HYDRO-MORPHOLOGICAL ASSESSMENT OF THE RIVER JAMUNA AND OLD DHALESHWARI OFFTAKE

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ABSTRACT

The offtakes are important links between the main rivers and the distributaries. An example is the Jamuna and Old Dhaleshwari offtake. The mouth of the river at offtake is not stable. At present, serious deposition has taken place at the mouth. This paper presents the hydro-morphological analysis of the Jamuna and Old Dhaleshwari offtake of Bangladesh to predict its sustainability. The present study has been undertaken to assess the hydraulic behavior of the Old Dhaleshwari River based on its flow carrying capacity. Satellite images, old maps and hydro-morphological data have been used to understand the morphology and planform of the river. From conveyance analysis rating curves have been developed for the cross sections in the vicinity of offtake for both Jamuna and Old Dhaleshwari. Analysis of historical hydrometric data and satellite images near the offtake has been carried out.

Keywords: *River offtake, River morphology, Rating curve, Conveyance analysis*

1. INTRODUCTION

The Old Dhaleshwari River is a distributary, 160 km long, of the Jamuna River in central Bangladesh. It starts off the Jamuna near the northwestern tip of Tangail District (BWDB, 2011).

The distribution of discharge and sediment transport at river offtake is a key factor for the long term morphological development of the main rivers (FAP24, 1996a). The dynamics of such offtakes have undoubtedly been of great significance during channel avulsion, such as: the occupation of the current Jamuna channel and Old Dhaleshwari channel. At present, serious deposition has taken place at the mouth, induced by intense char movement. The large discharges and heavy sediment loads carried by these rivers results in highly variable and dynamic channel morphologies characterized by rapid adjustments to the cross-sectional geometry, bankline positions and planform attributes (Noor, 2013).

The sediment transport distribution, in addition, may be influenced by the local planform and bathymetry at the offtake, which on the other hand are dependent on the planform and sediment transport conditions of the main river (FAP24, 1996a). A bar in front of the offtake may partly block the inflow to the distributary. For the development of the distributaries the offtakes are the crucial elements. At an offtake the flow and the sediment transport entering into the distributary are determined by the downstream conveyances, the local geometry of the offtake becomes less important. If more sediment is entering into the offtake than can be transported over a longer period, the distributary will start to aggraded. As a consequence less water is entering and hence this may start a self-accelerating process. It has been found that most offtakes are unstable: either the distributary start to die or gradually the distributary takes the function of the main river. They start to function only during higher stages. Any change in the stages in the main river will affect the flow (and sediment transport) entering into the distributary (Noor, 2013).

2. METHODOLOGY

Flow chart outlining the fundamental steps in the methodology is shown in Figure 1.

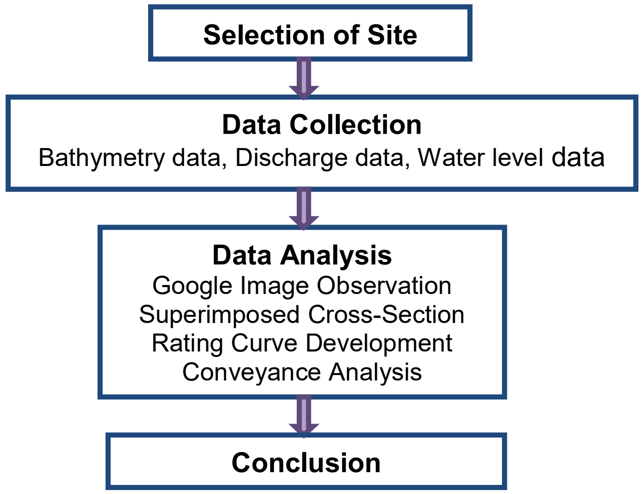

Figure 1: Fundamental steps of methodology

The study area in the Jamuna-Old Dhaleshwari offtake as shown in Figures 2 & 3. Data collected for cross-sections at the locations near offtake such as Tangail, Sirajganj, Manikganj. Data list is shown in Table 1.

Figure 2: Google Earth image of study area (Jamuna-Old Dhaleshwari Offtake)

Figure 3: Image of Jamuna-Old Dhaleshwari Offtake during 2016 (18th March)

Table 1: List of collected data (Source: BWDB)

Type of Data	**Location**	**Station**	**Available Time Period**
Bathymetry Data	Jamuna	RMJ 6.1 to RMJ 2	2005, 2006, 2008 & 2010 to 2014
	Old Dhaleshwari	RMD 1 to RMD 12	2003, 2008, 2013
Discharge Data	Jamuna	SW 46.9	2006 to 2014
	Old Dhaleshwari	SW 68.5	2006 to 2015
Water-level Data	Jamuna	SW 46.9	2006 to 2015
	Old Dhaleshwari	SW 50, SW68, SW68.5	2006 to 2014 (seasonal)

3. ANALYSIS

3.1 Present State of Old Dhaleshwari River

Due to the construction and associated river bank protection works of Jamuna Multipurpose Bridge on Jamuna River at Bangladesh, water flow through the Old Dhaleswari River was reduced significantly. The river remains usually dead during the dry season. The river feeds a little to its distributaries. As a result, the downstream rivers also remain dead at the dry season. Erosion of the river causes a great problem for the people surrounding the area. The actual river is lost for various man-made reasons. There are various industries near the banks of the river which dump untreated waste in the river. As a result, the river water quality is deteriorating day by day. Polluted water of Old Dhaleshwari is posing serious threats to public life as it is unfit for human use (Doza, 2013).

3.2 Morphological Analysis

3.2.1 Plan form analysis using satellite images

Satellite images of Old Dhaleshwari River for the years 2008, 2011, 2012, 2013 and 2016 have been extracted from the Google Earth. The years were chosen on the basis of availability of imagery. For the purpose of desk analyses, a reach from near the mouth to near Maddhapara is selected (Figure 4).

In order to analyze the plan form changes, bank line conditions are superimposed (Figure 5) for the above years. ArcGIS 10.2.2 software has been used for the purpose. The reach shows moderate bends.

Figure 4: Google Image of Old Dhaleshwari Planform

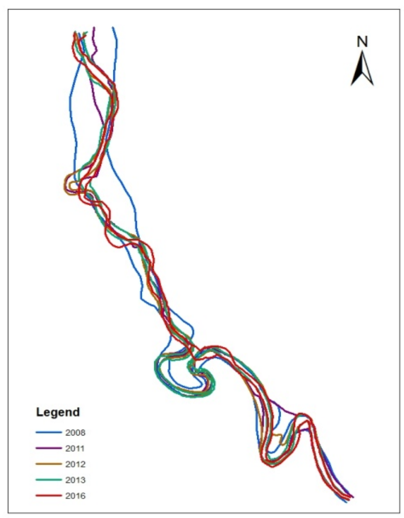

Figure 5: Superimposition of Old Dhaleshwari Planform of Selected Reach

3.2.2 Change in bed elevation

A change in bed elevation is, however, a useful indicator that channel characteristics are responding to a change in sediment load (Lisle, 1982). Superimposed cross-section plot shows aggradations and degradations over years. In case of Old Dhaleshwari River, main channel and bank has shifted greatly from 2003 to 2008. The channel has become narrower but deeper. But the carrying capacity has decreased over years. It is evident from the Figures 6 & 7 that cross-section near the offtake has changed more than cross-section relatively far from the offtake.

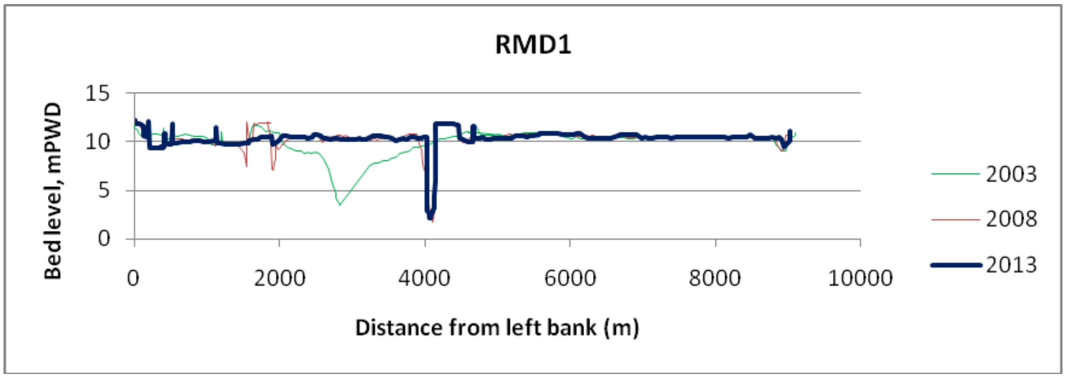

Figure 6: Superimposition of cross section near offtake (RMD1) in different years

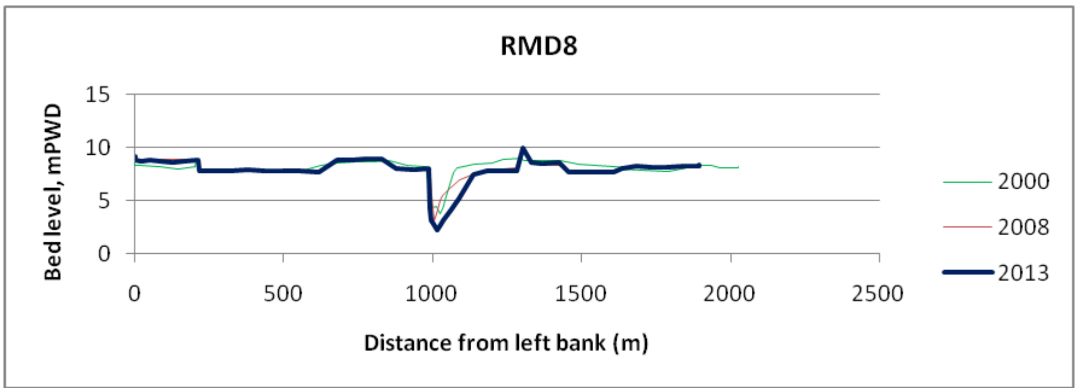

Figure 7: Superimposition of cross section relatively far from offtake (RMD8) in different years

3.3 Discharge and Water Level

Mean daily water level (MDWL) variation from year 2005 to 2015 at Tilli (SW68) of Old Dhaleshwari River is shown graphically in Figure 8. According to the Figure 9 water level is decreasing throughout the years in Old Dhaleshwari River.

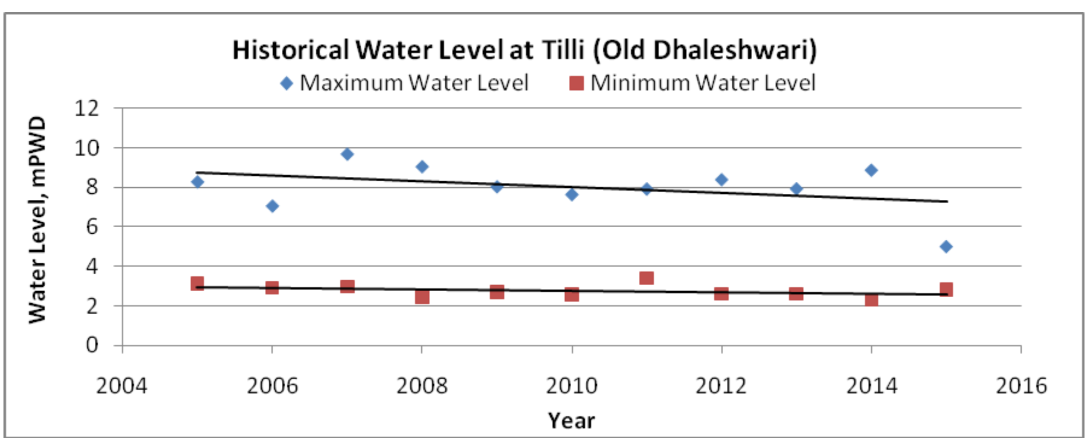

Figure 8: Maximum and Minimum MDWL variation from year 2005 to 2015 at Tilli

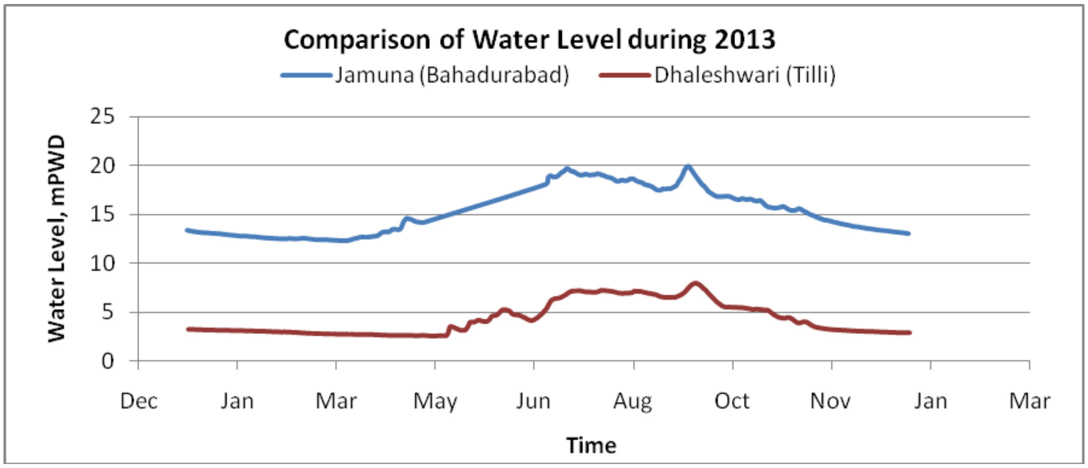

Figure 9: Comparison of Water Level at Jamuna and Old Dhaleshwari Rivers

3.4 Observations from Plotting of Mouth Sections of Jamuna-Old Dhaleshwari Offtake

The Old Dhaleshwari River starts off from a place between RMJ4 at upstream and RMJ4.1 at downstream of the Jamuna River. The flow continues through RMD1 and RMD2 of Old Dhaleshwari River near the mouth.

The cross-sectional area and depth of Old Dhaleshwari River is much less than that of Jamuna River. Figure 10 shows that the width of Old Dhaleshwari channel is very small compared to that of Jamuna. Hence the discharge carrying capacity is significantly low for Old Dhaleshwari River.

The dash lines in the figure indicate levels of water from datum. Water levels equal to 2m, 4m, 6m, 8m, 10m and 12m are shown in the figure. In case of lower water level such as 2m; the discharge cannot contribute to the Old Dhaleshwari channel. Old Dhaleshwari River will have no flow and will become dry. Though RMD2 has the elevation to permit flow even for this low water level case it won't be utilized. The bottom elevation of RMD1 cannot support the low flow.

The Highest water level such as 12m may cause flooding in Old Dhaleshwari River and areas adjacent to the river. The carrying capacity of Old Dhaleshwari River is not enough to accommodate this high level of flow.

The nearest cross-section to the offtake on Old Dhaleshwari River is RMD1. The next one is RMD2. RMD1 has its bottom elevation higher than RMD2. This elevation may be a sign of siltation near the offtake.

RMD1 has a smaller cross-section than RMD2. RMD1 also has its bottom elevation higher than the downstream section RMD2. Discharge from Jamuna River can only enter the Old Dhaleshwari river channel up to the highest capacity of RMD1. Larger cross sections present along the channel may not be utilized fully if the nearest section to mouth, RMD1 is not large enough.

RMJ4 at downstream of the offtake provides a larger cross-sectional area that that of RMD1. It increases the probability of less discharge entering the Old Dhaleshwari channel.

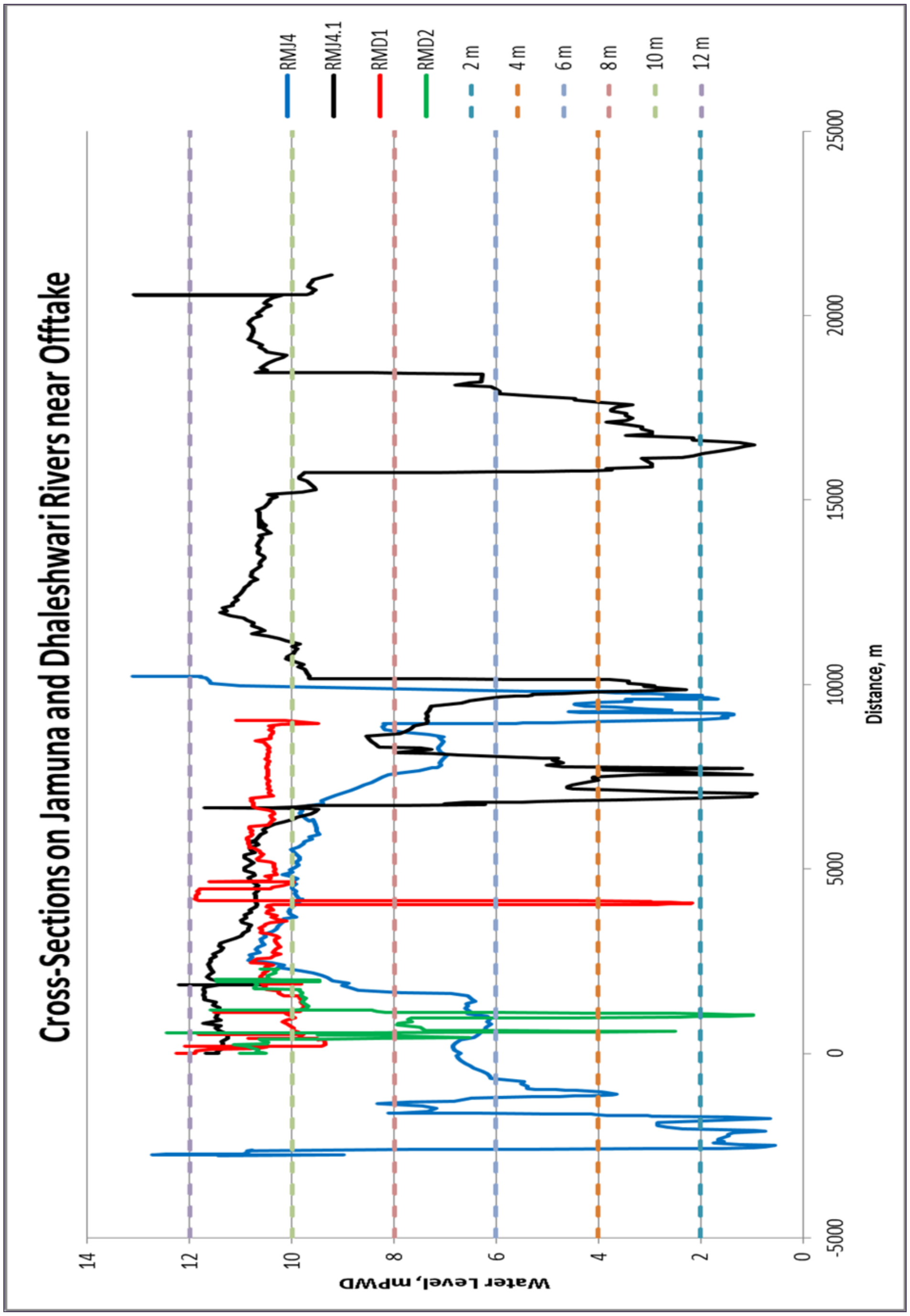

Figure 10: Cross-Sections of Jamuna River and Old Dhaleshwari River Near Offtake

4. DEVELOPMENT OF RATING CURVE

4.1 Using Collected Data

In hydrology, rating curve is a graph of discharge vs. stage (water level) for a given point/station on a stream/river, usually at gauging stations, where the stream discharge is measured across the stream channel with a flow meter/ADCP.

Rating curves have been developed for recent years for Bahadurabad station (SW 46.9) on Jamuna River (Figure 11) and Jagir station (SW 68.5) on Old Dhaleshwari River (Figure 12).

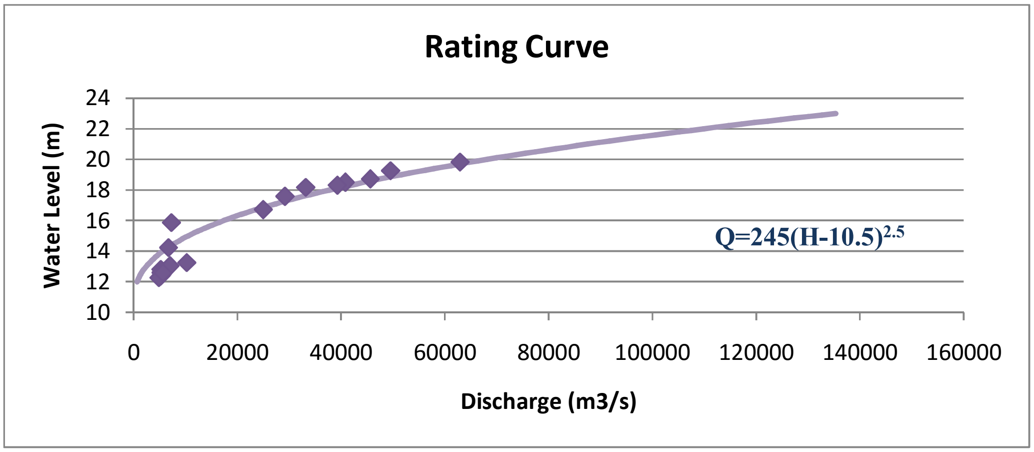

Figure 11: Rating curve for Bahadurabad Station on Jamuna River

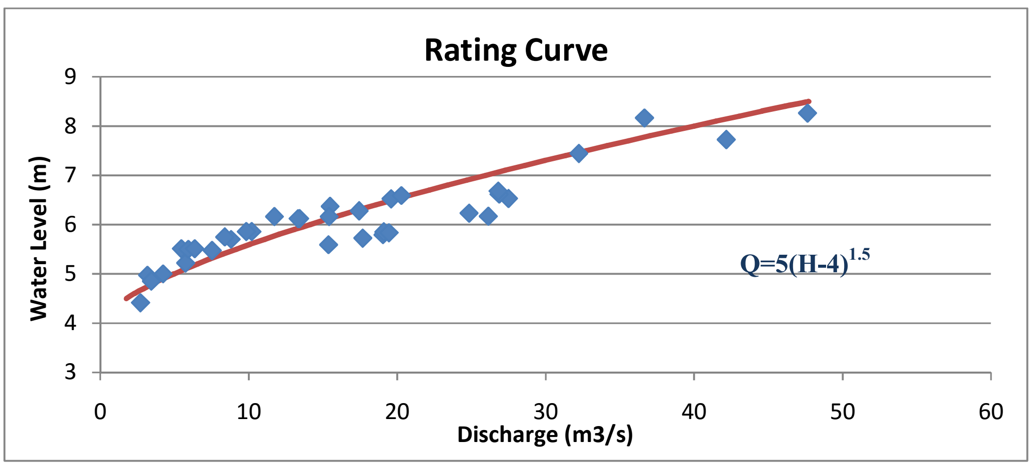

Figure 12: Rating curve for Jagir Station on Old Dhaleshwari River

4.2 Using Conveyance Analysis

Conveyance, K = $(AR^{2/3})/n$ where n is Manning's roughness coefficient. The discharge becomes Q = $K\sqrt{S}$. The Manning's roughness value of 0.025 and 0.018 is assumed for Jamuna and Dhaleshwari Rivers respectively from previous studies (Islam, 2016). Area and perimeter for the section near offtake on Jamuna River and Old Dhaleshwari River are computed by AutoCAD.

For computing the slope of the channel thalweg for both Jamuna River and Old Dhaleshwari River are plotted as shown in Figures 13 & 14 respectively. The trendline of the plot gives a close value for the slope of the channel. The longitudinal slope for Jamuna River is assessed to be 0.00015 m/m and 0.00004 m/m for Old Dhaleshwari River. The slope of the Old Dhaleshwari River is milder than that of the Jamuna River. Less discharge enters the Old Dhaleshwari River due to the slope disadvantage. Rating curves developed from conveyance analysis are compared in Figure 15 and obtained equations for the curves are shown in Table 2..

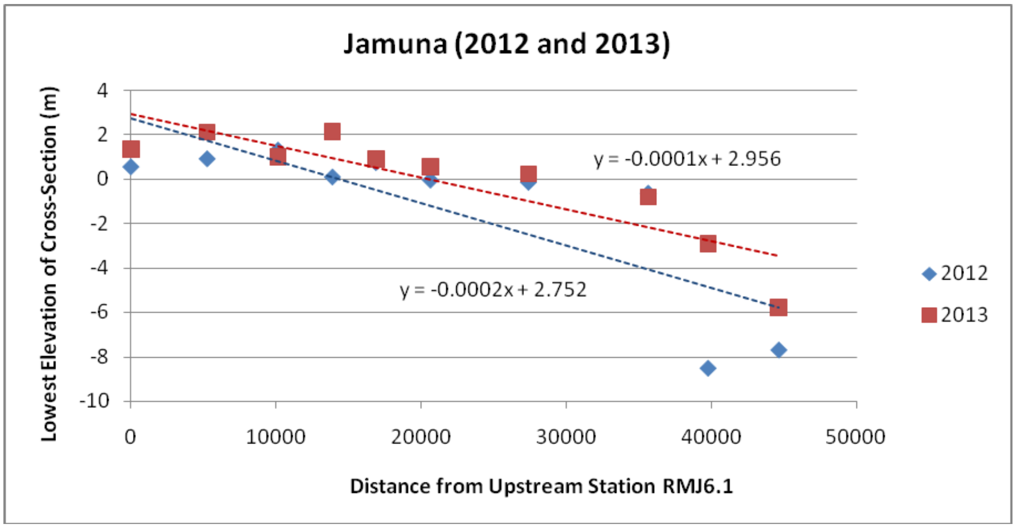

Figure 13: Thalweg from Station RMJ6.1 to Station RMJ2 on Jamuna River (2012 & 2013)

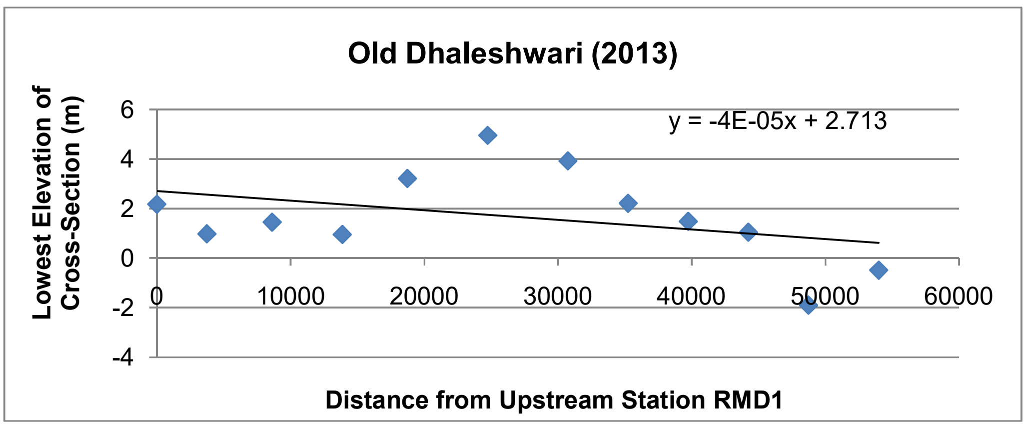

Figure 14: Thalweg from Station RMD1 to Station RMD12 on Old Dhaleshwari River (2013)

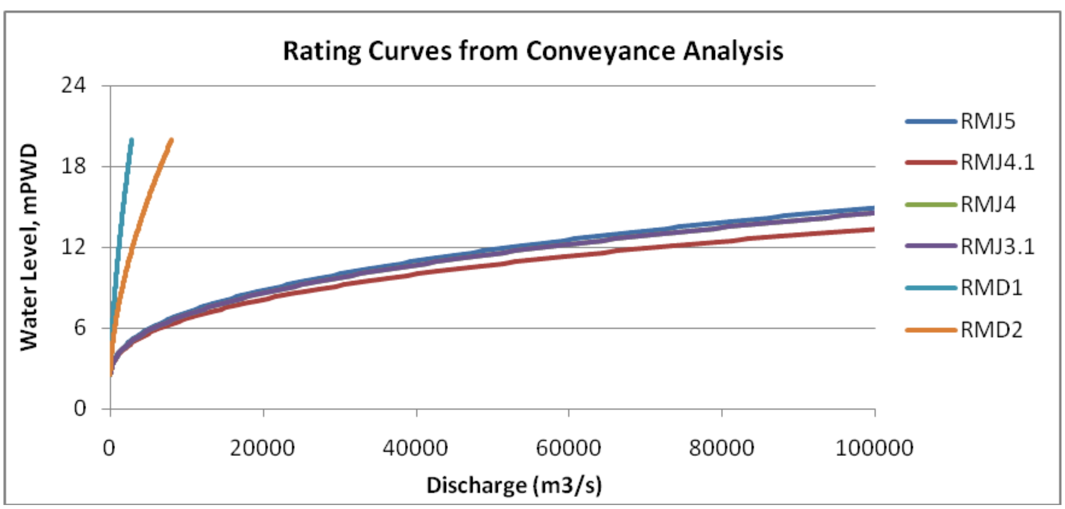

Figure 15: Comparison of Rating Curves Using Conveyance Analysis for Jamuna (RMJ5, RMJ4.1, RMJ4, RMJ3.1) and Old Dhaleshwari (RMD1, RMD2) Rivers

Table 2: Obtained equations of rating curve from conveyance analysis

Section	Equation for Rating Curve
RMJ5	$Q=166(H-2)^{2.5}$
RMJ4.1	$Q=180(H-2)^{2.6}$
RMJ4	$Q=180(H-2)^{2.5}$
RMJ3.1	$Q=180(H-2)^{2.5}$
RMD1	$Q=35(H-2)^{1.52}$
RMD2	$Q=56(H-2)^{1.72}$

5. CONCLUSIONS

The analysis includes planform analyses by using Google Earth image, superimposition of cross-sections, development of rating curves and conveyance analysis. Analysis of primary data shows that there is no flow in the Old Dhaleshwari River during dry period. The minimum depth of the river is about 1.0m which is almost static. The upper reach of the river has lower velocity compared to the lower part of the river reach. Therefore, the upper reach will face more siltation problem. It reveals that sedimentation has been occurring which leads to formation of sand bars. Prominent bank shifting is evident from the planform analysis. Natural cutoff has developed in recent years. From conveyance analysis rating curves have been developed for the cross sections in the vicinity of offtake for both Jamuna and Old Dhaleshwari. For the Old Dhaleshwari maximum discharge is obtained as 900 m^3/s and minimum discharge is obtained as 80 m^3/s (for Least Available Depth=1.5m) for cross section no.1 of Old Dhaleshwari that is RMD1. In reality the flow in Old Dhaleshwari River is not justified to ots full capacity. The developed rating curves also show the same. The assessments are made to define the boundary condition for setting up a HEC-RAC 4.1.0 model for the Old Dhaleswari River. The scope of further improvement remains for detailed analysis.

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