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A Study on Seasonal Variation of Hydrodynamic Parameters of Padma River

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Padma, a major river in Bangladesh is the main distributary of the Ganges flowing generally southeast for 120 kilometres to its confluence with the Meghna river. It has been traditionally considered a dominantly meandering river but recently switching over into a braided river due to its highly susceptible nature of erosion and deposition. To identify proper behavior and seasonal hydrodynamic variation of the Padma river, different hydrodynamic parameters have been included in this study. The reach is selected from Baruria transit at upstream to Mawa at downstream. Data of hydrodynamic parameters such as water level, velocity, discharge have been sorted, analyzed and plotted for the investigation of variation of various parameters during pre-monsoon, monsoon and post-monsoon seasons. The velocity, water level and discharge are found to be maximum during monsoon than pre-monsoon and post-monsoon. Discharge and water level approximately decrease in pre-monsoon and post-monsoon period by 76.3%, 75.7% and 59.3%, 57.4% respectively in comparison to monsoon period. From the data analysis, discharge and water level have been found to be maximum in monsoon 1998. It is also known that sediment transport rate is closely related to the velocity. The analysis also shows that velocity at monsoon period increase about 50% to 65% than pre-monsoon and post-monsoon period. Therefore during monsoon, high velocity results high sediment transport rate and ultimately contributes in erosion/deposition of river bed. It is hoped that the findings of this assessment will be helpful to understand the seasonal hydrodynamic nature of the Padma river and suggest possible future development works to be implemented on this river.

Keywords: Parameters; HEC-RAS ; Hydrodynamic; Padma River

Field of Research: Water Resources Engineering (River Hydrology)

1. Introduction

Bangladesh is a riverine country standing on a thick alluvial deposit. It is the result of deltaic activity of the main rivers, their tributaries and distributaries. Because of the inherent alluvium nature, the rivers of Bangladesh are hydro-morphologically dynamic

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differing from one another in their physical characteristics and general behaviors. The majority of the people in Bangladesh continue to rely on the rural land resources to support themselves. But the nature of these land resources is intimately related to the flood regimes of the rivers.

Bangladesh is a country blessed with abundant natural source of fresh sweet water. The three major rivers originating from Himalayas and flowing down the Northern regions of Indian Sub-continent reaches the Bay of Bengal through Bangladesh. These rivers frequently flood the vast plain of Bangladesh, deposit silt and contributed largely to create the fertile soil. People of this land use the water from these rivers and their tributaries for cultivation and livelihood. For thousands of years, people settled in this fertile and easily cultivable land along the rivers. Monsoonal flooding inundates 20% of the area each year, while major floods submerge a much greater area of the nation. For example, the mega-floods of 1988 and 1998 inundated 63% and 68% of the total area of Bangladesh, respectively (EGIS, 2002). Moreover, river bank erosion is also a serious hazard that directly or indirectly causes the suffering of about one million people annually (Elahi and Rogge, 1990). The natural setting of Bangladesh between the Himalayas and the Bay of Bengal, together with the meteorological characteristics of the tropical monsoon are responsible for the prevalence of flooding and river bank erosion in Bangladesh (Elahi, 1991). These two hazards such as flooding and river erosion are major contributors to the process of marginalization of rural peasantry.

The major rivers, including the Ganges, Brahmaputra-Jamuna, Padma and Meghna and their numerous tributaries and distributaries make Bangladesh a 'land of rivers'. The large discharges and heavy sediment loads carried by these rivers result in highly variable and dynamic channel morphologies characterized by rapid adjustments to the cross-sectional geometry, bank line positions and plan form attributes (Coleman, 1969). These overall changes keep a bad effect on every sphere of life. This effects navigation, agriculture, fishing, biodiversity and ecological balance. So proper hydrodynamic seasonal behaviors of the rivers of Bangladesh are very essential to know so that the actual characteristics and the changing pattern of the rivers can be understood. Among these rivers, the Padma shows great amount of seasonal hydrodynamic variations over the time. The mean annual rate of erosion along Padma river is very high. It has roughly a straight course in the upper reaches and a double thread braided lower reaches. It is found that the river has widened considerably. The depth of the Padma river is now 1.5 to 3 meters at different places(BIWTA);but at least 2.5 to 3 meters depth of water is necessary for normal movement of transport. During Pre-monsoon and Post monsoon the depth of water decreased considerably and affects navigation, agriculture, fishing, transportation etc. During Monsoon flood and river bank erosion is common phenomenon. So to mitigate these problems associated with it, a study on hydrodynamic seasonal variation of Padma river is of utmost necessity.

Though several studies have been conducted to understand the behavior of the rivers of Bangladesh. But most of these studies are based on yearly variation of river's hydrodynamic parameters, seasonal variation is hardly considered. In order to study the seasonal hydrodynamic variation of Padma river Microsoft Excel is used for determining different hydrodynamic parameters. A hydrodynamic study on Padma River will help us

to know its flow characteristics like rise and fall of water level, velocity and discharge. The specific objective of the study is to observe the seasonal variations of hydrodynamic parameters like water level, discharge and velocity in pre-monsoon, monsoon and post monsoon seasons. In the present research, the hydrodynamic and morphological analyses of Padma river have been performed using HECRAS model with a view to know the flow characteristics like rise and fall of water level, velocity and discharge affecting the sediment balance and bed level changes of the River under seasonal variation which would help to have a vivid idea on the seasonal variation of the parameters necessary to know before implementing structural intervention like bridge, barrage and weir on the river.

The paper has been organized in 6 segments as follows: Section 1 deals with Introduction focusing the background of the study and justification behind adopting the concept. Section 2 includes the previous studies on the Padma river and previous similar analysis on other major-minor rivers of Bangladesh as well as rivers of South Asia. Section 3 describes the major steps comprising the methodology of the study, section 4 deals with the analyses on the seasonal variation of the hydrodynamic parameters of Padma river. Conclusions and specific recommendations are provided in Section 5 and acknowledgement is in Section 6.

2. Literature Review

Considering the importance of understanding the seasonal change of hydrodynamic characteristics of alluvial rivers, major water courses of Bangladesh have drawn attention of different national and international researchers. Padma river is one of the major water course of the country. Previously Rahman (1978) studied erosion and deposition of Padma river. Later on Rahman (2007) studied the morphological changes of Padma-Meghna confluence. Then Hasan (2010) assessed environmental change detection of Padma river. Islam et al. (2009) and Yeasmin and Islam (2011) studied char-lands of Padma River basin in Ganges delta and changing trends of channel pattern of Ganges-Padma River respectively. Mondal (2016) estimated the hydrodynamic pattern changes and morphological parameter including bed shear stress of Ichamati River using HEC RAS model in West Bengal of India. Tang (2016) studied on Modelling and analysis of hydrodynamics and water quality for rivers in the northern cold region of China. Saha (2015) Studied different hydrodynamic characteristics and features of Surma River and performed analysis on change in peak flow due to Flash flood. Khan (2015) developed a hydrodynamic model of Khowai river using HECRAS which can be used to estimate the tidal volume of water flowing through the river and generation of watershed of Khowai river to estimate the runoff discharge and capacity of the Khowai river basin. Rahman (2015) analyzed the hydrodynamic and morphological parameters of Gorai river using Delft 3D focusing the effect of dredging on the hydro-morphological parameters. Roy(2015) Studied Hydro-morphological behavior of Padma river using Delft-3D focusing the hydro-morphological change of Padma river including the effect of tide at the downstream.

In similar previous studies on major as well as minor rivers of Bangladesh, gross nature and direction of backline shifting, erosion and deposition along the river bank using

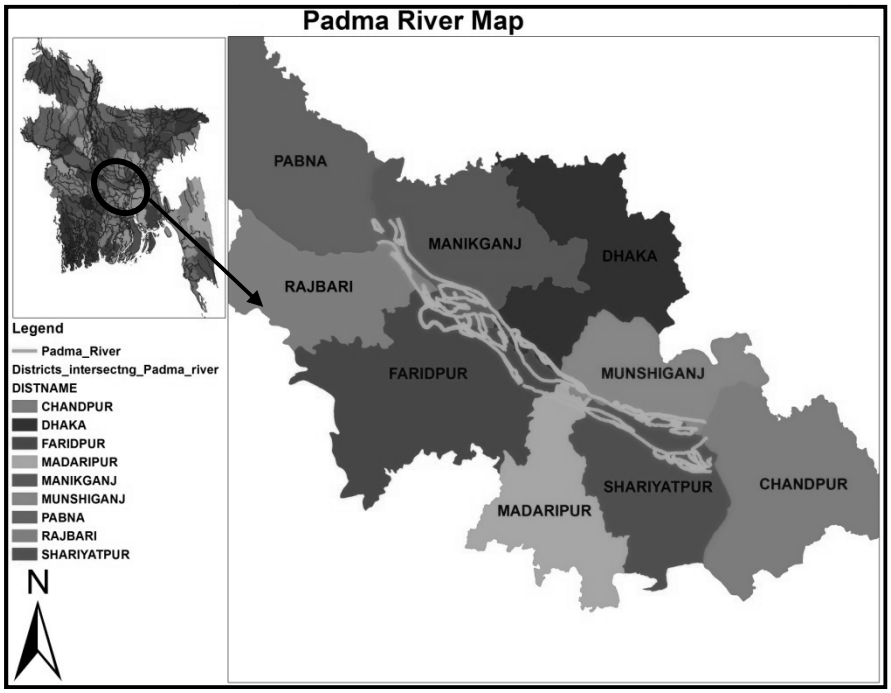
LANDSAT satellite images, effect of pre monsoon flash flood on the hydrodynamic parameters like water level, discharge and velocities and or the impact of flow availability on the water quality parameters have been focused but the detailed seasonal variation of flow and velocity field have not been highlighted much. That is why to analyze the temporal analyses on hydrodynamic parameters under seasonal basis have been set as the prime objective of the study.

3. Methodology

3.1 Study Area

The selected reach is approximately 93 km long starting from Baruria Transit at Upstream to Mawa at Downstream. Figure 1 shows the map of the study area.

Figure 1: Study Area



3.2 Data Collection

To setup a Hydrodynamic model, data on Water level, cross-section and discharge need to be collected. Required data for conducting the study have been summarized in following table named as Table 1.

Table 1: Types of Data Collected and Their Sources

Data	Location	Period	Source
Bathymetry(mPWD)	RMP 0.1 to RMP 7	2005	BWDB
Discharge(m^3/s)	Baruria Transit(91.9L)	1995-2015	BWDB
Water Level(m)	Mawa(SW 93.5L), Bhagyakul (93.4L), Baruria Transit (91.9L)	1995-2015	BWDB
Velocity(m/s)	Mawa(SW 93.5L), Bhagyakul (93.4L), Baruria Transit (91.9L)	1995-2015	BWDB

3.3 Data Analysis

Observed data of different hydrodynamic characteristics such as water level, velocity, discharge for the year 1995 to 2015 have been sorted, analysed and plotted for the investigation of variation of various parameters during pre-monsoon, monsoon and post-monsoon season by using Microsoft Excel.Though Bangladesh is said to have 6 seasons but with respect to precipitation, year can be divided into following 3 categories: Pre-monsoon season (March-May), Monsoon season (June-October), Post –Monsoon season (November-February). Each year's data is divided into 3 seasons and average, maximum and minimum of each parameter is calculated.

4. Result and Discussions

4.1 Water Level

The average water level is found to be maximum during monsoon than during pre-monsoon and post-monsoon from the observed data.In this period of time, the average water level decreases in pre-monsoon and post-monsoon period by approximately 59.3% and 57.4%respectively in the Baruria Transit station. The highest water level found in Bhagyakul and Baruria Transit station is 7.46 and 9.88 meter on 10 September,1998 and 24 July,2004 respectively. The Highest Average Water Level is Found in the Monsoon of 1998 as shown in Figure 2.

Figure 2: Seasonal Variations of Average Water Level (M PWD) in Pre-Monsoon, Monsoon & Post-Monsoon Period for the Year 1995 to 2015 at Baruria Transit

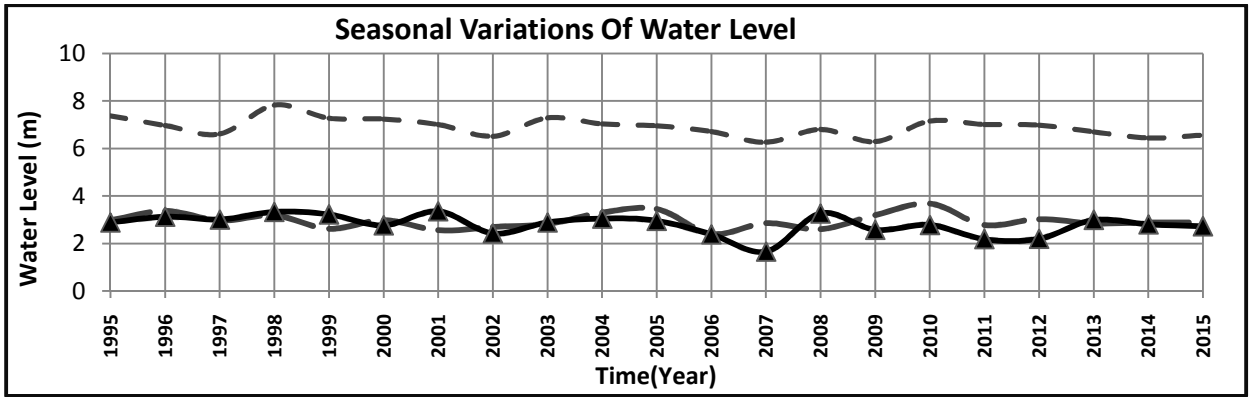
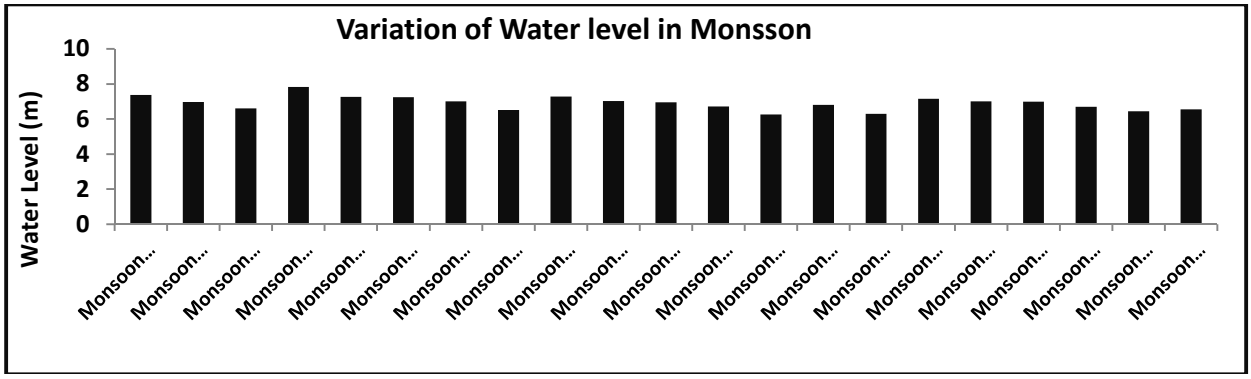
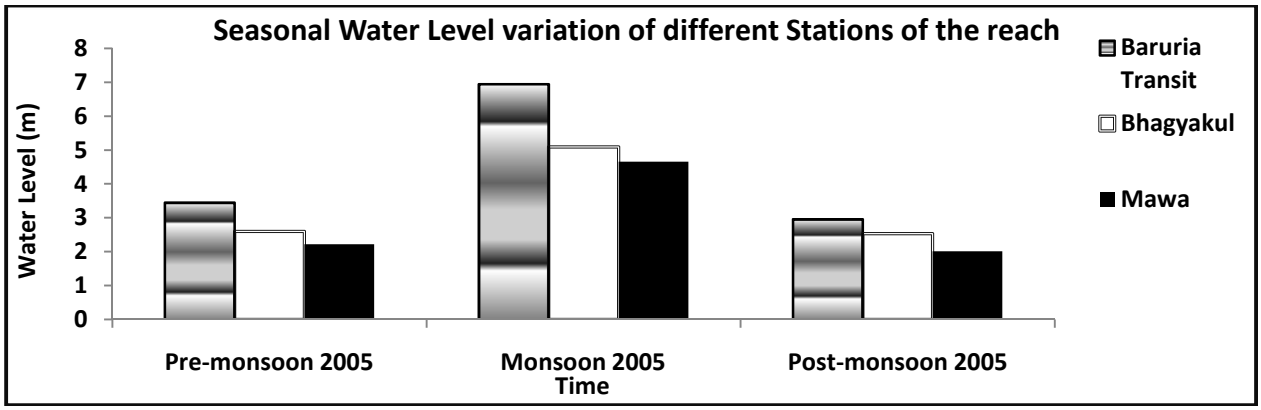


Figure 3: Variations of Average Water Level (M PWD) in Monsoon Period for the Year 1995 to 2015 at Baruria Transit



From the data analysis it is found that the average water level for a particular period of time in the upstream station Baruria Transit is greater than the downstream stations Mawa. The water level of Bhagyakul station which is between these two stations is greater than Mawa but less than Baruria Transit.

Figure 4: Seasonal Water Level (M PWD) Variation of Different Stations of the Reach in the Year 2005.



4.2 Discharge

The velocity and water level somewhat related to discharge and the discharge as expected is found to be maximum during monsoon than during pre-monsoon and post-monsoon. During this time, the average discharge decreases in pre-monsoon and post-monsoon period by 76.3% and 75.7%respectivelywith comparative to monsoon period in the Baruria Transit station as shown in Figure 5.

Figure 5: Seasonal Variations of Average Discharge in Pre-Monsoon, Monsoon & Post Monsoon Period for the Year 1995 to 2015 in Baruria Transit Station

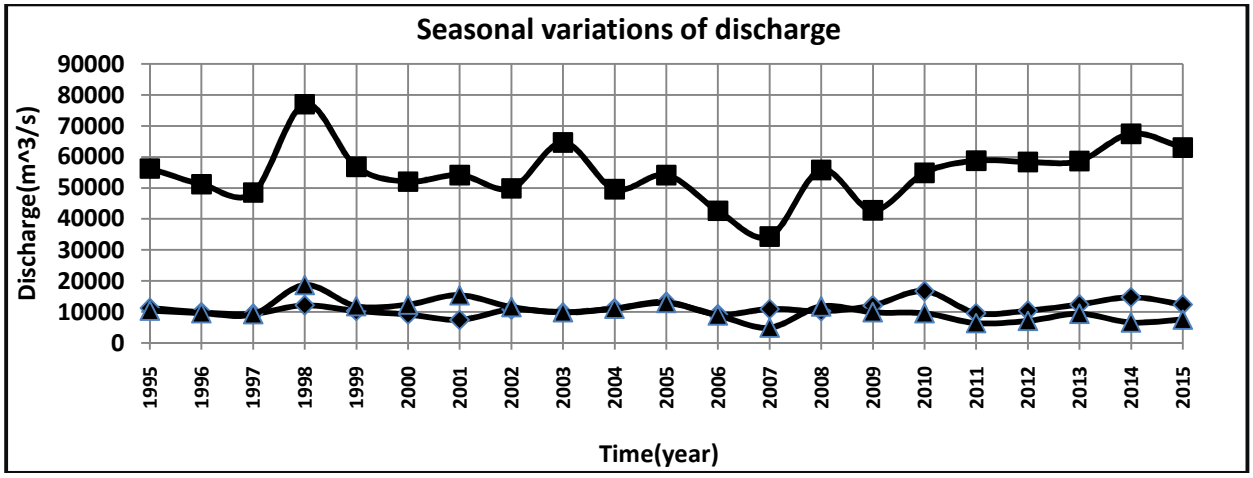
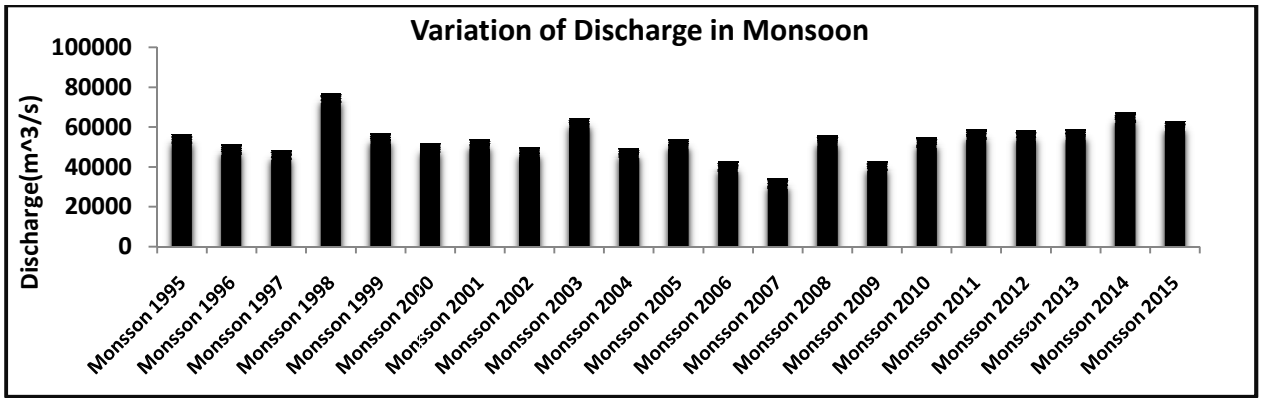


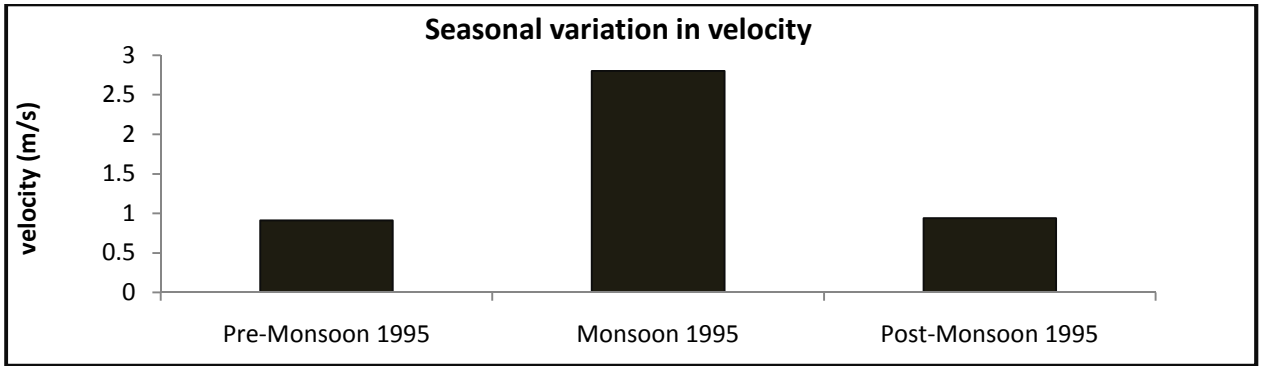
Figure 6: Variations of Average Discharge in Monsoon Period for the Year 1995 to 2015 in Baruria Transit Station



4.3 Velocity

The velocity is related to water level and discharge. It is found to be maximum during monsoon than during pre-monsoon and post-monsoon as expected. Figure 7 shows that in the year 1995, velocity in monsoon was maximum as 2.7 m/s at Baruria Transit. In both of pre and post-monsoon season, the velocity remained below 1 m/s always as shown in Figure 7.

Figure 7: Seasonal Variations of Average Velocity in Pre-Monsoon, Monsoon & Post-Monsoon Period for the Year 1995 in the Baruria Station



The Following Table, Table 2 Shows the Variation of Average Velocity in different Seasons at Two Stations named as Baruria transit and Bhagyakul for the year 2005. The values show that at both location the velocities in monsoon season occurred maximum as expected. lowest velocity at Baruria transit happened in pre-monsoon whereas the minimum velocity at Bhagyakul was obtained as 0.4974 occurred in post-monsoon.

Table 2: Variation of Average Velocity at Different Seasons at Two Stations

year	Season	Velocity at Baruria Transit (m/s)	Velocity at Bhagyakul (m/s)
2005	Pre-Monsoon	0.3855	0.5185
2005	Monsoon	0.7577	1.185
2005	Post-Monsoon	0.4144	0.4974

The major findings of the present study for the selected reach of the Padma River can be summarized as follows:

- The average water level, discharge and velocity all are found maximum in the monsoon than pre-monsoon and post-monsoon. The maximum velocity of flow and discharge at Baruria Transit was found 4.85 m/s and 141939.80 m^3/s respectively.
- The erosion/deposition is higher in Monsoon than in other seasons.So the change of bed level is insignificant during dry season compared to monsoon season. It is clearly observed that the variation of discharge over location is not significant but the seasonal variation is very high.Further analysis shows that,velocity is found maximum in Bhagyakul due to its narrow cross-sectional area than Baruria Transit.

5. Conclusions

A numerical 1D model using HEC-RAS software has been developed and applied in the Padma river for a reach extending from Baruria Transit to Mawa. After successive trial the model could be calibrated and validated. Then the details seasonal hydrodynamic assessment of the river has been conducted. This type of hydro-morphological

assessment studies can be carried out in most of the major rivers, estuaries and coastal regions of our country.From this study it is hoped that the findings of this assessment will be helpful to understand the seasonal hydrodynamic nature of the Padma river and suggest possible future development works to be implemented on this river. The developed hydrodynamic model on Padma river can also be used for the design and determining efficiency of bank protection measures on the river bank and assessing the change in water surface profile and flow field after the construction of the structure including afflux. One of the major limitation of the study is, in developing the hydrodynamic model of Padma river, the lateral outflow from the Padma river to its distributary Arial khan river has not been included. Output with greater precision can be generated If the river network can be dealt with instead of the single reach. Moreover more accurate set of data on mean daily discharge should be available to conduct the study with high precision level. To perform the analyses, rated discharge data have been generated using the concept of rating curve using the very few available data on discharge. Effect of tide at the downstream of the Padma river could also be included to incorporate the variation of water level induced by semi-diurnal tide. Recommendation for Further Study include following two as major ones-

• Calibrated and validated model of Padma River can be used in any further study to develop various hypothetical scenario on the impacts of structural interventions.
• Dredged section with relevant dimension and alignment can be introduced to analyze more variations and impact of dredging on the hydro-morphodynamic parameters.

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