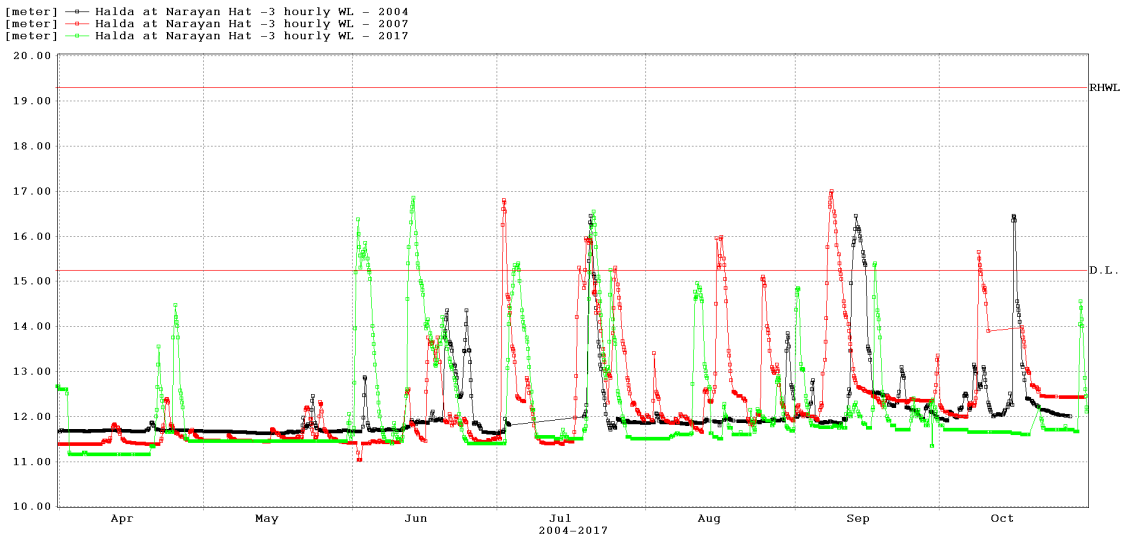


Figure 3.38 : Comparison of Hydrograph on Halda at Narayanhat

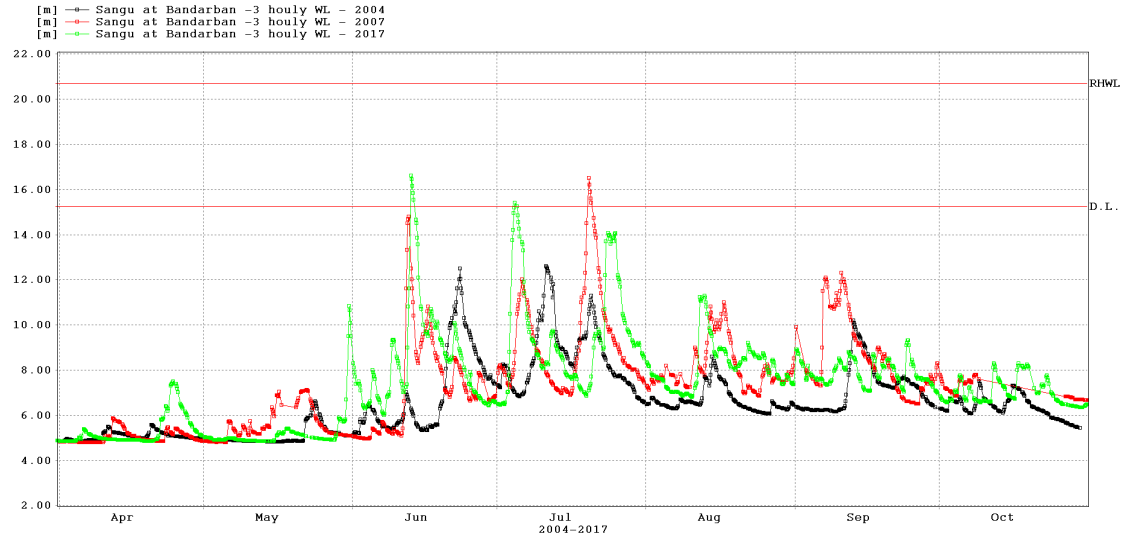


Figure 3.39: Comparison of Hydrograph on Sangu at Bandarban

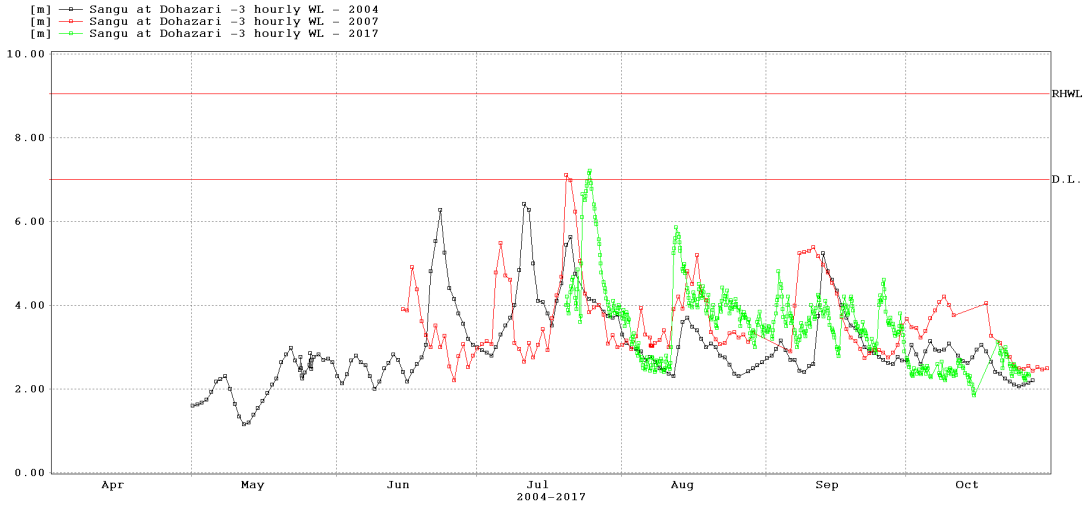


Figure 3.40: Comparison of Hydrograph on Sangu at Dohazari

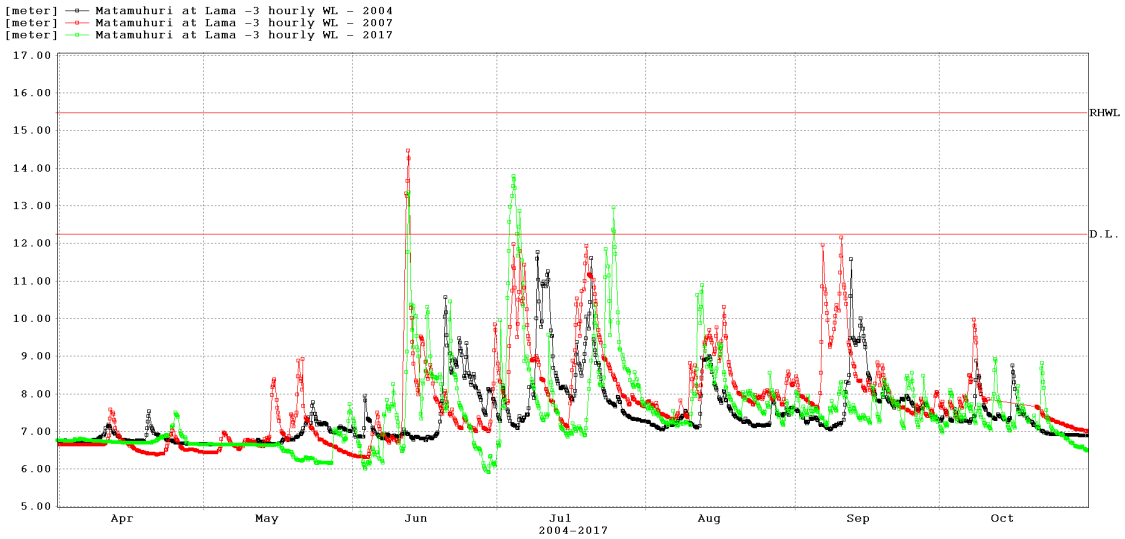


Figure 3.41: Comparison of Hydrograph on Matamuhuri at Lama

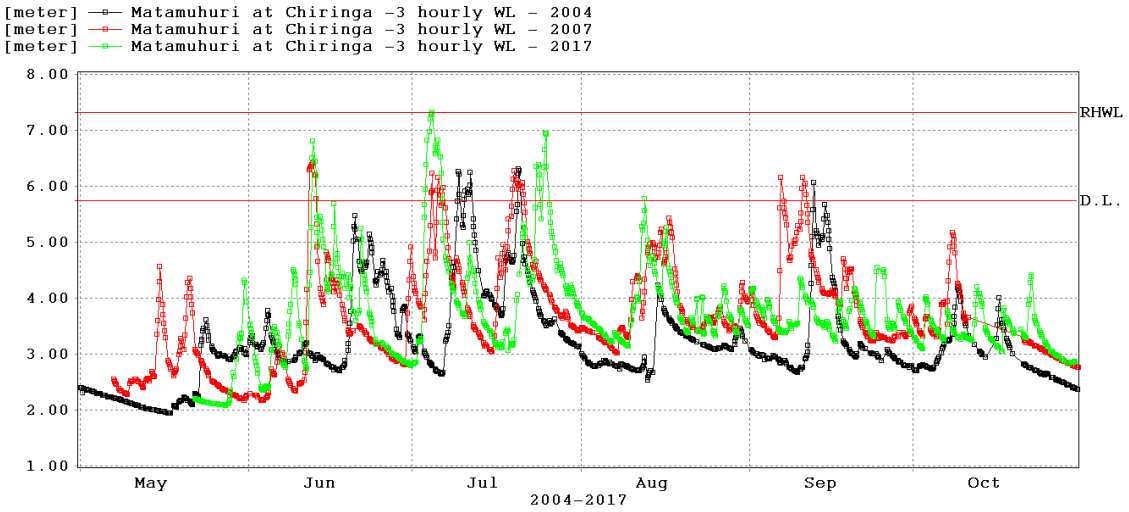


Figure 3.42: Comparison of Hydrograph on Matamuhuri at Chiringa

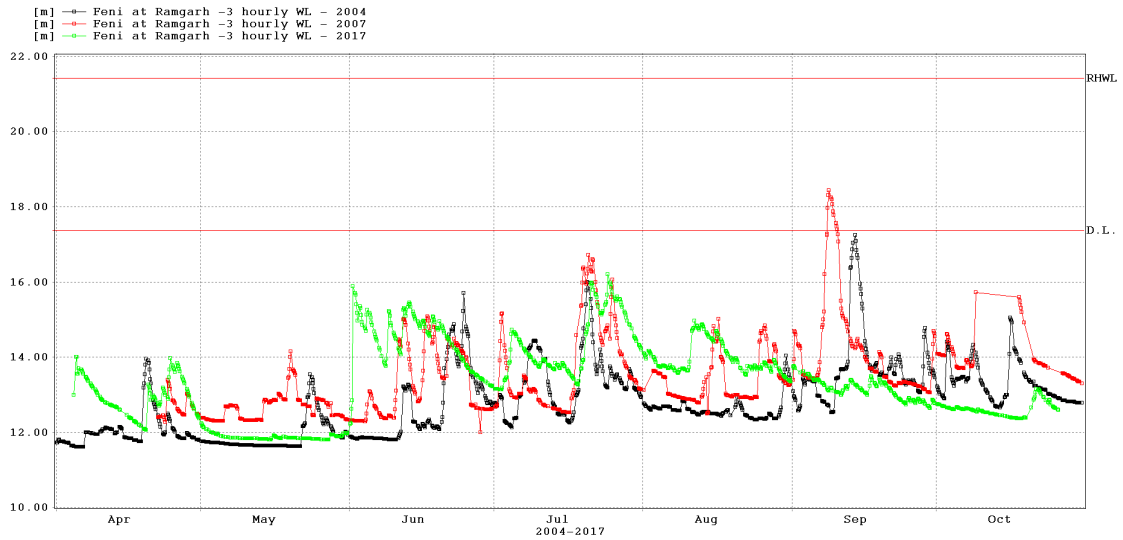


Figure 3.43: Comparison of Hydrograph on Feni at Ramgarh

CHAPTER 4: FORECAST EVALUATION, 2017

4.1 GENERAL

BWDB is the mandated organization for flood forecasting and warning services in Bangladesh as par the BWDB Act-2000. FFWC under BWDB has been carrying out this task through preparation of flood forecasting and early warning messages and its dissemination. Flood forecasting system of FFWC is developed using MIKE 11, a one-dimensional water modeling software used for the simulation of WLs and discharges in river networks and flood plains. The existing early warning system of floods provides a lead time of 120 hours, previously which was 72 hours. In order to meet the needs and expectations of flood forecast with increased lead times for cropping decisions, such as early harvesting, or to implement a contingency crop plan or protect infrastructure and preserve livelihoods, a research initiative was taken in July 2011 with support from CDMP-II under Ministry of Food and Disaster Management (MoFDM) (from middle of 2012 renamed as Ministry of Disaster Management and Relief) to increase lead time for deterministic flood forecast up to 5 days (120 hours) from then existing 3-days (72 hours) forecast and also to extend the flood forecast to few selected BWDB projects. Since June 2015, FFWC is generating and disseminating 5-days deterministic flood forecast with experimental 4th and 5th day forecast in 54 stations during monsoon on operational basis.

The Climate Forecast Applications in Bangladesh (CFAB) project was supported by USAID/OFDA to develop and evaluate three tire overlapping forecast systems with improved lead time during monsoon seasons of 2003 and 2004. It showed a success in forecasting the discharges at Hardinge Bridge station of Ganges and Bahadurabad station of Brahmaputra river of Bangladesh. From March 2006 – June 2009, CARE-Bangladesh and United States Agency for International Development (USAID), Dhaka supported the program with an objective to technology transfer and capacity building for sustainable end-to-end generation and application of flood forecasts through pilot projects at selected sites.

Under the project, the medium range probabilistic flood forecast with 10-days lead time was initiated to a limited number of places (18 stations) on experimental basis. After the termination of the support from the USAID-CARE, this has been continued with technical support from RIMES. Another initiative was started in July 2012 to expand the number of points for medium range 10-days probabilistic flood forecast with a view to increase the areal coverage, along with a long range seasonal flood forecast at 5 places on experimental basis with support from USAID through CARE-Bangladesh under SHOURHARDO-II programme with technical support from RIMES. Currently FFWC is experimentally generating medium range 10-days probabilistic flood forecast in 37 stations during monsoon and disseminating on a limited basis.

4.2 EVALUATION CRITERIA OF FORECAST PERFORMANCE

Two statistical criteria considered for the performance evaluation of the model are as follows:

- Mean Absolute Error, MAE
- Co-efficient of Determination, r^2

4.2.1. Mean Absolute Error (MAE)

MAE is the mean of the absolute difference between *Observed* and *Forecast* levels as shown in the following equation:

$$MAE = \frac{\sum_{i=1}^{n} |x_i - y_i|}{n}$$

Where,

$x_1, x_2 \ldots\ldots x_n$ are *Observed* water levels

$y_1, y_2 \ldots\ldots y_n$ are *Forecast* water levels

n is the number of *Observed/Forecast* levels

4.2.2. Co-efficient of Determination, r^2

r^2 is the *Co-efficient of Determination* for the correlation of *Observed* and *Forecast* water levels and is given by the relation as show in the equation below:

$$r^2 = \frac{\left[\sum_{i=1}^{n} \left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)\right]^2}{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2 \sum_{i=1}^{n} \left(y_i - \bar{y}\right)^2}$$

Where,

$x_1, x_2 \ldots\ldots x_n$ are *Observed* water levels

$\bar{x}$ is the average of *Observed* water levels

$y_1, y_2 \ldots\ldots y_n$ are *Forecast* water levels

$\bar{y}$ is the average of *Forecast* water levels

n is the number of *Observed/Forecast* levels

4.3 PRE-DEFINED SCALES TO EVALUATE FORECAST PERFORMANCE

The forecast performances for the monsoon-2015 have been evaluated from the statistical components r^2 (*Co-efficient of Determination*) and *MAE* (*Mean Absolute Error*). Values of the above two components in their ideal case are generally assumed to be in the order of $MAE = 0$

$r^2 = 1$

Utilizing above two indicators, 5 category scales have been used to describe forecast performances. Stations having a minimum value of 0.9 for r^2 and a maximum value of 15 centimeter for *MAE* have been considered as "*Good*" performance. Table 4.1 presents the definition of scales used in the evaluation:

Table 4.1 : Scales used for performance evaluation

Sl. No.	Scale	Value
1	*Good*	*MAE* <= 0.15 meter & r^2 >= 0.9
2	*Average*	*MAE* <= 0.2 meter & >0.15 meter and r^2 >= 0.7 & <0.9
3	*Not satisfactory*	*MAE* <= 0.3 meter & >0.2 meter and r^2 >= 0.4 & <0.7
4	*Poor*	*MAE* <= 0.4 meter& >0.3 meter and r^2 >= 0.3 & <0.4
5	*Very Poor*	*MAE* > 0.4 meter or r^2 < 0.3

Simulations were made for maximum 120 hours in the forecast period and forecasts were saved in the database at 24-hour and 48-hour, 72-hour, 96-hour and 120-hour intervals. Usually, the forecast quality gradually deteriorates with higher forecast intervals from the time of forecast. As lead time increases the forecast accuracy decreases.

4.4 DETERMINISTIC FORECAST STATISTICS AND PERFORMANCE, 2017

For deterministic forecasts, simulations were made up to 120 hours (5-days) in the forecast period. Total 46 stations located within the model area (including some boundary stations) are evaluated. The deterministic forecast statistics along with performance based on the aforementioned scale are provided in Tables 4.2 to 4.6 and in Figures 4.1 to 4.5. From the following tables it can be seen that for 1-day forecast 95.67% stations are within the range of Good and Average based on performance, while for 2-days, 3-days, 4-days and 5-days forecast 76.10%, 65.23%, 36.97% and 30.45% stations are within the range of Good and Average respectively. A number of stations near boundary showed poor performance for increased lead time, most of which had flow of flashy characteristics or were under upstream regulation outside territory. From the following tables it can also be seen that based on the average statistics of co-efficient of determination the forecasts were 97% (MAE 0.09m), 93% (MAE 0.16m), 88% (MAE 0.21m), 83% (MAE 0.27m) and 78% (MAE 0.32m) consistent respectively for 24, 48, 72, 96 and 120 hours in the monsoon of 2017.

Table 4.2: Statistics for 24-hours Forecast Performance (Year, 2017)

Sl. No.	Station	MAE (m)	r^2	Performance-48hrs
1	Aricha	0.05	1.00	Good
2	Baghabari	0.05	1.00	Good
3	Bahadurabad	0.06	1.00	Good
4	Bhagyakul	0.06	0.99	Good
5	Bhairab Bazar	0.05	0.96	Good
6	Bogra	0.18	0.93	Average
7	Chakrahimpur	0.10	0.99	Good
8	Chapai Nawabganj	0.07	1.00	Good
9	Chilmari	0.06	1.00	Good
10	Demra	0.07	0.94	Good
11	Derai	0.03	1.00	Good
12	Dhaka (Mill Barrack)	0.09	0.94	Good
13	Elashinghat	0.05	1.00	Good
14	Gaibandha	0.11	0.97	Good
15	Goalondo	0.05	1.00	Good
16	Gorai Rly Bridge	0.06	1.00	Good
17	Hardinge Br	0.05	1.00	Good
18	Jagir	0.08	0.99	Good
19	Jamalpur	0.17	0.98	Average
20	Kamarkhali	0.06	1.00	Good
21	Kaunia	0.19	0.86	Average
22	Kazipur	0.05	1.00	Good
23	Khaliajuri	0.03	1.00	Good
24	Kurigram	0.11	0.98	Good
25	Lakhpur	0.09	0.99	Good
26	Markuli	0.04	0.96	Good
27	Meghna Bridge	0.13	0.93	Good
28	Mirpur	0.07	0.99	Good
29	Mohadevpur	0.24	0.93	Not Satisfactory
30	Moulvi Bazar	0.29	0.79	Not Satisfactory
31	Mymensingh	0.15	0.98	Good
32	Naogaon	0.15	0.99	Good
33	Narayanganj	0.09	0.95	Good
34	Narsingdi	0.06	0.98	Good
35	Nayerhat	0.05	1.00	Good
36	Rajshahi	0.06	1.00	Good
37	Sariakandi	0.07	0.98	Good
38	Serajganj	0.06	1.00	Good
39	Sheola	0.13	0.95	Good
40	Sherpur-Sylhet	0.05	0.95	Good
41	Singra	0.07	1.00	Good
42	Sunamganj	0.09	0.96	Good
43	Sureswar	0.13	0.90	Good
44	Sylhet	0.11	0.96	Good
45	Taraghat	0.07	1.00	Good
46	Tongi	0.05	1.00	Good

Table 4.3: Statistics for 48-hours Forecast Performance (Year, 2017)

Sl. No.	Station	MAE (m)	r^2	Performance-48hrs
1	Aricha	0.08	0.99	Good
2	Baghabari	0.07	0.99	Good
3	Bahadurabad	0.11	0.98	Good
4	Bhagyakul	0.10	0.97	Good
5	Bhairab Bazar	0.08	0.95	Good
6	Bogra	0.35	0.76	Poor
7	Chakrahimpur	0.18	0.97	Average
8	Chapai Nawabganj	0.16	1.00	Average
9	Chilmari	0.12	0.97	Good
10	Demra	0.11	0.88	Average
11	Derai	0.05	0.99	Good
12	Dhaka (Mill Barrack)	0.14	0.87	Average
13	Elashinghat	0.08	0.99	Good
14	Gaibandha	0.20	0.91	Average
15	Goalondo	0.08	0.99	Good
16	Gorai Rly Bridge	0.12	1.00	Good
17	Hardinge Br	0.10	1.00	Good
18	Jagir	0.14	0.96	Good
19	Jamalpur	0.27	0.95	Not Satisfactory
20	Kamarkhali	0.10	1.00	Good
21	Kaunia	0.26	0.75	Not Satisfactory
22	Kazipur	0.10	0.98	Good
23	Khaliajuri	0.05	0.98	Good
24	Kurigram	0.21	0.90	Not Satisfactory
25	Lakhpur	0.15	0.96	Good
26	Markuli	0.06	0.92	Good
27	Meghna Bridge	0.21	0.81	Not Satisfactory
28	Mirpur	0.12	0.95	Good
29	Mohadevpur	0.40	0.84	Poor
30	Moulvi Bazar	0.45	0.56	Very Poor
31	Mymensingh	0.28	0.91	Not Satisfactory
32	Naogaon	0.28	0.94	Not Satisfactory
33	Narayanganj	0.15	0.87	Average
34	Narsingdi	0.09	0.95	Good
35	Nayerhat	0.09	0.99	Good
36	Rajshahi	0.13	1.00	Good
37	Sariakandi	0.12	0.95	Good
38	Serajganj	0.09	0.99	Good
39	Sheola	0.25	0.85	Not Satisfactory
40	Sherpur-Sylhet	0.09	0.91	Good
41	Singra	0.13	0.99	Good
42	Sunamganj	0.16	0.87	Average
43	Sureswar	0.22	0.75	Not Satisfactory
44	Sylhet	0.20	0.87	Average
45	Taraghat	0.13	0.99	Good
46	Tongi	0.09	0.97	Good

Table 4.4: Statistics for 72-hours Forecast Performance (Year, 2017)

Sl. No.	Station	MAE (m)	r^2	Performance-72hrs
1	Aricha	0.11	0.98	Good
2	Baghabari	0.11	0.98	Good
3	Bahadurabad	0.18	0.94	Average
4	Bhagyakul	0.13	0.96	Good
5	Bhairab Bazar	0.10	0.94	Good
6	Bogra	0.52	0.58	Very Poor
7	Chakrahimpur	0.24	0.95	Not Satisfactory
8	Chapai Nawabganj	0.25	0.99	Not Satisfactory
9	Chilmari	0.19	0.92	Average
10	Demra	0.15	0.82	Average
11	Derai	0.06	0.97	Good
12	Dhaka (Mill Barrack)	0.17	0.80	Average
13	Elashinghat	0.10	0.98	Good
14	Gaibandha	0.31	0.80	Poor
15	Goalondo	0.11	0.98	Good
16	Gorai Rly Bridge	0.17	0.99	Average
17	Hardinge Br	0.16	1.00	Average
18	Jagir	0.18	0.93	Average
19	Jamalpur	0.35	0.92	Poor
20	Kamarkhali	0.14	1.00	Good
21	Kaunia	0.30	0.69	Not Satisfactory
22	Kazipur	0.16	0.95	Average
23	Khaliajuri	0.07	0.96	Good
24	Kurigram	0.30	0.80	Not Satisfactory
25	Lakhpur	0.19	0.94	Average
26	Markuli	0.07	0.88	Average
27	Meghna Bridge	0.28	0.68	Not Satisfactory
28	Mirpur	0.16	0.89	Average
29	Mohadevpur	0.49	0.74	Very Poor
30	Moulvi Bazar	0.55	0.46	Very Poor
31	Mymensingh	0.38	0.83	Poor
32	Naogaon	0.39	0.87	Poor
33	Narayanganj	0.19	0.78	Average
34	Narsingdi	0.12	0.91	Good
35	Nayerhat	0.12	0.97	Good
36	Rajshahi	0.20	0.99	Average
37	Sariakandi	0.17	0.92	Average
38	Serajganj	0.14	0.97	Good
39	Sheola	0.36	0.75	Poor
40	Sherpur-Sylhet	0.11	0.86	Average
41	Singra	0.17	0.98	Average
42	Sunamganj	0.22	0.79	Not Satisfactory
43	Sureswar	0.29	0.59	Not Satisfactory
44	Sylhet	0.28	0.82	Not Satisfactory
45	Taraghat	0.18	0.97	Average
46	Tongi	0.12	0.94	Good

Table 4.5: Statistics for 96-hours Forecast Performance (Year, 2017)

Sl. No.	Station	MAE (m)	r^2	Performance-96hrs
1	Aricha	0.15	0.96	Good
2	Baghabari	0.14	0.96	Good
3	Bahadurabad	0.27	0.87	Not Satisfactory
4	Bhagyakul	0.15	0.94	Good
5	Bhairab Bazar	0.12	0.92	Good
6	Bogra	0.66	0.42	Very Poor
7	Chakrahimpur	0.30	0.92	Not Satisfactory
8	Chapai Nawabganj	0.33	0.98	Poor
9	Chilmari	0.28	0.84	Not Satisfactory
10	Demra	0.18	0.77	Average
11	Derai	0.08	0.96	Good
12	Dhaka (Mill Barrack)	0.20	0.74	Average
13	Elashinghat	0.14	0.95	Good
14	Gaibandha	0.39	0.70	Poor
15	Goalondo	0.15	0.96	Good
16	Gorai Rly Bridge	0.22	0.98	Not Satisfactory
17	Hardinge Br	0.21	0.99	Not Satisfactory
18	Jagir	0.23	0.90	Not Satisfactory
19	Jamalpur	0.42	0.88	Very Poor
20	Kamarkhali	0.18	0.99	Average
21	Kaunia	0.33	0.63	Poor
22	Kazipur	0.25	0.89	Not Satisfactory
23	Khaliajuri	0.09	0.94	Good
24	Kurigram	0.38	0.70	Poor
25	Lakhpur	0.22	0.92	Not Satisfactory
26	Markuli	0.09	0.84	Average
27	Meghna Bridge	0.34	0.56	Poor
28	Mirpur	0.20	0.84	Average
29	Mohadevpur	0.58	0.62	Very Poor
30	Moulvi Bazar	0.60	0.42	Very Poor
31	Mymensingh	0.46	0.77	Very Poor
32	Naogaon	0.51	0.79	Very Poor
33	Narayanganj	0.23	0.68	Not Satisfactory
34	Narsingdi	0.16	0.86	Average
35	Nayerhat	0.15	0.94	Good
36	Rajshahi	0.28	0.99	Not Satisfactory
37	Sariakandi	0.26	0.84	Not Satisfactory
38	Serajganj	0.22	0.93	Not Satisfactory
39	Sheola	0.45	0.67	Very Poor
40	Sherpur-Sylhet	0.13	0.84	Average
41	Singra	0.22	0.97	Not Satisfactory
42	Sunamganj	0.28	0.70	Not Satisfactory
43	Sureswar	0.35	0.46	Poor
44	Sylhet	0.35	0.76	Poor
45	Taraghat	0.22	0.95	Not Satisfactory
46	Tongi	0.16	0.89	Average

Table 4.6: Statistics for 120-hours Forecast Performance (Year, 2017)

Sl. No.	Station	MAE (m)	r^2	Performance-120hrs
1	Aricha	0.20	0.93	Average
2	Baghabari	0.19	0.93	Average
3	Bahadurabad	0.35	0.79	Poor
4	Bhagyakul	0.17	0.93	Average
5	Bhairab Bazar	0.14	0.90	Good
6	Bogra	0.77	0.31	Very Poor
7	Chakrahimpur	0.36	0.88	Poor
8	Chapai Nawabganj	0.42	0.96	Very Poor
9	Chilmari	0.36	0.75	Poor
10	Demra	0.20	0.74	Average
11	Derai	0.09	0.95	Good
12	Dhaka (Mill Barrack)	0.22	0.71	Not Satisfactory
13	Elashinghat	0.19	0.91	Average
14	Gaibandha	0.45	0.61	Very Poor
15	Goalondo	0.19	0.93	Average
16	Gorai Rly Bridge	0.28	0.97	Not Satisfactory
17	Hardinge Br	0.27	0.98	Not Satisfactory
18	Jagir	0.27	0.87	Not Satisfactory
19	Jamalpur	0.47	0.84	Very Poor
20	Kamarkhali	0.23	0.98	Not Satisfactory
21	Kaunia	0.37	0.54	Poor
22	Kazipur	0.32	0.81	Poor
23	Khaliajuri	0.12	0.90	Good
24	Kurigram	0.47	0.59	Very Poor
25	Lakhpur	0.26	0.89	Not Satisfactory
26	Markuli	0.10	0.81	Average
27	Meghna Bridge	0.39	0.46	Poor
28	Mirpur	0.22	0.80	Not Satisfactory
29	Mohadevpur	0.66	0.51	Very Poor
30	Moulvi Bazar	0.63	0.39	Very Poor
31	Mymensingh	0.52	0.72	Very Poor
32	Naogaon	0.62	0.72	Very Poor
33	Narayanganj	0.26	0.60	Not Satisfactory
34	Narsingdi	0.19	0.81	Average
35	Nayerhat	0.19	0.91	Average
36	Rajshahi	0.35	0.98	Poor
37	Sariakandi	0.33	0.75	Poor
38	Serajganj	0.31	0.87	Poor
39	Sheola	0.49	0.64	Very Poor
40	Sherpur-Sylhet	0.15	0.81	Average
41	Singra	0.26	0.96	Not Satisfactory
42	Sunamganj	0.32	0.62	Poor
43	Sureswar	0.41	0.37	Very Poor
44	Sylhet	0.41	0.72	Very Poor
45	Taraghat	0.26	0.92	Not Satisfactory
46	Tongi	0.19	0.84	Average

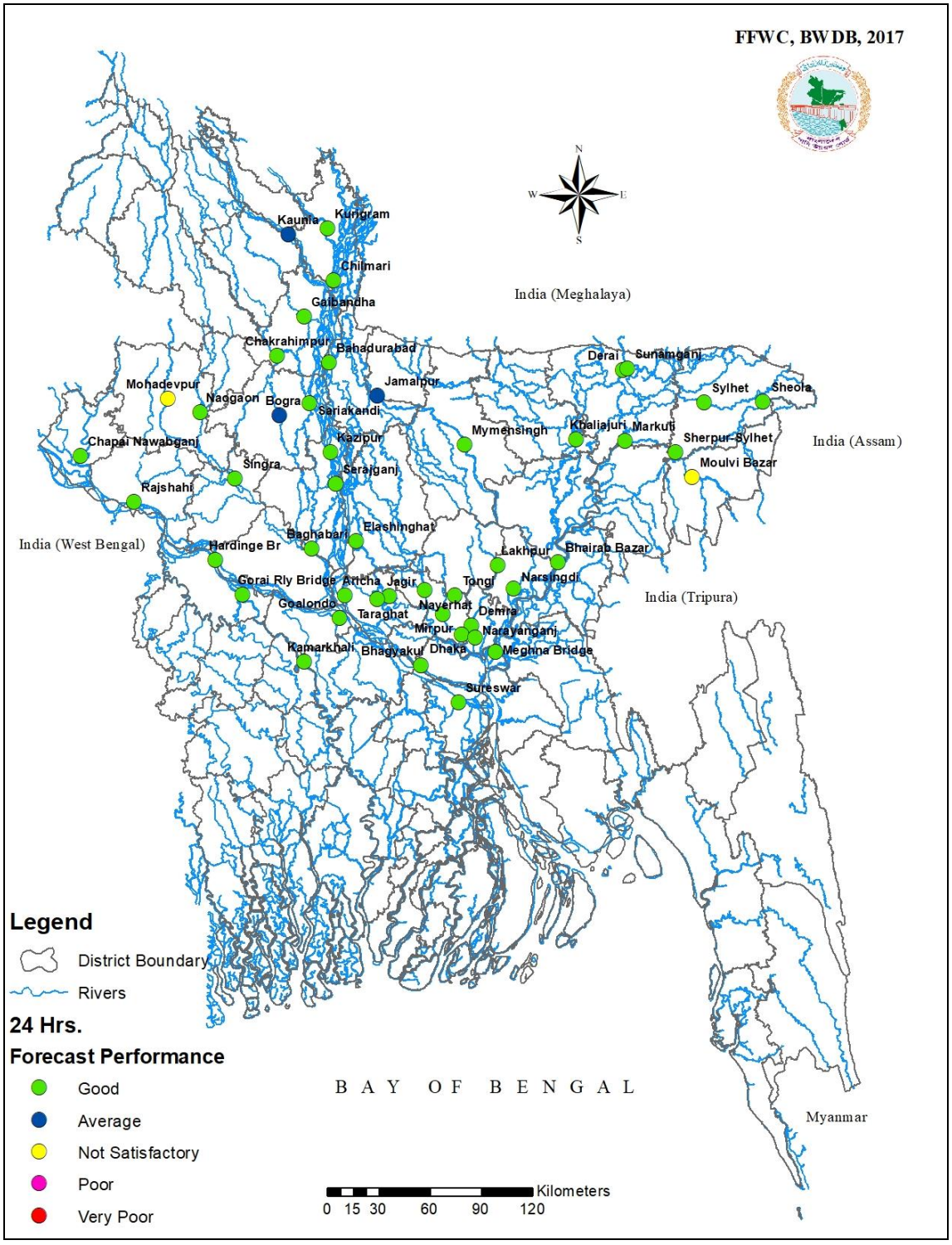


Figure 4.1 : 24-hrs Forecast Evaluation (Year, 2017)

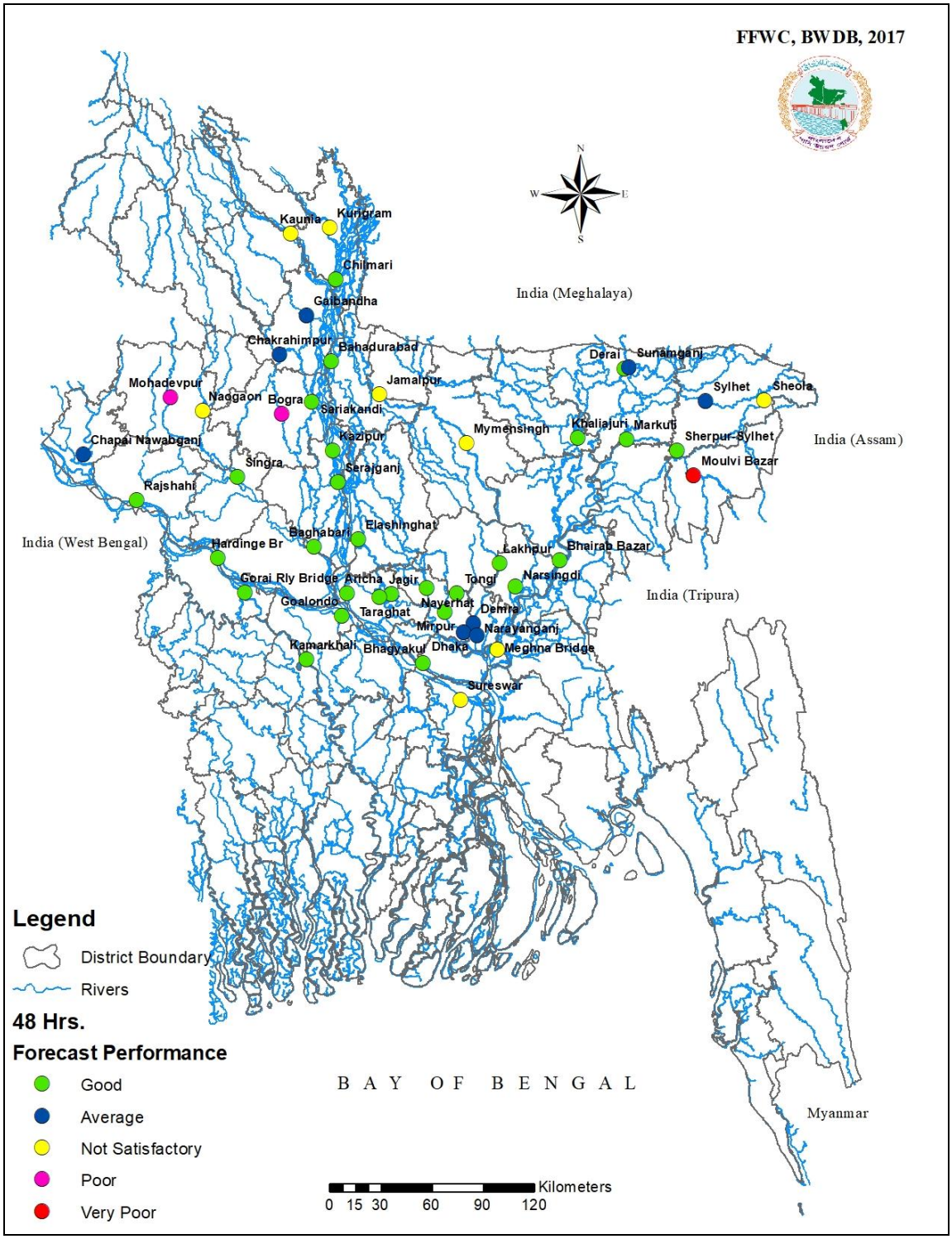


Figure 4.2 : 48-hrs Forecast Evaluation (Year, 2017)

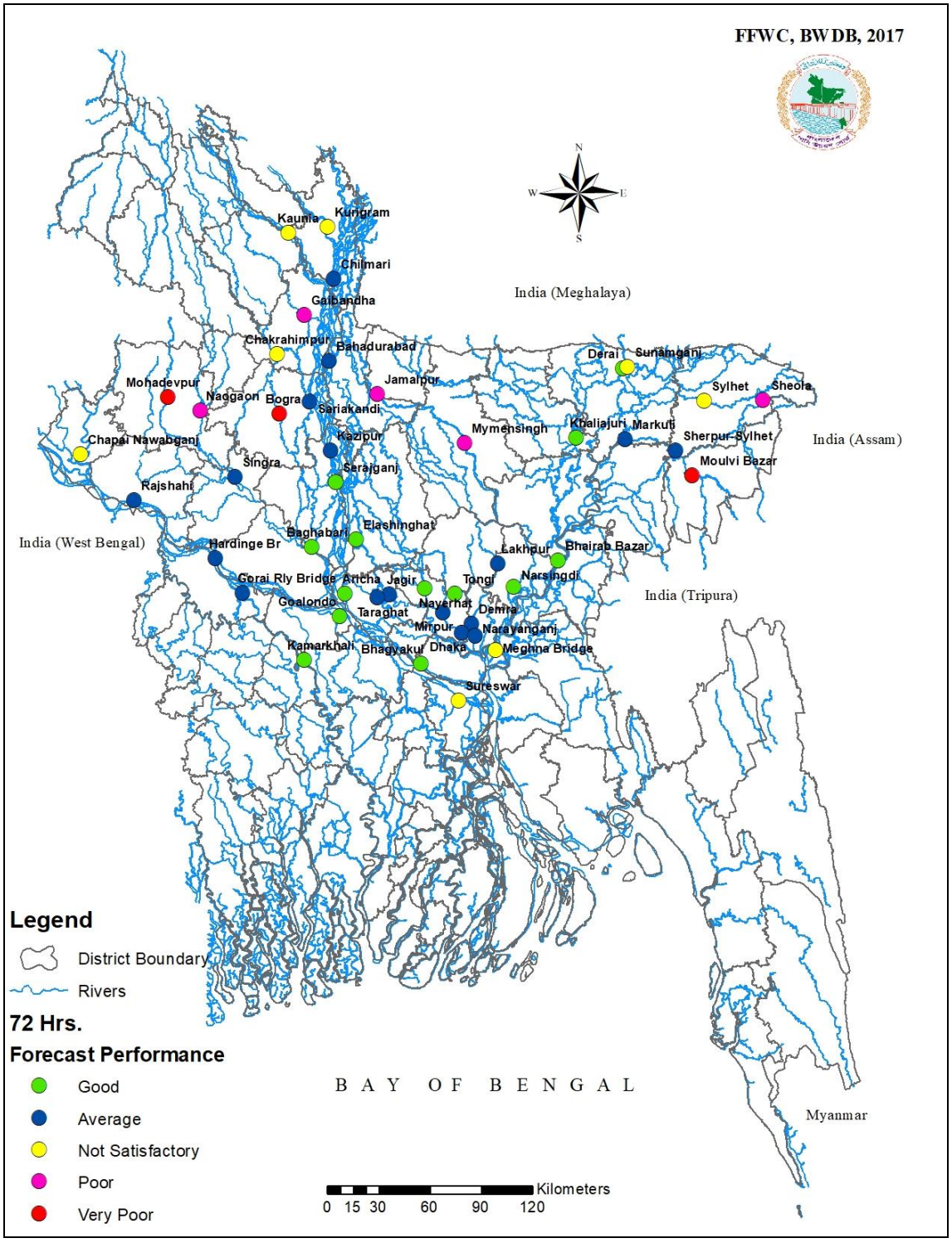


Figure 4.3 : 72-hrs Forecast Evaluation (Year, 2017)

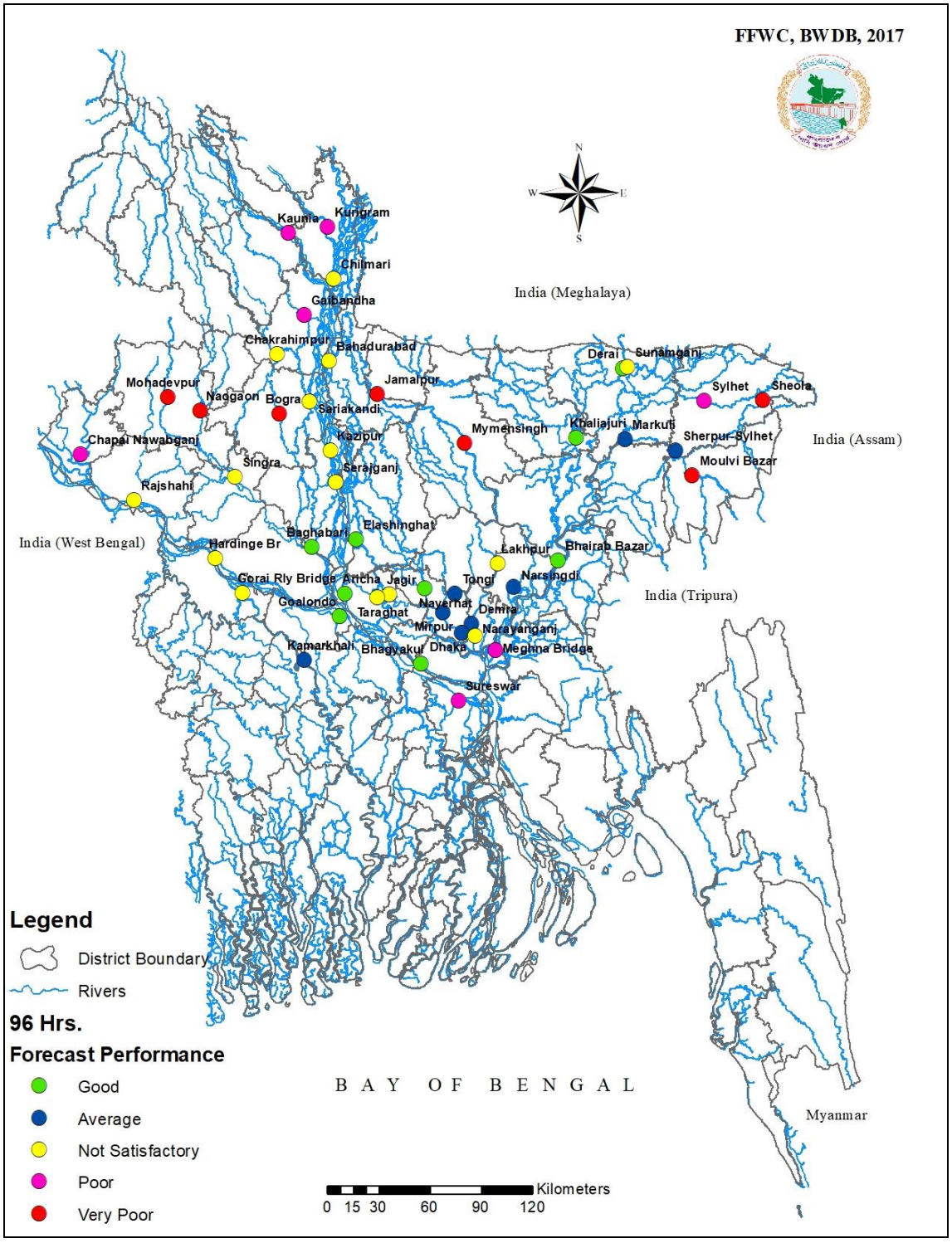


Figure 4.4 : 96-hrs Forecast Evaluation (Year, 2017)

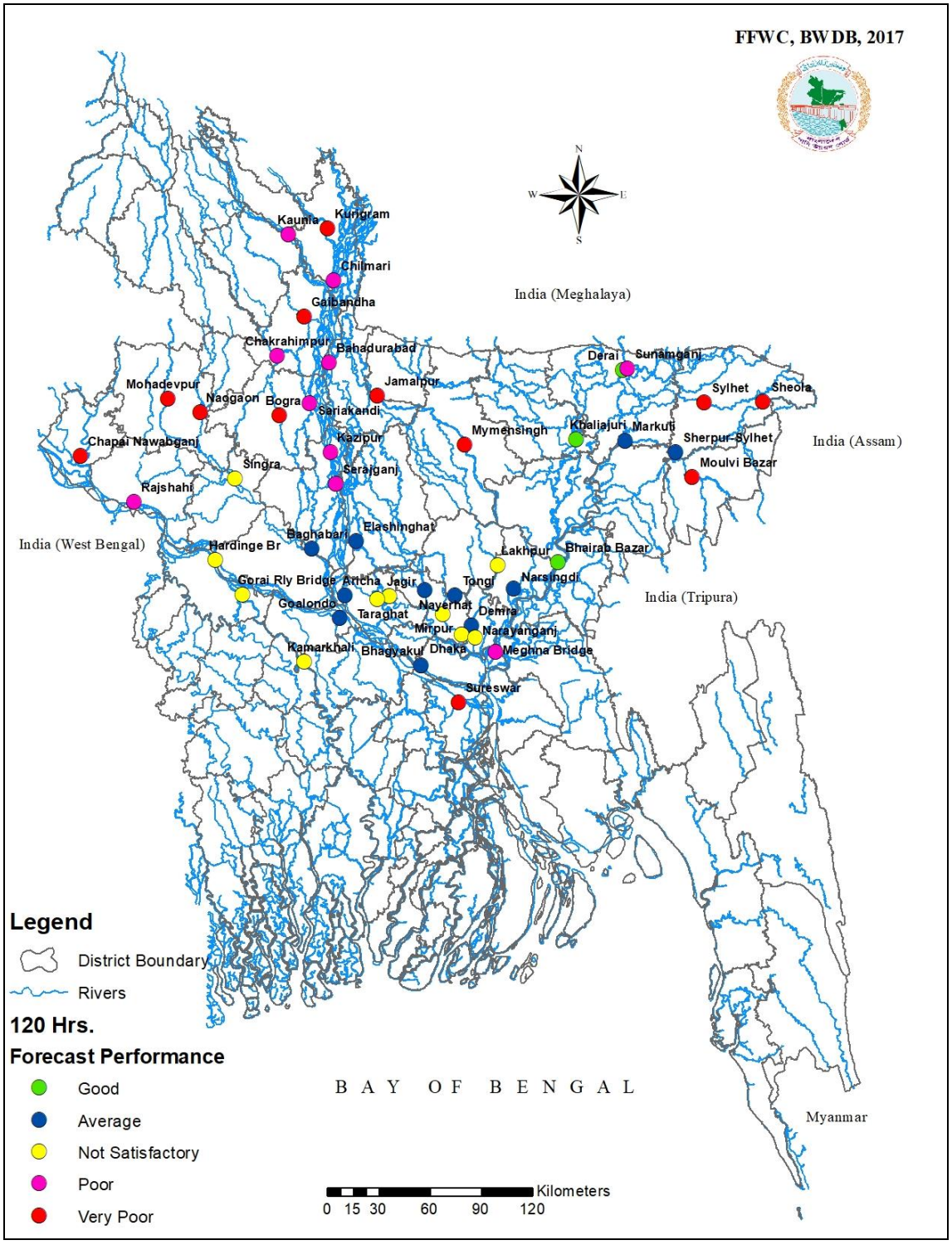


Figure 4.5 : 120-hrs Forecast Evaluation (Year, 2017)

CHAPTER 5 : INUNDATION STATUS

Flood inundation is a phenomenon that results from overtopping or overflowing of flood water to the river banks. In our country, this situation at a particular place occurs when the river water level exceeds the danger level of that particular place. During normal flooding, it is expected and observed that flood plain along the major rivers becomes inundated and after that flood water progressively enters the adjacent residential and commercial areas depending upon the severity of flood. In the monsoon 2017, the country experienced severe flooding but it did not prolong to catastrophic situation.

The flood of 2017 affected the Brahmaputra and Ganges basin during July-August and stayed for short to medium duration in most parts of the basins except at a few places where it was longer, while the magnitude was moderate to severe. Flood in the Meghna basin was erratic this year as besides severe flash flooding during pre-monsoon, there was an extensively long period of flooding (up to 92 days) during monsoon, especially in the low lying parts of Sylhet district which affected with moderate to severe intensity. The South Eastern Hill basin however experienced a few short duration flood events with moderate to severe intensity during 2017. This year 42% of the country got flood affected which corresponded to 35 nos. of flood affected districts.

Out of 30 Water Level (WL) monitoring stations in the Brahmaputra basin, at 22 stations WL crossed and remained over their respective DLs in 2017. This year flood wave hit the basin twice; first arrived at 1st week of July and later at the 2nd week of August in about one month's interval. Both the events were of about 2 weeks duration; however the 2nd wave hit with a flood of much higher magnitude and caused greater inundation. The stations that crossed and remained over DLs during months of July and August are Dharala at Kurigram for 12 days, Teesta at Dalia for 6 days, Jamuneswari at Badarganj for 8 days, Ghagot at Gaibandha for 15 days, Karatoa at Chakrahimpur for 10 days, Brahmaputra at Noonkhawa for 3 days, at Chilmari for 14 days, Jamuna at Bahadurabad for 25 days, Sariakandi for 24 days, Kazipur for 29 days, Serajgonj for 33 days, at Aricha for 12 days, Gur at Singra for 24 days, Atrai at Baghabari for 22 days, Dhaleswari at Elasinghat for 31 days, Old Brahmaputra at Jamalpur for 1 day, Shitalakya at Lakhpur for 22 days, at Narayanganj for 10 days, Tongi Khal at Tongi for 2 days, Kaliganga at Taraghat for 14 days and Dhaleswari at Jagir for 13 days; among which river levels at Dalia, Kurigram, Thakurgaon, Bahadurabad, Singra and Badarganj exceeded their previously recorded highest water levels during the second event in August. As a result, low-lying areas of Kurigram, Rangpur, Lalmonirhat, Nilphamari, Gaibandha, Bogra, Serajgonj, Tangail, Jamalpur, Natore, Pabna, Manikganj and Narayanganj districts experienced short to medium duration flooding during July-August 2017; the severity of which was normal to moderate in July, while severe in the Northern and North-Western districts in August but normal to moderate elsewhere within the basin.

In the Ganges basin out of 25 WL monitoring stations, at 16 stations rivers exceeded their respective DLs during July-August in monsoon 2017. This year the river Padma flowed above DLs at Goalondo and Bhagyakul for 20 days, while at Sureswar for 13 days. The other major rivers of the upper part of the basin which flowed above danger levels at stations are Mohananda at Rohanpur and Chapai Nawabganj for 14 and 6 days

respectively, Little Jamuna at Naogaon for 13 days, Atrai at Mohadebpur for 7 days, Karatoa at Panchagarh for 1 day, Punarbhaba at Dinajpur for 4 days, Ich-Jamuna at Phulbari, Tangon at Thakurgaon, Upper Atrai at Bhusirbandar 3 days each, Gorai at Kamarkhali for 3 days and Kobadak at Jhikargacha for 29 days. In July, only the Padma at Goalondo and Kobadak at Jhikargacha flowed above danger levels for short duration which caused normal flooding. However, during the 2nd-3rd week of August many parts of the basin got affected by floods, the duration of which varied from short to medium in most parts and magnitude was moderate to severe. The low lying areas of Rajbari, Faridpur, Manikganj, Munshiganj and Shariatpur districts were affected by moderate flooding of medium duration due to the river Padma during this period. The Northern districts of Panchagarh, Thakurgaon and Dinajpur experienced short duration flooding, while the North-Western districts of Naogaon and Chapai Nawabganj experienced medium duration flooding, nonetheless the severity varied from moderate to severe at affected places over these districts. Flooding situation prevailed for a longer time in parts of Jessore district due to very poor drainage condition along with high local rainfall during July-August.

Out of 26 WL monitoring stations in the Meghna basin, at 20 stations water flowed above their respective DLs resulting floods of short to prolonged duration at different parts of the basin during monsoon, starting on the very beginning of June and continuing till the 3rd week of September. The lower floodplains of the basin along the major rivers and some places within the 'Haor' areas got mostly affected. Among the major rivers which flowed above danger levels for long duration are: Surma at Kanaighat, Sylhet and Sunamganj for 92, 11 and 15 days respectively, Kushiyara at Amalshid, Sheola and Sherpur for 76, 88 and 76 days respectively, Khowai at Ballah and Habiganj for 34 and 18 days respectively, Old Surma at Derai for 37 days, Kangsha at Jariajanjail for 82 days and Titas at Brahmanbaria for 30 days. Among the other rivers which flowed above danger levels for shorter durations are Sarigowain at Sarighat for 9 days, Manu at Manu Railway Bridge and Moulvibazar for 6 and 11 days respectively, Dhalai at Kamalganj for 9 days, Bhugai at Nakuagaon for 3 days, Jadukata at Lorergarh and Someswari at Durgapur for 5 days each along with Gumti at Comilla and Debiddar for 1 and 2 days respectively. Water Level at Kanaighat on Surma, Amalshid and Sheola on Kushiyara flowed above danger levels almost continuously for around 2-3 months during 1st week of June to 3rd week of September, 2017 with relatively short intervals between; which surpassed the recorded duration of highly flooded years of 1988 and 1998. The un-embanked low lying areas of Sylhet and Moulvibazar districts were mostly affected due to this and flood intensity varied from moderate to severe. Low lying areas of Netrokona, Sunamganj and Brahmanbaria were affected by long duration of moderate flooding during 2nd week of August to 3rd week of September. The Habiganj and Moulvibazar districts were affected mostly by frequent intermittent flashy flood waves of moderate magnitude throughout the monsoon 2017 due to the Khowai, Manu and Dhalai rivers. The northern parts of Sunamganj, Netrokona and Sherpur districts were affected by infrequent flashy waves of moderate to high magnitudes with inundation of short duration during 2017.

In the South Eastern Hill basin, 7 out of the 9 water level monitoring stations crossed danger levels a few times during June-October period due to intense monsoon rainfall and presence of depressions formed over Bay of Bengal during monsoon 2017. However the stations flowed above danger levels for short durations and the rivers at stations which flowed above danger levels during June-October, 2017 are: Muhuri at Parshuram for 5

days, Halda at Narayanhat and Panchpukuria for 11 and 2 days respectively, Sangu at Bandarban and Doahazari for 3 days each along with Matamuhuri at Lama and Chiringa for 5 and 10 days respectively. This year flood hit the basin first at the beginning of June due to the associated heavy rainfall activity of the cyclonic storm 'Mora' which affected parts of Chittagong and Cox's Bazar districts for short duration. However, flood hit the major part of the basin at the last of 2nd week of June and at the 1st and 4th week of July. Due to a monsoon depression over Bay of Bengal at the last of the 2nd week of June, heavy rainfall occurred over the basin and inundations due to flash floods of moderate to severe intensity occurred at some parts of Chittagong, Bandarban and Cox's Bazar districts. During this time owing to ongoing heavy rainfall activity, on 12th June severe landslides occurred in hilly regions of Chittagong, Rangamati and Bandarban districts which took lives of many people. At the 1st week of July, excessive rainfall incurred flash floods of moderate to severe magnitude in some parts Bandarban and Cox's Bazar districts due to the river Matamuhuri. Within the last 12 days of July, due to another spell of heavy rainfall activity, some parts of Feni, Chittagong, Bandarban and Cox's Bazar districts were again hit by flash floods of moderate to severe magnitude, which was mostly severe at Feni. At the last of the 3rd week of October, due to an existing depression over Bay of Bengal and associated heavy rainfall activity, another severe flash flood hit some parts of Feni district due to the swelling of river Muhuri.

Like other previous years, this year also FFWC generated model based nationwide inundation map. Flood map has been generated from Flood Forecasting Model output result files found from MIKE 11 FF Rainfall-Runoff and Hydrodynamic modeling simulation using customized MIKE 11 GIS model as a routine activity during monsoon period. Here, Digital Elevation Model (DEM) having 300 m spatial resolution collected from Survey of Bangladesh (SoB) long ago is used with MIKE 11 GIS tool. This is to mention that flood peak arrived several times in 2017 which was attenuated during the fourth week of August. It was observed from monitoring that peak water level attained in Brahmaputra-Jamuna river on 16th August, in Padma river on 18th August and in Upper Meghna river on 24th August. FFWC observed total number of 30 flood monitoring stations above danger level on 15 August, 2017 which was the peak condition for this monsoon. Similar situation continued for next few days with severity in some places along the bank of Jamuna river. Figure 5.2 shows the observed inundation map for 16th of August and then 24, 48, 72, 96 and 120 hours forecasted inundation maps on the day from figures 5.3-5.7 respectively. The map on 16th August captures the inundation scenario of the country during monsoon 2017, except relatively small inundations at the North-Eastern and South-Eastern regions due to some isolated short term flood events. So with minor additions for isolated flood events, inundated area based on this map is around 62000 sq-km which is 42% of the country area and is the maximum inundated area found in this flood season. This inundated area excludes the permanent water bodies i.e. rivers, lakes, haors, ponds etc. The calculation of permanent water bodies is also a crucial issue. Some literature reviews and remote sensing based analysis depict that there are approximately 6-8% of permanent water bodies existing in Bangladesh.

Flood inundation for whole country is a macro level product showing a general overview of flood situation of the whole country due to coarse resolution DEM. A detail, authentic and finer resolution DEM shall significantly improve generation of inundation map even in the local level.

One of the limitations of this map is that none of the flood map output has been verified and so some obvious errors have been observed. One method currently in practice in operational flood forecasting is the verification of inundation map using satellite imagery. FFWC flood inundation map for peak condition of 2017 was verified with Synthetic Aperture Radar (SAR) based high resolution (10 m) satellite image from Sentinel-1 by European Space Agency (ESA). Radar based imagery are unsusceptible to cloud covers but susceptible to dense forests, so it would provide nearly accurate flooded area in the Northern and Central Parts of the country but may underestimate in South-western coastal parts and South-eastern hill regions due to dense forests. Because of non-availability of countrywide daily product, Sentinel-1 data from 12th to 22th of August was used to cover the whole country during peak condition and compared with the FFWC flood map of 16th August, 2017 (Figure 5.1). Both of the maps are in good agreement in detecting inundated areas in North-western and North-eastern parts of the country. The North and North-central parts have less inundation in FFWC map compared to Sentinel-1 possibly because of quick recession of water before 16th August due to high slope of terrain there, which the satellite was able to capture between 12th and 15th August. The coarse resolution of the DEM used in FFWC map may be another reason behind this undetected relatively small inundated areas. Nonetheless, there are much spatial variability in Central and coastal parts of South-central and South-western regions. FFWC's present flood model domain does not cover coastal parts and the South-eastern region, so model result is not appropriate for inundation analysis or verification of that part. The variability in Central parts may be an implication of coarse resolution of the DEM along with change in land use.

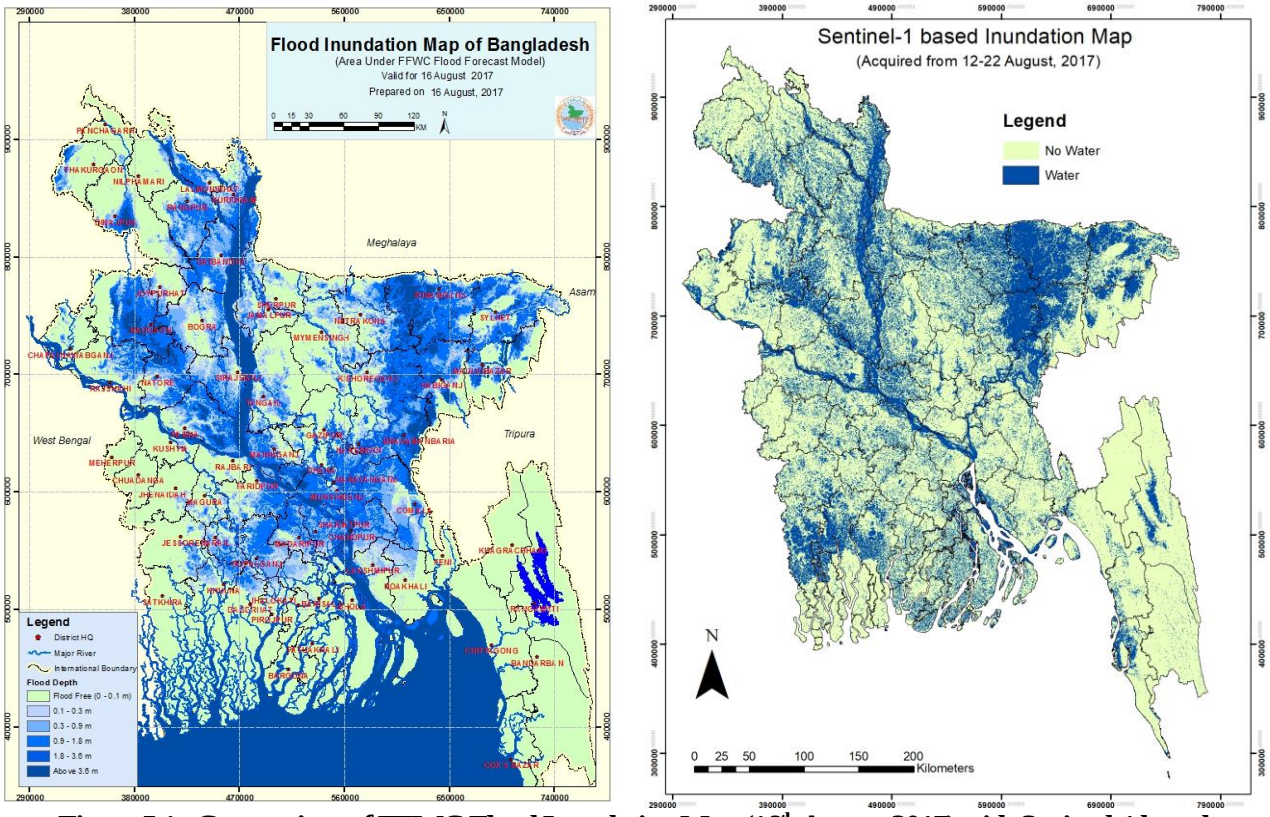


Figure 5.1: Comparison of FFWC Flood Inundation Map (16th August 2017) with Senitnel-1 based Inundation Map (between 12th -22nd August 2017)

FFWC MIKE 11 FF Flood super model was developed decade ago. After that, catchment characteristics, river morphology and climatology had changed significantly which were not incorporated in the model. That's why current inundation map explores underestimation as well as overestimation in some places. A total updating of model set up along with latest version of MIKE software are needed to overcome this problem.

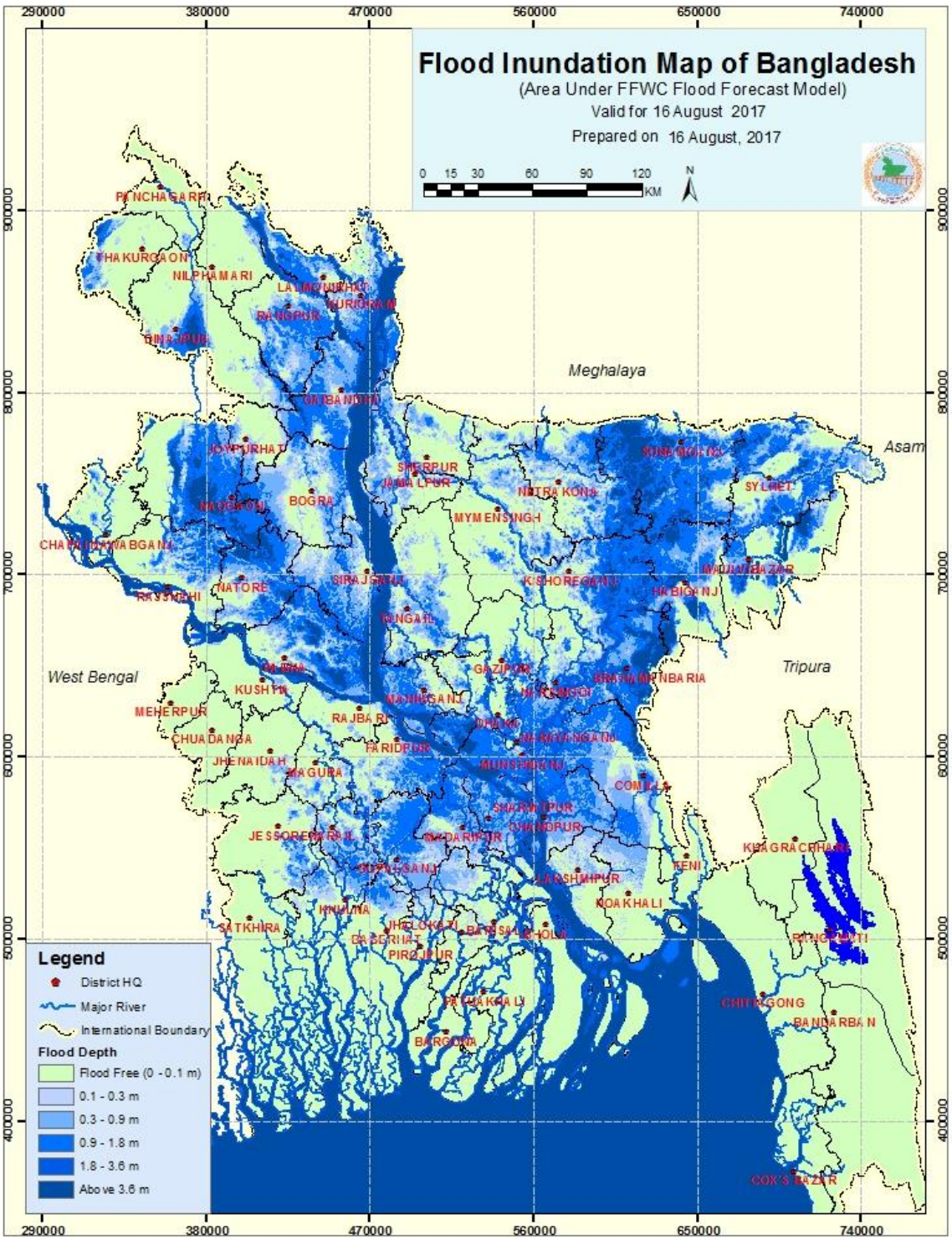


Figure 5.2: Flood Inundation Map of Bangladesh (on 16 August 2017)

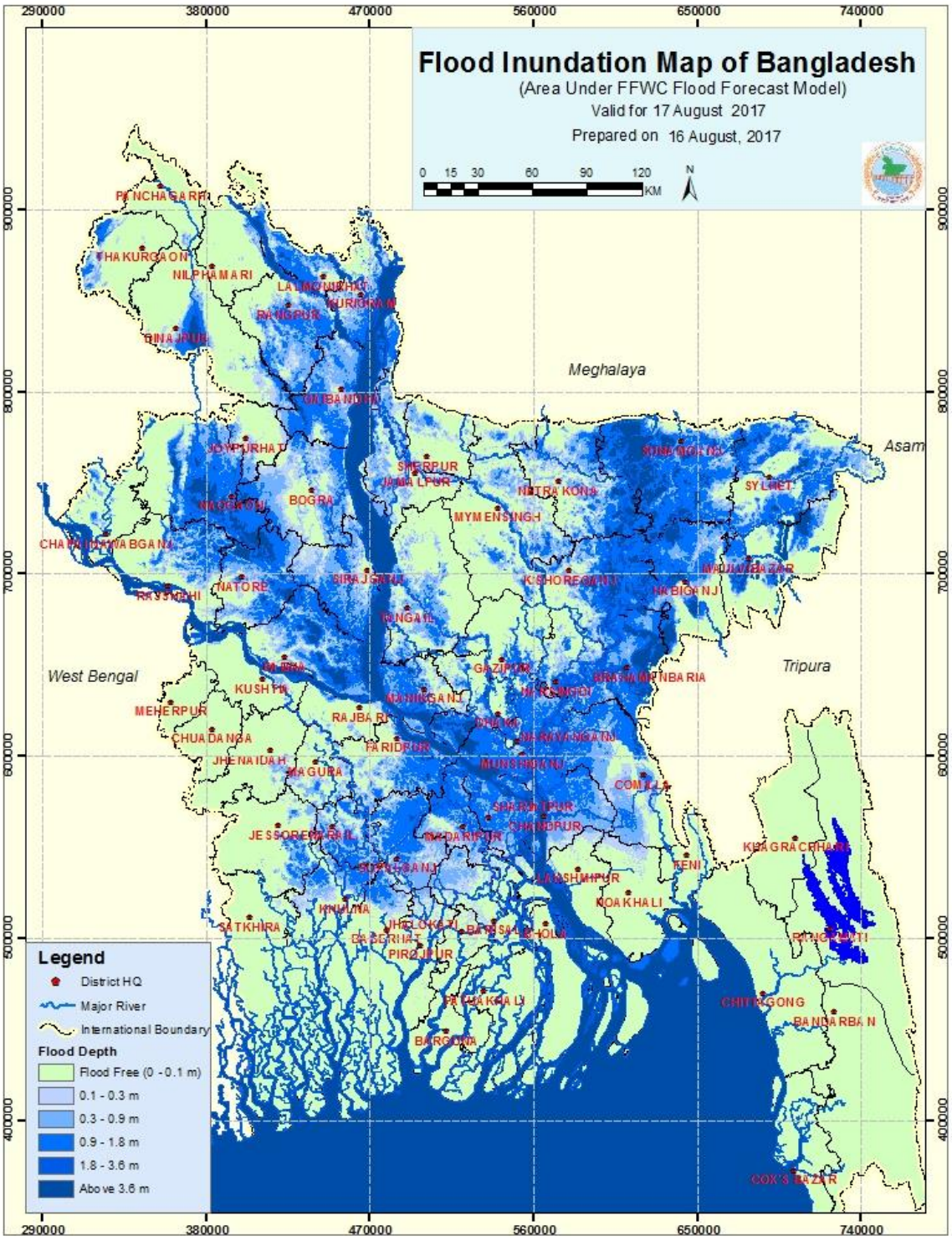


Figure 5.3 : Flood Inundation Map of Bangladesh (24hr Forecast Based on 16 August 2017)

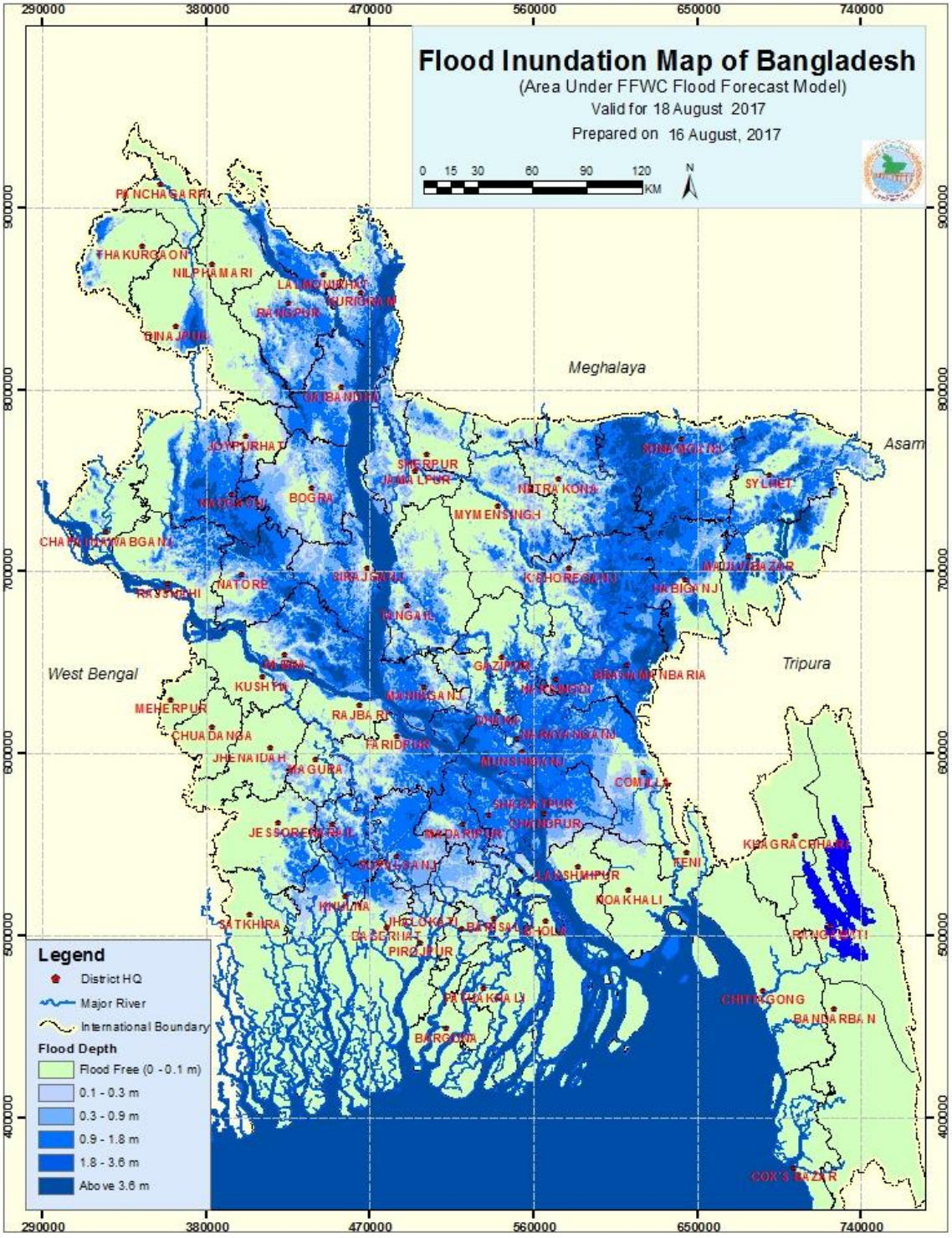


Figure 5.4: Flood Inundation Map of Bangladesh (48hr Forecast Based on 16 August 2017)

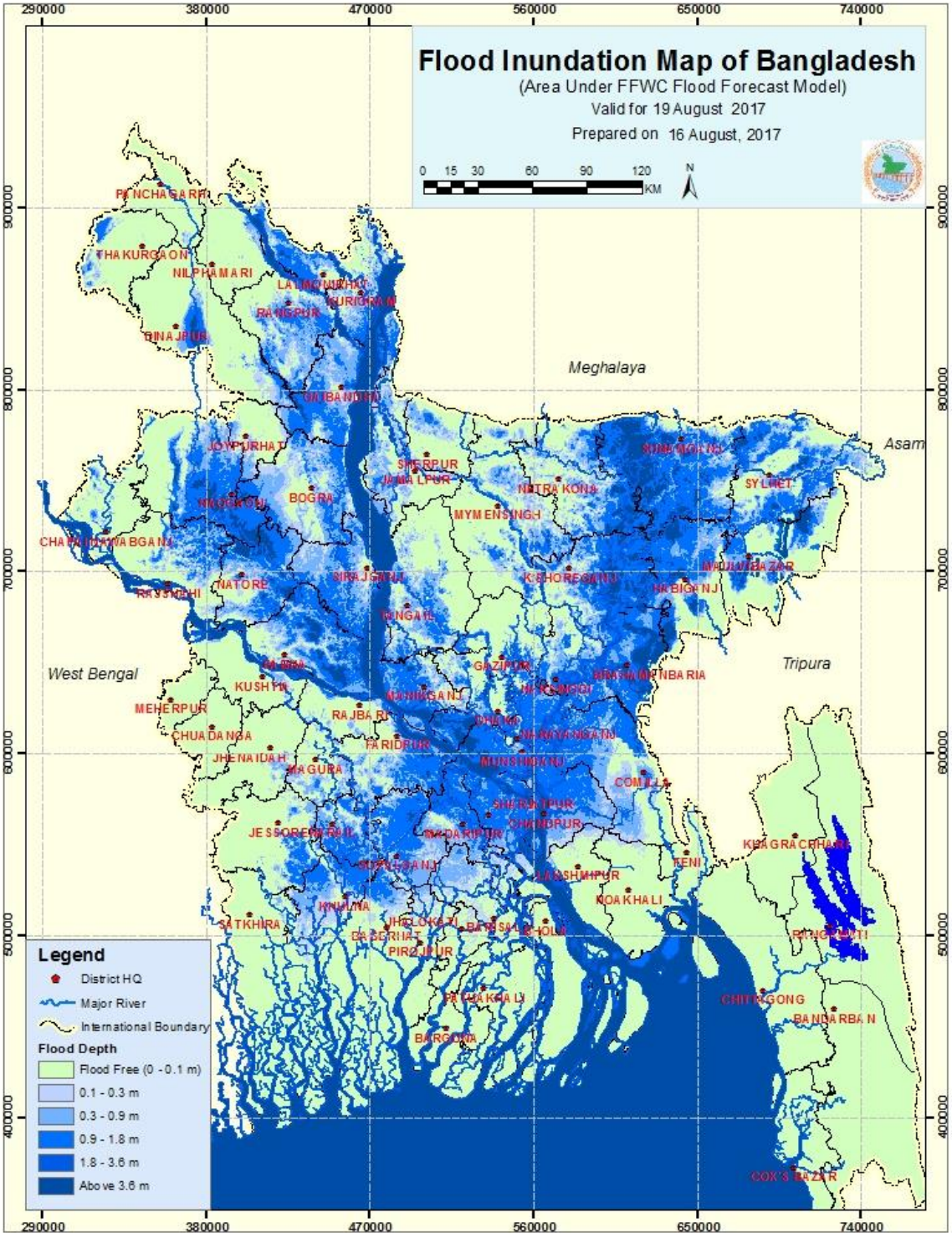


Figure 5.5: Flood Inundation Map of Bangladesh (72hr Forecast Based on 16 August 2017)

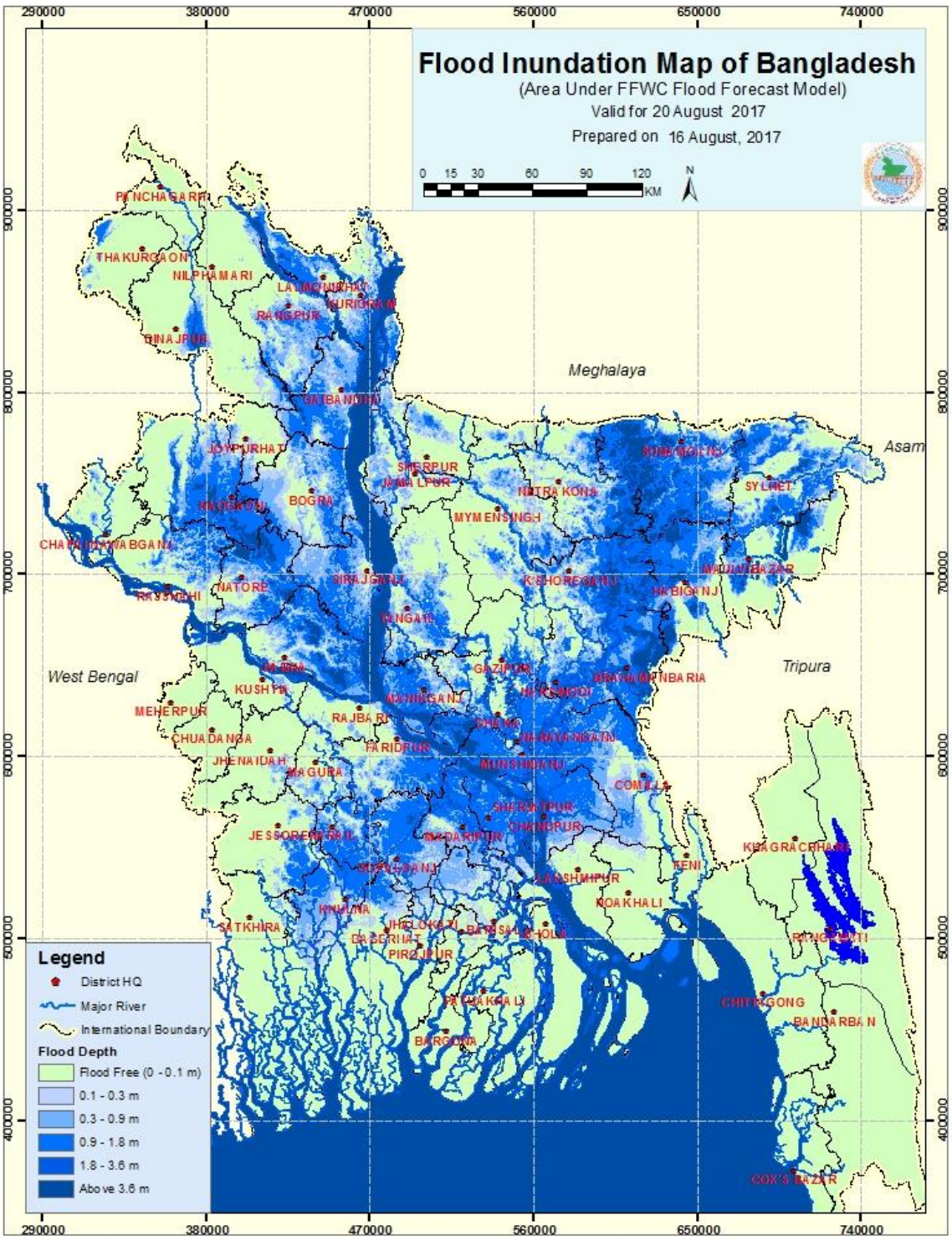


Figure 5.6 : Flood Inundation Map of Bangladesh (96hr Forecast Based on 16 August 2017)

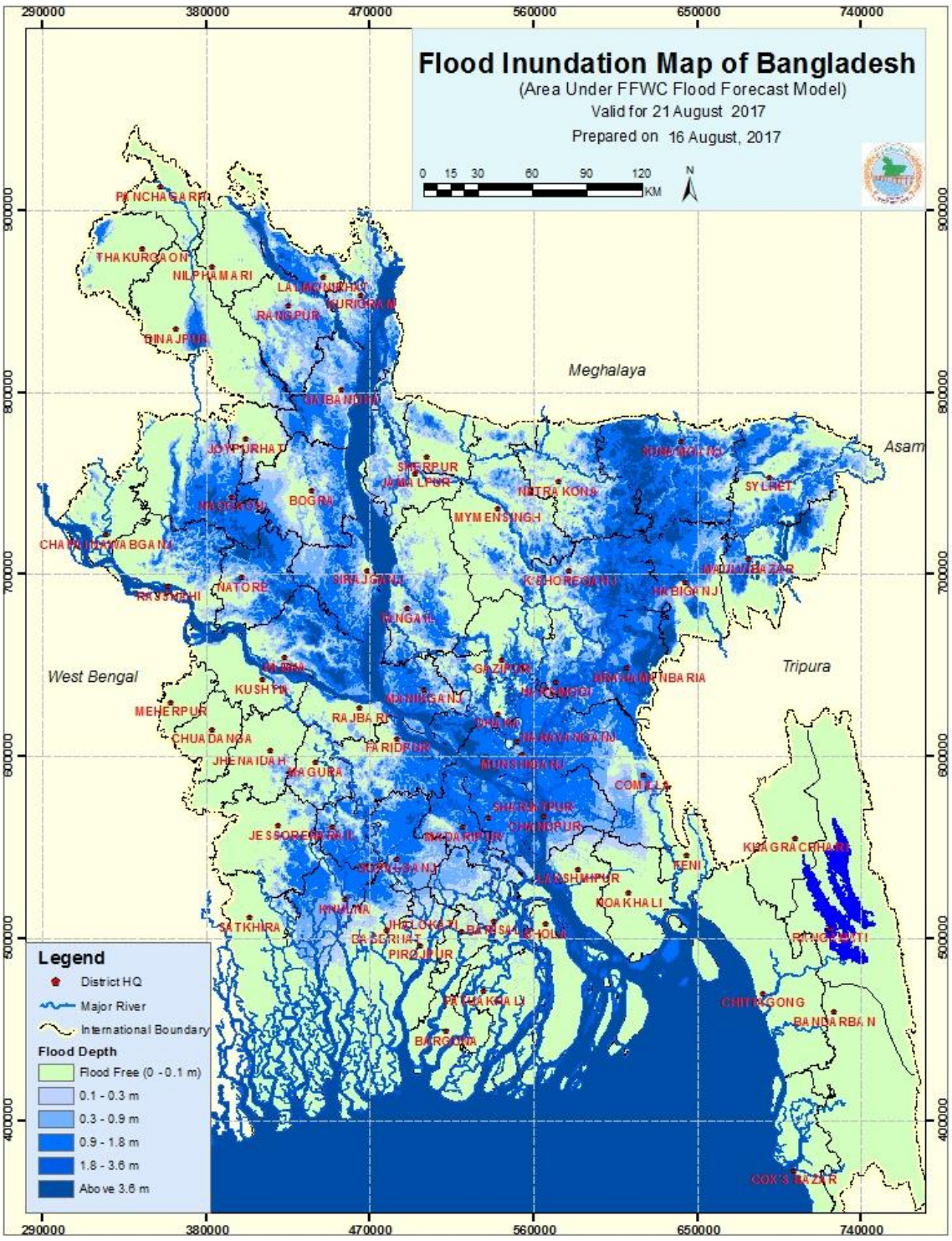


Figure 5.7 : Flood Inundation Map of Bangladesh (120hr Forecast Based on 16 August 2017)

CHAPTER 6: RESEARCH AND DEVELOPMENT

6.1 Flash Flood Forecast for North East Part

Experimental flash flood forecast has been generated and disseminated through e-mail and FFWC website (www.ffwc.gov.bd) during April-May period (period of threat for disaster) for the North East region. Flood forecast is produced with lead time of 3 days at 13 stations. The initial evaluation for the forecast during April-May period indicated good performance and acceptable. Further improvement is in progress and will be tested in the next season during April-May 2018. A bulletin and flood summary of Experimental Flash Flood forecast is provided in the **Annex-4 and 5**.

Figure 6.1: Flash Flood Web Portal

CHAPTER 7: PATTERN AND MAGNITUDE OF 2017 FLOODS

7.1 Early Flood in North East Region

North-East haor region of Bangladesh experienced flooding in early April due to heavy rainfall in Meghalaya and Barak basin. The rainfall event started in the last week of March and continued till first week of April. Table 7.1 and 7.2 show rainfall from 29 March to 5 April in some stations in Meghalaya and Barak basin and monitoring stations in the north east region in Bangladesh. The second rainfall event started at the end of third week and continued till mid of last week of April. Similarly, table 7.3 and 7.4 show rainfall from 18 April to 27 April in some stations in Meghalaya and Barak basin and monitoring stations in the north east region in Bangladesh. All the rainfall monitoring stations received more rainfall than their monthly normal during the month of April. Table 7.5 shows actual and normal rainfall of the north east region in April 2017. As a result of heavy rainfall activity, water level in river rose very sharply within few days. Table 7.6 shows amount of rise of water level of the river Surma, Kushiyera and Kangsha between 27/03/2017 to 02/04/2017.

Table 7.1 : Recorded rainfall Meghalaya and Barak basin during 29/03/2017 to 05/04/2017 (Rainfall in mm)

Date	Silchar	Kailasahar/Manu	Cherrapunjee	Shillong
29/03/2017	0	0	48	1
30/03/2017	81	57	151	19
31/03/2017	242	41	165	35
01/04/2017	35.2	15	280	25.4
02/04/2017	18.30	3	237.4	5.40
03/04/2017	66.10	5	164	21
04/04/2017	57.7	19	136.8	24.1
05/04/2017	21.6	61	2.2	4.2
Total	521.9	201	1184.4	135.1

Table 7.2: Recorded rainfall in major stations in the north east region during 29/03/2017 to 05/04/2017 (Rainfall in mm)

Date	Kanaighat	Sylhet	Sunamganj	Sheola	Sherpur	Manu Rly Br.	Moulvi Bazar	Habiganj	Durgapur	Lourergorh	Nakuagaon	Jariajanjail
29/03/2017	3	10	35	0	7	0		15.7	18	63	183	79
30/03/2017	135	142	102	182	125	46	124	95	28	65	22	75
31/03/2017	150	61	38	92	20	18	5	10	53	20	6	10
01/04/2017	93	121	134	142	0	0	3	3.5	33	116	10.5	10
02/04/2017	72	154	86	162	10	0	0	0	1	108	8.5	0
03/04/2017	47	77	37	62	75	40	0	0	21	23	13.5	18
04/04/2017	98	76	50	65	35	28	15	5.5	21	52	24	8
05/04/2017	24	17	8	34	38	62	50	95	8	0	2	12
Total	622	658	490	739	310	194	197	224.7	183	447	269.5	212

Table 7.3: Recorded rainfall Meghalaya and Barak basin during 17/04/2017 to 27/04/2017 (Rainfall in mm)

Date	Silchar	Kailasahar/Manu	Cherrapnjee	**Shillong**
17/04/2017	0.40	1.80	0	0.10
18/04/2017	0	0	0	0
19/04/2017	12	0	98.6	0
20/04/2017	37.1	17.3	20	7.9
21/04/2017	17.4	135.4	16	2.2
22/04/2017	5.50	13.40	88.4	2.2
23/04/2017	8.5	47	44.40	18.70
24/04/2017	5.30	20.80	7.60	2.50
25/04/2017	26.7	29	4.6	0
26/04/2017	107.7	11.4	58.4	0
27/04/2017	41.4	18.6	327.2	0
Total	262	294.7	665.2	285.2

Table 7.4: Recorded rainfall in major stations in the north east region during 17/04/2017 to 27/04/2017 (Rainfall in mm)

Date	**Sylhet**	**Sunamgonj**	**Moulvi Bazar**	**Lorergorh**	**Srimangol**	**Habiganj**
17/04/2017	0	0	-	0	2	-
18/04/2017	0	0	0	0	0	-
19/04/2017	0	0	0	0	0	0
20/04/2017	60	30	46	60	44	80
21/04/2017	36	52	26	22	194	95
22/04/2017	18	46	42	53	12	2
23/04/2017	20	23	10	44	16	50
24/04/2017	21	6	11	0	8	20
25/04/2017	34	26	9	6	28	35
26/04/2017	73	26	0	22	10	0
27/04/2017	22	3	0	0	0	0
Total	284	212	144	207	314	282

Table 7.5: Rainfall of major stations in the north east region in April 2017 (Rainfall in mm)

Station	**Normal**	**Actual**	**Deviation**	**1daymax**	**10day max**
Kanaighat	457	773	316	124	392
Sylhet	386.5	890	503.5	154	557
Sunamganj	287	607	320	134	361
Sheola	403.7	911	507.3	162	558
Moulvi Baza	263	374	111	145	213
Manu Rly Br	262.8	451	188.2	62	246
Habiganj	228.2	460	231.8	95	303
Sherpur	199	594	395	94	340
Durgapur	160	312	152	45	151
Lorergarh	211	594	383	116	315
Nakuagaon	162	373.2	211.2	75.5	222.2
Jariajanjail	77	313	236	51	192
B.Baria	129.2	301	171.8	96	266
Bhairab Bz	167.7	177	9.3	54	166

Table7.6: Rise of water level in major rivers between 27/03/2017 to 02/04/2017

	Water level in (mPWD)					
River	**Kushiyara**	**Kushiyara**	**Kushiyara**	**Surma**	**Surma**	**Kansgha**
Station	**Amalshid**	**sheola**	**Sherpur**	**Sunamganj**	**Sylhet**	**Jariajanjail**
Date						
27/03/2017	6.81	4.75	3.12	2.12	2.73	4.30
02/04/2017	15.77	13.52	7.85	7.58	11.19	8.20
Amount of Rise (meter)	8.96	8.77	4.73	5.46	8.46	3.90

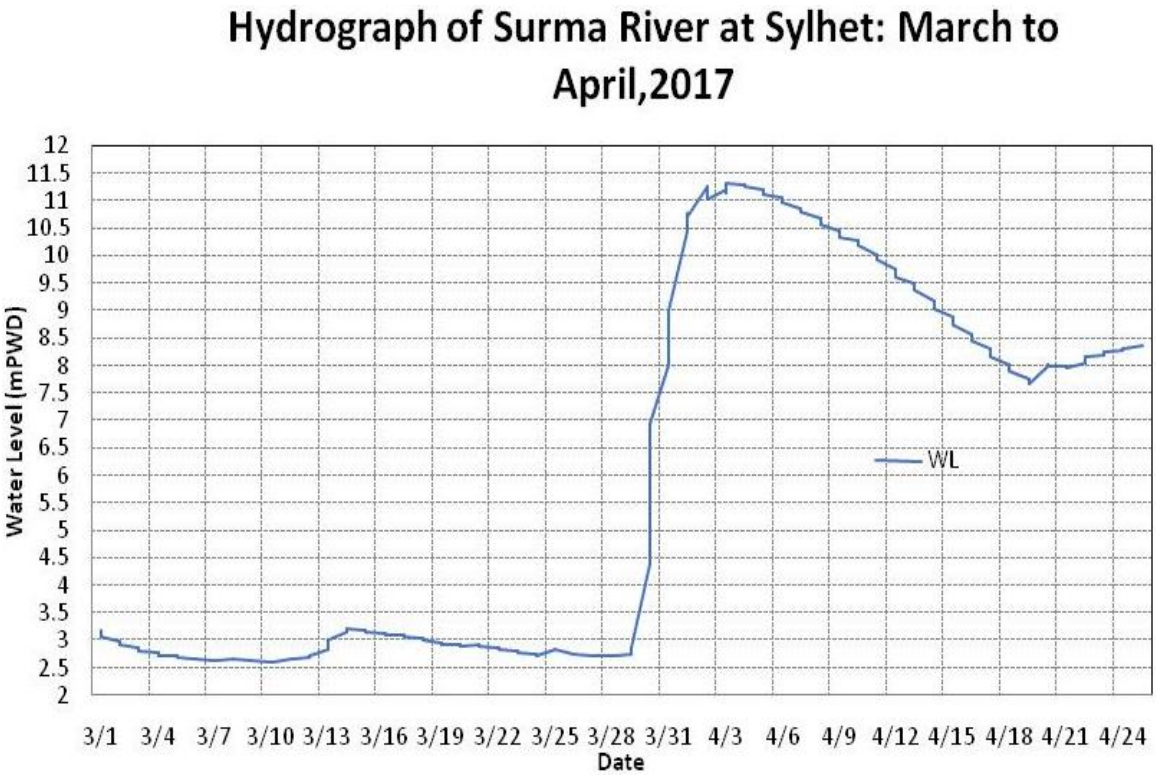


Figure 7.1 : Hydrograph of Surma river at Sylhet

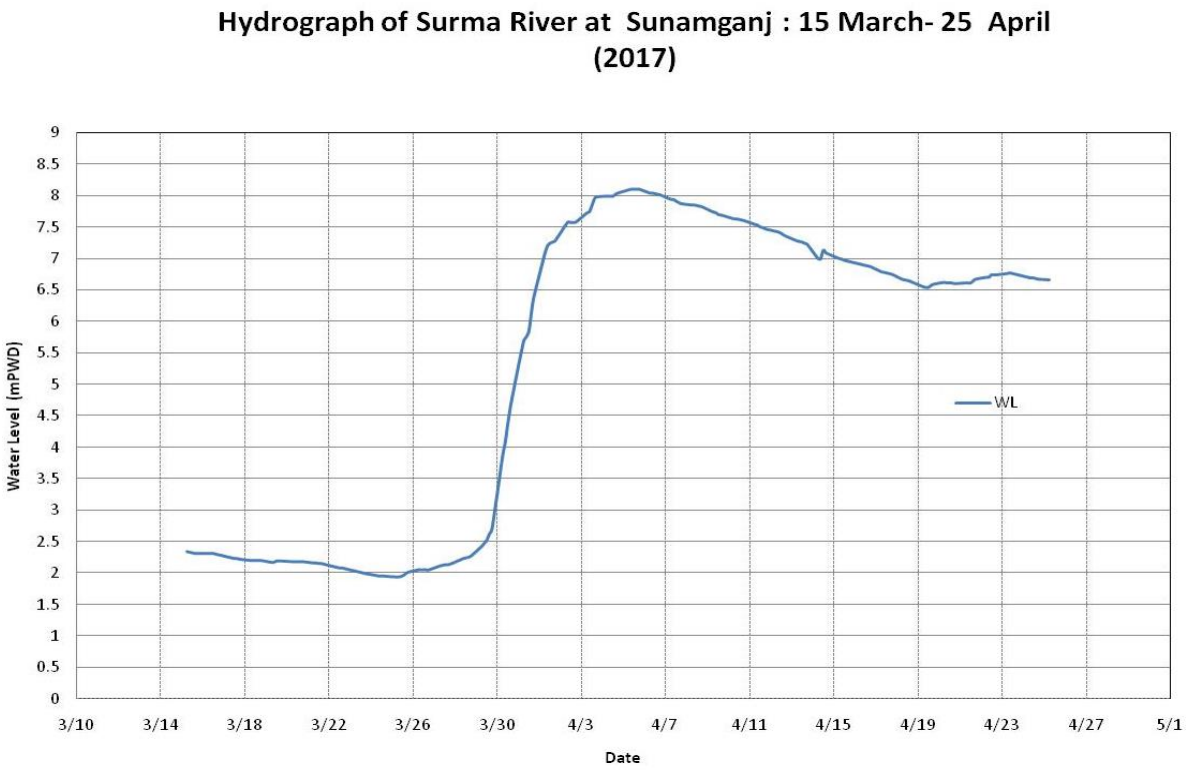


Figure 7.2: Hydrograph of Surma river at Sunamganj

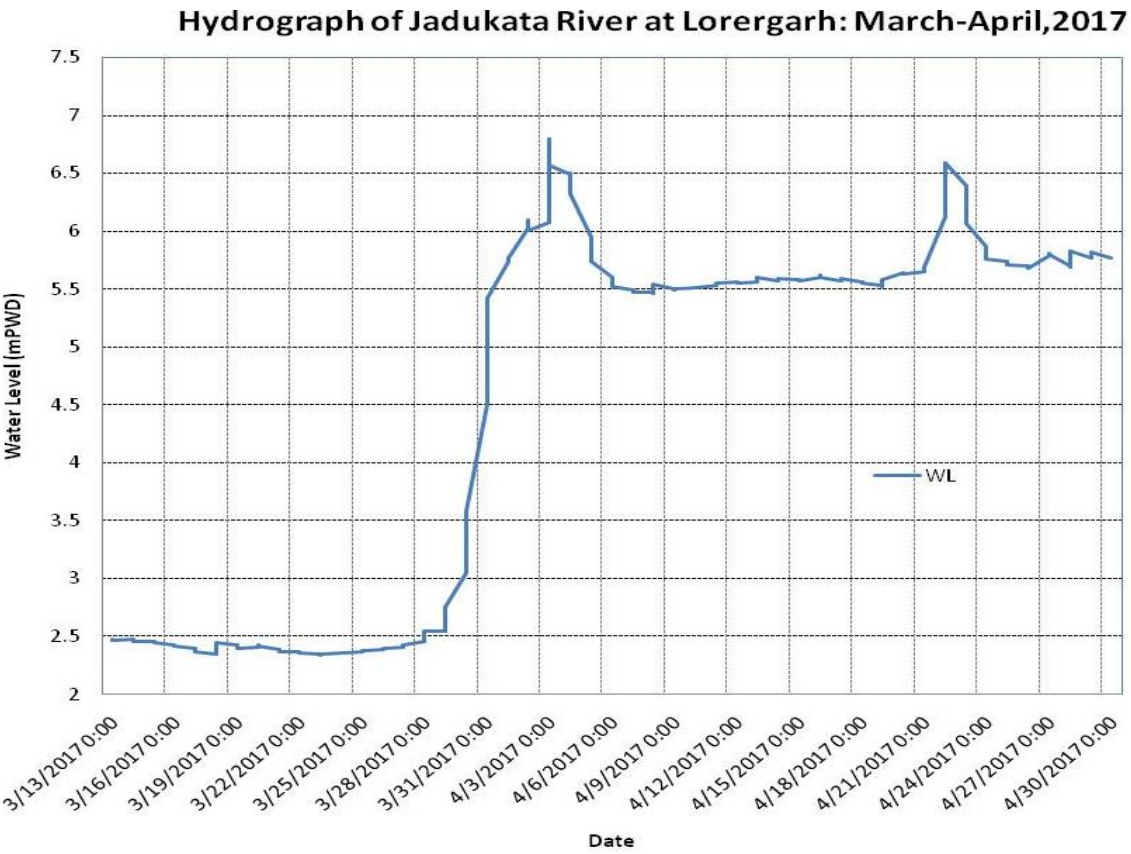


Figure 7.3: Hydrograph of Jadukata river at Lorergarh

7.2 Flood in North-West region

Although monsoon flood is common for the North-West region, some places in the region have experienced unprecedented flood in 2017 monsoon. The flood in Dinajpur was very unusual in 2017. Generally the rivers in Dinajpur, Thakurgaon, Panchagrh receive flood water during the monsoon due to local rainfall as well as rain in the upstream catchment and the river does not overflow. But during the monsoon 2017, the rivers of these three districts overflowed their banks due to extreme rainfall within a short time. At some places, river water level crossed its previous recorded highest levels (Table 7.13).

Table 7.7: Actual Rainfall during May to September, 2017

Stations	May	June	July	August	September
Panchagarh	260.9	232	343	914.9	232.5
Thakurgaon	173.80	480	450	1138	218
Dinajpur	146	229.8	194.6	552	122.7
Kurigram	407.5	261.5	438	356	227.5
Dalia	389	509	445	907	279
Rangpur	267	146	394	524	170
Chilmari	443	169	504	335	279
Gaibandha	222	218	426	382	233
Bogra	264	147.3	516.4	248.8	253
Sirajganj	231	201.8	257	183.1	102
Pabna	168.4	247.7	516	272	322
Naogaon	245.8	193.9	447	311	198.5
Mohadebpur	183	60	265	432	95
Rajshahi	152	100	420	202	152
Rohanpur	104.5	30	352	360	305.8
Chapai Nawabganj	119.6	60.5	315	289	131

Table 7.8: Activity of Monsoon during 7 August to 14 August, 2017

Region	7 August	8 August	9 August	10 August	11 August	12 August	13 August	14 August
Sub-Himalayan West Bengal and Sikkim	Active	Active	Active	Active	Active	Vigorous	Normal	Normal
Assam and Meghlaya	Active	Normal	Normal	Active	Active	Active	Active	Normal
Arunachal Prodesh	Normal	Active	Vigorous	Vigorous	Vigorous	Active	Active	Normal

Table 7.9: Rainfall Events in North-West region

Sl.Nr.	**Station**	**Rainfall (08/08/2017 to 14/08/2017) (mm)**
1	Thakurgaon	948
2	Panchagarh	640
3	Dinajpur	470
4	Dalia	711
5	Kurigram	213
6	Rangpur	355

Table 7.10: Rainfall Events in the Upper catchment of Teesta-Dharla-Dudkumar

Sl.Nr.	Station	Rainfall (08/08/2017 to 14/08/2017) (mm)
1	Gajaldoba	410
2	Domohoni	570
3	Jalpaiguri	590
4	Cuchbihar	640
5	Mathabhanga	710
6	NH-31 Bridge	600
7	Alipurduar	1070

Table 7.11: Rainfall events in Assam

Sl.Nr.	**Station**	**Rainfall (08/08/2017 to 14/08/2017) (mm)**	**Remarks**
1	Dhubri	220	Assam
2	Goalpara	330	
3	Guwahati	130	

Table 7.12: Days of Water Level above Danger Levels at Major Rivers in the North

River	Station	No. of Days in July	No. of Days in August
Tangaon	Thakurgaon	-	3
UpperAtrai	BhusirBandor	-	3
Little Jamuna	Nagon	-	4
Atrai	Mohadevpur	-	7
Mohanada	Rohanpur	-	11
Mohananda	Chapainawabganj	-	6
Punarbhaha	Dinajpur	-	4
Karatoa	Panchagar	-	1
Dharala	Kurigram	04	8
Dudhkumar	Patgram	02	06
Teesta	Dalia	04	2
Ghagot	Ghaibandha	07	8
Brahmaputra	Chilmari, Kurigram	07	7
Jamuna	Bahadurabad, Jamalpur	12	13
Jamuna	Sariakandi, Bogra	11	13
Jamuna	Kazipur, Sirajganj	11	13
Jamuna	Sirajganj	05	21
Dhaleswari	Elasin, Tangail	14	15
Atrai	Bagabari	05	12

Table 7.13: Severe Flood at Several Places

River	Station	Previous RHWL (mPWD)	Level in 2017 (mPWD)
Tangaon	Thakurgaon	51.26	51.30
Teesta	Dalia	52.95	53.05
Dharala	Kurigram	27.66	27.84
Jamuna	Bahadurabad	20.71 (2016) 20.62(1988)	20.84
Jamuneswari	Badarganj	33.12	33.61
Gur	Singra	13.53	13.67

7.3 Flood in Assam

According the Times of India, flood hit Assam severely and was the worst flood in 29 years.

1. **Number of People Affected: 33.5 Lakh**
2. **Villages Affected: 3186 villages were severely damaged in 25 districts**
3. **Districts Affected: Lakhimpur, Jorhat, Golaghat, Cachar, Dhemjai, Biswanath, Karimganj, Sonitpur, Majuli, Barpeta, Nagaon, Nalbari, Sivasagar, Morigaon, Chiranng, Dibrugarh, Dhubri, Kokrajhar, South Salmara**
4. **Reported human lives lost – 157**

Figure 7.4: News Clip from the Daily Anandabazar (India)

CHAPTER 8: CONCLUSION

The floods of 2017 have been found different in character and magnitude. In brief it is found that in April the Meghna basin experienced 90% higher rainfall than its normal and very importantly most quantity of rainfall occurred within 1-5 April and 19-22 April, which caused unusual severe flash flood in the Meghna basin. This early flash flood caused huge damages to crops.

During the month of May, all the basins received less rainfall than normal and the country remained flood free. However after the formation of cyclonic storm 'Mora' at the end of May, early monsoon rains in the beginning of June caused the Surma, Kushiyara, Manu and Khowai rivers within Meghna basin to overflow the un-embanked low lying lands. While the peak was receding, a strong monsoon depression formed over the Bay of Bengal which incurred another spell of heavy rainfall activity at the last of 2nd week of June. During this time, the South East Hill basin was hit by severe flash floods at places and most notably received high life casualties at hilly places due to landslides. The rain incurred flash floods in Meghna basin too due to the river Khowai, while the Surma-Kushiyara rivers crossed danger levels again and remained above for the rest of the month at some stations. The Meghna and South East Hill basins received 15% and 21% more rainfall respectively than their monthly normal in June, while the other basins received less. The Northern, North-western and Central parts remained flood free during this time.

In July, the first major monsoon flood event of the season occurred as flood wave hit the Brahmaputra basin in the first week which caused normal to moderate flooding along the Jamuna and some other major rivers. During this time, severe flash flood hit the South East Hill basin too. However the water level of major rivers in Meghna basin remained steady and continued to remain above danger level at some points. Flood stayed for medium duration in the Brahmaputra basin which became flood free within 3rd week and remained so for the rest of the month. The water level of major rivers in Meghna basin started receding too from the 3rd week and fell below danger levels at the end of the month. However due to another spell of heavy rainfall activity along the coastal region after 18 July, series of flash floods occurred at places within the South East Hill basin. During this time, flood situation prevailed at some places of Jessore district in the South-western region due to localized heavy rainfall associated with poor drainage therein. The Ganges and the South East Hill basins received 26% and 29% more rainfall than their monthly normal in July, while the other basins received less.

In the beginning of August, the ongoing monsoon rain activity shifted towards the Meghna basin and then shifted towards the Brahmaputra basin. Due to some extremely heavy rainfall activity between the first and second week, the water level of the major rivers of the basins started rising, with a rapid rise of the river Brahmaputra along with other Northern rivers. The Brahmaputra and Surma-Kushiyara rivers crossed danger levels almost simultaneously on around 12 August. The river Ganges was also in rising trend at that time. The flood situation attained its peak on around 15 August, with 30 out of 90 water level monitoring stations of FFWC reported above danger levels. Meanwhile flood affected the Northern and North-western regions greatly which was quite remarkable too, as no such incident took place in recent past especially at Panchagarh, Thakurgaon and Dinajpur districts which are rarely flood affected. Flood wave from the Brahmaputra moved in central part of the country within 3rd week and caused moderate flooding in low

lying parts of the districts along the river Padma. This was the second major monsoon flood event of the season and a severe one. Dhaka city remained flood free throughout the event. The water started receding from the central part after 18 August and became flood free at the end of month. By this time the river Ganges started receding too. However it continued flowing above danger levels at some points on the Surma-Kushiayra rivers in the Upper Meghna basin. The localized flood in the South-western region persisted during the first half of month but then became flood free. The Brahmaputra, Ganges, and Meghna basins received 11%, 5% and 45% more rainfall than normal in August. The South East Hill basin however received less rainfall than normal in August and remained mostly flood free except at a few isolated places.

In September, except at the South East Hill basin, the country received less rainfall than normal while it was slightly below normal in Meghna basin. The stations flowing above danger levels in the Meghna basin remained steady for few days, but fell below around the middle of month. All the other basins remained mostly flood free throughout the month except at a few isolated places for short duration. The flood free situation persisted throughout the major parts of the country in October too, despite receiving more rainfall than normal. However due to presence of depression over Bay of Bengal and associated concentrated heavy rainfall activity over Muhuri and Khowai basin during 18-22 October, flash flood hit Feni and Habiganj. It was severe in Feni and caused damages.

Flood pattern in 2017 was quite unusual. There was a very early severe flash flood in April in the 'Haor' areas of Meghna basin, along with long spell of monsoon flooding at low lying places, which surpassed the recorded duration of previous floods at some points. Flood in the Brahmaputra basin in August was different too as it flooded even some areas in the North which remain mostly flood free. However the flood was of medium duration, so it did not lead to catastrophic situation. Frequent flash flood activities were also persistent in the Meghna and South East Hill basins throughout the season. Notable was the late flash flood around the end of season at Feni and Habiganj. It is also noteworthy that the year 2017 was a nearly normal monsoon, however the skewness in temporal and spatial distribution of rainfall brought severe floods this year.

FFWC continued issuing 5-days deterministic flood forecast for major rivers of the country throughout monsoon 2017 as a routine activity, excluding the coastal and South-eastern hilly regions. With an average of around 97% and 92% forecast accuracy for 24 and 48 hours respectively, performance up to 2 days was quite satisfactory for most of the stations. Forecast up to 72 hours was good at the central region, but average at boundary parts with notably less accuracy for flashy streams. Forecast performance for 96 hours was good at central part but lacked accuracy elsewhere, while 120 hours forecast being not up to mark. The 96 and 120 hours forecasts are still experimental and continuously under development. As a whole, the forecasting performance by FFWC was satisfactory for major river systems up to 72 hours but needs further attention for small and flashy rivers.

The flood warning message was disseminated nationwide through different news media, news agencies, fax, e-mail, web-site (www.ffwc.gov.bd) and IVR (1090) through mobile phone. The flood forecast information has been used by various communities and organizations: national and international disaster management and relief operators, many Government agencies, NGOs and BWDB itself.

The accumulated flooded area was 42% of the whole country (62,000 Sq. km approximately) and 35 districts were affected, most of which experienced moderate to severe flooding.

Annex-1

5 Days Deterministic Forecast (Experimental 4th & 5th Day) for 24, 48, 72, 96 & 120 Hrs

FFWC, BWDB

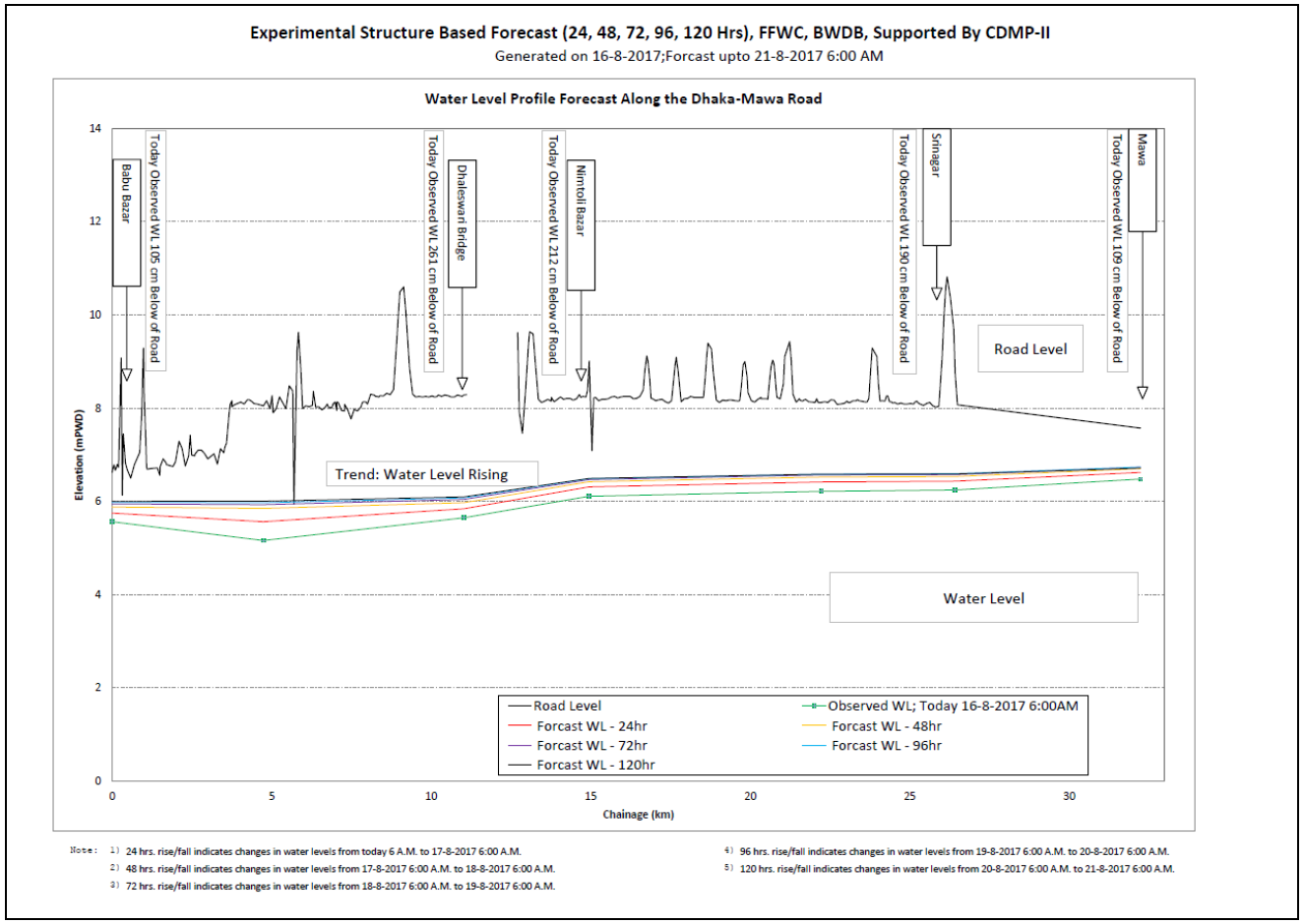
SL NO	River	Station	D.L. (meter)	Today 16-08 6:00 AM (meter)	24-hrs forecast 17-08 6:00 AM (meter)	24-hrs +Rise -fall 17-08 6:00 AM (cm)	24-hrs +above -below D.L. 17-08 6:00 AM (cm)	48-hrs forecast 18-08 6:00 AM (meter)	48-hrs +Rise -fall 18-08 6:00 AM (cm)	48-hrs +above below D.L. 18-08 6:00 AM (cm)	72-hrs forecast 19-08 6:00 AM (meter)	72-hrs +Rise -fall 19-08 6:00 AM (cm)	72-hrs +above -below D.L. 19-08 6:00 AM (cm)	96-hrs forecast 20-08 6:00 AM (meter)	96-hrs +Rise -fall 20-08 6:00 AM (cm)	96-hrs +above -below D.L. 20-08 6:00 AM (cm)	120-hrs forecast 21-08 6:00 AM (meter)	120-hrs +Rise -fall 21-08 6:00 AM (cm)	120-hrs +above -below D.L. 21-08 6:00 AM (cm)
1	Atrai	Mohadevpur	18.59	19.38	18.82	-56	+23	18.38	-43	-21	18.01	-37	-58	17.68	-33	-91	17.38	-30	-121
2	Atrai	Atrai	13.72	-	15.03	-	+131	15.05	+2	+133	15.04	-1	+132	15.01	-2	+129	14.98	-4	+126
3	Atrai	Singra	12.65	13.04	13.10	+6	+45	13.12	+2	+47	13.12	0	+47	13.12	0	+47	13.10	-2	+45
4	Karatoa-Atrai-GGH	Baghabari	10.40	11.16	11.22	+6	+82	11.22	0	+82	11.19	-3	+79	11.15	-4	+75	11.09	-5	+69
5	Little Jamuna	Naogaon	15.24	15.93	15.85	-8	+61	15.79	-6	+55	15.71	-7	+47	15.62	-9	+38	15.54	-8	+30
6	Karatoya	Chakrahimpur	20.15	20.37	20.38	+1	+23	20.36	-2	+21	20.32	-4	+17	20.27	-5	+12	20.20	-7	+5
7	Karatoya	Bogra	16.32	14.91	15.20	+29	-112	15.27	+7	-105	15.27	0	-105	15.25	-2	-107	15.23	-2	-109
8	Teesta	Kaunia	30.00	28.98	28.94	-4	-106	28.92	-1	-108	28.91	-2	-109	28.91	0	-109	28.90	0	-110
9	Ghagot	Gaibandha	21.70	22.53	22.50	-3	+80	22.35	-15	+65	23.15	+80	+145	22.90	-25	+120	22.65	-25	+95
10	Dharla	Kurigram	26.50	27.27	27.16	-11	+66	27.04	-12	+54	26.92	-12	+42	26.79	-13	+29	26.66	-13	+16
11	Brahmaputra	Chilmari	24.00	24.80	24.69	-11	+69	24.56	-13	+56	24.42	-14	+42	24.27	-15	+27	24.11	-16	+11
12	Jamuna	Bahadurabad	19.50	20.84	20.73	-11	+123	20.63	-11	+113	20.50	-12	+100	20.37	-13	+87	20.23	-14	+73
13	Jamuna	Sariakandi	16.70	17.95	17.87	-8	+117	17.79	-8	+109	17.69	-9	+99	17.60	-9	+90	17.47	-13	+77
14	Jamuna	Kazipur	14.85	16.72	16.64	-8	+179	16.54	-9	+169	16.43	-11	+158	16.31	-12	+146	16.18	-13	+133
15	Jamuna	Serajganj	13.35	14.81	14.74	-7	+139	14.64	-10	+129	14.51	-13	+116	14.38	-13	+103	14.24	-14	+89
16	Jamuna	Porabari	12.27	-	12.56	-	+29	12.49	-7	+22	12.39	-10	+12	12.29	-10	+2	12.17	-12	-10
17	Jamuna	Aricha	9.40	9.97	10.05	+8	+65	10.06	0	+66	10.02	-3	+62	9.98	-5	+58	9.91	-7	+51
18	Old Brahmaputra	Jamalpur	17.00	16.42	16.36	-6	-64	16.28	-8	-72	16.19	-9	-81	16.07	-11	-93	15.95	-12	-105
19	Old Brahmaputra	Mymensingh	12.50	10.48	10.73	+25	-177	10.80	+7	-170	10.77	-3	-173	10.71	-6	-179	10.63	-8	-187
20	Bangshi	Nayerhat	7.32	5.45	5.62	+17	-170	5.80	+18	-152	5.96	+16	-136	6.10	+14	-122	6.22	+12	-110
21	Old Dhaleswari	Jagir	8.23	6.90	7.26	+36	-97	7.61	+35	-62	7.98	+36	-25	8.22	+24	-1	8.35	+13	+12
22	Dhaleswari	Kalagachia	4.88	-	5.71	-	+83	5.83	+12	+95	5.90	+6	+102	5.93	+3	+105	5.94	+1	+106
23	Kaliganga	Taraghat	8.38	7.75	8.13	+38	-25	8.39	+26	+1	8.55	+16	+17	8.65	+9	+27	8.69	+4	+31
24	Tongi Khal	Tongi	6.08	5.45	5.63	+18	-45	5.78	+15	-30	5.89	+11	-19	5.97	+9	-11	6.04	+6	-4
25	Turag	Mirpur	5.94	5.15	5.33	+18	-61	5.46	+14	-48	5.56	+9	-38	5.63	+7	-31	5.68	+5	-26
26	Buriganga	Dhaka (Mill Barrack)	6.00	4.70	4.88	+18	-112	5.02	+13	-98	5.08	+7	-92	5.12	+3	-88	5.13	+2	-87
27	Buriganga	Dhaka (Hariharpara)	5.79	-	5.74	-	-5	5.87	+13	+8	5.94	+7	+15	5.97	+3	+18	5.99	+1	+20
28	Balu	Demra	5.75	5.11	5.30	+19	-45	5.45	+15	-30	5.55	+10	-20	5.63	+7	-12	5.68	+5	-7
29	Lakhya	Narayanganj	5.50	5.22	5.40	+18	-10	5.54	+14	+4	5.63	+8	+12	5.68	+5	+18	5.71	+3	+21
30	Dhaleswari	Elashinghat	11.40	12.30	12.29	-1	+89	12.24	-5	+84	12.18	-6	+78	12.12	-6	+72	12.05	-7	+65
31	Lakhya	Lakhpur	5.80	5.98	6.20	+22	+40	6.41	+21	+61	6.58	+17	+78	6.71	+13	+91	6.81	+9	+101
32	Dhaleswari	Munshiganj	5.20	-	5.74	-	+54	5.87	+13	+67	5.94	+7	+74	5.97	+3	+77	5.98	+1	+78
33	Mohananda	Chapai Nawabganj	21.00	20	20.16	+16	-84	20.15	-1	-85	20.06	-9	-94	19.96	-10	-104	19.84	-11	-116
34	Ganges	Rajshahi	18.50	17	17.11	+11	-139	17.20	+9	-130	17.27	+7	-123	17.31	+4	-119	17.31	0	-119
35	Ganges	Hardinge Br	14.25	13.47	13.59	+12	-66	13.69	+10	-56	13.76	+7	-49	13.81	+5	-44	13.82	+1	-43
36	Ganges	Talbaria	12.80	-	12.86	-	+6	12.96	+11	+16	13.04	+8	+24	13.10	+6	+30	13.11	+1	+31
37	Padma	Goalondo	8.65	9.41	9.52	+11	+87	9.54	+2	+89	9.52	-2	+87	9.49	-3	+84	9.44	-6	+79

Note :
1) 96 hrs. (4th day) & 120 hrs. (5th day) forecasts are experimental.
2) 24 hrs. rise/fall indicates changes in water levels from today 6 A.M. to 17-8-2017 6:00 A.M.
3) 48 hrs. rise/fall indicates changes in water levels from 17-8-2017 6:00 A.M. to 18-8-2017 6:00 A.M
4) 72 hrs. rise/fall indicates changes in water levels from 18-8-2017 6:00 A.M. to 19-8-2017 6:00 A.M.
5) 96 hrs. rise/fall (experimental) indicates changes in water levels from 19-8-2017 6:00 A.M. to 20-8-2017 6:00 A.M.
6) 120 hrs. rise/fall (experimental) indicates changes in water levels from 20-8-2017 6:00 A.M. to 21-8-2017 6:00 A.M.
7) "+ above" means water level flowing above danger level, "-below" means water level flowing below danger level.

Page: 1 of 2

A sample of 5 days Forecast Bulletin

Annex-2



A sample of Structure Based Forecast Bulletin

Annex-3

FLOOD INFORMATION CENTRE
FLOOD FORECASTING & WARNING CENTRE
BANGLADESH WATER DEVELOPMENT BOARD
WAPDA BUILDING, 8TH FLOOR, DHAKA.
E-mail: ffwcbwdb@gmail.com, ffwc05@yahoo.com; Site: http://www.ffwc.gov.bd ; Tel: 9550755, 9553118; Fax: 9557386

RAINFALL AND RIVER SITUATION SUMMARY AS ON AUGUST 16, 2017

OUTLOOK

- *The Jamuna and Ganges-Padma rivers are in rising trend, while the Brahmaputra river is in falling trend.*
- *The Surma river is in falling trend, while the Kushiyara river is in steady state.*
- *The Brahmaputra river may likely to continue falling in next 48 hours, while the Jamuna river may likely to become steady in next 24 hours.*
- *The Ganges-Padma river may likely to continue rising in next 72 hours.*
- *The Surma-Kushiyara river may likely to continue falling in next 24 hours.*

Staions Above Danger Level (As on 16 August 2017, 09:00 am):

River	Station Name	Rise(+)/Fall(-) (cm)	Above Danger Level (cm)
Dharla	Kurigram	-20	+76
Jamuneswari	Badarganj	+3	+145
Ghagot	Gaibandha	0	+83
Karatoa	Chak Rahimpur	+8	+25
Brahmaputra	Noonkhawa	-11	+3
Brahmaputra	Chilmari	-8	+79
Jamuna	Bahadurabad	+1	+134
Jamuna	Sariakandi	+9	+126
Jamuna	Kazipur	+16	+151
Jamuna	Serajganj	+20	+148
Jamuna	Aricha	+23	+59
Gur	Singra	+10	+40
Atrai	Baghabari	+29	+79
Dhaleswari	Elasin	+24	+93
Lakhya	Lakhpur	+3	+20
Ich-Jamuna	Phulbari	-9	+7
Little Jamuna	Naogaon	+13	+71
Atrai	Mohadebpur	+26	+79
Padma	Goalundo	+21	+77
Padma	Bhagyakul	+17	+15
Surma	Kanaighat	-10	+85
Surma	Sylhet	-14	+30
Surma	Sunamganj	-12	+57
Kushiyara	Amalshid	+1	+74
Kushiyara	Sheola	-3	+67
Kushiyara	Sherpur-Sylhet	0	+3
Oldsurma	Derai	+10	+18
Kangsha	Jariajanjail	-24	+138
Titas	B. Baria	+10	+13

RAINFALL

Significant rainfalls recorded during last 24 hrs ending at 09:00 AM today:

Station	Rainfall(mm)	Station	Rainfall(mm)	Station	Rainfall(mm)
Habiganj	78.0	Rangamati	60.0	Chittagong	52.0
Lama	72.0	Mohadebpur	56.0	Ramgarh	49.8

General River Situation

Monitored water Level stations	90	Steady	4
Rise	60	Not reported	0
Fall	26	**Rainfall at Stations above 100mm**	***0***
Above danger level	**29**	Rainfall at Stations above 50mm	*5*

For Further Query, Feel Free to Contact:
01712731191, 01952253970

(Sarder Udoy Raihan)
Sub-Divisional Engineer
Duty Officer, FFWC, BWDB.
Cell no: 01952253970

A Sample Flood Situation Summary

Annex-4

FLOOD INFORMATION CENTRE, FLOOD FORECASTING & WARNING CENTRE
BANGLADESH WATER DEVELOPMENT BOARD, WAPDA BUILDING, 8TH FLOOR, DHAKA.
E-mail: ffwcbwdb@gmail.com, ffwc05@yahoo.com, Website: http://www.ffwc.gov.bd Tel: 9553118, 9550755 Fax: 9557386

Flash Flood Forecast Bulletin for North East Region as on April 07, 2017

Station Name	River Name	Experimental		06-Apr-17	07-Apr -17		08-Apr -17		09-Apr -17	
		Pre-monsoon DL	Pre-monsoon RHWL	Observed 9:00 AM	Forecast 9:00 AM	24-Hr Rise/Fall	Forecast 9:00 AM	48-Hr Rise/Fall	Forecast 9:00 AM	72-Hr Rise/Fall
Kanaighat	Surma	13.2	15.26	13.07	12.65	-42	12.08	-99	11.43	-164
Sylhet	Surma	11.25	12.44	10.83	10.65	-18	10.36	-47	10.02	-81
Sunamganj	Surma	8.25	9.75	7.94	7.93	-1	7.86	-8	7.76	-18
Amalshid	Kushiyara	15.85	18.28	15.32	14.71	-61	14.08	-124	13.42	-190
Amalshid	Kushiyara	15.85	18.28	15.32	14.71	-61	14.08	-124	13.42	-190
Sheola	Kushiyara	13.5	14.6	13.28	12.93	-35	12.5	-78	12.07	-121
Sherpur	Kushiyara	9	9.68	8.95	8.93	-2	8.92	-3	8.89	-6
Markuli	Surma-Meghna	8.5	8.51	8.27	8.26	-1	8.26	-1	8.25	-2
Sarighat	Sarigowain	12.8	14.48	11.04	10.95	-9	10.8	-24	10.58	-46
Manu RB	Manu	18	20.42	15.3	14.68	-62	14.2	-110	13.78	-152
Moulvi Bazar	Manu	11.75	13.25	10.72	10.14	-58	9.91	-81	9.75	-97
Ballah	Khowai	21.64	26.12	20.91	20.53	-38	20.23	-68	20.03	-88
Habiganj	Khowai	9.5	12	7.35	6.93	-42	6.46	-89	6.11	-124
Kamalganj	Dhalai	19.82	21.18	18.38	18.22	-16	18.01	-37	17.88	-50
Nakuagaon	Bhogai-Kangsa	22.4	26.01	19.15	19.17	2	19.17	2	19.12	-3
Lourergorh	Jadukata	8.53	11.85	5.48	5.47	-1	5.46	-2	5.44	-4
Durgapur	Someswari	13	15.2	9.37	9.32	-5	9.28	-9	9.2	-17
Jariajanjail	Bhogai-Kangsa	9.75	13.37	7.96	7.98	2	7.9	-6	7.81	-15

+ Rise, - Fall

An Experimental Bulletin for Flash Flood Forecast

Annex-5

FLOOD INFORMATION CENTRE,
FLOOD FORECASTING & WARNING CENTRE
BANGLADESH WATER DEVELOPMENT BOARD, WAPDA BUILDING, 8TH FLOOR,
DHAKA.
E-mail: ffwcbwdb@gmail.com, ffwc05@yahoo.com,
Website: http://www.ffwc.gov.bd
Tel: 9553118, 9550755 Fax: 9557386

Flash Flood Early Warning Bulletin for North East Region as on April 29, 2017

Outlook:

Rainfall:

No Significant rainfall has been recorded during last 24 hours except Lourergorh and no forecast of heavy rainfall within Bangladesh and adjoining Indian catchments for the next 48 hours.

Station	Rainfall (mm)
Lourergorh	50

General River Condition:

Monitored WL Stations	Rise	Fall	Steady	Not Reported	Stations above DL
18	06	11	00	01	0

Flood Condition:

- ***The Surma, Bhugai, Jadukata and Someswari rivers of North-Eastern region are in rising trend. The Kushiyara , Khowai, Manu and Kangsha rivers are in falling trend.***
- ***The Surma river may likely to fall in next 24 hours.***
- ***The Kushiyara, Khowai, Manu and Kangsha rivers may likely to continue falling in next 48 hours.***

An Experimental Summary for North East region