

A STUDY ON THE IMPROVEMENT OF WATER RETENTION CAPACITY OF THE LOWER KARATOA RIVER UNDER BOGURA DISTRICT THROUGH DREDGING AND SETTING UP OF A PROPOSED REGULATOR

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Abstract

The Lower Karatoa River originates from the Jamuneshwari-Karatoa (Upper Karatoa) River at Gobindogonj upazila under Gaibandha district and flows towards the west. From Gobindogonj upazila, the Lower Karatoa flows through Bagura district and finally falls into Bangali River under Sherpur upazila. At present, the Lower Karatoa River is fully silted up and dried up due to lack of water flowing through it. Therefore, a study is undertaken by River Research Institute (RRI) to support the design of proposed dredging and new regulator in the Lower Karatoa River using scale modelling. There is an existing regulator at its offtake whose sill level is around 3.0 meter above the water level of Upper Karatoa during dry season. A new regulator is proposed in addition to the existing regulator whose sill level is below the sill level of existing regulator to pass more flow in the Lower Karatoa River. The model is an undistorted model having horizontal and vertical scale 1:50. The study reach covers around 3.0 km of Upper Karatoa River and 1.5 km of Lower Karatoa River. The study reveals that one 4-vent regulator (each vent width 3.0 m) having sill level 14.50 mPWD is recommended to construct in the field just downstream of existing regulator. The recommended dredged channel has bottom width 15 m, side slope 1:2 and longitudinal slope 5.5 cmkm⁻¹. Maintenance dredging for two successive years as suggested is recommended.

Keywords: Karatoa River, Maintenance dredging, Regulator, Scale model, Sill level, Silted up, Undistorted.

Introduction

The Jamuneshwari-Karatoa is one of the oldest branches of the Teesta River. It flows towards South-East direction and is divided into two branches at Gobindogonj upazila of Gaibandha district. One-part flows towards the east through Katakhal River and falls into Bangali River. Another branch flows towards the west as Lower Karatoa. From Gobindogonj upazila, the lower Karatoa flows through Shibgonj, Bagura Sadar, Shahjahanpur & Sherpur of Bagura district and finally falls into Bangali River at Khanpur area of Sherpur upazila. This combined flow is called Karatoa and enters Sirajgonj District. **Fig.1** shows the satellite image around the study area. The flow path of the river Karatoa is of meandering type and its flow path has changed several times in the past and so its name. As a result, it has become difficult to identify the main branch of this river. At present it is considered as a part of the Deonai-Choralkatha-Jamuneshwari-Karatoa river system (RRI, 2022).

Karatoa River is an intriguing river, formerly the main channel of the Teesta, and perhaps a distributary of the Brahmaputra. In the Siyar-al-Mutakhkhirin it is recorded that this river was three times the size of the Ganges when Bakhtiyar Khalji invaded the Northern Region (1115 AD). Tectonic disturbances had broken it up into four distinct parts. The northern part, called the Dinajpur-Karatoa, is the main source of the Atrai. It rises in a marsh in Baikanthapur in Jalpaiguri (India), but also receives water from underground streams. In Khansama upazila its name changes to Atrai. The Dinajpur-Karatoa was connected with the Rangpur-Karatoa north of Khansama, but very little water now passes down that channel. The upper part of Rangpur-Karatoa originates in the Jalpaiguri district of India and is known as the Deonai-Jamuneshwari up to Gobindogonj upazila.

The Jamuneshwari-Karatoa flows in slight meanders south-southeast to Gobindogonj upazila where the mainstream turns

east through the Katakhal and falls into the Bangali. The portion of the former river passing through Shibganj upazila is dry most of the year. It effectively separates the Rangpur-Karatoa from the Bogura-Karatoa. The latter river flows south past Bogura town till it joins the Bangali to make Phuljhor River, which falls into the Hurasagar.

The maximum discharge of the Bogura-Karatoa is below 3,000 cusec and has declined rapidly since the construction of the Brahmaputra Right Embankment. The fourth part, the Pabna-Karatoa, is a moribund riverbed near Handial. Various other channels are also pointed out as parts of the Old Karatoa. The ancient Karatoa must have been a large river. In Ven den Brouck's map of Bengal, prepared in 1660, it is shown as a large channel, and in the map of Rennell, prepared in 1776, it is still a major river. As late as 1810, Buchanan-Hamilton writes of it as a very considerable river. The decline, however, came so rapidly after the 1820 flood that the old banks of the river are distinctly traceable. The river was formerly sacred to the Hindus, as the derivation of the name shows. Kar (hand) and Toa (water) signified that the river was formed by the water, which was poured on the hands of Siva, when he married the mountain goddess Parvati. The system formed by the rivers Karatoa, Atrai, Gur, Gumani and Hurasagar has a total length of about 597 km and is free from tidal influence. (RRI, 2023).

In another study done by Chowdhury *et al.* (2017) the bathymetry of the Karatoya River was obtained using both echo-sounding and field survey techniques. The study showed that the river bed was highly variable and complex, with depths fluctuating from 1 meter to about 30 meters. The study also recognized several submerged sand bars and channels, and a few areas of erosion and siltation. There is little literature available on the 100-year return period flood discharge of the Karatoya River. However, a study was done to find out the flood frequency analysis of the Karatoya River using the L-moment method. The study found that the

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Generalized Extreme Value (GEV) distribution provided the best fit for the yearly highest flood data. The estimated 100-year return period flood discharge was found to be $3,438 \text{ m}^3 \text{ s}^{-1}$, which is a very important element for the design of hydraulic structures and flood control measures along the river.

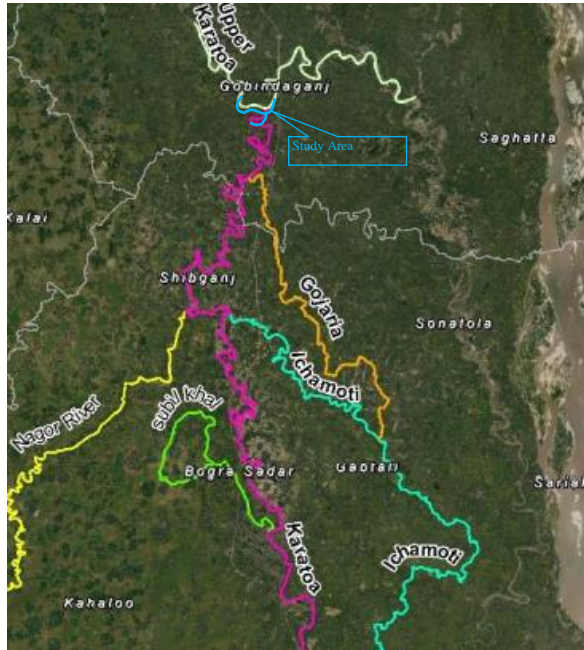


Fig.1. Satellite image around the study area (IWM, 2022).

The water quality of the Karatoa River is a subject of major concern due to man-made activities. The river is highly polluted, with high levels of faecal coliform bacteria, heavy metals, and organic pollutants. The poor water quality of the river has significant implications for human health, aquatic biodiversity, and ecosystem services. The Karatoa River has a rich biodiversity of aquatic plants and animals. Sarker *et al.* (2015) stated the river supports various commercially important fish species, such as the Rohu, Catla, and Mrigal. However, the biodiversity of the river is under threat due to habitat destruction, overfishing, and pollution. The Karatoa River is one of the important sources of livelihood for the local communities. Haque *et al.* (2019) stated the river provides irrigation, fishing, and transportation water. The river also has cultural and religious significance, with several remarkable temples along its banks. However, the river is also a source of argument due to the sharing of water resources between all stakeholders, including farmers, fishermen, and industries. In short, the river faces versatile challenges, including pollution, habitat disintegration, and water resource issues, which require collaborative efforts from all stakeholders to address. Further analysis is also necessary to understand the dynamics of the river and develop effective management strategies to conserve and sustainably and fruitfully utilize its resources (RRI, 2023).

Methodology

An overall morphological model is constructed which includes a river stretch covering around 3km of Upper Karatoa River and 1.5 km of Lower Karatoa River. The model bed is prepared according to the bathymetric survey of December, 2022 as shown in Fig.2. In order to meet the scale conditions for reproducing the flow and sediment transport processes simultaneously as well as to meet the roughness

condition of the model, an undistorted model with suitable geometric scales has been planned. The model layout is shown in Fig.3. The main purpose of this model is to provide support to the design of the dredging as well as suitable & optimal dredging alignment through the Lower Karatoa River. Moreover, the model will help to optimize the design of proposed regulator and fix up the sill level of the same.

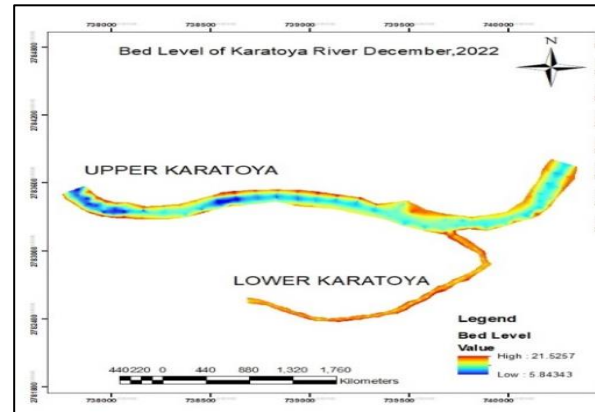


Fig. 2. Initial bathymetry of Karatoa River (Surveyed on December 2022).

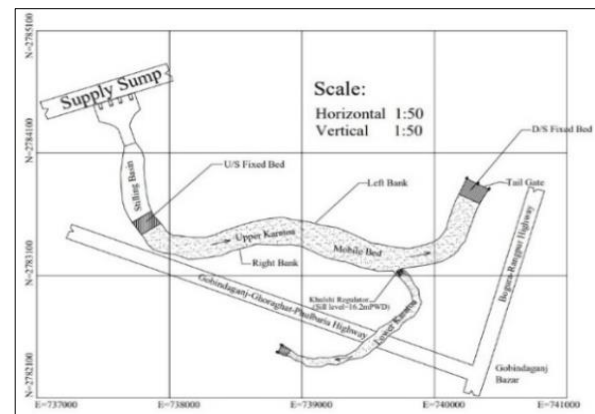


Fig. 3. The layout of the model.

Dredging has been proven as an effective process to control the deposited sediment to prevent flooding and make a pathway for the main channel flow (Gob *et al.*, 2005; Zinger *et al.*, 2011). The process also allows us to further solve engineering problems related to sedimentation and erosion in rivers, estuaries, and coastal seas (Van Rijn, 2005). A better prediction of erosion-sedimentation scenarios is inevitable to justify the long-term effectiveness of dredging, which could further promote the design strategies based on qualitative and quantitative analysis. Prediction of accurate scour depth and deposition of the braided river is methodologically very challenging because of the variation in simple path-length distribution resulting in over-scouring (Kasprak *et al.*, 2019).

The sustainability of any river dredging depends on the intelligent/well planned dredging. There is always a tendency of silting up of the dredged channel by sediment which comes from the adjacent region and acts as a kind of sheet that accelerates the silting process of the channel. It is found in some cases that the dredged channel has gotten silted up within one monsoon. Therefore, successful and sustainable river dredging involves a number of issues that must be understood and addressed well in dredge plan and design.

These issues involve various morphological changes such as formation of shoals, islands and chars, meandering tendency of the river, effect of construction of hydraulic structures, damages to the bank, effect of afforestation/deforestation and tectonic occurrences. Some of the issues may be addressed by modeling prior to preparation of dredge plan and design.

Post dredge monitoring of these issues may also be supplemented by model studies, as per requirements, to take timely corrective measures to maintain its morphology and to check local erosion damages. Physical modeling may be used as an important tool to assist in optimal dredge plan as well as to assist in post dredge monitoring. The effect of dredging around the surrounding areas and upstream and downstream of the same can be predicted by this model and effective dredging strategies may be devised.



Fig. 4. Installment of Khulshi regulator in the model.

Sediment is fed into the model manually. Generally, the rate of sediment feeding for a particular model discharge is determined first by using sediment transport formulae/relation proposed by different researchers. For this model the sediment transport formulae proposed by Engelund and Hansen (1967) has been used to determine the initial sediment feeding rate. The sediment feeding rate, however, has been calibrated. The calibration of sediment feeding rate has been done by taking measurements of bed levels along a few cross-sections located at different parts of the model at a regular interval of time. Calibration of sediment feeding rate involves a condition where bed level remains more or less unchanged. It means whatever sediment is fed into the model is transported out of the model. RRI open air model bed of dimension 100m × 80m is used for reproduction of the overall undistorted morphological model. The initial bathymetry of the model is reproduced based on the field survey data collected under the framework of this study. The model is a sand bed morphological model. The model has been constructed based on selected geometric scales. Khulsi regulator has been constructed in the model as per scale down and shown in Fig. 4. The construction of model involves a series of tasks. Besides selection of geometric scale ratios, the model bed has been prepared by uprooting the grass, dismantling of the previous works in the selected model bed and disposal of debris, removing the old sand from the model bed and filling the same with new fine sand having required median size, procurement of model construction materials, collection of bathymetric and bank line data etc.

Test Scenarios

The proposed test scenarios of the model along with various Test & flow conditions are mentioned in Table 1.

Table 1. Test Scenarios of the Model.

No.	Tests	Test conditions	Flow Conditions
1	Calibration test (T0)	Existing (without project) condition.	2.33 year return period discharge and corresponding water level.
2	Base run (T1)	Existing (without project) condition.	2.33 year return period discharge and corresponding water level.
3	Application test (T2)	Dredging in the Lower Karatoa River with bottom width 12m, side slope 1:1.5 and longitudinal slope 7 cmkm ⁻¹ (as per DPP of BWDB).	2.33 year return period and other discharges and corresponding water levels .
4	Application test (T3)	Proposed regulator (4-vent, sill level 15.70 mPWD) in addition to existing regulator (3-vent, sill level 16.2 mPWD) and dredging in the Lower Karatoa River with bottom width 15 m, side slope 1:2 and longitudinal slope 7.0 cmkm ⁻¹ proposed by IWM.	2.33 year return period and other discharges and corresponding water levels.
5	Application test (T4)	Proposed regulator (4-vent, sill level 15.7 mPWD) in addition to existing regulator (3-vent, sill level 16.2 mPWD) and dredging in the Lower Karatoa River with bottom width 15m, side slope 1:2 and longitudinal slope 7.0 cmkm ⁻¹ proposed by IWM.	Design discharge (10 year return period) and corresponding water level.
6	Application test (T5)	Proposed regulator (4-vent, sill level 15 mPWD in addition to existing regulator (3-vent, sill level 16.2 mPWD) and dredging in the Lower Karatoa River with bottom width 15 m, side slope 1:2 and longitudinal slope 5.5 cmkm ⁻¹ proposed by IWM.	2.33 year return period discharge, design discharge and other discharges and corresponding water levels.
7	Application test (T6)	Proposed regulator (4-vent, sill level 14.5 mPWD in addition to existing regulator (3-vent, sill level 16.2mPWD) and dredging in the Lower Karatoa River with bottom width 15m, side slope 1:2 and longitudinal slope 5.5 cm.km ⁻¹ . proposed by IWM.	2.33 year return period discharge, design discharge and other discharges and corresponding water levels.

Model Calibration

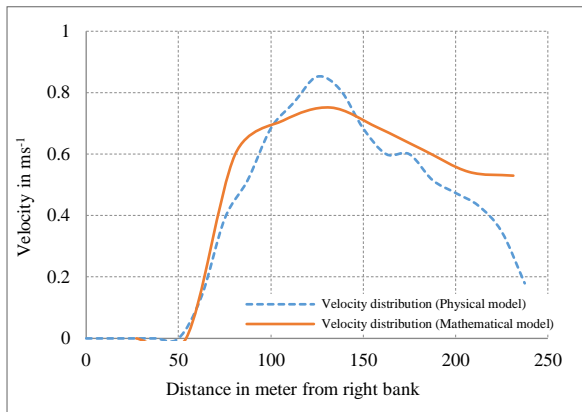


Fig. 5. Comparison of velocity distribution at 900m u/s of Khulshi Regulator for 2.33 year return period in test T0.

This test is carried out with existing (without project) condition. The purpose of calibration test is to calibrate the

model i.e., to simulate the model with prototype conditions. Calibration test is done using peak discharge ($Q=578$ cumec) and corresponding water level. Model calibration is done to ensure that the model is able to reproduce the flow condition, morphological behavior and sediment transport in the field. The calibration of the model primarily aims to see whether the model is able to reproduce a more or less similar bathymetry as is measured during field survey under imposed conditions to bring about similarity between model and prototype in terms of flow and sediment transport simultaneously.

Base Run (T1)

Base run is conducted with existing regulator and model bathymetry obtained after calibration test has been used as initial bathymetry. Table 2 shows discharge distribution between the Upper & Lower Karatoa River in Base Run T1. Some photographs of model before and during running conditions in base run (T1) are shown in Fig. 6 & Fig. 7 respectively.

Table 2. Discharge Distribution between the Upper and Lower Karatoa River in Base Run T1.

Discharge	Flow entered in to Upper Karatoa River upstream of confluence (cumec)	Flow passing through Lower Karatoa River (cumec)	% of flow passing through Lower Karatoa River
Peak flow from 2.33 year discharge	578	20	3.46%



Fig.6. A view of the model bed before test run in test T1.



Fig.7. Model under running in base condition (T1).

Application Test (T2)

This test has been conducted with existing regulator and having dredged channel of Lower Karatoa River. The dredged channel proposed in this test is shown in Fig. 8. A super-imposed cross-section between existing bed level and dredged channel proposed by DPP is shown in Fig. 9 (near

to the Khulshi regulator). Table 3 shows discharge distribution between the Upper and Lower Karatoa River in test T2. Some photographs of model during & after running conditions in test T2 are shown in Fig. 10 and Fig. 11 respectively.

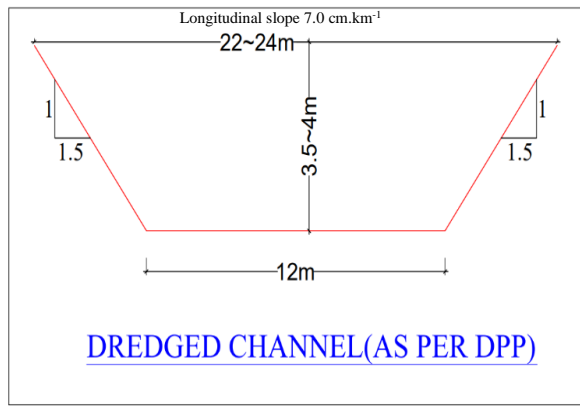


Fig. 8. Design of dredged channel for application test (T2).

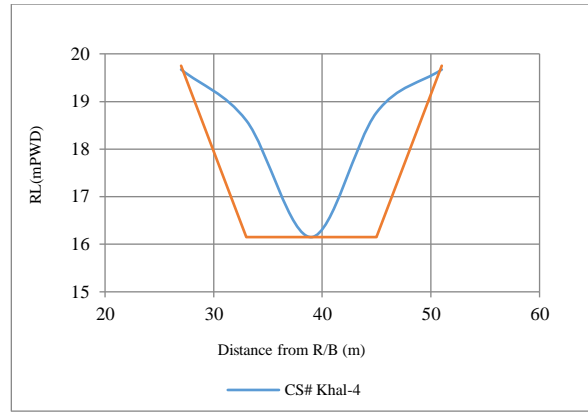


Fig. 9. Super-imposed cross-section between existing bed level and dredged channel (near to the Khulshi regulator) in test T2.



Fig. 10. Model under running condition (T2).



Fig. 11. Model bed after test run in the vicinity of existing regulator (T2).

Table 3. Discharge distribution between the Upper and Lower Karatoa River in test T2.

Name of Month	Flow entered in to the Upper Karatoa River upstream of confluence (cumec)	Flow passing through the Lower Karatoa River (cumec)	% of flow passing through the Lower Karatoa River
Jan	37.47	0	0.0
Feb	34.1	0	0.0
Mar	32.11	0	0.0
Apr	33.31	0	0.0
May	43.02	0	0.0
Jun	178.8	3.6	2.0
Jul	99.62	1.88	1.9
Aug	120.45	2.2	1.8
Sep	245.02	5.6	2.3
Oct	93.69	1.8	1.9
Nov	54.67	0	0.0
Dec	36.49	0	0.0

Application Test (T3)

This test has been conducted with proposed regulator (4-vent, sill level 15.7mPWD) in addition to the existing regulator using 2.33 year discharges. **Table 4** shows discharge

distribution between the Upper and Lower Karatoa River in test T3. Some photographs of model during & after running conditions in test T3 are shown in **Fig. 12** and **Fig. 13** respectively.

Table 4. Discharge distribution between the Upper and Lower Karatoa River in test T3.

Name of Month	Flow entered in to the Upper Karatoa River upstream of confluence (cumec)	Flow passing through the Lower Karatoa River (cumec)	% of flow passing through the Lower Karatoa River
Jan	37.47	0	0.0
Feb	34.1	0	0.0
Mar	32.11	0	0.0
Apr	33.31	0	0.0
May	43.02	0	0.0
Jun	178.8	10.54	5.9
Jul	99.62	5.48	5.5
Aug	120.45	6.7	5.6
Sep	245.02	18.8	7.7
Oct	93.69	5.2	5.6
Nov	54.67	not measurable	-
Dec	36.49	0	0.0



Fig. 12. Flow through the Upper and Lower Karatoa River (T3).

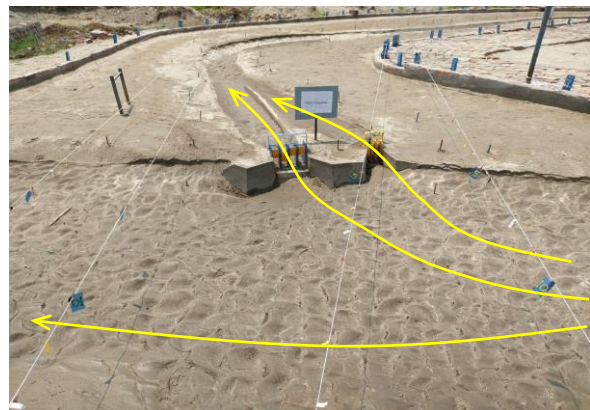


Fig. 13. Model bed after run in the vicinity of proposed & existing regulator (T3).

Application Test (T4)

This test is same as test T3 but carried out with design discharge only. **Table 5** shows discharge distribution

between the Upper and Lower Karatoa River in test T4. Some photographs of model before & during running conditions in test T4 are shown in **Fig. 14** and **Fig. 15** respectively.

Table 5. Discharge distribution between the Upper and Lower Karatoa River in test T4.

Discharge	Flow entered in to the Upper Karatoa River upstream of confluence (cumec)	Flow passing through the Lower Karatoa River (cumec)	% of flow passing through the Lower Karatoa River
Design Discharge	1117	82	7.3



Fig. 14. Dry bed condition of before Test run (T4).



Fig. 15. Flow through the existing and proposed regulator (T5).

Application Test (T5)

This test has been conducted with proposed regulator (4-vent, sill level 15 mPWD) in addition to the existing regulator using 2.33 year discharges and design discharge.

Table 6 shows discharge distribution between the Upper and Lower Karatoa River in test T5. Some photographs of model before & during running conditions in test T5 are shown in **Fig. 16** and **Fig. 17** respectively.

Table 6. Discharge distribution between the Upper and Lower Karatoa River in test T5

Name of Month	Flow entered in to the Upper Karatoa River upstream of confluence (cumec)	Flow passing through the Lower Karatoa River (cumec)	% of flow passing through the Lower Karatoa River
Jan	37.47	1.89	5.04
Feb	34.1	not measurable	-
Mar	32.11	not measurable	-
Apr	33.31	not measurable	-
May	43.02	2.33	5.42
Jun	178.8	14.36	8.03
Jul	99.62	8.06	7.60
Aug	120.45	9.82	7.98
Sep	245.02	20.14	8.12
Oct	93.69	7.54	7.53
Nov	54.67	3.12	5.70
Dec	36.49	1.83	5.01
Design Discharge	1117	89.36	8.0



Fig. 16. Dry bed condition of before Test run (T5).



Fig. 17. Flow through the existing and proposed regulators in the model (T5).

Application Test (T6)

This test has been conducted with proposed regulator (4-vent, sill level 14.5 mPWD) in addition to the existing regulator using 2.33 year discharges and design discharge.

Table 7 shows discharge distribution between the Upper and Lower Karatoa River in test T6. Some photographs of model during & after running conditions in test T6 are shown in **Fig. 18** and **Fig. 19** respectively.

Table 7. Discharge distribution between the Upper and Lower Karatoa River in test T6.

Name of Month	Flow entered in to the Upper Karatoa River upstream of confluence (cumec)	Flow passing through the Lower Karatoa River (cumec)	% of flow passing through the Lower Karatoa River
Jan	37.47	2.11	5.63
Feb	34.1	1.92	5.62
Mar	32.11	1.80	5.60
Apr	33.31	1.87	5.60
May	43.02	2.45	5.69
Jun	178.8	14.61	8.17
Jul	99.62	7.60	7.63
Aug	120.45	9.76	8.10
Sep	245.02	20.70	8.45
Oct	93.69	7.08	7.56
Nov	54.67	3.19	5.84
Dec	36.49	2.03	5.57
Design Discharge	1117	92.15	8.25



Fig. 18. Dry bed condition at and around the existing and proposed regulators in the model (T6).



Fig. 19. Flow through the existing and proposed regulator in the model (T6).

Conclusion

The following conclusions have been drawn based on physical model study: From Kamarpara Bazar to Chandpur Arefia Govt. Primary School, the near right bank velocity of Upper Karatoa River is high enough to cause bank erosion when tested with design discharge condition. Bank erosion may continue at this area if appropriate bank protection measures are not taken. Float tracks reveal that the right bank of the Upper Karatoa River is under flow attack in the immediate upstream of its off-take mouth (Khulshi Regulator). Maximum velocity in the right bank of Upper Karatoa River remains about 1.5 ms^{-1} and the same in the left bank of Lower Karatoa River is found to about 1.0 ms^{-1} under design discharge. Under different test conditions (with dredged channel and proposed intervention) and for monthly average discharge the flow through the Lower Karatoa River

is increased by about 2, 2.5 and 3 times in tests T3, T5 and T6 respectively compared to base (existing) condition. For all test conditions with dredging noticeable flow velocity along the dredged channel occurs in the beginning. However, with the passage of time the dredged channel gets gradually filled up with a corresponding fall in the magnitude of flow velocity. The rate of filling is relatively faster in the upstream part of the dredged channel compared to that in the downstream portion of the same.

In the present physical model, a 3.0km stretch of the Upper Karatoa and 1.5km stretch of the Lower Karatoa River have been included. Therefore, morphological developments beyond the study reach under different discharge conditions remain unknown. Also, the rate of bank erosion varies spatially and temporarily and depends on several factors. The composition of bank materials in model and prototype are not

same. Therefore, it is not possible to predict the rate and extent of bank or char erosion quantitatively. The hydraulic performance of interventions (dredging and proposed regulator) under Test T6 appears to be satisfactory in terms of flow and sediment distribution into the Lower Karatoa River. The model results indicate that the average percentage of filling up of the dredged channel is about 15% in one year. The volume of filling up of the dredged channel is found about 15,00m³ in the Lower Karatoa River in one year is found from T6 (1.5km length from offtake). For test T6 conditions the maximum thickness of deposition is 1.8m and the average thickness of deposition after one year is 0.65m.

Model results show that with the proposed dredging in place the dredged channel will get filled up by about 15,000m³ within a year. Further filling up of the dredged channel may occur in the subsequent year reducing the flow capacity of the dredged channel if no maintenance dredging is carried out. Monitoring of the developments in the dredged channel is very important to assess the need, frequency and volume of maintenance dredging. Cross-section survey at some preselected locations covering the entire length of the dredged channel before dredging, after dredging and during post monsoon period is needed for monitoring purpose as well as to assess need for maintenance dredging and its volume. It appears from the model results that maintenance dredging is needed once in a year and may be carried out for two years following the capital dredging. The proposed maintenance dredging is needed to keep the dredged channel active and serve the intended purpose. It is suggested to dredge the entire length of the channel within one year period as partial dredging may induce large siltation during the monsoon period.

The percentage of discharge distribution between the Karatoa River Upper and Lower varies with the variation of oncoming flood discharge and sill level of regulator. The percentage of flow distribution into the Lower Karatoa River increases with the increase in the magnitude of oncoming flood discharge and with the decrease in the sill level of the proposed regulator. Maintenance dredging is required to ensure the flow in the Lower Karatoa River Lower all over the year. If a four vent regulator (each vent width 3m) having sill level 14.50 mPWD is constructed in the field just d/s of existing regulator; there will be some flow in the month of November to May.

Recommendation

The following recommendations have been drawn based on physical model study:

From Kamarpara Bazar to Chandpur Arefia Govt. Primary School, right bank of the Upper Karatoa River 850m bank protection measures should be taken. Proposed interventions (regulator and dredging) under test T6 are recommended to achieve the project objectives in terms of allowing more or less flow into the Lower Karatoa River in most of the months or time of a year with regular monitoring and maintenance dredging at the off-take and in the downstream of the same. The implementation of the recommended bank protection works may be carried out immediately for the protection of the erosion prone Kamarpara Bazar to Chandpur Arefia Govt. Primary School area and to prevent further bank erosion in the coming years.

The mean bed level of the dredged channel in the downstream of the off-take may go up due to morphological changes hampering its conveyance capacity. Therefore, maintenance dredging with frequency once in two years is suggested. Monitoring of the developments in the dredged channel is suggested for taking decision as to maintenance dredging. Cross-section survey along the dredged channel at some preselected locations before dredging, after dredging and during post monsoon period is needed for this purpose. The model bed has been reproduced based on bathymetric survey data of December, 2022. The bed configuration of the Karatoa river within the study reach might have undergone changes during monsoon period of 2023. Therefore, recommended dredging length and alignment may be adjusted according to the field condition during implementation.

A 4-vent regulator (each vent width 3m) having sill level 14.50 mPWD is recommended to construct in the field just downstream of existing regulator. Dredging is recommended in the Lower Karatoa River as it is fully silted up. The recommended length of dredged channel is 123 km. The recommended dredged channel has bottom width 15m, side slope 1:2 and longitudinal slope 5.5 cmkm⁻¹. Maintenance dredging for two successive years as suggested under test T6 is recommended. Without maintenance dredging the objective of the proposed capital dredging may not be fulfilled.

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