A Study on Prediction of Bed Level Changes and Bank Line Shifting of the Selected Reach of Jamuna River

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ABSTRACT

Jamuna river is one of the major rivers of Bangladesh and it is morphologically very dynamic.Jamuna river is a braided river with complex morphological behavior. Erosion-deposition and bank line shifting of this river is the common morphological processes. In this study, the bed level changes has been carried out using riverflow2d model. Then 1D HEC-RAS model was used to extract five important hydro-dynamic variables such as maximum discharge, velocity, slope, Water surface elevation and minimum WSE. After that, observed bank erosion rate and five variables has been processed using MATLAB. Machine learning & Deep learning technique was used to calibrate the regression model, The best regression model was used to predict bank erosion rate for year 2019 with and without consideration of bel level changes. It has found that without considering the effects of bed level changes the multivariate regression model estimated the bank erosion rate which is not well matched with observed bank erosion but with considering the bed effects it has found that the regression model gave good agreement comparing with observed bank erosion rate. This study will be helpful to estimate bankline shifting and bed level changes of alluvial braided river like Jamuna using 2D morphological modelling tools. The developed model and results will be useful primarily for suitable flood control and river training alignment of the reach under study.

Keywords: RIVERFLOW 2D, HEC-RAS, Regression Model, Bankline shifting, bed level effects.

1. INTRODUCTION

Jamuna river is one of the major rivers of Bangladesh and it is morphologically dynamic. According to a recent study by CEGIS (2018), the bank line of the Jamuna river had been eroded by about 93,302 ha along the 220 km long Jamuna between 1973 to 2017 [1]. CEGIS utilized the dry period satellite images for their bank line shifting and prediction [2]. However, it can be claimed that such prediction also to be required the analysis of hydro-morphological conditions of the river bank and bed of the river reach under study. In the recent past, few studies were conducted to assess morphological conditions of alluvial river reach using a numerical model. For instance, Mohammad (2012) studied on bank erosion process by the CCHE-2D model. They reported that the numerical model is applicable to study bank erosion by analyzing the dominant variables involved in the fluvial processes of alluvial rivers [3]. Ashraf, M. (2018) predicted the erosion rate of the bank by coupling excess shear stress to the output from the 2D hydrodynamic model and found good agreement with the observed erosion rate [4]. He used 2D Model but predicted only one fixed location. Hasan, M.Z. (2018) used the DELFT3D model to assess of the hydro-morphological response of the Jamuna river by introducing Gyrones in the river bank and concluded that the shear stress and velocity gradually decrease with increasing number of gryones [5].

Saadon et al. (2020) used the Nonlinear AutoRegressive model with eXogenous inputs and QR factorization model. This model was used to predict the bank erosion rate of Sg. Bernam,Selangor, Malaysia. Soil characteristics and other parameters such as hydraulic variables was used as input variables and bank erosion rate was used as output variable [6].

Present study deals with the bed level changes and riverbank shifting of the selected reach of Jamuna river based on the hydrodynamic conditions of the riverbank. Analyses for bank line shifting and bed level changes will be carried out using the HEC-RAS model coupling with RIVERFLOW 2D model respectively [7,8]. In this study, HEC-RAS 1D is used as five variables can extract easily from data table and can process with Matlab. But in 2D model, the variables cannot extract along the length.

The specific objectives of this study are:

1. To set up a two-dimensional hydro- morphological and one-dimensional model for the selected reach of Jamuna River.
2. To assess bed level changes in terms of net erosion-deposition of the selected reach of Jamuna using

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the RIVER FLOW 2D model.

3. To analyze the bank shifting of the selected reach of Jamuna river(left bank) using MATLAB regression model incorporating bed level changes

2. METHODOLOGY

2.1 Study Area

In this study, Jamuna river reach of 120 km long starting from Bahadurabad station to Bhuapur (opposite to Sirajganj) will be selected for model setup as shown in Figure.01.

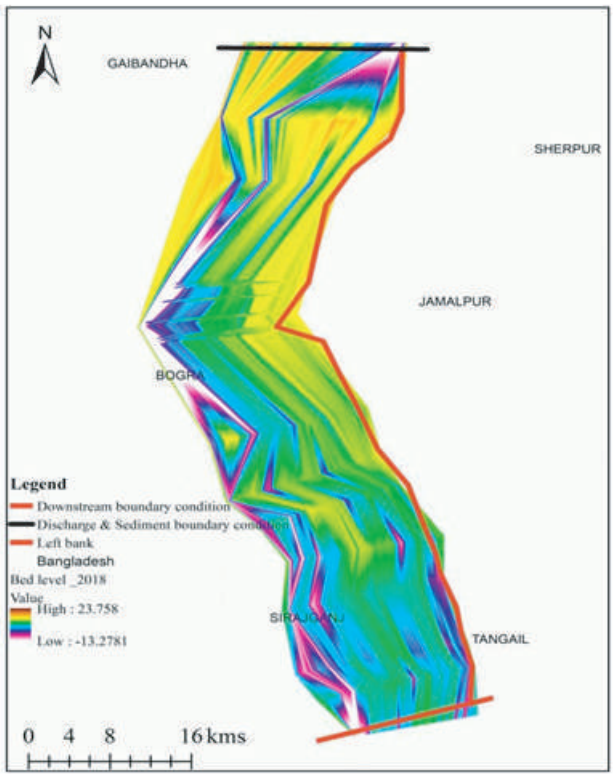

Fig. 1: Study area

2.2 Data Collection

Cross-sectional data were collected for the year 2018 from BWDB. Water level data of three stations that are Bahadurabad (SW46.9L), Kazipur (SW49A) and Sirajgonj (SW49) was collected for the year 2018-2019. Sediment concentration data at Bahadurabad was collected from Bangladesh Water Development Board for the year 2018-2019 (Table 1).

Table-I: Data Collection

Data type	Source	Data location	Period
Discharge	BWDB	Bahadurabad	2018-2019
Water level	BWDB	SW49A,SW49, SW46.9	2018-2019
Cross-section	BWDB	RMJ #13-#7	2018-2019
Sediment data	BWDB	Bahadurabad	2018-2019

2.3 Flow Diagram of Methodology

2.3.1 Bed Level Changes

First, Bathymetry was generated from the cross-section of the year 2018. This Bathymetry was incorporated in RIVERFLOW 2D model. Then boundary conditions and tri-mesh was generated. Then model was run. For morphological modelling, the sediment data was given at the Bahadurabad station for the year 2018. The river reach was considered from upstream of Bhadurabad to Sirajgonj station. The calibration was done using cross-section for the year 2019 near Kazipur station. When river erosion occurs at the bed, this erosion will propagate towards the river bank. In general, such morphological changes occur in the rising and falling limb of the hydrograph. Considering high, medium and average flow conditions, this morphological process was analyzed using 2D morphological model simulation (Fig. 2).

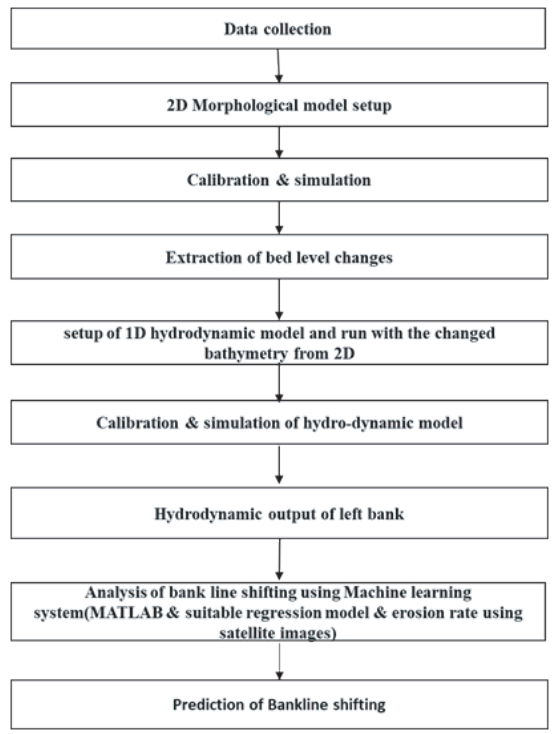

Fig. 2: Flow diagram

2.3.2 For Bank Line Shifting

The hydrodynamic model was set up and have been calibrated and simulated for the water level at the Kazipur station for the years 2018 and 2019 respectively. Five variables representing hydro-dynamic conditions along the riverbank such as Left overbank(LOB)/Right overbank(ROB) discharge, maximum WL, maximum velocity, minimum WL, the slope have been extracted at 300 m interval from the output table of HEC-RAS (Fig.02). Bank shifting of the corresponding interpolated cross- section was estimated. Five input and one output variables have been processed using MATLAB and the regression model were calibrated for the year 2018 to estimate the bank erosion rate of Jamuna river at Jamalpur district for the year 2019. Again, exact hydro-dynamic procedure was followed as described above. Here, the effect of bed level changes was considered and new cross-section was used from the simulated bed level of the year 2019. Then boundary condition was given and model was run for the year 2019.

3. RESULTS & DISCUSSIONS

3.1 Calibration and Simulation of 2D Morphological Model

RIVERFLOW 2D hydro-morphological model was used for calibration and simulation of the 2D morphological model. The calibration was done at Kazipur station using the water level for the month of June, July, August of the year 2018 which is shown in figure.05. It has been seen that in the downstream length of this study area, the changes in bed level are very significant. It has been seen that a high bed level was observed in the narrow channel. From Fig.04, it has found that erosion of bed level was observed in near the right bank up to 12 meters and on the left bank, it has observed that there is bed deposition occurred ranging from 1 to 20 meters.

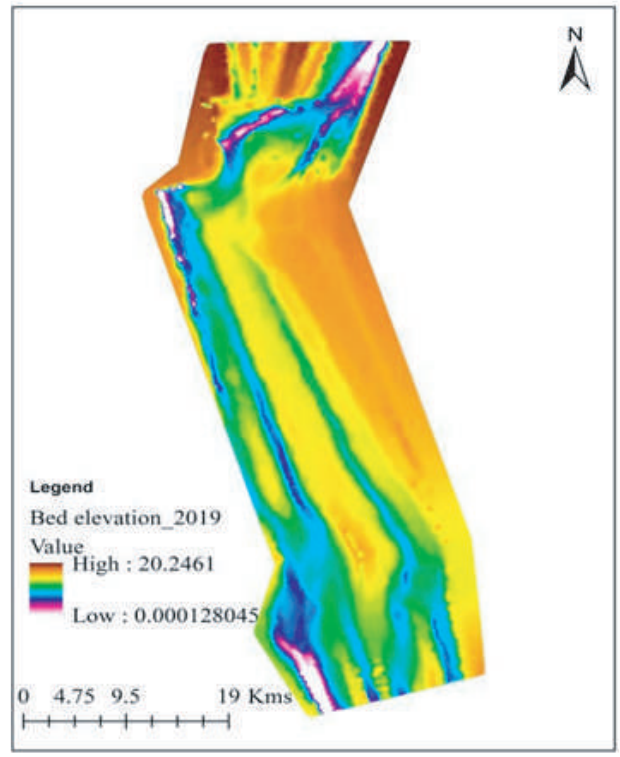

Fig. 3: Simulated bed level for the year 2019

After 2 years simulation of hydro-morphological model (Fig. 3), erosion was observed at upstream near the bar where flow bifurcates. But near the right bank such as Bogura, Sirajganj district has been eroded ranging from 1 to 12 meter. Deposition was observed in the left bank and for this, velocity was increased, maximum and minimum water level was increased. For this effect, with the considerations of bed level effects, some bank erosion was observed near this location which is shown in Fig. 6.

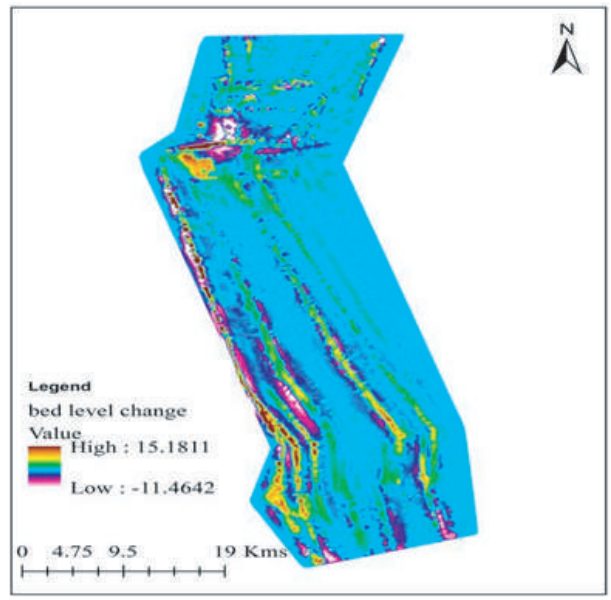

Fig. 4: Changes bed level

The hydro-morphological model was calibrated near Kazipur station using water level. Comparison between simulated and measured WL was done to evaluate model performance (Fig. 05). R^2 was found 0.86. It can be said that there is good agreement between observed and simulated water level.

Fig. 5: Comparison between simulated and measured cross-section

3.2 Calibration and Simulation of 1D Hydraulic Model

1D hydraulic model was done by HEC-RAS 1D. The model was calibrated with water surface elevation using Manning's 'n' at Kazipur station for the year 2018. For the Manning value of 0.029, it has found very good agreement between between the simulated water surface elevation and observed water surface elevation and the co-efficient of correlation (R2) was found 0.86 (Fig. 6). Then the calibrated model was simulated for the year 2019.

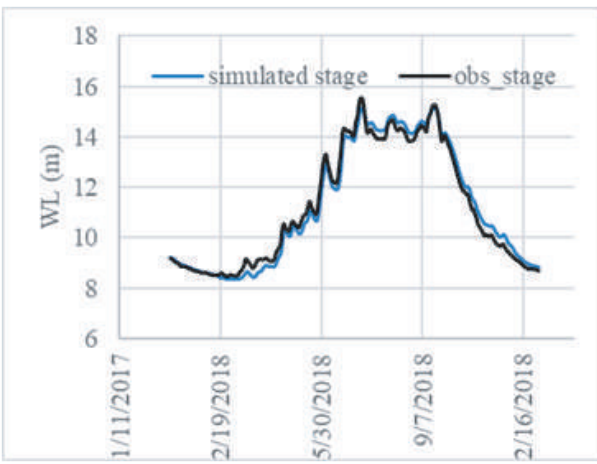

Fig. 6: Analysis graph of best regression model

4. CONCLUSION

The research work was carried to determine the effect of bed level changes in the prediction of bank line shifting using Machine learning and deep learning technique. The best regression model was used to predict bank erosion rate which was calibrated for the year 2018. This model was used to predict bank erosion with and without consideration of bed level effects. When the bed level effect was counted, the value of every variable was increased by a percentage of 5-10% which indicated that bed deposition has occurred near the left bank and the prediction considering the bed level effect gave satisfactory results. But without considering bed level effects, it has been found that the simulation of bank erosion rate along the left bank of the selected reach is not matched with the observed bank erosion rate. Thus, the effect of bed level changes should be considered to predict bank erosion as bed level changes also affect in changes in hydrodynamic conditions.

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