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Study of Kulsi River Reach and its sediment transport modelling using HEC-RAS

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Abstract: Rivers are easily accessible resources of water for miscellaneous uses. But the erosion and sedimentation for different rivers are unique and so its study is importance. The analysis of sediment in river under different conditions is a base for predicting a river's behaviour and for decision making on engineering aspects. River Kulsi, a southern tributary of the Brahmaputra, is considered as one of the last refuges of the endangered Gangetic dolphin in Assam. Kulsi originates in the Meghalaya (25°38′N, 91°38′E) and enters Assam after travelling about 12 km from its place of origin. It finally discharges into the main Brahmaputra at Nagarbera.

In river like kulsi, where sufficient data is not available, numerical model is of high demand for sediment transport analysis. Since bathymetric data of the river is not available, QGIS and remote sensing act as important tools for extraction of the bed profile of the river. QGIS and HEC-RAS was used for this purpose in this study. This study is carried out to simulate the process of erosion, deposition and sedimentation using HEC-RAS model to assess sedimentation and erosion processes in 2.5 Km stretch of Kulsi River downstream from the Kulsi River at upstream site. Ackers-White sediment transport equation is used to analyse the characteristics of sediment transport and helps to obtain total erosion and deposition of the river for different cross section.

Keywords**:** GIS mapping, Erosion, Sedimentation, Kulsi River, HEC-RAS 5.05, Ackers white formula.

I. INTRODUCTION

An alluvial stream is said to be in equilibrium when its banks and bed remain stable for a long period of time. The above mentioned condition is achieved when the sediment load carrying capacity of the channel becomes equal to the sediment load entering the channel at any particular time. The factors which govern the flow in an alluvial stream are: bed slope of the channel, size of the sediments in channel bed and bank and the velocities of water. Any change in one or more of these factors i.e. slope, sediment size, water and sediment discharge disturbs the equilibrium of the stream and results in change in bed slope of the stream unless a new equilibrium is reached. Such changes in bed slope result in rising of bed or lowering of bed and the change in bed level may either be local or over a longer reach. Hydraulic modelling and flood inundation mapping are performed to provide important information from a flood event including the level of inundation and water surface elevations within the study area. A hydraulic simulation model is a mathematical representation of the physical hydraulic processes that occur during a flood event. Such processes can be described by Conservation of Mass, Conservation of Momentum, and Conservation of Energy equations in either one, two or three dimensions. Channel roughness is a variable parameter which depends upon various factors like surface roughness, vegetation cover, irregularities of channel, alignment of channel etc. River modelling is a tool to study the area of a river which is very vulnerable to flood. With the help of different software such as ARCGIS, HEC-RAS, CCHE2D, MIKE we can construct the model of a river and by calibrating the model it gives output for different inputs. In the present study emphasis has given to understand the erosion model of Kulsi River, which includes prediction of fluvial erosion, mass failure and their prediction with the help of HEC-RAS and ARCGIS. In order to determine the cross section of a river bed for a fully developed flow, a methodology has been presented to determine the mean depth of flow, the bed slope, sediment concentration from the available data. From the cross section we can calibrate the river bathometric data to obtain the bank erosion using HEC-RAS 5.0.5.

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II. STUDY AREA

River Kulsi, a southern tributary of the Brahmaputra, is considered as one of the last refuges of the endangered Gangetic dolphin (*Platanista gangetica gangetica*) in Assam. Wakid and Braulik have reported a total of 29 dolphin individuals. The presence of a top carnivore and an indicator species like the dolphin, not only indicates the significance of the river, but also presents a picture of the healthy freshwater ecosystem. Dolphin is to a river, as tiger is to a forest. And indeed it is true in case of Kulsi. Kulsi originates in the Meghalaya (25°38′N, 91°38′E) and enters Assam after travelling about 12 km from its place of origin. It finally discharges into the main Brahmaputra at Nagarbera. It is indeed a life-giving river with rich biodiversity. However, at present Kulsi is facing serious threats in the form of sand mining, overfishing, uncontrolled motorboat traffic, river-bank erosion, construction of dam, etc. Proper planning, further research and awareness activities are necessary to sustain the ecology of the river. Kulsi river, a south bank tributary of the Brahmaputra river system. It is composed of three rivers, namely Khri, Krishniya and Umsiri. All of which originate from west Khasi hill range and flows north. The river is known as Khri in the upper catchments and after being joined by two other tributaries namely Krishniya and Umsiri, within the Khasi hills in Meghalaya it flows north-west and enters Assam at Ukium and after that it flows north upto Kulsi village through the plains of Kamrup District of Assam. Finally it outflows into the Brahmaputra near Nagarbera. The river Kulsi drains out a total area of 3770 sq. km within the Kamrup and Goalpara District of Assam as well as west Khasi hills and East Garo hills district of Meghalaya –out of the total catchment, 685 sq. km is plain catchment in Assam and 3085 sq. km is hill catchment is Meghalaya and Assam.The total length of Kulsi from its source to outfall is about 220 km. Out of which 100 km is in Meghalaya and rest 120 km is in Assam. It is interesting to note that all these three rivers originate from more or less the same altitude. All the three rivers are joined by innumerable number of small hilly streams and rivulets till they join together and flow down as Kulsi. After joining the combined river flows with the name of Khri for a distance of about 15 km it is joined by the Umsiri which flows for a distance of about 32 km before meeting at Ukium. After this the river flows almost straight north for a distance of about 20 km with the name Kulsi near the village Kulsi where it bifurcates into two branches. One branch flows by the western side of Kulsi reserve forest and the other by eastern side of it; both are known as Kulsi, one as eastern Kulsi and the other as central Kulsi. The central Kulsi again bifurcates into two rivers near village Hatigarh and the left arm is known as Kharkhari and the right arm flows as original Kulsi. After this bifurcation the river Kulsi enters into the alluvial plain (flood plain of the Kulsi and the Brahmaputra) and is comparatively shallow having meandering plan form. The eastern most channel (Kulsi) is joined by two small channels from its right before crossing the N.H.37 near Kukurmara.

Fig1: Kulsi River

III. DATA COLLECTION

1. Discharge data of Kulsi River for different station was collected from water resources department, Lower Assam Investigation Division.
2. Sediment data was collected by Sieve Analysis at Geo Technical Laboratory, Assam Engineering College.

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IV. METHODOLOGY

ASSUMPTION

Some of the following assumptions are involved in analytical that used in this version of the model:

1. Flow is quasi-steady, gradually varied.
2. Flow is one dimensional (i.e., velocity components in directions other than the direction of flow are not accounted for).
3. River channels have “small” slopes, say less than 1:10.
4. The incoming sediment load was obtained by setting the upper BC to “equilibrium load”
5. The value of wash load is neglected because it is a very small value.
6. Bank and toe erosion is not considered. Model was developed to simulate the in- channel sediment transport and erosional/depositional dynamics, because the only supply of sediment in the model was from the bed material of the river.

V. RESULT AND DISCUSSION

Fig 1. Depicts the amount of rainfall occurs in Kulsi River for the period of 1 year (1st January 2016 to 31st December 2016) in Kamrup Rural District. In this Flow hydrograph it is clearly seen that highest amount of rainfall occurred in the month of June to August and less amount of rainfall occurred in the month of December. Fig 2. Depicts the change in Bed orientation before and After Erosion in the river. In this case it is observed that Maximum Erosion take place in River Station 300m and minimum erosion takes place at river station 1850m. so we can conclude that Station 1850m is a stable Cross Section. Fig 3. Depicts the invert change in Kulsi river and it is seen that maximum invert change occurs at Station 350m and Maximum invert change is approximately 1.5m to 1.9m. Fig 4, Fig 5, Fig 6 depicts the Change in velocity, change of effective depth, change in effective width in kulsi River as we know that the rainfall occurred maximum in the month of June in the north east region so in that month the rate water flowing through river is also large. Fig 4. Depicts that maximum velocity change occurred in River station 950m and it lies between 3m to 4m. Similarly in Fig 5. Maximum Effective depth is in River station 300m and the value of the depth is 1270m. Fig 6. Depicts that maximum with occurred in River Station 1850m.

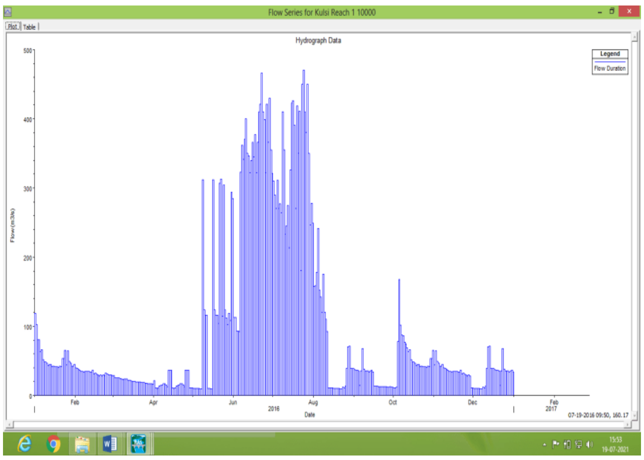

Fig1. Flow hydrograph of the river reach taken at upstream end

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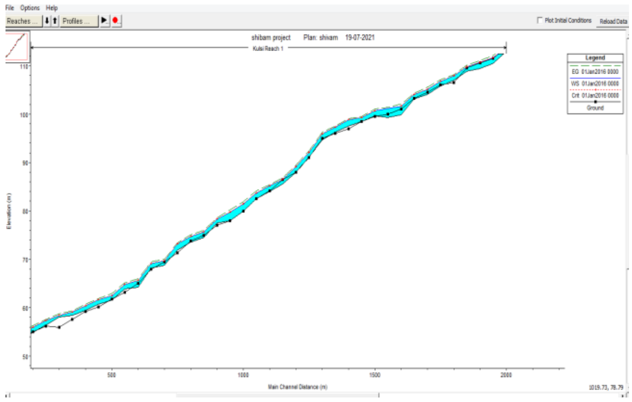

Fig2. Bed gradation before and after the erosion

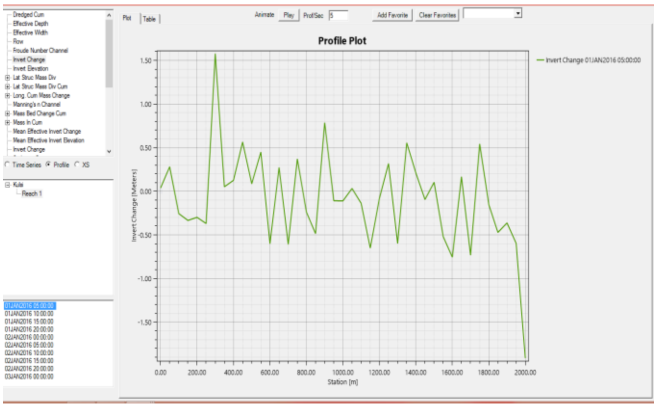

Fig3. Graph between invert change and station for river station 10000m of CV

Fig4. Graph between velocity and station for river station 10000m of CV

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Fig5. Graph between effective depth and station for river station 10000m of CV

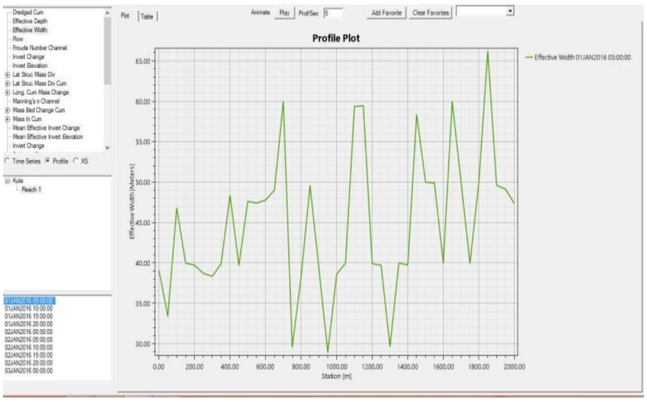

Fig6. Graph between effective Width and station for river station 10000m of CV

VI. CONCLUSION

HEC-RAS software was used in the simulations and in general the model executed well, once all factors input data were set within ranges. In this study of sediment transport capacity for Kulsi River reach, the following conclusions were achieved:

1. The estimated Manning's coefficients for the calibrated model is 0.035. Out of the 43 cross sections in the study area the sediment transport capacity at the main channel at all the river station shows deposition and the rest shows erosion respectively. Number of river station showing the amount of erosion is greater than those showing of deposition.
2. By simulation of model in HEC RAS 5.0.5 out of 43 cross-section for 1 year (from 1stjan to 31st Dec2016) the amount of erosion is maximum in RS 300m and minimum in RS 1850m. So we can conclude that RS 1850m is a stable cross-section.
3. From this study it seen that the maximum invert change takes place in RS 300m.
4. Effective depth, effective breath, velocity are directly related to discharge so these three changes are maximum in June to October month. Due to heavy rainfall, mass flow is peak in those months, so bathometric parameters are such as depth, breath, velocity and discharge are also large.
5. Kulsi River modelling will help to study the effect of the various parameters of sediment transport on the catchment and we can use the model for flood mitigation planning and river training programmers.

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FUTURE SCOPE OF THE STUDY

1. Similar case is to be studied with other software like MIKE 11, CCHE 2D etc. and validation of their results with field data is to be done.
2. Two or more cases are to be studied with the present model and then by comparing results with field observation data it is to be found out under what circumstances the model is the most suitable to use.
3. Similar case is to be studied with 1D, 2D and 3D Sediment transport models and it is to be observed if they offer the same results or if they differ and to what extent they differ.
4. The morphometric analysis can be done in order to study overall morphology of the catchment and to carry out further hydrological analysis.
5. Study is to be carried out for different rivers and the data is to be analysed and compared with field data.
6. On the basis of above information check dam, percolation tank and rock fill dam can be Planned and constructed at suitable sites.

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