ANNUAL REPORT 2022-2023

River Research Institute

75

Years of Excellence

Since 1948

Research for Sustainable Water Resources Development

RIVER RESEARCH INSTITUTE
Ministry of Water Resources
Government of the People's Republic of Bangladesh

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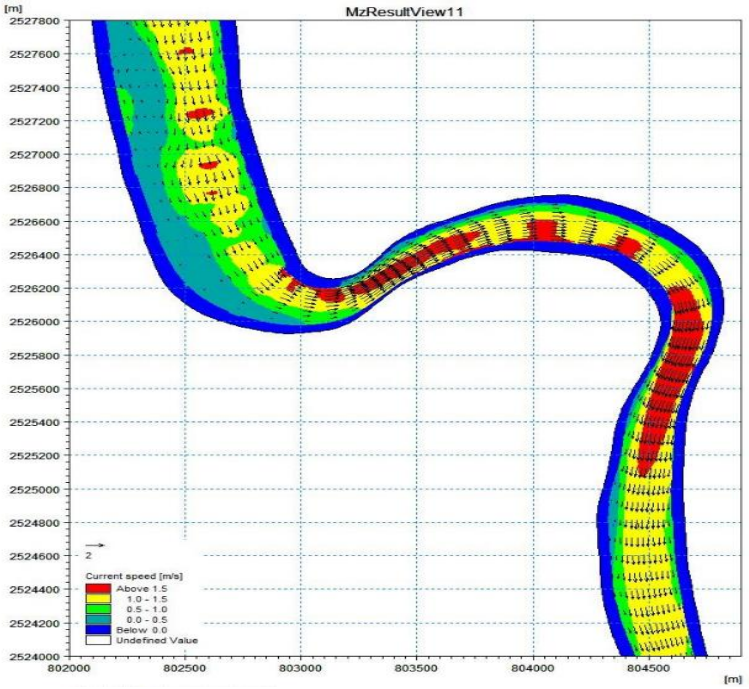
Teesta River Model Study



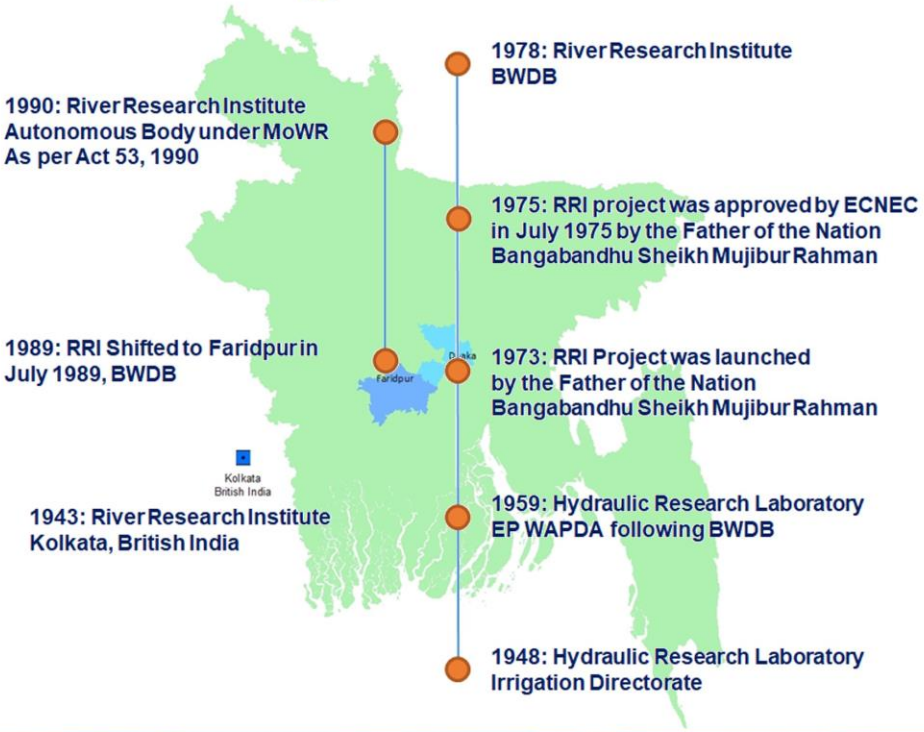
Mathematical Model Study

EIA Baseline data Collection

Father of the Nation

Bangabandhu Sheikh Mujibur Rahman

Chronological Index of RRI



One of the earliest model studies done by RRI
Model Experiment for the prevention of erosion at Sirajgonj by the river Jamuna
Year: 1953

River Research Institute

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JULY 2022- JUNE 2023

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River Research Institute

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EDITORIAL NOTE

The annual report provides an insight into the functions and activities of RRI highlighting the contribution made in the river management and water resources development during the fiscal year 2022-23. The report comprises of a brief description of the findings of physical and mathematical model studies, testing of various engineering properties of soil, concrete, water quality, sediment samples etc. It also contains the research and development activities, staff development, financial management, projects with revenue received, future trend etc. which will assist to provide useful information to the organizations and individuals working in the water sector.

The annual report of RRI reflects all the activities achieved in the fiscal year 2022-23. It includes overall account of the institute, activities performed by its different directorates and monetary management in the fiscal year of 2022-23. It also highlights the background, objectives and outcomes of different physical as well as mathematical model studies and the testing conducted for various properties of soil, concrete, water and sediment as well. Furthermore, this report encompasses the human resource development, research and development activities, development and future prospects etc. which will assist in rendering useful information to the organizations as well as individuals employing in the water sector.

The Editorial Committee likes to express its sincere thanks and gratitude to Chief Advisor Mr. S M Abu Horayra, Director General (Joint Secretary) of RRI for his valuable propositions, essential guidelines and support in publishing this report. The committee sincerely recognizes the guidance provided by the advisors for making this report informative and comprehensive. The committee is also indebted to the relevant personnel who have extended their efforts and co-operation in preparing and publishing this report in time.

A K M Ashrafuzzaman
Principal Scientific Officer
and
Convener
Editorial Committee

MESSAGE

From State Minister

Ministry of Water Resources
Government of the People's Republic of Bangladesh

I would like to extend my immense pride and profound gratitude as we celebrate the 75th anniversary of the River Research Institute of Bangladesh. This momentous occasion marks a significant milestone in the Institute's history and serves as a testament to our nation's commitment to the sustainable management and conservation of our precious rivers. For three-quarters of a century, the Institute has been at the forefront of pioneering research, setting high standards for river management, and serving as an invaluable resource for policymakers and stakeholders alike. The tireless efforts of dedicated scientists, researchers, and staff have been instrumental in addressing the myriad challenges faced by our rivers, from water quality to sedimentation and flood management to biodiversity conservation.

The singular institution within our nation, distinguished by its possession of Physical Modelling facilities and seasoned expertise, became the Hydraulic Research Laboratory (HRL) in 1948. It is worth noting that the profound insight of the greatest Bengali of all time, the eminent visionary leader, and the revered Father of the Nation, Bangabandhu Sheikh Mujibur Rahman, extended to encompass the paramount significance of effective water resources management in steering the nation towards sustainable development. This very conviction impelled him to advocate for the institute's transformation into a statutory entity, thereby precipitating the River Research Institute (RRI) project's inception in 1973. Significantly, this seminal project received the imprimatur of the Father of the Nation himself, as it secured approval under his esteemed chairmanship during a session of the Executive Committee of the National Economic Council (ECNEC) held in the illustrious month of July in the year 1975. This epoch-making decision laid the foundation for the institution that stands before us today, bearing the name of RRI.

Throughout its illustrious history, RRI has been steadfast in furnishing invaluable technical support in conceptualising, designing, and realising various water infrastructure development and associated projects. This commitment has transcended time, encompassing endeavours ranging from the venerable Karnafuli Hydropower project to the contemporary epoch of transformative development spearheaded by the esteemed daughter of the Father of the Nation, the Honourable Prime Minister Sheikh Hasina.

In consonance with the overarching developmental vision of the present government, RRI has assumed a pivotal role in the successful execution of numerous monumental projects, thus reinforcing its stature as an indispensable partner in the nation's progress. The roster of these transformative endeavours includes but is not confined to the Padma Bridge, Bangabandhu Railway Bridge, Payra Bridge, Ganges Barrage Study, Buriganga River Restoration, and the comprehensive management of vital waterways, including the Padma, Brahmaputra, Teesta, and Korotoa Rivers, to name a few through Physical Modelling. This august institution has leveraged its Mathematical Modelling capabilities to conduct essential studies, contributed to the enhancement of Haor Roads, and been instrumental in realising multiple bridges spanning the breadth of our beloved Bangladesh. Additionally, RRI has actively engaged in Geotechnical investigations on riverbank failures, conducted rigorous research in water pollution and environmental preservation, and embarked on numerous similar initiatives.

RRI has demonstrated an unwavering commitment to capacity augmentation throughout this period, courtesy of judiciously planned projects for institutional development. This concerted effort has culminated in establishing state-of-the-art hydraulic, geotechnical, and environmental laboratories emblematic of world-class research facilities. The River Research Institute (RRI) stands as a stalwart bastion of expertise and innovation, contributing profoundly to our nation's progress and sustainable development journey. Its history, replete with achievements and forward-looking initiatives, testifies to its pivotal role in realising Bangladesh's aspirations and its steadfast commitment to global sustainability objectives. I urge RRI scientists to conduct more fundamental and applied research so that RRI can establish itself as one of the prominent scientific institutions in the world.

Joy Bangla, Joy Bangabandhu
May Bangladesh live forever

Zaheed Farooque, MP
State Minister, Ministry of Water Resources
Government of the People's Republic of Bangladesh

MESSAGE

From Deputy Minister

Ministry of Water Resources
Government of the People's Republic of Bangladesh

I have the distinct honour and privilege to extend my warmest greetings to all of you as we celebrate the remarkable 75-year journey of the River Research Institute (RRI). As the Deputy Minister of the Ministry of Water Resources of Bangladesh, I am deeply honoured to represent our government and our nation in commemorating this significant milestone.

The institute, established initially as the Hydraulic Research Laboratory (HRL) in 1948, holds a distinguished place in the annals of our nation's scientific and development history. In 1973, the nomenclature transitioned to the River Research Institute. This was a momentous transformation under the guidance of the illustrious and far-sighted visionary, the Father of the Nation, Bangabandhu Sheikh Mujibur Rahman. This pivotal evolution was realized through a project carefully considered and approved by the esteemed Executive Committee of the National Economic Council (ECNEC), presided over by the Father of the Nation himself, in July 1975.

This transformative journey marked one of the watershed moments in the trajectory of the institute, heralding its ascent to becoming a statutory body within the Ministry of Water Resources. The continued progress and relevance of the institute have been greatly facilitated by the unwavering support and visionary leadership of Honourable Prime Minister Sheikh Hasina.

Under the farsighted leadership of Prime Minister Sheikh Hasina, Bangladesh has ascended to unprecedented heights, emerging as a global exemplar of development and progress. The nation's remarkable achievements owe much to the successful execution of numerous monumental projects, which have significantly contributed to the advancement of our beloved country. The institute has played a pivotal role in these transformative endeavours by providing invaluable research and technical assistance.

Noteworthy projects such as the Padma Multipurpose Bridge, Bangabandhu Railway Bridge, Payra Bridge, Buriganga River Restoration, and the comprehensive management of vital waterways, including the Padma, Brahmaputra, Teesta, Korotoa, and Haor Roads, stand as testaments to RRI's firm commitment to national development. Furthermore, the institute's capacity has expanded remarkably during this period, owing to diligent efforts in institutional development and capacity-building projects, phase-I and II, whereas phase-III is on the table. These endeavours have established state-of-the-art hydraulic, geotechnical, and environmental laboratories, some of those rank among the world's most advanced facilities. These include 2D and 3D wave generators, ADCP, RTK GPS, tri-axial testing machines, soil and thermal resistivity meters, rotary drilling rigs, CHNS/O analysers, TOC analysers, laser particle size analysers, etc.

In the pursuit of our national aspirations and alignment with global imperatives, these cutting-edge laboratories will undoubtedly play a significant role in propelling Bangladesh toward the realization of the Sustainable Development Goals and Bangladesh Delta Plan 2100, thereby underscoring the critical role of RRI in shaping a sustainable and prosperous future for our nation.

Since many impacts of climate change are felt in the arena of hydrological cycle, river environmental flows (e-flows) can form an essential tool for water management. So far, I know very few studies have been done in this regard. A deep understanding of e-flow regimes can help communities prepare for and adapt to the impacts of climate change. I hope RRI scientists will take the necessary course of action to better understand the e-flow regimes of both transboundary and national rivers.

Joy Bangla, Joy Bangabandhu
May Bangladesh live forever

AKM Enamul Hoque Shameem, MP
Deputy Minister, Ministry of Water Resources
Government of the People's Republic of Bangladesh

MESSAGE

From Secretary

Ministry of Water Resources
Government of the People's Republic of Bangladesh

I take immense pleasure and a profound honour to represent our government and our nation in celebrating the remarkable 75-year journey of the River Research Institute. This institution has been an unwavering pillar of knowledge and expertise in river research and conservation. The institute's role in the water sector is significant in national economic development. I am thrilled that the institute's performance in discharging its responsibilities is up to the mark.

As an essential organization in the water sector, RRI is rendering appreciable services to the nation in the fields of hydraulic, geotechnical, and environmental studies. RRI is the only institute in the country with unique experience conducting physical model studies of different kinds of river engineering projects. Physical modelling is a tool that supports the planning and hydraulic design of water infrastructures precisely and economically. RRI also conducts Hydro-Morphological studies of different development projects using mathematical modelling software (MIKE series). River Research Institute tests soil samples, water samples and construction materials from government and non-government agencies for their development works. Environmental and Social Impact Assessment (ESIA) Study is crucial for sustainable development. This vital task has been done for the last few years, indicating RRI's capacity growth.

Flooding is a recurring problem in Bangladesh. Therefore, sustainable river management is a burning issue for Bangladesh. Cyclones, storm surges, tidal bores and shoreline shifting cause coastal problems in Bangladesh. Crops are damaged due to the intrusion of saline water. To address these water-related problems and devise sustainable solutions, RRI has much to contribute. In this regard, RRI should undertake research activities to develop technically sound and innovative solutions to the problems.

Water resources management is critical in the face of climate change to reduce water scarcity and meet the demands of an expanding population. River basin prioritization of watersheds has gained significance in natural resource management, particularly in watershed management. I wish for RRI scientists to conduct research and studies on the basin scale for proper watershed management.

I urge RRI scientists to harness innovative solutions to solve contemporary issues and problems in Water Resources Engineering using top-notch technology.

I would like to sincerely thank the editorial committee of RRI for their sincere efforts in preparing this report. I hope this report will be helpful for the readers to be cognizant of the functions and activities of the institute.

Nazmul Ahsan
Secretary, Ministry of Water Resources
Government of the People's Republic of Bangladesh

MESSAGE

From Director General

River Research Institute (RRI), a statutory public organization, under the Ministry of Water Resources, Government of the People's Republic of Bangladesh, has been established in 1948 with the then name Hydraulic Research Laboratory (HRL) to provide technical support to different development initiatives regarding water resources development undertaken by various ministries of Bangladesh as well as to conduct fundamental research and share knowledge on rivers and allied problems and merged with a wing of Bangladesh Water Development Board and renamed as RRI in 1978.

There have been three directorates at RRI. Through these directorates RRI effectuates its activities. The directorates are namely Administration and Finance Directorate, Hydraulic Research Directorate and Geotechnical Research Directorate. Administration and Finance Directorate provides administrative support to the technical directorates, facilitates overall administration of RRI, accounts and audit, estate, library, public relation and photography and establishment along with operation and maintenance of physical facilities of RRI. Physical and Mathematical Modelling are prime functionality of Hydraulic Research Directorate. This directorate deals with model tests, studies and researches in the field of Flood Control and Drainage, Bank Protection and Stabilization, Coastal Engineering, Hydraulic Structure and Irrigation etc. Geotechnical Research Directorate carry out tests of soil, sediment, water, rod, brick, cement etc. with state of the art instruments. Alongside tests of different materials, research in the field of geotechnical and environmental engineering are also been conducted by Geotechnical Research Directorate. In the age of global warming and climate change sustainable development is very crucial for the existence of human being in the earth. That's why Environmental and Social Impact Assessment (ESIA) study of various development projects and fundamental investigation on the river and its environment is needed. In this regard RRI conducts ESIA studies for various development projects.

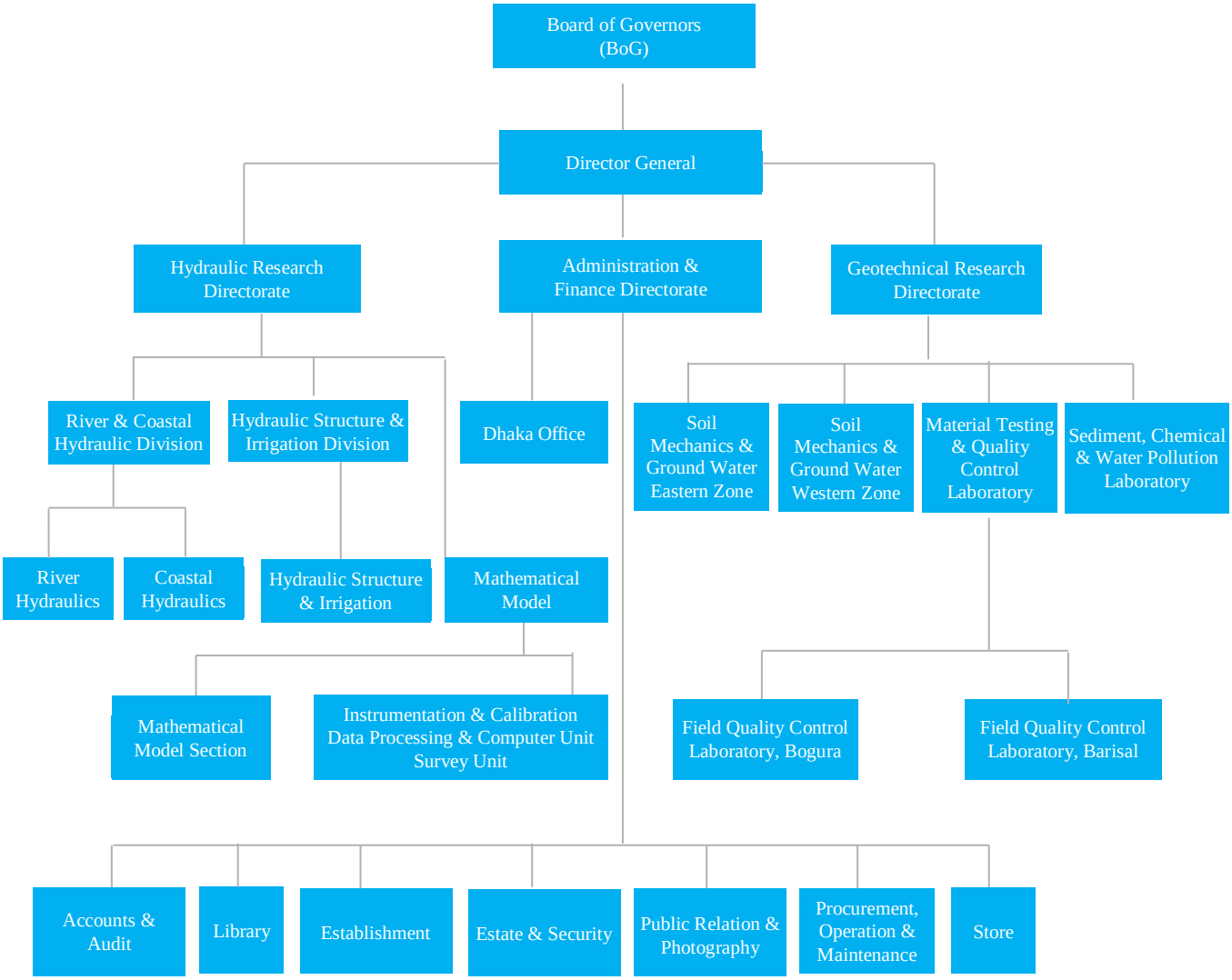
During the fiscal year 2022-23 RRI carried out two researches titled i) "Assessment of Eco-hydrological characteristics and water quality of Surma River in Sylhet Bangladesh" and ii) "Assessment of Morphometric Parameters, Environmental flow and Bio-physical aquatic status of Bakkhali River Basin". In addition to these researches, three physical models and four mathematical models have accomplished during this fiscal year also.

All of the activities that RRI do is to achieve the targets and goals of Sustainable Development Goal (SDG)-6 and Bangladesh Delta Plan (BDP)-2100.

Finally, I hope this annual report will provide the reader with good insight about the functions and activities of RRI during the fiscal year 2022-23. Sincere thanks are due to editorial committee and others who have contributed for the publication of this annual report.

S M Abu Horayra
Director General
River Research Institute

ORGANIZATIONAL STRUCTURE



ACTIVITIES OF RRI

The activities of RRI as per the River Research Institute Act, 1990 (Act 53 of 1990) are directed towards the achievements of the following objectives:

To carry out studies for design supports in river training, riverbank protection, flood control, irrigation and drainage works and to conduct research in river engineering, sediment control, estuary and tidal effects by means of physical model.

To conduct mathematical model studies on river flow and regional flow network, hydrology, surface and ground water utilization and environmental issues with special attention to salinity intrusion and water quality with a view to develop the water resources.

To perform tests on construction materials required for river training, riverbank protection, flood control, irrigation and drainage structures and to inspect and evaluate the quality of the construction works thereof.

To conduct training program on the above-mentioned subjects and to publish reports and periodicals related to technical aspects.

To advise the Government, Local Authority or any organizations regarding the problems and best approach towards the solution on the above-mentioned subjects.

To co-operate and conduct joint ventured research work with other similar local or foreign organizations.

To take any necessary steps for performing the above-mentioned works.

WHAT KIND OF SERVICE CITIZENS CAN EXPECT FROM RRI

Providing consultancy services for viable technical solutions to the problems related to riverbank erosion, flooding, drainage and irrigation.

Assisting in development of water resources by devising appropriate technological solutions for maintaining river flow, use of surface and ground water, environmental protection and reducing salinity.

Testing and assessment of quality of soil, sediment, water as well as materials used for construction of water infrastructures for water resources development and river management.

Conducting applied research on river management, sediment control of river, coast and estuary management etc. using physical and mathematical modelling technology and publishing the research results in report form as well as in periodicals and journals.

Field level implementation of research outcomes in limited form to assess its effectiveness.

Conducting basic research to develop understanding of river and coastal processes for the sake of applied research works.

Taking up problem oriented research and studies as to decrease in dry season flow of the rivers, sedimentation in river bed, loss of navigability of rivers, increase in flooding, long-term water logging etc. to furnish the outcomes to the planners and decision makers.

Taking up projects for capacity building of the institute as well as human resource development and conducting joint venture multi-disciplinary studies.

Determining the physical, chemical and engineering properties of sediment along with various chemical properties of surface and ground water such as arsenic, iron, calcium, magnesium, sulphate, carbonate, potassium, salinity, etc.

INTRODUCTION

River Research Institute (RRI) is a national research organization in Bangladesh. It is working as a statutory public authority under the Ministry of Water Resources (MoWR), Government of the People's Republic of Bangladesh. RRI has a Board of Governors (BoG) comprising ten members chaired by the Hon'ble Minister, MoWR, Government of the People's Republic of Bangladesh which reviews and evaluates the activities of RRI and approves important proposals so that it can run with all its activities properly. Director General is the Chief Executive of the institute and responsible for implementation of the decisions approved by the BoG. The activities of RRI are conducted by three directorates namely, Hydraulic Research Directorate, Geotechnical Research Directorate, and Administration and Finance Directorate. The first two directorates operate the research activities while the last is responsible for the overall administration and financial activities of RRI and works for its development.

RRI is set up with a view to devising plans and actions to develop water resources in a sustainable manner to meet the development needs of Bangladesh. Since its establishment, RRI has been conducting multi-disciplinary and problem-oriented tests and researches in the field of River Hydraulics, Hydraulics of Structure and Irrigation, Coastal Hydraulics, Soil Mechanics, Material Testing and Quality Control, Sediment Technology, Hydro-chemistry, Geo-chemistry and Instrumentation. The results of such tests and research are playing a vital role in providing information and recommendations regarding different water resources development plans and interventions.

RRI has been conducting physical modelling in the field of water resources since its establishment. RRI has also been involved in Mathematical modelling since 2009. Physical and mathematical modelling tools are complementary to each other. Both physical and Mathematical model have been proved very essential for sound engineering judgments to find out solutions for different water resources development projects. In view of this, RRI has adopted hybrid-modelling approach by using physical as well as Mathematical modelling to improve the understanding of different water systems, which may lead to safe and less expensive solutions for engineering problems. RRI has the mandate for conducting hydrodynamic and morphological study of the river mainly to derive and verify the design parameters of any hydraulic structures, bank protection and river training works.

RRI has conducted in-house training and seminars in 2022-2023 fiscal year for skill development of its scientists as well as other staffs and officials. During fiscal year 2022-23, two research seminars held at RRI on 22 June 2022 titled "Assessment of Eco-hydrological characteristics and water quality of Surma River in Sylhet Bangladesh" and "Assessment of Morphometric Parameters, Environmental flow and Bio-physical aquatic status of Bakkhali River Basin". In addition to these, there were other training courses with different title. A short description of the on-going research works and innovation project are furnished under the section "Research and Development". Moreover, a number of officials and staffs are trained out-side training. Details description of in-house training, out-side training and seminar are also summarised under the section "Human Resource Development".

As per requirements of different clients, some proposals have been submitted for model studies and correspondence with the relevant organization is going on. A good number of soil, water, sediment and construction material samples are received from different projects of Bangladesh Water Development Board (BWDB) and other organizations. These samples are tested with the sophisticated laboratory equipment of RRI as routine works of Geo-technical Research Directorate. The results and findings are sent to the project authorities concerned. Recently, many pieces of equipment have been procured under IDCB project (Phase-II) for Geo-technical Research Directorate as well as Hydraulic Research Directorate. In addition, the operation and maintenance activities of office and residential buildings, roads, rest house, vehicles, water supply system, sewerage system, power distribution system including power generator etc. are routinely done as presented under the section Administration and Finance Directorate.

Qualified and trained personnel are very much essential to meet the objectives of RRI and maintain its standard to the international level. For this purpose, a number of officials have already been completed their higher studies and obtained training in the related fields at home and abroad. Many others are expected to be trained in the near future. At present RRI has shortage of junior officers to undertake more responsibilities. For this reason, recruitment of junior officials is under consideration. The existing manpower is, however, well experienced and well trained in the field of hydraulic, geotechnical and environmental engineering. Detailed list of existing scientists, supporting and managerial staffs is shown in Annexures. List of abbreviations is shown in the Annexures. RRI has also been publishing journal named 'Technical Journal' yearly since 1991. RRI's technical journal got recognition in 2000 by ISSN - International Centre, 20, rue Bachaumont, 75002 Paris - France and its serial has been registered as ISSN 1606-9277 with key-title: Technical journal - River Research Institute, abbreviated key- title: Tech. J. - River Res. Inst. Multidisciplinary research activities and case studies of different water resources projects are published in the journal.

RRI undertakes sports and cultural activities and observes all national days. RRI officials and staffs along with their families take part spontaneously in the sports and cultural activities. In addition, RRI takes part in different world and international days such as “world water day” and different national program taken by the government.

HYDRAULIC RESEARCH

The Hydraulic Research Directorate has three divisions such as (i) River and Coastal Hydraulics (ii) Hydraulic Structure and Irrigation and (iii) Mathematical Model. These three divisions carry out studies and research work in the field of flood control and drainage, river training and bank protection, coastal engineering, hydraulic structure and irrigation etc. by means of physical and mathematical modelling along with other laboratory testing and studies. This directorate is well equipped with physical and mathematical modelling facilities.

(i) River and Coastal Hydraulics Division

This division conducts studies and researches related to river training, river erosion protection, flood control, river engineering, river sediment control, river estuary, tidal phenomena etc. by means of physical modelling. Local scour, 3-dimensional flow phenomena like eddy and vortex, morphological processes and developments etc. are only possible to reproduce well in physical model. Moreover, the real phenomena that are happening in the field are only possible to visualize by physical modelling. This division also involves mathematical modelling of river and coastal related problems.

(ii) Hydraulic Structure and Irrigation Division

This division conducts studies and researches to determine the proper alignment of different hydraulic structures related to civil engineering such as bridge, barrage, sluices, culverts, groynes, revetment etc. as well as to verify the design parameters by means of physical modelling. The physical processes/phenomena, which are not possible to describe well by empirical formula or mathematical expression, can easily be reproduced precisely in physical model. This division also involves mathematical modelling related to hydraulic structure & irrigation.

(iii) Mathematical Modelling Division

RRI conducts hydrological and morphological studies in the field of flood control and drainage, river training and bank protection, coastal engineering, hydraulic structure and irrigation etc. by means of mathematical modelling. Mathematical modelling is

complementary to physical modelling for correlation of results and also for any sound engineering judgment. It is a very useful tool for research and studies and also for the sustainable development of water resources projects.

Physical Modelling

Physical modelling is an authentic tool, which can be used confidently to verify the effectiveness of any structural intervention in the river and coastline protection works by reproducing the natural phenomena of river and coastal hydro-morphology at a reduced scale. The causes of any river and coastal engineering problems are identified and its mitigation measures are investigated through physical modelling. Local scour, 3-dimensional flow phenomena like eddy and vortex, morphological processes and developments etc. are possible to reproduce well in physical model. The important design parameters such as local scour around the structure, flow field, maximum velocity, appropriate location, dimension and orientation of hydraulic structures, spacing between groyne/spur like structures etc. can also be obtained by physical modelling. The physical process/phenomena, which are not possible to describe well by empirical formula and mathematical expression, can be easily reproduced precisely in physical modelling. Moreover, the real phenomena that are happening in the field are only possible to visualize by physical modelling.

RRI has sufficient physical modeling facilities including indoor and outdoor model areas. Other available facilities include various measuring instruments, tide generator, wave generator, sediment feeder, power generator, workshop etc. So far, more than two hundreds of Physical model studies of different projects have been conducted by Hydraulic Research Directorate since 1948. Some of the important Physical model studies carried out at RRI is given below.

Local Scour around temporary cross-bar in the Teesta Barrage Model

Important Physical Model Studies conducted at RRI and achievement in the past

Name of the project	Year of completion	Objectives of the Physical modelling
Physical Modelling Component to Support the Feasibility Study for Augmentation, Conservation and Wise Use of Surface Water Resources through Dredging of the Upstream of Teesta Barrage and Bank Protection Work of the Teesta River in Kurigram District	2023	The main objective of the physical modeling is to investigate feasibility of augmentation and conservation of surface water resources through dredging of the upstream of Teesta barrage
Physical Modelling Component for Feasibility Study for the Management of Karatoa River System and Rehabilitation of FCD Projects on Both Bank of Nagar River in Bogura District	2023	Overall management of Karatoya River Basin and assessing the feasibility to take up the proposed implementation project titled "Karatoya River Improvement Project".
Physical Modelling Component for Feasibility Study for the Management of the Brahmaputra and Jinjiram River Basins through Flood Control, Drainage Facility and Bank Protection in Kurigram District	2023	The main objective of the study is the management of the Brahmaputra and Jinjiram river basins in Kurigram district through flood control, drainage facility and river bank protection.
Sustainability of the Buriganga River Restoration Project (Revised)	2021	To augment 141 cumec dry season flow in the Buriganga river by diverting 245 cumec water from the Jamuna River through the New Dhaleswari-Pungli-Bangshi-Turag-Buriganga River system.
Padma River Dredging Management Project	2019	To investigate the efficacy of dredging options, strategies and spoil disposal plan
Sustainability of the Buriganga River Restoration Project	2019	To finalize the layout of the off-take structure such as guide bund, intake canal and sedimentation basin in order to get required discharge in Dhaleshwari River.
Bangabandhu Railway Bridge Project	2018	To determine the local scour around the proposed Bangabandhu Railway Bridge pier and to check the efficacy of the existing RTW with proposed railway bridge pier.
Laboratory Based Study Using Concrete Block Mats to control River Bank Erosion	2018	To determine the cost effectiveness and sustainability of Concrete Block Mats compared to traditional method of river bank protection
Paira Bridge Project	2016	To finalize the type, location, dimension and hydraulic design parameters of the proposed river training works
Ganges Barrage Project	2013	To finalize the location, effectiveness and design parameters of the proposed barrage.
Padma Multipurpose Bridge Project	2013	To check the efficacy of river training structure.
3rd Karnaphully Bridge Project	2006	To decide the effectiveness and design parameters of bridge piers.
Gorai River Restoration Project	2001	To find out the suitable options for sustainable measures.
Bangabandhu Multipurpose Bridge Project	2000	To find out the efficacy of river training structure and to solve instantly arising any difficulties during the period of erection.
Paksey Roadway Bridge Project	1996	To verify the efficacy of river training structure.
Silt Trap Model for Teesta Barrage Project	1994	To finalize the effectiveness and design parameters of the barrage component.

Physical model studies conducted at RRI during the financial year 2022-23

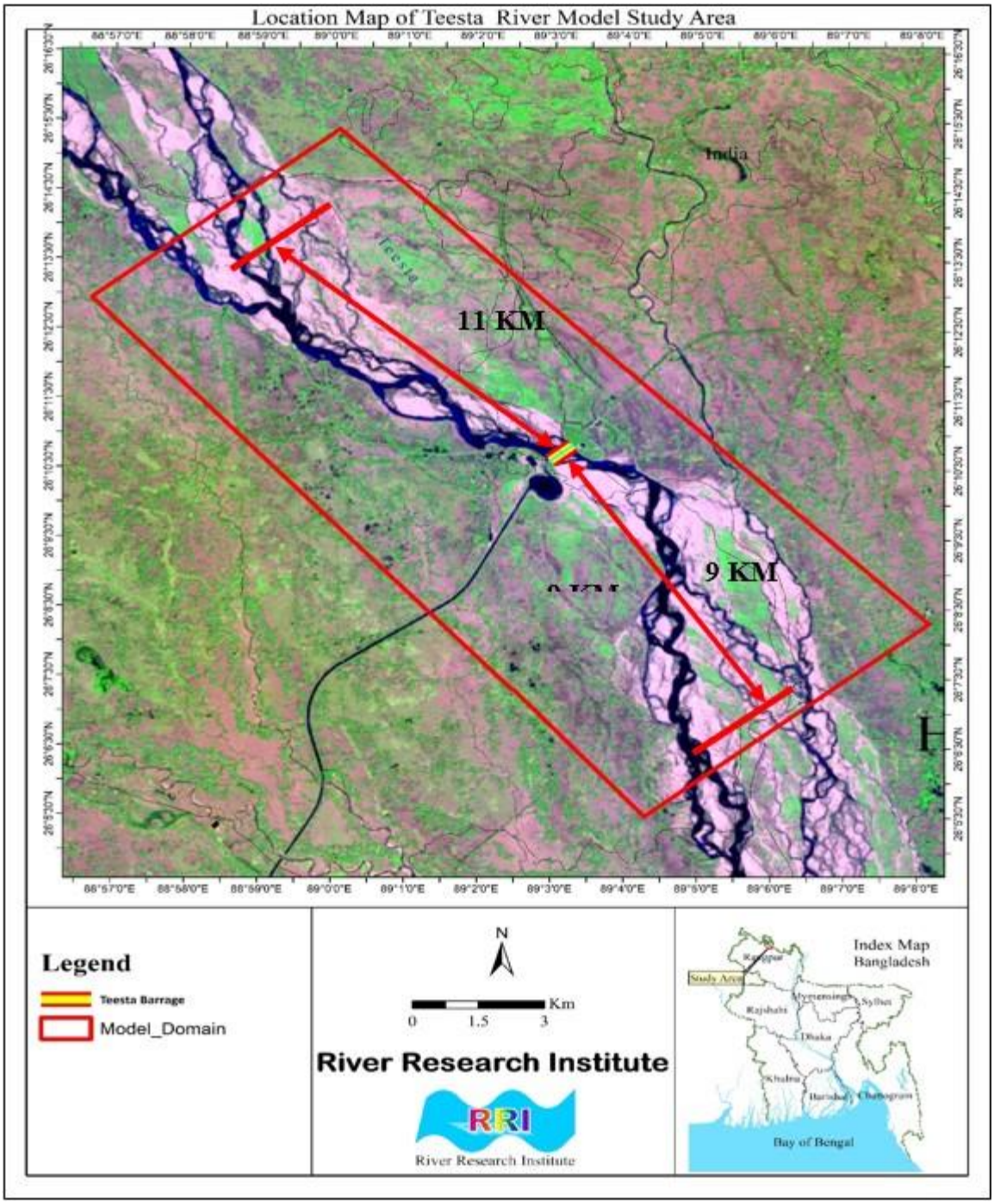
Physical Modelling Study for Feasibility Study for Augmentation, Conservation and Wise Use of Surface Water Resources through Dredging of the Upstream of Teesta Barrage and Bank Protection Work of the Teesta River in Kurigram District

The Teesta is the fourth largest transboundary river shared between Bangladesh and India. It is a tributary to the world's largest sandy braided river Brahmaputra which is known as the Jamuna in its lower reaches in Bangladesh. The Teesta originates from the glacier near Pahunuri in Sikkim and finds its way through the Darjeeling ridge in a narrow and deep george, and follows a meandering course. After entering West Bengal at Melli Bazar the river traverses about 30km through hilly terrain in southeast direction and reaches the plains of West Bengal at Sevoke near Siliguri and becomes braided with sandy-gravel bars and multiple channels. Gazaldoba barrage is located 25km from the Sevoke and after Gazaldoba the river predominantly a sandy braided river. The river then enters into Bangladesh after about 75km (along the main channel) from the Gazaldoba Barrage through Dahagram under Patgram upazila of Lalmonirhat district. Within the Bangladesh territory the river traverses a length of about 115km and finally meets the Brahmaputra River in Fulchhari upazila of Gaibandha district.

The Teesta is the only significant river in the northern region of Bangladesh that plays a vital role in boosting agricultural production in this region. Teesta barrage in Bangladesh at Dalia point of Duani in Hatibandha upazila of Lalmonirhat district was constructed to use Teesta water for irrigation. The construction of the barrage started in 1979 and that of the irrigation canals in 1984, and was completed in 1997-98. The barrage is a 615m long concrete structure fitted with 44 radial gates having a discharge capacity of 12,750 cusec of water. It is used to divert 280 cusec of water for irrigation through a canal taking off on the right bank.

The Teesta is the most dynamic river and fourth largest transboundary river shared between Bangladesh and India. Within the Bangladesh territory Teesta River pattern is braided consisting of a network of small channels and chars (islands). The river carries down huge amounts of sediment from the Himalayas every year. The bed of the Teesta River is being silted up due to high sedimentation, which reduces its carrying capacity and causes shifting of river course. The sedimentation process is going on for decades. Consequently, the water level rises frequently to the danger level even due to occurrence of a normal flood event. This threatens the Teesta Barrage and undermines the real purpose of the barrage construction.

In addition to that, the flow of Teesta River is hitting strongly the right and left banks as the water storage capacity of upstream is decreased. As a result, the right and left banks of the river Teesta are being eroded. The strong currents are damaging the important structures such as spurs, groynes and dams built on the river. If the sedimentation process increases over time, the danger level of water of Teesta Barrage will easily be exceeded which will be a threat to the existing hydraulic infrastructures including the barrage.



Study area for conducting physical model study

The Teesta Irrigation Project is the largest irrigation project of Bangladesh dependent on the Teesta River. Due to the lack of dredging of the Teesta River, the water storage capacity is decreasing, therefore sufficient water cannot be provided for irrigation. Water of the Teesta River is the main contributor to the fertility of the land on its both sides. If the water of the Teesta can be retained, it would increase crop production.

The maximum water level shows an increasing trend which indicates increasing intensity of floods in the upstream of Teesta River. It means more infrastructure vulnerability to floods. But increasing maximum water level with decreasing flow means that the river is experiencing siltation or aggradation. With the impending threat of climate change, the water balance of the Teesta Basin has become an important factor of the water stressed region.

In consideration to the above-mentioned problems, re-excavation / dredging is very important to increase the carrying capacity of the river and keep its course stable. Also, on the eve of the approval of the project

"Rehabilitation and Expansion of Command Area of Teesta Irrigation Project" at the ECNEC meeting held on 4 May 2021, the Hon'ble Prime Minister directed to excavate 16 km area of Teesta River inside Bangladesh on the upstream of Teesta Barrage. It is therefore essential to check the feasibility of augmentation and conservation of surface water resources through dredging of the upstream of Teesta barrage as well as address the wise use of surface water resources for irrigation expansion and livelihood improvement by using the existing river and irrigation systems. The storage volume of water at the upstream of Teesta barrage can be used for diverting it into the adjacent rivers/ khals through the establishment of a linking channel/khal.

In addition to that a project of BWDB to protect bank erosion of Gotiashama and Bogurapara area under Rajahaat Upazilla of Kurigram district is under process. Assessment of the feasibility of the bank protection works of those areas is essential for taking over the project.

Under the circumstances, Bangladesh Water Development Board (BWDB) has decided to conduct a detailed feasibility study for augmentation, conservation and wise use of surface water resources through dredging of the upstream of the Teesta barrage and bank protection work of the Teesta River in Kurigram. In order to meet some objectives of the feasibility study namely suitability and sustainability of the proposed dredging/re-excavation in the upstream of the Teesta barrage, identification of main course of the river, bank protection etc. physical modeling is a useful tool for decision support. In fact, physical modeling is a complementary tool to mathematical modeling to understand the morphological development trend of a river in with and without intervention conditions leading to come up with useful outcomes for planning and design of any river engineering project.

In Bangladesh, River Research Institute (RRI) is the sole organization equipped with physical modeling facilities and expertise. Therefore, BWDB has decided to commission RRI to carry out the physical model investigation of the study project and a contract agreement was signed between BWDB and RRI at Dhaka on 23th May 2022 to this end. The main purpose of the physical modelling is to investigate feasibility of augmentation and conservation of surface water resources through the dredging of the upstream of Teesta barrage. With this end in view six alternative dredging options have been devised for investigation. The options are Option-1, Option-2, Option-3, Option-4.1, Option-4.2 and Modified Option-1. Dredging both upstream and downstream of the existing Teesta barrage has been considered under Option-4.1 and Option-4.2. On the other hand, four cross-bars together with dredging have been considered under Option-1, Option-2 and Modified Option-1. Model investigation mainly aims to assess the effectiveness of dredging in terms of increasing storage volume, flood peak attenuation and land reclamation using dredged materials. Moreover, identification of the possibilities of irrigation expansion through conservation of surface water resources, determination of the long-term impacts of dredging/re-excavation on surface water and ground water resources, identification of the main course of the Teesta River in the downstream of the Teesta barrage etc. are also issues to be addressed.

Layout of Teesta Barrage Model at RRI

Conclusions

- The morphology of the Teesta river has undergone substantial changes due to numerous interventions all along the Teesta river course in the form of dam, barrage and bridge and withdrawl of river water for irrigation purpose has led to severe shortage of dry season flow in the downstream;

- Unilateral withdrawal of Teesta river water by constructing Gajoldoba barrage has severely affected;

- the purpose of Teesta Barrage Irrigation Project of Bangladesh;

- The mean bed level of the Teesta river in the upstream and downstream of the Teesta barrage at Dalia has gone up leading to increase in flood peak and reduced storage capacity in the upstream of the barrage;

- Due to shortage of surface water people in the Teesta Barrage Project area are increasing getting dependent on ground water for dry season irrigation leading to depletion of groundwater level;

- Dredging is anticipated as a solution to the prevailing problems associated with the Teesta Barrage Project;

- Model results indicate that dredging alone or dredging along with other interventions (cross-bar) is likely to contribute to increasing storage capacity and attenuating flood peak;

- Large scale dredging as proposed in the DPP (Option-3) of Bangladesh Water Develoment Board (BWDB) appears to be not feasible because of very high cost of dredging and other tehnical and management issues involved;

- Dredging under Option-4.2 is also large scale dredging that involves very high cost. Under this option large bed erosion may take place in the undredged area immediately downstream of the barrage. There is also potential for generation of complex flow structures just downstream of the barrage leading to development of deep scour hole;

- Dredging under Option-4.1 appears to be effective in terms of incresaed storage capacity and reduced flood peak compared to base condition. However, total capital dredging of 126.25 Mm^3 both in the upstream and downstream of the barrage will require large number of dredgers (anout 200 numbers) to complete the dredging works within a year given the capacity of 20-inch cutter suction dredger (CSD) mostly available in Bangladesh. Moreover, the dredged channel upstream of the barrage may get filled up by about 57% within five years of dredging and more or less similar development is anticipated for the dredged channel downstream of the barrage. Therefore, monitoring and maintenance dredging will be required.

- Requirement of capital dredging under Option-1, Option-2 and Modified Option-1 is much less compared to that under other three options. However, construction of four solid cross-bars together with dredging has been considered under these options. It appears from the model results that an increase in the bottom width and length of the dredged channel within a practical limit will result in more storage volume. However, upto a limit the rate of filling up of the dredged channel will be higher for a larger dredged channel section.

- The arrangement of solid cross-bars under Option-1, Option-2 and Modified Option-1 is likely to block about 50% of the conveyance of the river in base condition. As a result, the first cross-bar (from upstream) as well as cross-bar 3 and cross-bar 4 may come under impinging flow attack. Paralell current is likely to occur along the upstream face of these cross-bars from right side to left side;

- The considered spacing between the successive solid cross-bars apears to be insufficient. Introduction of one additional cross-bar may be considered to reduce the spacing between the successive cross-bars. It will reduce the protrusion of flow into the area between two successive cross-bars and thereby, will reduce the impinging flow attack on the cross-bars downstream of cross-bar-1 (from upstream);

- The presence of cross-bars under Option-1, Option-2 and Modified Option-1 will make the existing groynes within them completely ineffective. On the other hand, for Option-1 and Option-2 two T-head groynes in between cross-bar 4 and existing Teesta barrage will remain actively functional in the beginning. However, their functioning will contunue to decrease with the passage of time as the main flow channel will tend to shift towards the left side;

- For Option-1, Option-2 and Modified Option-1 high velocity of flow will occur at the head of the cross-bars as well as within the dredged channel in the beginning. However, the

magnitude of maximum velocity as well as average velocity will continue to decrease with the progress of bed erosion at and around the dredged channel in front of the cross-bars. Scour hole will be developed at the head of all cross-bars. The reported mimimum bed levels at the head of the cross-bars are qualitative due to presence of scale effects in reproduction of scour depth;

- For all considered options relatively more flow concentration is noticeable near the right guide bund (undersluice part) at the barrage location and also for all options there is potential for right bank erosion beyond the downstream termination of the right guide bund; and

- Dredging in the immediate upstream of the barrage appears to be more effective than dredging in the far upstream of the same in terms of achieving increased storage capacity.

Recommendations

- Dredging together with other intervention (cross-bar) may be considered in the upstream of the barrage to increase storage capacity and to reduce flood peak;

- Large scale dredging may be avoided as it involves very high cost as well as management and environmental issues;

- Considereing the limited scope for beneficial use of stored water Modified Option-1 may be a feasible option as it requires less dredging, which is affordable and manageable;

- Five solid cross-bars instead of four solid cross-bars within the same stretch of the river along the right bank may be considered under Modified Option-1 to reduce the spacing between the successive cross-bars;

- The cross-bars should be strong enough to withstand likely impinging flow attack and scour depth. The reported minimum scour levels at the head of the cross-bars are indicative;

- The dredged materials may be dumped at the planned disposal location under Modified Option-1;

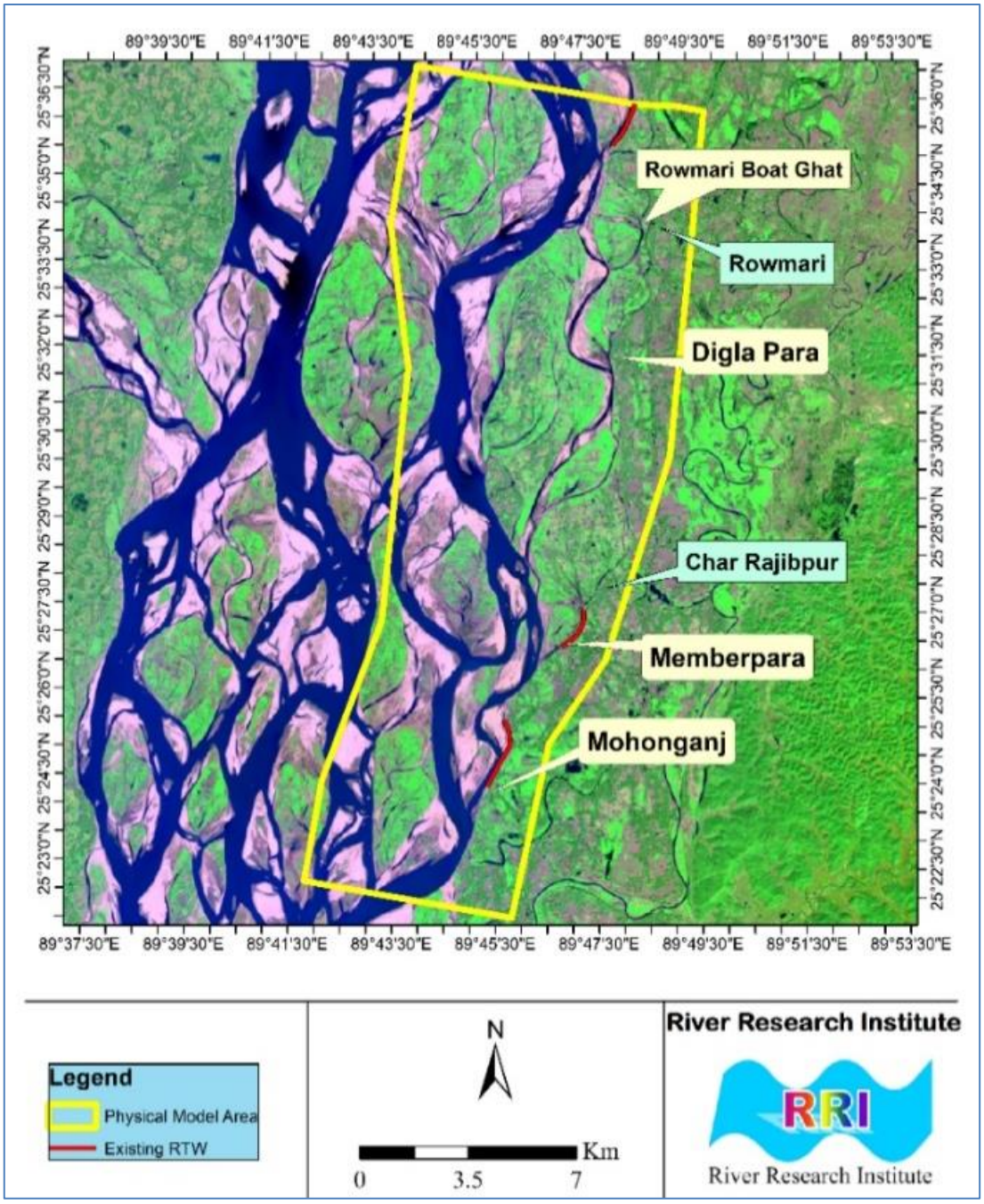
- Right bank erosion situation beyond the downstream termination of right guide bund of the Teesta barrage should be monitored and appropriate erosion protection measure may be undertaken, if necessary; and

- Post monsoon bathymetric survey may be carried out in the intervention area at an interval of two years to decide about the need for maintenance dredging.

Physical Modelling Component for Feasibility Study for the Management of the Brahmaputra and Jinjiram River Basins through Flood Control, Drainage Facility and Bank Protection in Kurigram District

The Brahmaputra is one of the major rivers of the greater GBM (Ganges-Brahmaputra-Meghna) basin. Originating from the Manas Sarovar Lake region of the Himalayas in Tibet, the river enters into Bangladesh at Rowmari upazila. Rowmari and Rajibpur are two upazilas under Kurigram district located near the left bank of the Brahmaputra River. Both of the upazilas are suffering from flood every year. Visiting the affected area after 2020 flood, the Hon'ble Minister of State, Ministry of Water Resources (MoWR) promised the local people about construction of flood protection embankment together with protection of the river bank. Also, the Hon'ble Minister of State, Ministry of Primary and Mass Education sent a DO letter to the Hon'ble Minister of State of the Ministry of Water Resources in this regard. In this connection, BWDB is formulating a project titled "Construction of town protection flood control embankment in Rowmari and Rajibpur upazilas of Kurigram" for which a feasibility study covering the left bank of the Brahmaputra River at Rowmari and Rajibpur upazila is required before undertaking the implementation project.

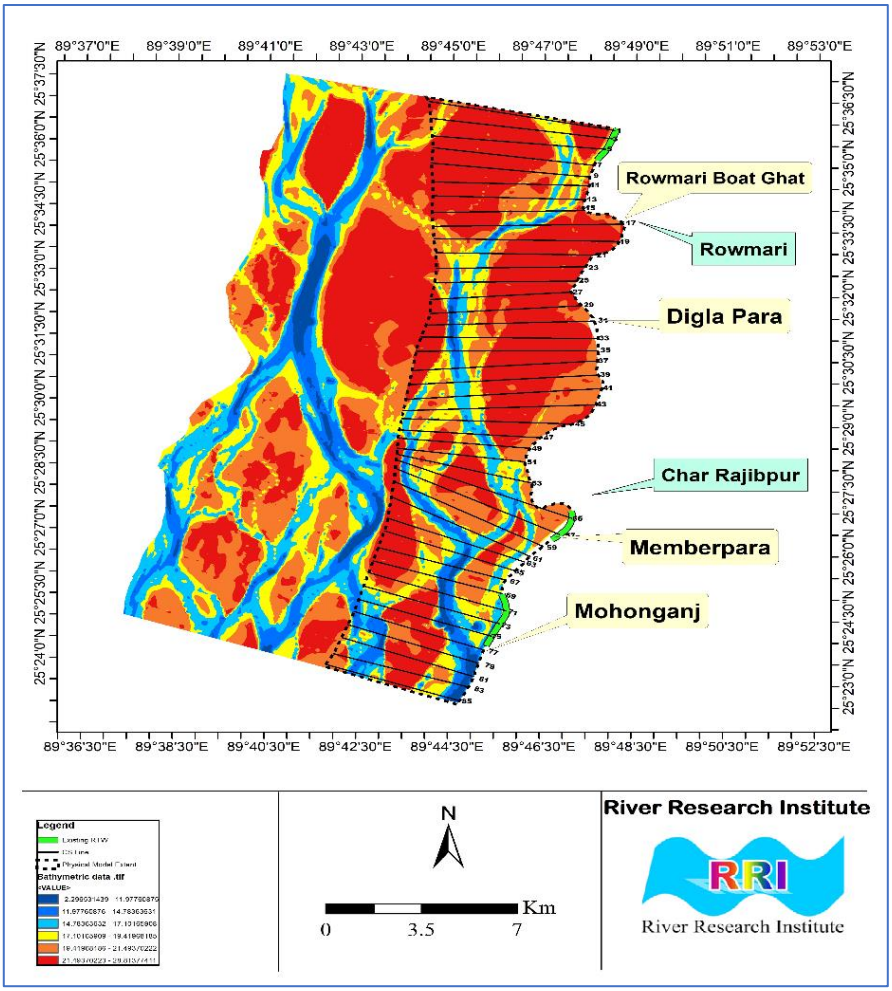
In view of the above, BWDB has decided to conduct a detailed feasibility study for the management of the Brahmaputra River in Kurigram district. Assessment of the feasibility of town protection embankment together with regulators and river bank protection along the left bank of Brahmaputra River at Rowmari and Rajibpur upazila in Kurigram District will be considered in the study. The DPEC meeting of the proposed study project was held on 02 February 2022 in the Ministry of Water Resources (MoWR). The Ex-Senior Secretary of MoWR presided over the meeting. As per decision of the meeting, the study area for Brahmaputra River has been extended up to Shanandabarihaat of Jamalpur district. In Bangladesh, River Research Institute (RRI) is the sole organization equipped with physical modelling facilities and expertise. Therefore, BWDB has decided to commission RRI to carry out the physical model investigation of the study project. A contract agreement was signed between BWDB and RRI on 16.08.2022 to conduct the above-mentioned study.



Satellite Image of the study area

The main purpose of this model is to provide decision support for determining of suitable and optimal design of bank protection work as well as to fix up dredging alignment, if necessary and also to investigate the efficacy of the alternative measures to ensure a stable river course.

An overall distorted morphological model is constructed which includes a river stretch covering around 26 km of Brahmaputra River. 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, a distorted model with suitable geometric scales has been planned. The model has been constructed having horizontal scale 1:600 and vertical scale 1:80. This model covers part width of the river from the left bank so that 30% to 40% of the total discharge may pass within the lateral boundary. The model is planned to come up with the hydraulic design parameters of the interventions and to assess the impacts of the same qualitatively.



Initial bathymetry of Brahmaputra River within the study reach

Layout of Brahmaputra River Model at RRI

Conclusions

- The near left bank velocity is high enough to cause bank erosion at unprotected places when tested for flood discharge of 2.33 year and 100 year. Bank erosion may continue at these areas if appropriate bank protection measures are not taken immediately;

- Float tracking in the base run reveals that the left bank of the Brahmaputra River is under flow attack at the unprotected areas;

- In base condition (T1), maximum velocity around the existing protective work at the upstream of Rowmari Boat Ghat, at Memberpara and at Mohonganj is found as 1.32, 1.32 and 0.92 m/s respectively for 2.33 year discharge and as 1.34, 0.94 and 1.40 m/s respectively for 100 year discharge;

- In test T2 (Option-1), maximum velocity around the proposed protective work at Rowmari Boat Ghat, at Dighla Para and at Memberpara is found as 0, 1.52 and 1.17 m/s respectively for 2.33 year discharge and as 0, 1.63 and 1.75 m/s respectively for 100 year discharge;

- In test T3 (Option-2), maximum velocity around the proposed protective work at Rowmari Boat Ghat, at Dighla Para and at Memberpara is found as 0, 0.59 and 0.19 m/s respectively for 2.33 year discharge and as 0, 0.77 and 1.00 m/s respectively for 100 year discharge;

- In test T4 (Option-3), maximum velocity along the proposed protective work placed around Dighla Para Char is found as 1.78 m/s for 2.33 year discharge, 4.5 km downstream from the upstream end of the proposed protective work and as 2.81 m/s for 100 year discharge, 5.1 km downstream from the same;

- In base condition (T1), with respect to initial bed level maximum scour depth around the existing protective work at upstream of Rowmari Boat Ghat, at Memberpara and at Mohonganj is found as 3.52 m (17.84 mPWD), 2.32 m (19.84 mPWD) and 1.36 m (20.43 mPWD) respectively for 100 year flood discharge;

- In test T2 (Option-1), with respect to initial bed level maximum scour depth around the proposed protective work at Rowmari Boat Ghat, at Dighla Para and at Memberpara is found as 0.96 m (20.85 mPWD), 0.96 m (18.73 mPWD) and 6.88m (18.32 mPWD) respectively for 100 year flood discharge;

- In test T3 (Option-2), with respect to initial bed level maximum scour depth around the proposed protective work at Rowmari Boat Ghat, at Dighla Para and at Memberpara is found as 1.12 m (20.69 mPWD), 4.72 m (25.06 mPWD) and 6.88 m (11.43 mPWD) respectively for 100 year flood discharge;

- In test T4 (Option-3), with respect to initial bed level maximum scour depth along the proposed protective work placed around Dighla Para Char is found as 12.72 m. The corresponding minimum scour level is 8.88 mPWD. It has happened at around 5.7 km downstream from the upstream end of the proposed protective work for 100 year flood discharge;

- The maximum scour depths and corresponding minimum scour levels obtained from different options are qualitative due to presence of scale effects in reproduction of scour holes;

- The proposed bank protection works proposed by IWM and introduced along the left bank at their appropriate positions is found to be working well as noticed from the model study. However, still there are three places along the left bank where bank erosion may occur as revealed from the physical model investigation (Test T2, Option-1) in addition to the bank protection work proposed by IWM**.** The location of these erosion prone places is in the downstream of the existing protective works (Faluar Char Nouka Ghat), in the downstream of the protective work proposed by IWM at Rowmari Boat Ghat (Chaktabari, Jadurchar Union) and at Char Rajibpur (Char Velamari). Protection against bank erosion is also needed at these places;

- In Option-2, the flow velocity along the dredged channel in the beginning of the test varies from 0.42 m/s to 1.63 m/s and from 0.94 m/s to 2.04 m/s for 2.33yr and 100yr discharge respectively. With the passage of time flow velocity along the dredged channel is found to have decreased due to progressive filling up of the dredged channel. The upstream portion of dredged channel gets silted up earlier than the downstream portion;

- For the considered dredge plan and design under Option-2 the total volume of material to be dredged is 27217863 m^3. The likely volume of material that may get deposited in the dredged channel within a year for an extreme event (100 year discharge) is 12715570 m^3;

- The dredged channel is found to have gotten mostly silted up in the upstream part of the channel and the average percentage of filling up

of the dredged channel is about 46.72% in one year;

- The average dredging area and dredging depth is 49,04,119 m^2 and 5.55 m respectively;
- The near bank velocity along the left bank of the river within the study reach is reduced to some extent due to the introduction of dredged channel. However, this positive effect of the dredging may diminish with time due to progressive filling up of the dredged channel;
- It appears from the model results that maintenance dredging is needed once in a year and may be carried out for two to three years following the capital dredging;
- If the proposed capital and maintenance dredging is accomplished it will ensure the stability of the bank protection works by reducing the flow attack near the left bank and thereby, reducing the near bank flow velocity. However, proposed dredging involves economic, management, availability of dredger, environmental and other issues to be considered for implementation;
- Monitoring of the developments in the dredged channel will be needed 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;
- For char stabilization, the length of the protective work around Dighla Para Char proposed by IWM is 21.654 km. The proposed protective work may come under high flow attack during flood period and consequently large scour hole may develop near the protection works;
- Char stabilization may be implemented following an adaptive approach i.e. systematic construction of the protective works together with monitoring and assessment of morphological developments allowing for improvement and optimization in the design of protective works;
- Char stabilization around Dighla Para Char under Option-3 (T4) will be helpful for massive land reclamation. However, this option involves cost, environmental and other issues; and
- In the present physical model, a 26 km stretch of the Brahmaputra River covering part width has been reproduced. 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 model is able to reproduce bank erosion qualitatively. Therefore, it is not possible to predict the rate of bank or char erosion quantitatively.

Recommendations

- It is revealed from the examination of historical satellite images that over the last four decades the Brahmaputra River has shown an overall widening trend due to increase in the braiding intensity leading to widespread bank erosion in the project area and elsewhere. Due to left bank erosion of the Brahmaputra River in the project area numerous people have lost their homesteads and valuable lands. Many infrastructures are also swallowed up by the river. At present the widening trend of the Brahmaputra River is reversing. Therefore, emphasis should be put on reclamation of lost land in all river stabilization projects concerning the Brahmaputra River;
- Interventions considered under Option-3 may be implemented in the field in order to meet the project objectives despite the fact that it entails massive construction and huge cost. The implementation of the proposed protective works should be adaptive;
- Systematic construction techniques as outlined under Adaptive Approach for Implementation may be followed;
- Monitoring and assessing the river behaviour in response to phased construction should form the basis for improving and optimizing the design of proposed protective works; and
- There should be a concrete plan for beneficial use of the reclaimed land including resettlement of displaced people.

Physical Modelling Study for Feasibility Study for the Management of Karatoa River System and Rehabilitation of FCD Projects on Both Bank of Nagar River in Bogura District

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 Katakhali 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 and Sherpur of Bagura district and finally falls into Bangali river at Khanpur area of Sherpur upazila.

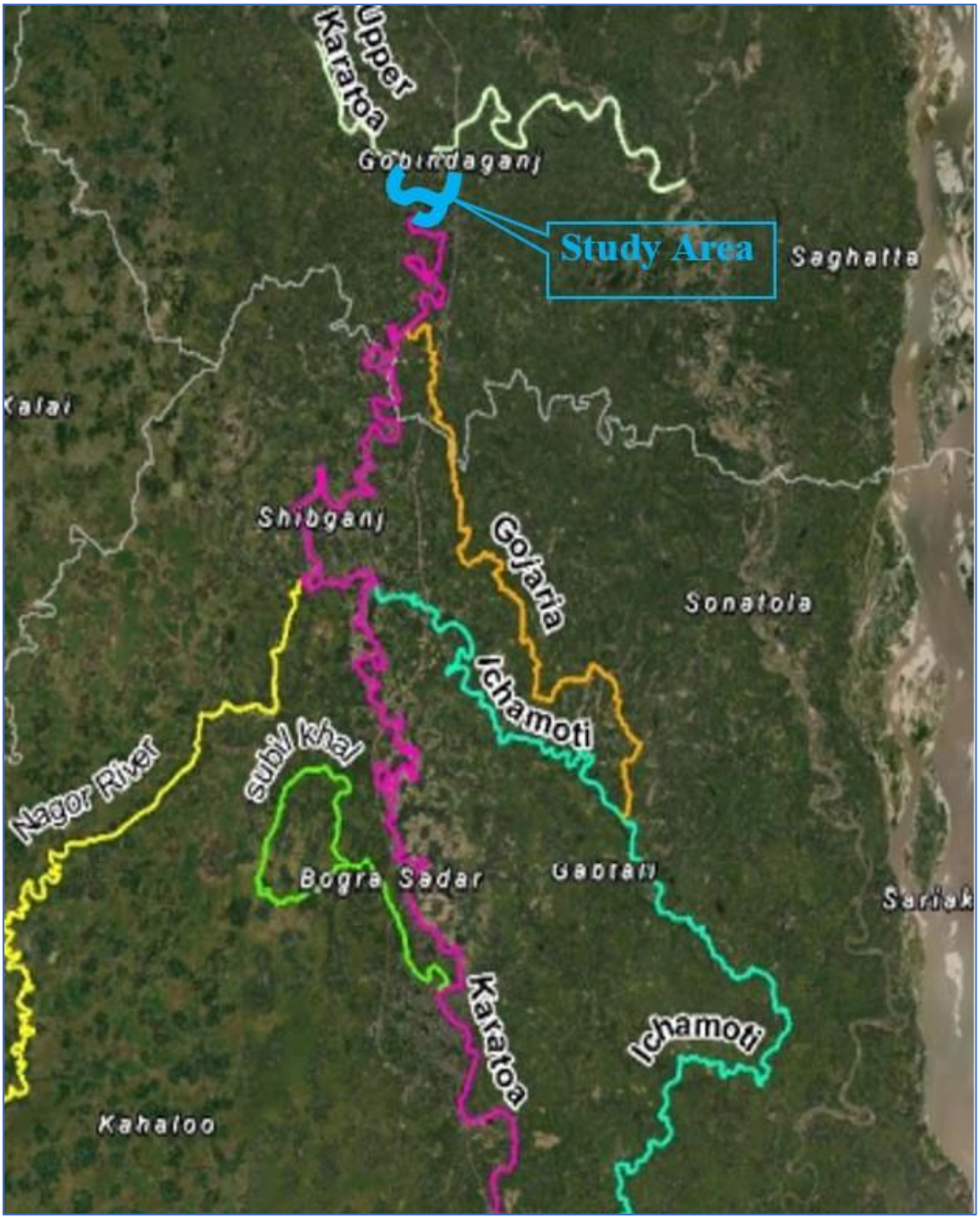
The Lower Karatoa river system has undergone large scale siltation and its conveyance capacity is largely reduced. In order to control flood discharge of the Lower Karatoa river a 3-vent regulator is constructed at its off-take. Given the size of the regulator and its sill level flow from the upper Karatoa river cannot enter into the Lower Karatoa river in most of the months of a year. Even during the monsoon season flow in the Lower Karatoa river is insufficient. As a result, the river is now in a state of dying affecting water environment, agriculture, fishery, navigation in the project area. In order to improve the physical condition of the Lower Karatoa river BWDB has taken up a feasibility study for augmentation of flow and conservation of water in the Lower Karatoa river. Dredging is anticipated as a means to improve conveyance and water retention capacity of the river. In this regard, it is very important to ensure entry of more or less round the year flow from the Upper Karatoa river to the Lower Karatoa river. However, it is not possible without appropriate structural measures at the off-take of the Lower Karatoa river.

The physical modeling component of the feasibility study is planned mainly to provide technical support in selecting suitable interventions at the Lower Karatoa off-take by assessing hydraulic and morphological performance of a number of alternative interventions. Accordingly, RRI has conducted the physical model study under an agreement with BWDB.

The study area for the feasibility study covers the entire Karatoa-Nagar River system. The physical model study focuses on the devising of appropriate interventions at and around the Lower Karatoa off-take to facilitate more or less round the year flow into the same together with identification of erosion vulnerable areas within the study reach. To this end, construction of an undistorted physical model has been planned covering 2.5km stretch of the Upper Karatoa river and 1.5km stretch of the Lower Karatoa river.

The data needed for model set up, design and operation are collected from Institute of Water Modeling (IWM), Dhaka. IWM has carried out field survey for collection of primary data namely bathymetric data, bank line data, sediment data etc. RRI has collected most of the both primary and secondary data needed for the model study from IWM. Latest maps and satellite imageries covering the study reach have been collected from different sources including USGS. Historical satellite imageries of study area were also collected for different periods. These satellite imageries were super-imposed to have an understanding of the changes in the channel pattern with the passage of time due to morphological developments. The preliminary drawings of the proposed regulator dredge plan and dredge design for the proposed dredging options and design drawings of the proposed bank protection works that are to be implemented on the bank of the Karatoa River are collected from BWDB and IWM.

In the model study, a total of eight tests have been conducted including model calibration (T0) and base run (T1). Model calibration and base run is carried out in existing condition i.e. without any planned intervention. On the other hand, six application tests (T2-T7) have been conducted with proposed interventions (dredged channel and 4-vent regulator) in place.



Study area and Karatoa - Nagar River system in the satellite image (IWM, 2022)

Flow through the Upper and Lower Karatoa River Model

Model bed after run in the vicinity of proposed & existing regulator

Conclusions

- The Lower Karatoa river has undergone large scale siltation leading to significant reduction it its conveyance capacity;
- The existing 3-vent Khulshi regulator is functioning as the inlet of flow into the Lower Karatoa river and due to relatively higher elevation (16.2mPWD) of its sill level flow of the Upper Karatoa river cannot enter into the Lower Karatoa river for 8 to 9 months of a year;
- Dredging with appropriate off-take management measures are needed to rejuvenate the Lower Karatoa river system;
- Right bank erosion of the Upper Karatoa river from Kamarpara Bazar to Chandpur Arefia Govt. Primary School in the upstream of the Khulshi regulator may continue to occur if appropriate bank protection measures are not taken;
- The percentage of discharge distribution into the Lower Karatoa river varies to some extent with the variation in the magnitude of oncoming discharge of the Upper Karatoa River as well as with the variation in the sill level of the proposed regulator;
- In order to augment Lower Karatoa discharge a new regulator in the immediate downstream of the existing Khulshi regulator is needed;
- The intervention proposed in the DPP of BWDB is not feasible as it allows only 5.7% of the average discharge of the Upper Karatoa river to enter into the Lower Karatoa river. Also, it does not ensure more or less round the year flow in the Lower Karatoa river;
- Under different test conditions (as in T3, T4, T5, T6 and T7) the average monthly discharge in the Lower Karatoa river is found to have increased compared to the base (existing) condition;
- For all test conditions the magnitude of discharge as well as flow velocity in the Lower Karatoa river is relatively higher in the beginning of test run compared to that at the end of the same. It might have happened due to deposition of sediment at the off-take and elsewhere in the study reach;
- For all test conditions the rate of filling of the dredged channel is relatively faster in the upstream part of the Lower Karatoa river;
- Model results of test T3 to test T7 indicate that increase in bottom width and lowering of bottom level of dredged channel ensure more flow in the Lower Karatoa river. However, feasible bottom width of the dredged channel is 15m as further increase in the same may lead to land acquisition problem;
- The appropriate side slope of the dredged channel is 1V:2H and appropriate bottom level of the dredged channel at the off-take is 14.5mPWD as it admits more or less round the year flow in the Lower Karatoa river;
- Interventions considered under test T6 and test T7 perform well in terms of flow in the Lower Karatoa river as percentage of flow of the Upper Karatoa river and likely volume of sedimentation at the off-take and elsewhere in the study reach during flood discharge;
- Removal of proposed 4-vent regulator and keeping the off-take open to flow as in test T7 allows relatively more flow to enter into the Lower Karatoa river and also induces relatively less sedimentation at the off-take. However, due to absence of any discharge regulation system flooding potential in the downstream reaches of the Lower Karatoa river remains;
- The interventions under test T6 may induce right bank erosion of the Upper Karatoa river in the immediate upstream and downstream of the regulators;
- In test T6, the deposition volume within the dredged channel (1.5km long stretch starting from the off-take) for average and design discharges is found to be about 10,650m3 and 12,515m3 respectively. Most of the reported sediment deposition occurs within 800m from the off-take;
- In test T7, the deposition volume within the dredged channel (1.5km long stretch starting from the off-take) for average and design discharges is found to be about 9,502m3 and 11,265m3 respectively. Most of the reported sediment deposition occurs within 800m from the off-take;
- In test T6 and test T7, on the average about 13.37% and 12.09% of the dredged channel (1.5km from the off-take) may get filled up within one year after capital dredging for design discharge;
- Likely average thickness of deposition in the dredged channel (1.5km from the off-take) for

design discharge in test T6 and test T7 is 0.507m and 0.46m respectively;

- Anticipated maximum thickness of deposition at the off-take for design discharge in test T6 and test T7 is 1.12m and 0.87m respectively;

- Bank erosion products might have contributed to the reported deposition volume under different test conditions;

- Maintenance dredging over 1.0km stretch (starting from the off-take) of the Lower Karatoa is needed at an interval of two years to prevent progressive siltation of the dredged channel with time and consequent reduction in its conveyance capacity;

- Monitoring of the developments in the dredged channel is very important to assess the actual 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 the need for maintenance dredging and its volume; and

- In test T6 and test T7 longitudinal slope of the dredged channel is considered as 5.5cm/km. An increase in the longitudinal slope may reduce flooding potential and flood depth in the downstream reaches of the Lower Karatoa river.

Recommendations

- Proposed interventions under test T6 and test T7 come up with satisfactory results in terms of flow and sediment distribution into the Lower Karatoa river. Interventions under test T6 are recommended for implementation although the performance of interventions under test T7 is relatively better than that under test T6. Flood mitigation in the downstream reaches of the Lower Karatoa river may not be achieved easily in absence of any discharge regulation system at the off-take of the same;

- Reported right bank erosion problem of the Upper Karatoa river over an extent of about 850m from Kamarpara Bazar to Chandpur Arefia Govt. Primary School may be addressed by taking appropriate bank protection measures;

- After implementation of the recommended interventions right bank erosion situation of the Upper Karatoa river in the immediate upstream and downstream of the regulators may be monitored closely and appropriate erosion protection measures may be undertaken, if necessary;

- Maintenance dredging of the Lower Karatoa river over an extent of 1.0km (starting from the off-take) may be undertaken at an interval of two years to ensure more or less round the flow in the Lower Karatoa river;

- Monitoring of morphological developments in the dredged channel may be conducted through post monsoon cross-section survey at 100m spatial interval and need for maintenance dredging and its location and volume may be assess by analyzing the survey data; and

- An increase in the longitudinal slope of the dredged channel from 5.5cm/km to 7.5cm/km may be considered in order to reduce flooding potential and flood depth in the flood prone areas along the downstream reaches of the Lower Karatoa river.

Mathematical Modelling

At present time, Mathematical modelling tool is being widely used all over the world for research and studies in the field of water resources engineering. It has become an important tool for decision support in planning and management of water resources and sustainable water infrastructure development. In many cases Mathematical modelling is complementary to physical modelling to arrive at sound engineering judgment as to planning, design and implementation of water infrastructure projects. In view of this fact, the GoB has equipped RRI with mathematical modelling facilities (MIKE Series) to enhance its quality of works. It is expected that RRI will play a vital role in water sector as well as in other related sectors to make the water resources development cost effective and sustainable. It can be mentioned here that RRI has already completed a number of mathematical model studies from 2009 to till. Some of the Mathematical model studies conducted by RRI are mentioned hereafter.

Important Mathematical model studies conducted at RRI in the past

- Detail Engineering Design of Kurigram Irrigation Project (South Unit).

- Wazed Miah Bridge project in Rangpur District under Rangpur Road Division of RHD.

- Road Bridge over the Banar River on Mymensingh-Goffargaon-Toke Road in Mymensingh District under Mymensingh Road Division of RHD.

- Road Bridge over the river Lohalia at Boga in Patuakhali District under Patuakhali Road Division of RHD.

- Hydro-morphological Study for Pagla-Jagannathpur-Raniganj-Aushkandi Road Project in Sunamganj District under Sunanganj Road Division of RHD.

- Road Bridge over the Kalni River in Habiganj District under Habiganj Road Division of RHD.

- Road Bridge at Nalua-Baherchar over the river Pandab-Paira in Patuakhali District under Patuakhali Road Division of RHD.

- Road Bridge over the Monu River in Moulvibazar District under Moulvibazar Road Division of RHD.

- Hydro-Morphological Study for the Proposed Laxmipasha bridge at 23rd km of Barishal (Dinarer Pool)- Laxmipasha-Dumki Highway (Z-8044) on the Porar Dhon River under Roads and Highways Department (RHD.

- Hydro Morphological Study for the Proposed Banaripara bridge at 2nd km of Banaripara-Najirpur Highway (Z-7710) on the Sandha river under Roads and Highways Department (RHD)

- Hydro Morphological Study for the Proposed Atul Nagar Ghat Bridge at 28th km of Pirojpur-Najirpur-Matibhanga-Patgati-Gonapara Highway (Z-7704) on the Kaliganga River under RHD

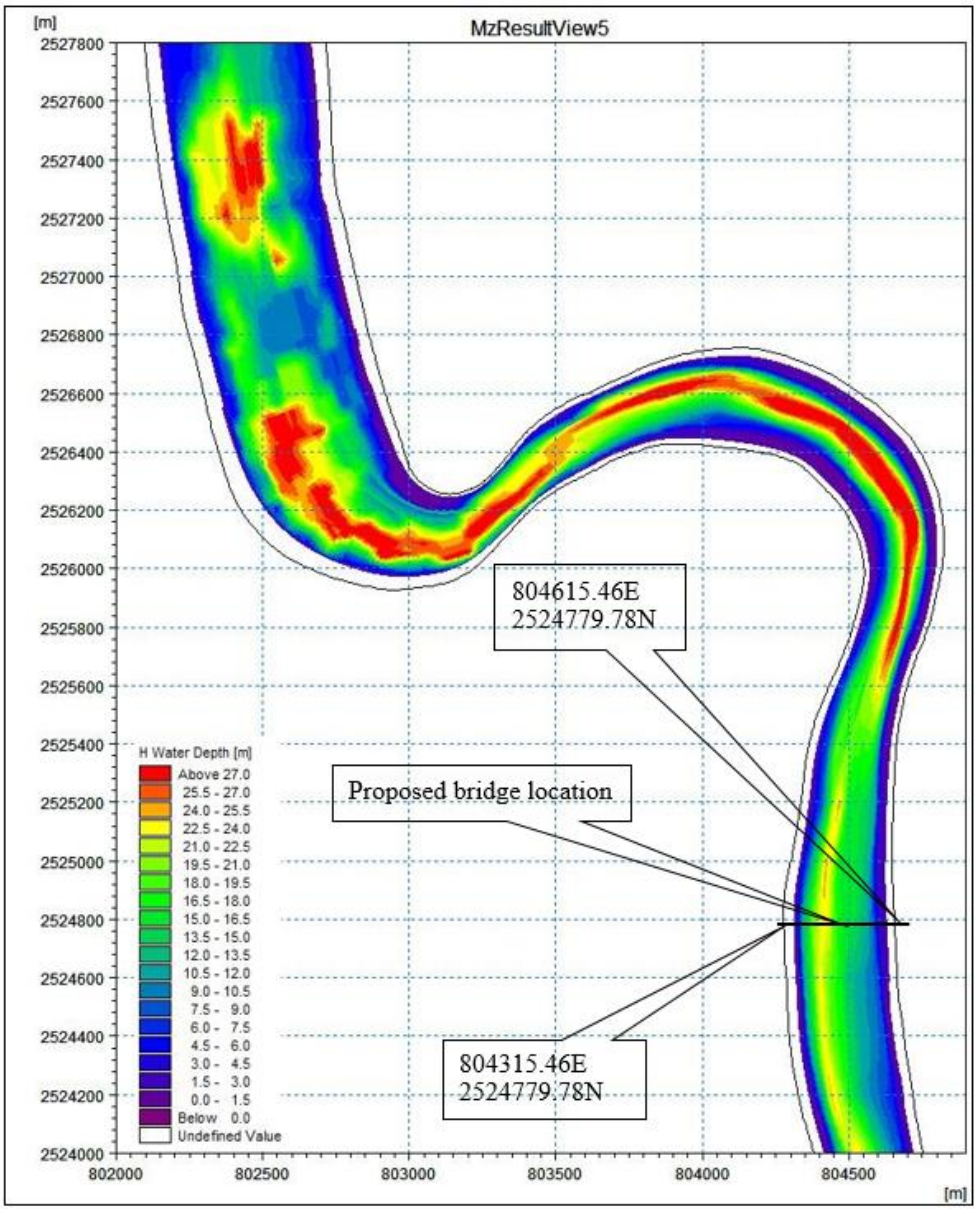
- Hydro Morphological Study for the Proposed Bishkhali Bridge at 6th km of Binapani-Kachua-Betagi-Mirjaganj-Patuakhali Highway (Z-8052) on the Bishkhali river under RHD

Mathematical model studies conducted at RRI during the financial year 2022-23

Hydro-Morphological Study of the Atul Nagar Ghat Bridge at 28th km of Pirojpur-Nazirpur-Matibhanga-Patgati-Gonapara Highway (Z-7704) on the Kaliganga River under Roads and Highways Department

The proposed Atul Nagar Ghat Bridge is located at 28th K.M. of Pirojpur – Nazirpur –Matibhanga – Patgati - Gonapara Highway (Z-7704) on the Kaliganga River. This road is the shortest way of road communication for the people of Malikhali Union, Daulbari Dodra Union with Nazirpur Upazila of Pirojpur District. The location of the proposed Atul Nagar Ghat Bridge is at Malikhali Union (Left bank of the river) and Matibhanga Union (on the right bank of river) of Nazirpur Upazila. To join the eastern part with the western part of Nazirpur Upazila, it is essential to construct Atul Nagar Ghat Bridge. At present the people of Malikhali Union, Daulbari Dodra Union have no opportunity of roadway connection to use Pirojpur – Nazirpur – Matibhanga – Patgati - Gonapara Highway without construction Atul Nagar Ghat Bridge. After the completion of project, vehicles will be able to move safely. Better marketing opportunities will be opened and farmers will get fair price of their products. It will immensely contribute to the overall economic growth of this area. The Malikhali Union and Daulbari Dodra Union are resourceful with rice and fish cultivation. If the bridge is constructed, it will be easier to transport these products from Nazirpur Upazila to other parts of the country.

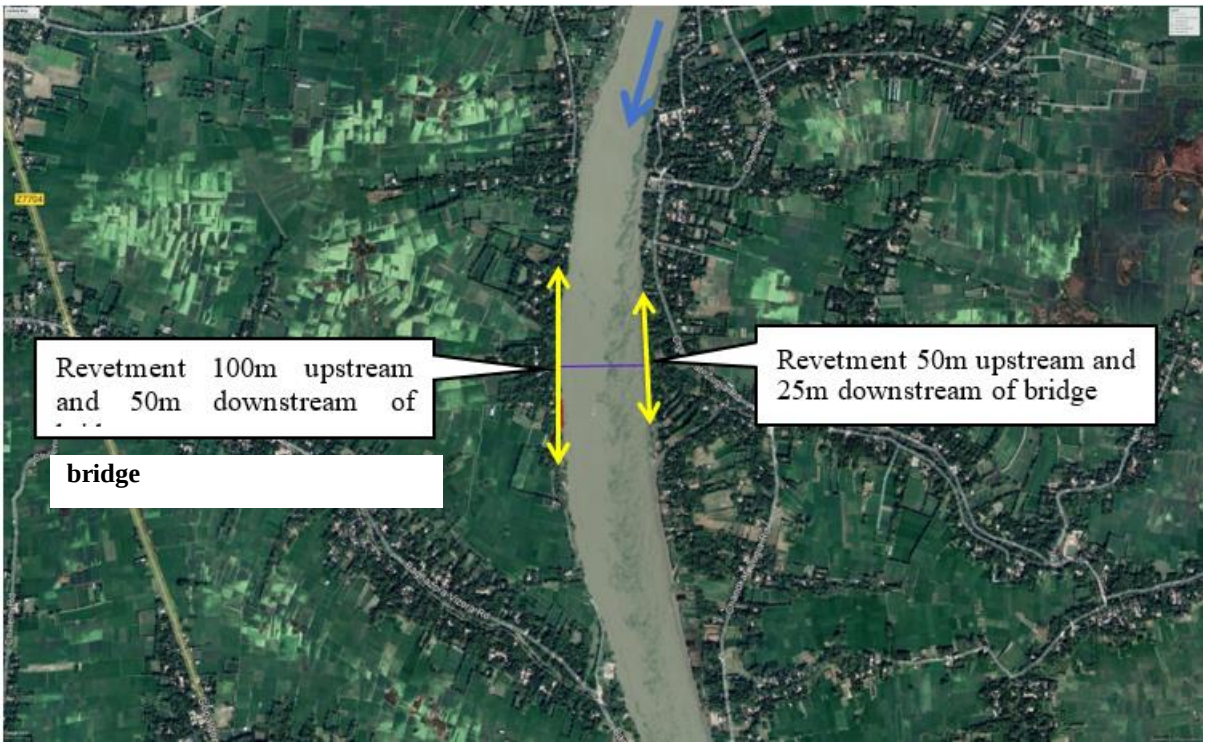
Under the above mentioned circumstance, that Roads and Highways department (RHD) has set targets for the 8th Five Year Plan, including the construction of bridges/culverts of 37,500 meters of length, reconstruction of bridges/culverts of 4100 meters of length etc. The new targets will ensure an uninterrupted highway network by identifying and connecting the missing links of the road network. As a part of these goals, RHD has taken up an action to construct Atul Nagar Ghat Bridge. Based on the outcomes of the hydro-morphological study conducted in the past and recent field conditions RHD has prepared a Development Project Proposal (DPP).



Proposed position and orientation of the Atul Nagar Ghat bridge

The proposed study will focus on the detailed hydrological and morphological conditions of the Kaliganga River in determining a suitable location for the bridge, alignment of the bridge, bridge opening, hydraulic design variables of the bridge piers, abutment/guide bund, formation level of the approach road at bridge abutment and access road, type of road slope protection works, if required etc. In addition to this, this study should also investigate the threat of bank failure adjacent to the proposed road bridge and thus suggest suitable type and properly aligned river training works, if required. Along with the determination of the necessity of river training works (RTW); this proposed study should provide the hydraulic design variables for this protective work.

Under this circumstance RHD has requested River Research Institute to verify the efficacy and justification of the proposed road structures by employing the already developed two-dimensional mathematical model. In order to comply with the request, the existing model has to be updated including the changes in topography that have been occurred in the recent past particularly along the existing road alignment. The model investigation is intended to come up with required number of road structures and their types, locations and dimensions in order to avoid or to minimize the adverse impacts of the road project on natural flooding, drainage and sedimentation.



Placement and length of suggested bank revetments in the upstream and downstream of the bridge

Objectives of the Study

- To determine the actual width of opening of the bridge.
- To determine the discharge of water flow of the catchment area near the bridge site, passing under this bridge before, during and after the rainy season so that the bridge approach is permanently stable from erosion caused by heavy wave action.
- To design slope protection work, if required of the approach road and river bank within the vicinity of the bridge.
- To conduct Environmental Impact Assessment (EIA) of the bridge.

Conclusions

- In the study reach the river flows through Ganges tidal floodplain physiographic units. The sediments are mainly non-calcareous clays but they are silty and slightly calcareous on riverbanks Bank erosion does occur there but at a slow pace. Mass wasting is the mechanism of bank failure;
- Analysis of satellite images and recent cross-section data and model results show that there is both lateral and vertical stability problems at the bend locations The river is more or less stable at the crossing in terms of bank erosion;
- The proposed bridge over the Kaliganga river should be located at straight reach 4000m downstream of the Atul Nagar ghat;
- The river is embanked against tidal and monsoon flooding of the low lying floodplain. It appears that the river is still under process of self-adjustment in response to human intervention;
- The thalweg profile in the vicinity of the proposed bridge shows the potential for large bed degradation at the meander bends in the upstream and downstream of the bridge location. The minimum bed level along the bridge axis is -21.75mPWD whereas the minimum bed level at the bend locations is as low as -35.4mPWD;
- This hydro-morphological study considered a bridge having a length of 300m. The Roads and Highways Department provided the design information, including the length. For the selected Option 3, which is located approximately 4000m downstream from the Atul Nagar Ghat, the right end co-ordinate of the bridge is 804315.468 mE, 2524779.780 mN (22.803127°N, 89.964247°E) and left end co-ordinate of the bridge is 804615.46 mE, 2524779 mN (22.803072°N, 89.967167°E). The orientation of the bridge should be as shown in Section 5.5 of Chapter Five;

- The design discharge for the bridge and bridge substructure is 4600 m^3/s;
- The design water level for the bridge and bridge substructure is 3.22mPWD;
- The standard high water level (SHWL) is 2.80 mPWD and the standard low water level (SLWL) is -0.45;
- The approach road formation level at access road and at abutment is 4.12 mPWD and 13.62mPWD respectively. The length of the approach road is 475m;
- The bottom level of the bridge girder should be kept at 15.63 mPWD;
- The bridge deck level at centerline of the bridge is 18.63mPWD;
- The main bridge consists of two equal middle spans of 110m and two 40m spans on either sided. The above-mentioned span arrangement has been provisionally decided upon with input from the RHD and will be finalized during the feasibility and design stages, taking into account a range of technical matters;
- The design scour level at the abutment is -16.54mPWD. The bottom level of pile foundation for the abutment should be placed well below this level;
- The design scour level for the bridge pier is suggested to be -29.7mPWD. The bottom level of the pile foundation should be set well below this level;
- The Kaliganga is a part of complex tidal river system. The planform of the parent river (Goari, kumer etc.) has undergone substantial changes and the off-take position is shifted in the past. The orientation of any off-taking river to its parent river has large bearing on flow and sediment distribution. Therefore, there is a degree of uncertainty in the future morphological developments at and around the proposed bridge location;
- It is highly unlikely that any loop cut-off may occur in the near future in the upstream and downstream of the proposed bridge location;
- In order to ensure long-term safety of the bridge bank protection works in the form of bank revetment may be undertaken in the upstream and downstream of the proposed. The suggested length of the bank revetment along the right and left bank of the bridge is 150m and 50m respectively. The position of the bank revetment and its preliminary design drawings will be furnished in the Final Report;
- The slopes of the approach embankment should be protected against uncertain calamities. The protection work along both the right and left approach road is extended up to a distance of 20m. The preliminary design drawings of the abutment protection and approach embankment side slope protection works will be furnished in the Final Report;
- The weighted average of the three options with consideration of multiple criteria has been presented in Section 4.2 of Chapter 4. Out of 80, option-1 scored 56, option-2 scored 52 and option-3 scored 62. Therefore, the hydro-morphological study team of the RRI and the Bridge Management Wing of the RHD have concluded that option-3 is the best option.
- The needed length of approach road on each side of the bridge is 475m.
- The proposed bridge is aligned more or less perpendicular to the flow direction.

Recommendations

- The bridge may be constructed at the suggested location. The length of the main bridge may be considered as 300m;
- The suggested hydrological and hydraulic design parameters of the bridge may be considered;
- Option-3 may be considered as more appropriate alignment for bridge and link road (approach road and access road);
- The suggested bank and approach road slope protection works may be considered in the light of the preliminary design drawings furnished under this study;
- The developments in the river channel at the bend locations in the immediate upstream and downstream of the proposed bridge should be monitored very closely; and
- Technical assistance of River Research Institute may be sought for monitoring of hydraulic and morphological conditions in the vicinity of the bridge.

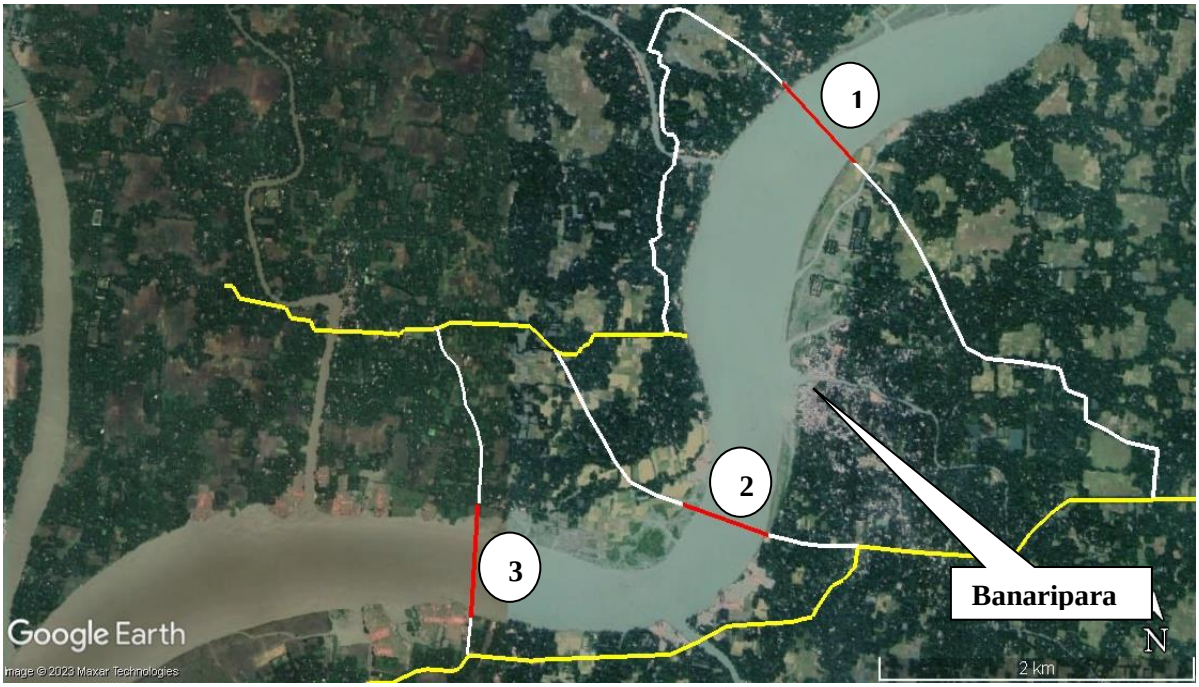
Hydro-Morphological Study of the Bishkhali bridge at 6th km of Binapani-Kachua-Betagi-Mirjaganj Patuakhali Highway (Z-8052) on the Bishkhali river under Roads and Highways Department

Construction of Banaripara Bridge is a shortlisted task for Roads and High Ways Department (RHD) to construct over the Sandha river at 2nd Km of Banaripara - Najirpur Highway (7710) for uninterrupted road communication between Banaripara upazila of Barishal district and Najirpur upazila of Pirojpur district as a part of 5 year plan of the Roads and Highways Department (RHD) for the construction of bridges/culverts of 37,500 meters in length, reconstruction of bridges/culverts of 4100 meters in length, etc. The new targets will ensure an uninterrupted highway network by identifying and connecting the missing links of the road network. For implementation of aforementioned program RHD has taken up a few consultancy services for feasibility studies and detailed designs of many bridges under different zones. Bridge Construction and Maintenance circle of RHD has prepared a shortlist of bridges needing replacement and reconstruction. Among these bridges, feasibility studies of two proposed bridges under the Barishal zone, one is the Banaripara bridge over the Sandha River, have been started. Considering the channel gap, the Banaripara bridge of 700 meters long.

Road Division, RHD, has decided to conduct a comprehensive hydro-morphological study "Hydrological and Morphological Study for proposed Banaripara Bridge over the river Sandha at 2nd km of Banaripara - Najirpur Highway (7710) under Barishal Road Division" for planning and design support of the bridge and associated river training works, if any. The Terms of Reference (ToR) of the study intend an in-depth hydraulic and morphological modeling program as a means of obtaining the necessary information for providing the hydraulic design of the proposed bridge, approach road of proposed bridge and its associated river training work (RTW). The proposed study will focus on the detailed hydrological and morphological conditions of the Sandha River in determining a suitable location for the bridge, alignment of the bridge, bridge opening, hydraulic design variables of the bridge piers, abutment/guide bund, formation level of the approach road at bridge abutment and access road, type of road slope protection works, if required etc. In addition to this, this study should also investigate the threat of bank failure adjacent to the proposed road bridge and thus suggest suitable type and properly aligned river training works, if required. Along with the determination of the necessity of river training works (RTW), this proposed study should provide the hydraulic design variables for this protective work.

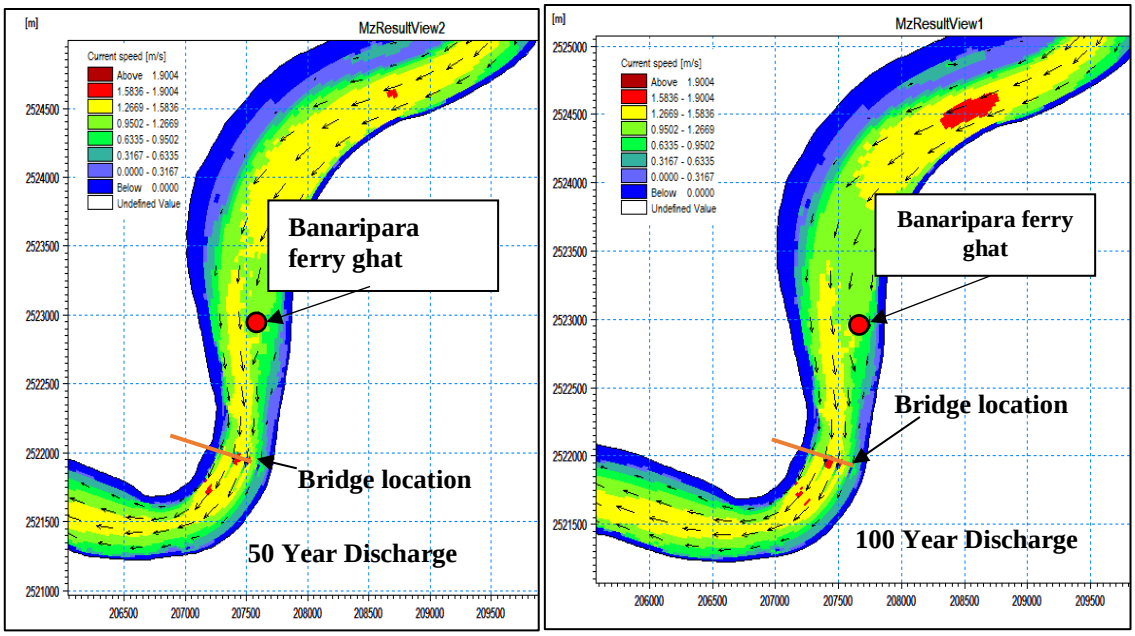
Bridge hydraulics in tidal waterways must account for the various sources of flow. These include upland floods, normal upland daily flows, tides, currents, storm surges and winds. The stability of the tidal waterways must also be considered. Contraction scour can occur at constrictions to flow and local scour can occur at obstructions to flow. All these processes must be considered in the design and evaluation of bridge crossings in tidal waterways.

Based on the analysis of field data and historical satellite images three likely more or less stable locations have been identified where the proposed bridge could be sited. Loation-1 is upstream of the Banaripara ferry ghat whereas Location-2 and Location-3 are downstream of the same. The hydrodynamic assessment is made focusing on these three likely bridge locations. An examination of physical features in the study area indicates that if Location 3 is selected as bridge location the link roads on right sides of the bridge are to cross some existing khals and other drainage roots. Moreover, the length of the link road (approach road and access road) will be much longer compared to that for other. No other benefit is comprehensible if the bridge is sited at Location 1. Therefore, Location 3 may be discarded as a feasible bridge location for further analysis. However, both Location 1 and Location 2 are not much away from the existing and planned RHD roads and the bridge at any of these two locations can be connected with the existing road without opting for a long link road. However, relocation of existing homesteads and facilities may not be completely avoided for construction of the link road.



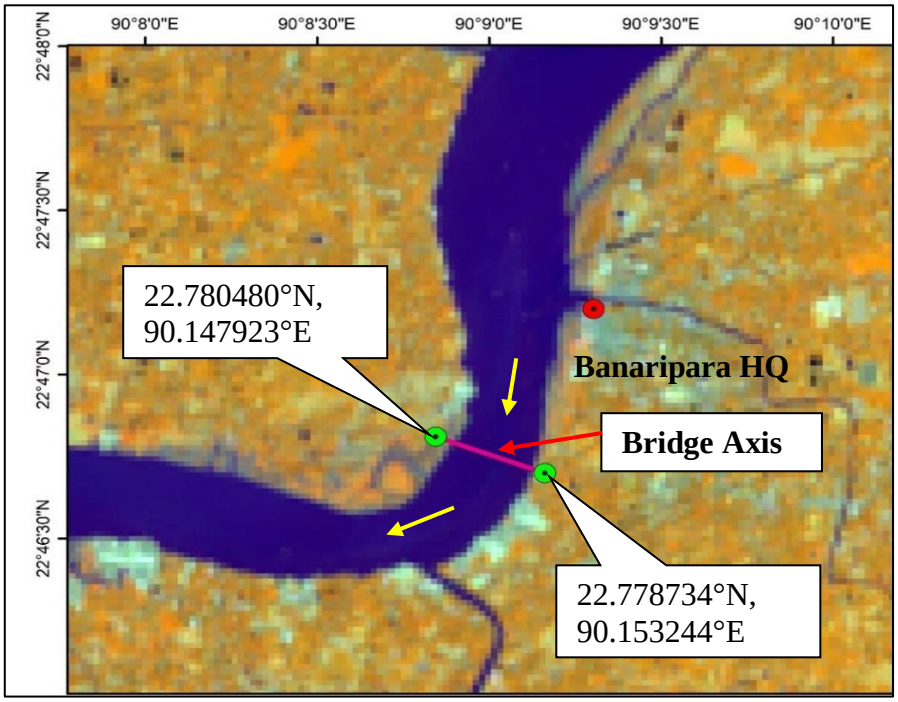
Likely bridge and link road alignment at three alternative bridge locations

The study team came to the decision to suggest a location for the proposed Banaripara bridge after analysis of the survey data and interaction with RHD design team and design consultant at option-2 which is about 1000m downstream from the Banaripara ferry ghat.



Velocity field at and around the bridge for 50 year and 100 year return period discharges

Generally, the orientation of the bridge should be perpendicular to the flow direction. It reduces bridge constriction and thereby, reduces scour depth around the bridge piers and abutments. The considered site for the bridge is mostly agricultural land and some houses were observed during the field visit. There is no expensive structure was observed in the site. So, bridge alignment can avoid skew and placed at right angle to the river flow. Right end co-ordinate of the bridge is 207159.02 m E, 2522043.82 m N (22.780480° N, 90.147923° E) and Left end co-ordinate of the bridge is 207702.92 m E, 2521839.92 m N (22.778734°N, 90.153244°E). The position and orientation of the bridge are shown below.



Proposed position and orientation of the Banaripara bridge

Objectives of the Study

Hydro-morphological study of a river is an essential part of the feasibility study and detailed design. Flood discharge highest flood level, velocity, depth, flow area, flood frequency, historic flow route of river, sediment load and characteristics, bank and bed erosion characteristics are the important parameters obtained from hydro-morphological study. The study should be based on detailed hydrological, morphological and hydraulic analysis of the river system, using mathematical modelling to determine the width of the opening of this bridge, required slope protection work of the approach road and river bank protection and computation of design flood discharge, design flood level etc. The Hydro-morphological study with the following Service:

To determine the actual width of opening of the bridges;

To determine the discharge of water flow of the catchment area near the bridge site, passing under this bridge before, during and after the rainy season so that the bridge approach is permanently stable from erosion caused by heavy wave action; and

To design slope of protection work, if required of the approach road and river bank within the vicinity of the bridge.

Conclusions

- Analysis of satellite images and recent cross-section data and model results show that there is both lateral and vertical stability problems at the bend locations in the immediate upstream and downstream of the
- Proposed bridge location. The river is more or less stable at the proposed bridge location in terms of bank erosion;
- The thalweg profile in the vicinity of the proposed bridge shows the potential for large bed degradation at the meander bends in the upstream and downstream of the bridge location. The minimum bed level along the bridge axis is -22.71mPWD whereas the minimum bed level over the study reach is found -31.5 mPWD, which is about 6700m downstream of the bridge location;
- This hydro-morphological study considered a bridge having a length of 1,300m with viaduct at both sides (main bridge: 580m and viaduct 720m). The right end co-ordinate of the main bridge is 207159.02 m E, 2522043.82 m N (22.780480° N, 90.147923° E) and Left end co-ordinate of the bridge is 207702.92 m E, 2521839.92 m N (22.778734°N, 90.153244°E). The Roads and Highways Department provided the design information, including the length. For the selected Option-2, which is located approximately 1000m downstream from the existing Banaripara ferry ghat.
- The standard high water level (SHWL) is 2.77 mPWD and the standard low water level (SLWL) is 0.06 mPWD;

- The approach road formation level at access road and at junction with viaduct is 4.19 mPWD and 15.77mPWD respectively. The length of the approach road is 580 m in both sides of the bridge;

- Suggested bottom level of the bridge girder at the center of the bridge is 21.70mPWD;

- The main bridge consists of one 110m long span in the middle, four 90m long spans (two spans on each side of the middle span) and two 55m long spans (one span on both side after 90m spans). There will be 24 (twenty four) viaducts (twelve in the left side and twelve in the right side) of 30m length each. The above-mentioned span arrangement has been provisionally decided upon with input from the RHD and will be finalized during the feasibility and design stages, taking into account a range of technical matters.

- The design scour level for the bridge pier is suggested to be -39.99mPWD. The bottom level of the pile foundation should be set well below this level;

- The design scour level at the abutment is -18.68mPWD. The bottom level of pile foundation for the abutment should be placed well below this level;

- In order to ensure long-term safety of the bridge bank protection works in the form of bank revetment may be undertaken in the upstream and downstream of the proposed bridge. The suggested length for the bank revetment along the right bank is 75m (50m upstream and 25m downstream of the bridge axis). On the other hand, the same along the left bank is 150m (100m upstream and 50m downstream of the bridge axis). There should be provision for appropriate end termination of the revetment works;

- The slopes of the approach embankment should be protected against current under an unforeseeable extreme event. The protection work along the right approach road may be extended up to a distance of 50m and the same for the left abutment is 40m.

Recommendations

- The bridge may be constructed at the suggested location. The length of the main bridge may be considered as 580m and the length of viaduct 720m (360m on each side of the bridge). However, the length and other design arrangement can be revisited during the detailed design/construction stage;

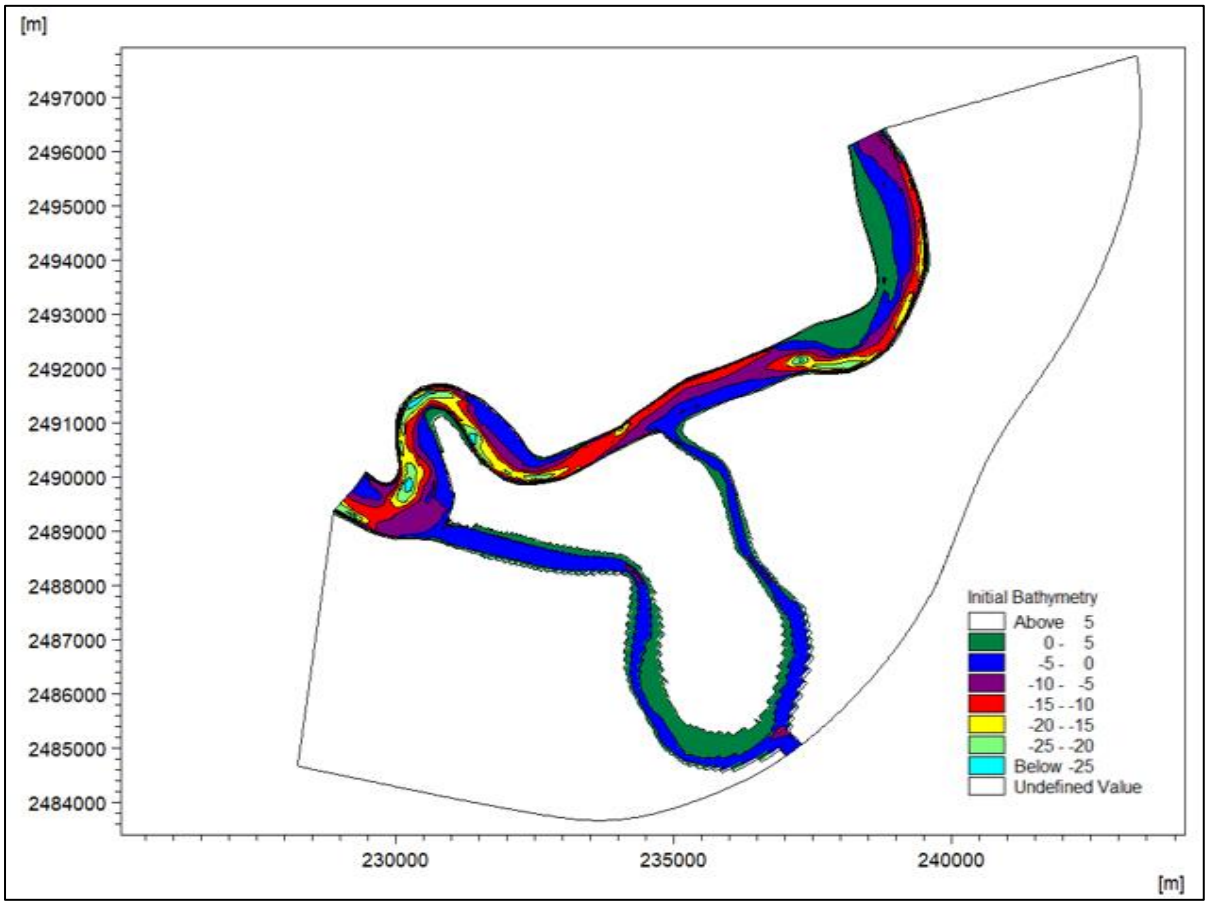
- Technical assistance of River Research Institute may be sought for monitoring of hydraulic and morphological conditions in the vicinity of the bridge.

Hydrological and Morphological study for the Proposed Laxmipasha Bridge at 23rd km of Barisal (Dinarer Pul)- Laxmipasha-Dumki highway (Z-8044) on the Porar Dhon River under Roads and Highways Department.

Barisal district is located in the South-Central Region (SCR) of Bangladesh. The Barisal (Dinarerpul)-Laxmipasha-Dumki Road is an important and the shortest way of road communication for the people of the area with Patuakhali, Barisal and Dhaka. The Porar Dhon River would be crossed on this road by the proposed Laxmipasha Bridge, facilitating a smoother connection in the region. A good number of villages, bazaars and trade centres are connected to this zilla road through LGED and other union and village roads. The traffic volume on this road is significant and the number of light and heavy vehicles is increasing day by day. After completion of the project vehicles will be able to move safely. Better marketing opportunities will be opened and farmers will get fair price of their products. It will immensely contribute to the overall economic growth of the area. At present Ferry service has been provided by RHD to cross the river.

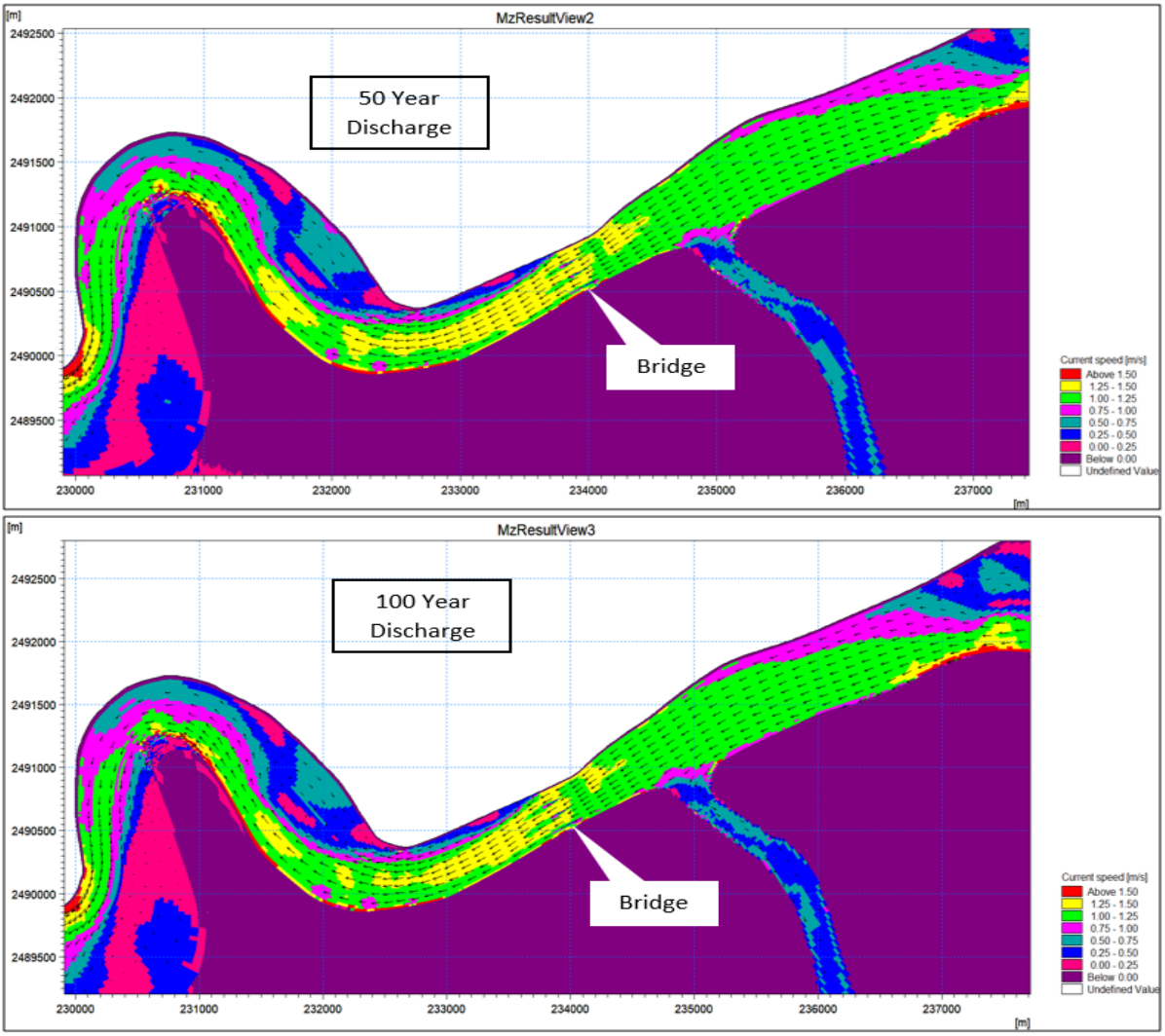
The Porar Dhon River is a meandering, dynamic and tidally affected river. Porar Dhon River originates from lower Meghna River and travels in the downstream as naming the Paira River and then spills directly to the Bay of Bengal naming Buriswar in its lower end. Like other coastal rivers, river Porar Dhon is associated with strong tidal current, salinity and waves. Fine sediment is transported by tidal currents into the sea. Therefore, selection of a suitable bridge location and bridge waterway opening requires detailed verification of likely hydrological scenarios and the present erosion trend as well as future likely river plan form development. On the other hand, due to tidal influence, determining hydraulics of scour depths and river training works would require special consideration of the steepest recession of flood. The hydrology of the study area is very complicated as four types of climatic factors influence its hydrology. These climatic factors are cyclonic surge, tidal flow, monsoon flow and sea level rise due to global warming. Thus, to investigate the combined effect of these four factors are very important to determine the vertical clearance and horizontal clearance of bridge. Implementation of the proposed bridge may cause adverse impact on tide, sedimentation and erosion. Therefore, these issues should be addressed carefully. Under the above situations, Roads and Highways Department (RHD) commissioned River Research Institute (RRI), Faridpur to carry out study undertaken by Bridge Construction and Maintenance Circle,

RHD. Necessary hydrological and sediment data have been collected through a field survey campaign. Historical hydrological data of the rivers concerned and satellite images of the study area have been collected from available sources. The collected data have been processed and analysed to the extent of deriving necessary inputs for the MIKE21C model to be developed for hydraulic analysis of bridge and other information relevant to the proposed bridge. The initial bathymetry of the model is formed by use of the recently surveyed bathymetric data.



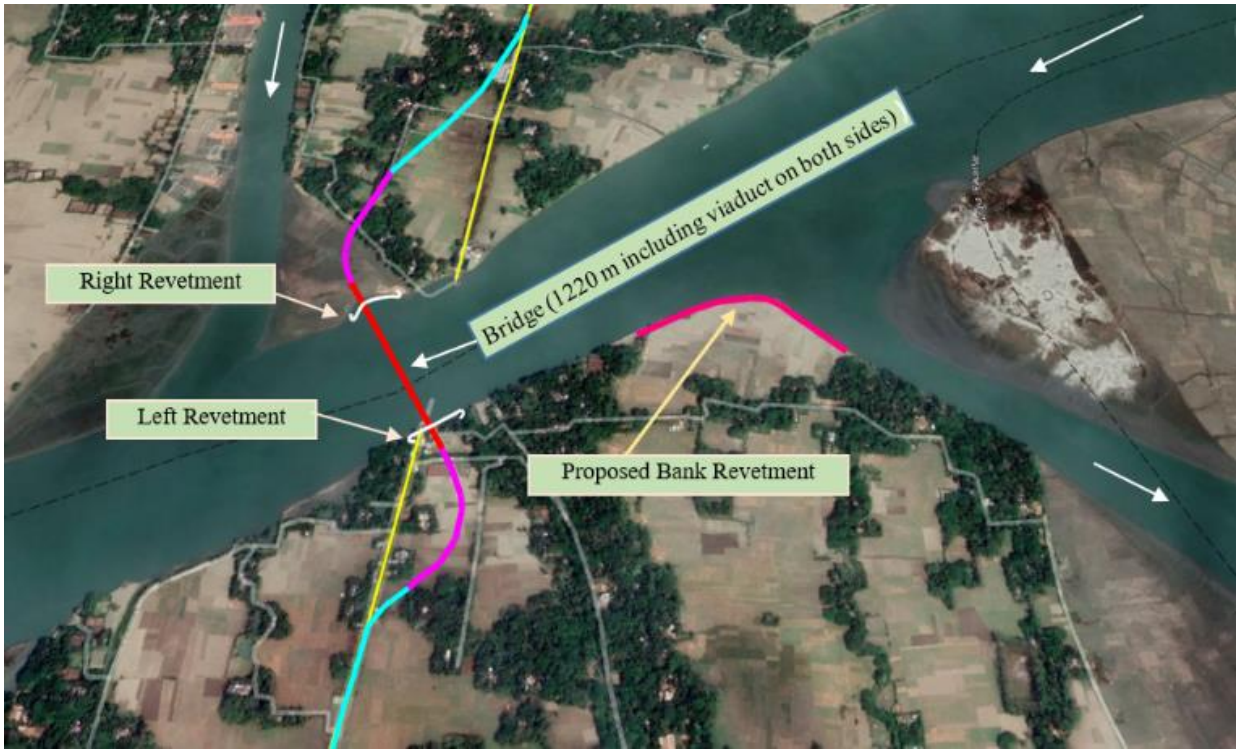
Initial bathymetry of the model

Based on the model results, it appears that flow patterns are almost similar for 100 year and 50 year discharges, with the only difference being a bit higher velocity for the higher discharge. The major flow occurs along the right bank of the river just upstream of the likely bridge location after then towards left bank for all discharges. The bridge may increase the flow velocity along the outer bank of the immediate upstream and downstream bends, which speeds up bank erosion. The velocity distributions for different return period discharges are shown below. Examination of historical satellite images of the study area and consultations with the people point to the fact that substantial bank erosion did occur upstream and downstream of the Laxmipasha ferry ghat, and at present the rate of erosion is rather low. Moreover, the constriction caused by the bridge piers may cause an increase in the flow velocity at and in the immediate upstream and downstream of the bridge. For this reason, to understand the complex fluvial processes of the river, to guarantee safety against flooding and bank erosion regular monitoring of the river should be maintained.



Velocity field at and around the proposed bridge location for different return period discharges

In consideration of long term safety of the bridge, bank protection works in the form of bank revetment or guide bund has been proposed along the both banks in the river. The river has been experiencing erosion and accretion along both banks, resulting in a noticeable shift in its off-take position, which has moved approximately 1.6 km over the past few decades. Therefore, it is crucial to apply bank protection measures at the current off-take position of the river to safeguard against further shifting. The suggested bank revetment works with bridge orientation are presented below.



Placement suggested bank with proposed bridge location in the Porar Dhon river

Objective of the Study

Hydro-morphological study of a river is an essential part of the feasibility study and detailed design. The overall objective of the proposed study is to determine the suitable location of bridge along with alignment of approach road and to provide the hydraulic design and approach road including river training works, if required from hydrological and morphological considerations. The specific objectives are as follows:

- To determine the actual width of opening of the bridge.
- To determine the discharge of water flow of the catchment area near the bridge site, passing under this bridge before, during and after the rainy season so that the bridge approach is permanently stable from erosion caused by heavy wave action.
- To design slope protection work, if required of the approach road and river bank within the vicinity of the bridge.
- To conduct Environmental Impact Assessment (EIA) of the bridge.

Conclusions

- Analysis of satellite images and recent cross-section data and model results show that there are both lateral and vertical stability problems at the bend locations in the immediate upstream and downstream of the proposed bridge location. The river is more or less stable at the proposed bridge location in terms of bank erosion;
- The thalweg profile in the vicinity of the proposed bridge shows the potential for large bed degradation at the meander bends in the upstream and downstream of the bridge location. The minimum bed level along the bridge axis is -14.87mPWD whereas the minimum bed level is found -29.41 mPWD, which is about 3,240 m downstream of the bridge location.
- This hydro-morphological study considered a bridge having a length of 1,220 m, including viaducts on both sides. The Roads and Highways Department provided the design information, including the length. The bridge location is approximately 250m downstream from the existing Laxmipasha ferry ghat, the right end coordinate of the bridge is 233859.9E (22.506868°), 2491233.31N(90.412965°), and the left end coordinate of the bridge is 233992.45E(22.497233°), 2490163.45N(90.414436°).
- The design discharge for the bridge and bridge substructure is 6661 m^3/s and 6853m^3/s respectively;

- The design water level for the bridge and bridge substructure is 3.32 mPWD; The standard high water level (SHWL) is 2.44 mPWD and the standard low water level (SLWL) is -0.45 mPWD;

- The approach road formation level at access road and at junction with viaduct is 4.22 mPWD and 16.87mPWD respectively. The length of the approach road is 632.5m in both sides of the bridge and the bottom level of the bridge girder at the center of the bridge should be kept at 21.37 mPWD;

- The main bridge consists of two 110m spans in the middle and 90m and 50m spans on either side. A total of 24 viaducts, 12 on the left side and 12 on the right side, each measuring 30m in length, have been considered. The above-mentioned span arrangement has been provisionally decided upon with input from the RHD and will be finalized during the feasibility and design stages, taking into account a range of technical matters.

- The design scour level at the abutment is -17.78mPWD. The bottom level of pile foundation for the abutment should be placed well below this level and the design scour level for the bridge pier is suggested to be -28.53mPWD. The bottom level of the pile foundation should be set well below this level;

- There is a degree of uncertainty in the future morphological developments at and around the proposed bridge location; In order to ensure long-term safety of the bridge bank protection works in the form of bank revetment may be undertaken in the upstream and downstream of the proposed bridge. The suggested length of the bank revetment along the right bank is 130m (90m upstream & 40m downstream from bridge alignment) and bank revetment along the left bank is 125m (75m upstream & 50m downstream from bridge alignment) respectively. Also, the suggested length (excluding curved termination) of bank revetment at the off-take position (covering an extant of 330m of the left bank of Porar Dhon river and an extent of 220m of the right bank of Karkhana river) is 550m.

Recommendations

The bridge may be constructed at the suggested location. The length of the bridge may be considered as 1,220m (including viaducts on both sides). However, the length and other design arrangement can be revisited during the detailed design/construction stage.

- The suggested hydrological and hydraulic design parameters of the bridge may be considered;
- The suggested bank, abutment and approach road slope protection works may be considered in the light of the preliminary design drawings furnished under this study;

- The developments in the river channel at the bend locations in the immediate upstream and downstream of the proposed bridge should be monitored very closely; and

- Technical assistance of River Research Institute may be sought for monitoring of hydraulic and morphological conditions in the vicinity of the bridge.

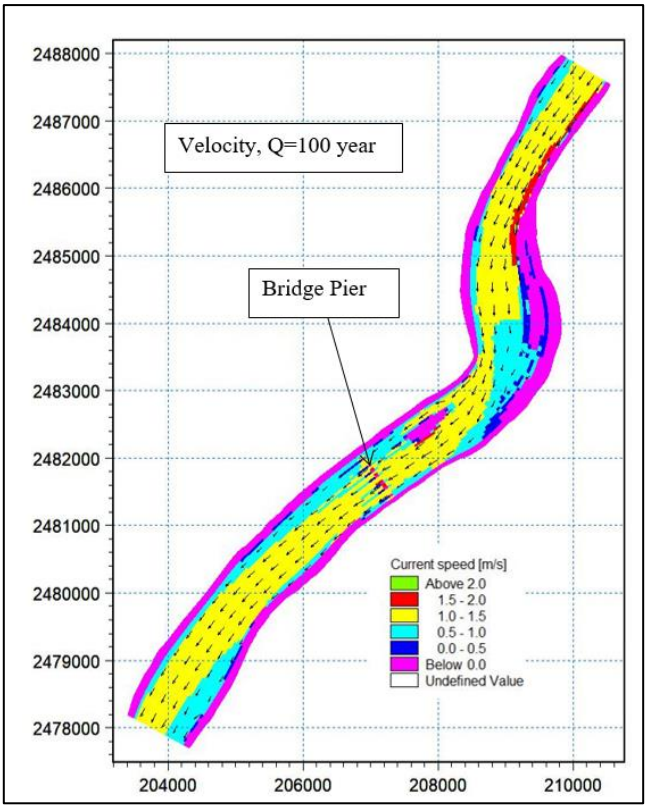
Hydrological and Morphological Study for the Proposed Banaripara bridge at 2nd km of Banaripara (Danduat)- Nazirpur Highway (Z-7710) on the Sandhya River under Roads and Highways Department.

Barishal division is located in the south-central region of Bangladesh. Barishal,Patuakhali, Barguna, Jhalokathi and Pirojpur are five districts under Barishal division where many polders are located. The proposed Bishkhali Bridge is at 6th km of Binapani - Kachua-Betagi-Mirjaganj - Patuakhali Highway (Z-8052) on the Bishkhali river under RHD. Binapani - Kachua - Betagi - Mirjaganj - Patuakhali Road is a RHD zilla road (Z-8052) which starts from Binapani of Kanthalia upazila under Jhalokathi district and connect with the Patuakhali district. This road is the shortest way of road communication for the people of the area with Barguna, Patuakhali, Pirojpur and Jhalokathi. The location of the proposed roadway bridge is at around Shouljalia - Betagi ferry ghat over the Bishkhali river. The river system at and around Bishkhali is complex. At present Ferry service has been provided by RHD to cross the river.

The Bishkhali is a meandering, dynamic and tidally affected river. Bishkhali river is the continuation of the Kirtonkhola and Nalchity rivers. The Arial Khan picks up the name 'Bhasani Char' as it enters into Bhasani Char of the Barishal sadar upazila. Similarly, it changes her name as the Kirtankhola at 5 km north of Barisal town, as Nalchity in Nalchity upazila under Jhalokati district and turns into Bishkhali after entering Jhalokati town. At this point, after creating a great meander the river flows south into the Bay of Bengal. The Bishkhali receives the water of the Madhumati and Katcha through the Kaukhali and the Gabkhan Khal joining with the river near the meander. The river maintains a connection with the Burishwar river system through the Bakdugh, Ayla, etc at the lower reach of Bamna upazila and falls into

the Bay of Bengal through the mouth of the Baleswar - Haringhata at 13 km down of Patharghata. The total length of the river is 96 km. The average width of the river from its origin to first 30 km is about 1 km and the rest is about 2 km. The average depth is about 16m. Like other coastal rivers, river Bishkhali is associated with strong tidal current and waves. Fine sediment is transported by tidal currents into the sea.

The river falls within the coastal boundary of the country which comprises of extensive flat coastal and deltaic land of the Ganges delta and crossed by large tidal rivers discharging into the Bay of Bengal. Therefore, selection of a suitable bridge location and bridge waterway opening requires detailed verification of likely hydrological scenarios and the present erosion trend as well as future likely river plan form development. On the other hand, due to tidal influence determining hydraulics of scour depths and river training works would require special consideration of steepest recession of flood. The hydrology of the study area is very complicated as four types of climatic factors influence its hydrology. These climatic factors are cyclonic surge, tidal flow, monsoon flow and sea level rise due to global warming. Thus, to investigate the combined effect of these four factors are very important to determine the vertical clearance and horizontal clearance of bridge. Implementation of the proposed bridge may cause adverse impact on tide, sedimentation and erosion. Therefore, these issues should be addressed carefully.



Velocity fields at and in the vicinity of the likely bridge at location for 100 year return period discharge

Under the above situations, Roads and Highways Department (RHD) commissioned River Research Institute (RRI), Faridpur to carry out study undertaken by Bridge Construction and Maintenance Circle, RHD. A contract was signed between RRI and RHD to this end on June 28, 2022. The study has been carried out in the light of the Terms of Reference (ToR). Necessary hydrological and sediment data have been collected through a field survey campaign. Historical hydrological data of the rivers concerned and satellite images of the study area have been collected from available sources. The collected data have been processed and analysed to the extent of deriving necessary inputs for the MIKE21C model to be developed for hydraulic analysis of bridge and other information relevant to the proposed bridge.

Objectives of the Study

- To determine the actual width of opening of the bridges;
- To determine the discharge of water flow of the catchment area near the bridge site, passing under this bridge before, during and after the rainy season so that the bridge approach is permanently stable from erosion caused by heavy wave action;

- To design slope protection work, if required of the approach road and river bank within the vicinity of the bridge.

- To conduct Environmental Impact Assessment (EIA) of the bridges.

Conclusions

- In the study reach the river flows through Ganges tidal floodplain physiographic units. The sediments are mainly non-calcareous clays but they are silty and slightly calcareous on riverbanks Bank erosion does occur there but at a slow pace. Mass wasting is the mechanism of bank failure;

- Analysis of satellite images and recent cross-section data and model results show that there is both lateral and vertical stability problems at the bend locations in the immediate upstream and downstream of the Betagi-Shouljalia ferry ghat. Betagi-Shouljalia ferry ghat is located at the inflection point of two consecutive meander bends. The river is more or less stable at the crossing in terms of bank erosion;

- The proposed bridge over the Bishkhali river should be located at the inflection point between two consecutive meander bends at and around the Betagi-Shouljalia ferry ghat;

- The river is embanked against tidal and monsoon flooding of the low lying floodplain. It appears that the river is still under process of self-adjustment in response to human intervention;

- The thalweg profile in the vicinity of the proposed bridge shows the potential for large bed degradation at the meander bends in the upstream and downstream of the bridge location. The minimum bed level along the bridge axis is -17.28mPWD whereas the minimum bed level at the bend locations is as low as -24.76mPWD;

- The selected length of the main bridge is 880m. The total length of the bridge including viaduct is 1480m. The orientation of the main bridge should be as shown in Section 5.5 of Chapter 5. Right end co-ordinate (UTM) of the main bridge is 206830.83E, 2482091.56N; Left end co-ordinate (UTM) of the main bridge is 207324.50E, 2481362.82N; Right end co-ordinate (UTM) of the viaduct is 206648.07E, 2482330.10N; Left end co-ordinate (UTM) of the viaduct is 207451.41E, 2481090.83N;

- The proposed bridge is aligned at an angle of about 3^{o} with the river;

- The design discharge for the bridge and bridge substructure is 9950 m^3/s;

- The design water level for the bridge and bridge substructure is 4.19mPWD;

- The standard high water level (SHWL) is 2.36mPWD and the standard low water level (SLWL) is -0.40mPWD;

- The recorded lowest water level (LWL) at the end of December 2022 is -0.20mPWD;

- The approach road formation level at access road and at viaduct end is about 5.09mPWD and 14.84mPWD respectively. The length of the both side approach road is about 488m;

- The bottom level of the bridge girder (soffit level) should be kept at 21.29mPWD;

- Eight spans of the main bridge length about 880m may be considered. The length of each span is about 110m. On the other hand, for 600m long viaduct 20 equal spans having 30m length of each span may be considered;

- The design scour level at the abutment is -18.18mPWD. The bottom level of pile foundation for the abutment should be placed well below this level;

- The design scour level for the bridge pier is suggested to be -34.52mPWD. The bottom level of the pile foundation should be set well below this level;

- It is highly unlikely that any loop cut-off may occur in the near future in the upstream and downstream of the proposed bridge location;

- In order to ensure long-term safety of the bridge bank protection works in the form of bank revetment may be undertaken in the upstream and downstream of the proposed bridge. Bank protection works in the form of bank revetment has been proposed for left bank in the upstream of the proposed bridge is 200m and in the downstream of the proposed bridge is 50m. On the other hand, bank protection works in the form of bank revetment has been proposed for right bank in the upstream of the proposed bridge is 100m and in the downstream of the proposed bridge is 100m. The preliminary design drawings of the bank revetment have been furnished in the Appendix-I;

- The slopes of the approach embankment should be protected against any unforeseen calamity.

The protection work along both sides of the approach roads may be extended up to a distance of 30m;

- Among the three options for bridge and link road (approach road and access road) option-01 appears to be most suitable and therefore, is suggested for implementation of the bridge. The needed length of the approach road on each side of the bridge is 488m; and

- The link road roads (approach and access) on both sides of the bridge will encounter existing drainage routes. In order to facilitate smooth drainage, it is suggested to provide road structures on the proposed link roads where necessary.

Recommendations

- The bridge may be constructed at the suggested location. The length of the bridge may be considered as about 1480m (880m main bridge and 600m viaduct) which can be finalized by the design Engineer;

- The suggested hydrological and hydraulic design parameters of the bridge may be considered;

- Option-01 may be considered as appropriate alignment for bridge and link road (approach road and access road);

- The suggested bank, abutment and approach road slope protection works may be considered in the light of the preliminary design drawings furnished under this study;

- The developments in the river channel at the bend locations in the immediate upstream and downstream of the proposed bridge should be monitored very closely; and

- Technical assistance of River Research Institute may be sought for monitoring of hydraulic and morphological conditions in the vicinity of the bridge.

Proposals for physical and mathematical model study

- During the 2022-23 financial year, RRI has submitted a number of technical and financial proposals to different clients for physical and mathematical model studies. Besides, RRI is in close contact with different organizations for taking up studies to address different water related problems and to devise sustainable solutions. Some of the proposed studies are mentioned hereafter.

- Physical Modelling Study in connection with "Detailed Study for Restoration and Development of Water Resources Management System of Polder 31 under Dacope Upazila in Khulna District".
-
- Hydro-Morphological Study for construction of Old Shibsa Bridge over the Old Shibsa River at 2nd Km of Paikgacha-Soladana-Batiaghata Road (Z-7608) under Road Division, Khulna.
-
- Hydro-Morphological Study for construction of Moyur Bridge-2 over the Moyur River at 4th Km of Bangabondhu Economic Zone under Road Division, Khulna.

Introducing Drone Technology

Adaptation to technology has a great importance for better understanding of relevant process in context of research and study. For sake of this River Research Institute has introduced drone technology to take aerial images of study area, physical model pictures, bank line of rivers.

Aerial view of study area captured by drone

Aerial view of bamboo bandal captured by drone, Isalmpur, Jamalpur




GEO-TECHNICAL RESEARCH

Geo-technical Research Directorate comprises of three divisions. These are Soil Mechanics and Groundwater Eastern & Western Zone division (Soil mechanics division), Material Testing & Quality Control division and Sediment, Chemical & Water pollution division. The scope of works and facilities available in each division are narrated in the following sections.

Soil Mechanics and Ground Water Eastern & Western Zone (Soil Mechanics Division)

Soil Mechanics and Groundwater Eastern and Western Zone of Geo-technical Research Directorate is an utmost important wing of RRI. It has been conducting tests and research work for the determination of different physical parameters of soils which are required for planning and design of the infrastructures of flood control, irrigation, drainage, water development and other development projects. Ground Water Circle (GWC) of BWDB and other organizations explore site and complete their boring and collect soil samples from different project sites in connection with construction of hydraulic structures like bridges, dams, barrages, regulators, sluices, weirs, flood control and river training works and other relevant works. Site investigation and boring logs are prepared by them are sent to RRI with collected samples. RRI has developed sufficient laboratory facilities for testing of soil samples received from the clients. The soil samples of these zones are tested with great care by the scientists and trained / skilled soil technicians. Finally, the reports on the tested soil samples are prepared based on field investigation and laboratory analysis of data. The reports focus on the engineering characteristics of the soil samples according to the foundation needs. Then the approved report is sent to the respective clients along with bill. The works executed in connection with soil testing, analysis and publication of reports during 2022-2023 have been discussed briefly in this section.

Receiving procedure of soil samples

The disturbed soil samples were collected by driving split spoon sampler and undisturbed soil samples in Shelby tubes by the clients and sent to the Soil Mechanics and Groundwater laboratory of Geo-technical Research Directorate of RRI. A total 483 nos. of samples from GWC of BWDB and other organizations in fiscal year 2022-23 were received in the laboratory. All the samples were tested and reports were sent to the respective clients.

Testing of soil samples

At first all the soil samples are visually examined in the laboratory and representative samples are selected for necessary testing. Generally, tests are conducted for determining Natural Moisture Content (NMC), Grain Size Distribution, Atterberg Limits, Density (γ), Void Ratio (e), Compression Index (Cc), Unconfined Compressive Strength (q_u), Shear Strength (cohesion c and angle of internal friction Φ), by Direct Shear, Tri-axial Shear with or without pore pressure, California Bearing Ratio (CBR) value and Permeability value etc. As per planned schedule, different tests are performed simultaneously in order to work out all necessary parameters quickly within the shortest possible time. Other necessary soil parameters are also tested according to client's requirements.

Sample preparation for Limit test of disturbed soil samples (left) Compaction testing Electro Mechanical Instrument (right)

List of samples received (project-wise in chart), billed amount and volume of work executed during 2022-23 in Soil Mechanics & Ground Water Division

Sl No.	Report No.	Name of Division / Client	Name of Project/Work	No. of Sample Received & Tested	Billed amount (Taka)
01	01 (2022-2023)	Mr.kamruzzaman Nayem. Southern Engineering & technology,flat A 5. H#35.R#02.S#13.Uttara , Dhaka.	Larsen & toubro Limited is constructed river crossing towers over Rupsha River near Botiyaghata, Khulna.	01	6,000.00
02	02 (2022-2023)	Executive Engineer, Sunamganj O & M Division-1, BWDB, Sunamganj.	Construction of Boglakhali regulator (8 vent with Boat pass) under Sunamganj O & M Division, BWDB, Sunamganj.	03	146400.00
03	03 (2022-2023)	Executive Engineer ,Sunamganj O & M Division-1, BWDB, Sunamganj.	Construction of Muchibari regulator (3-vent with boat pass) under Sunamganj O & M Division, BWDB, Sunamganj.	03	116850.00
04	04 (2022-2023)	Sakil Ahmed Engineer, Development Construction Ltd, Uttara model town, Dhaka.	Testing of Soil sample for Design and Build Jetty and other associated works at Mongla port. Under Development Construction Ltd, Uttara Model Town, Dhaka -1230.	08	22800.00
			Total	15	292050.00

Field services of Soil Mechanics and Ground Water Eastern & Western Zone (Soil Mechanics Division)

In order to assist the quality control of earth works of different projects, RRI sends experienced technicians on deputation to the field in response to the request from the project authority (mainly from BWDB).

During the deputation period, technicians are involved in conducting in-situ tests for the on-going projects. During the fiscal year 2022-2023, three trained soil technicians were posted in the different working sites. Technicians are deputed in the field for several quality control works such as Field Compaction, Relative Density, Grain Size, Limit, Natural Moisture Content, Hydrometer, Field Quality Control, Loss-on-ignition etc. at different projects.

Soil Resistivity meter (left) Drilling Rig (right) for sub-surface soil exploration

Material Testing and Quality Control Division

The Material Testing and Quality Control discipline of Geo-technical Research Directorate deals with the determination of physical and engineering properties of concrete and concrete materials normally used for different types of river training works, hydraulic structures and other infrastructures. It also involves 'Laboratory Trial Mix' and computation of concrete mix design to attend particular design strength with materials to be used in the construction works. At present this discipline has two types of working facilities viz. laboratory oriented testing & research facilities and the other is monitoring & evaluation of construction works by conducting field tests and investigations for quality control of concrete to the ongoing projects.

Laboratory activities in 2022-23 fiscal year

During the fiscal year 2022-23, a total of 264 number samples/specimens of cement, sand, shingles/stone chips, bricks, concrete cylinders were received from the different ongoing projects under the different divisions of BWDB and other Govt. and Non-Govt. organizations for conducting tests as specified by the clients.

Category-wise list of samples received from different BWDB Divisions and other organizations during the fiscal year 2022-23

Sl. No.	Name of division/ Other organization/ Field laboratory	Local Sand	Sylhet Sand	Stone Chips	Cement	Concrete cylinder	Concrete Core Block	MS Rod	Brick/ Hollow Brick	Total sample
1	Faridpur O&M Division, BWDB, Faridpur.	3	8	7	7	27	14	15		**81**
2	Sub-Divisions of Faridpur O&M Division, BWDB, Faridpur.	1	1	1	1	6	3	12	3	**28**
3	Magura O&M Division, BWDB, Magura.						5			**5**

Sl. No.	Name of division/ Other organization/ Field laboratory	Local Sand	Sylhet Sand	Stone Chips	Cement	Concrete cylinder	Concrete Core Block	MS Rod	Brick/ Hollow Brick	Total sample
4	Gopalgonj O&M Division, BWDB, Gopalgonj.	2	2	2	2	3				**11**
5	Shariatpur O&M Division, BWDB, Shariatpur.	9	11	11	11	24	0	44		**110**
6	Kustia, O&M Division, BWDB, Kustia.		2	2		6				**10**
7	Meherpur, O&M Division, BWDB, Meherpur.	2	2	1	1					**6**
8	Md. Taufiqur Haider Chowdhury						1			**1**
9	Excecutive Engineer, DPHE, Faridpur.	1		1	1			6	3	**12**
	Total	**18**	**26**	**25**	**23**	**66**	**23**	**77**	**6**	**264**

Name of the Projects, total no. of samples received and billed amount & recovery amount of different BWDB Divisions and other organization during the fiscal year 2022-23.

Sl. No.	Name of division/Other organization/ Field laboratory	Total nos. of sample tested	Billed amount (in Taka)	Recovery (in Taka)
1	Faridpur O&M Division, BWDB, Faridpur.	81	219450	219450.00
2	Sub-Divisions of Faridpur O&M Division, BWDB, Faridpur.	28	47725	47725.00
3	Magura O&M Division, BWDB, Magura.	5	24000	24000.00
4	Gopalgonj O&M Division, BWDB, Gopalgonj.	11	38325	38325.00
5	Shariatpur O&M Division, BWDB, Shariatpur.	110	239925	239925.00
6	Kustia, O&M Division, BWDB, Kustia.	10	14400	14400.00
7	Meherpur, O&M Division, BWDB, Meherpur.	6	21150	21150.00
8	Md. Taufiqur Haider Chowdhury	1	4800	4800.00
9	Excecutive Engineer, DPHE, Faridpur.	12	22975	22975.00
Total		**264**	**632750**	**632750.00**

Recently purchased equipment (supported by IDCB Project, Phase-II) for Concrete and Material Testing Laboratory: Concrete crushing machine (Controls, Italy) (left) and Core cutter machine (Hilti, Switzerland) (right) used for cutting concrete block and extract core.

Field services (Deputation of Technicians)

For quality control of works, a few numbers of trained technicians were deputed in the field in response to the request from the project authority. During the fiscal year 2022-23, three number of technicians were deputed in the different work sites of BWDB.

Sediment, Chemical and Water Pollution division

Sediment, Chemical and Water Pollution division is one of the important testing and research discipline of Geo-technical Research Directorate of RRI. There are two laboratories under this division, namely Sediment Technology laboratory and Chemical and Water Pollution laboratory. Test and analysis of various kinds of sediment samples of different rivers of Bangladesh are being carried out in the Sediment Technology laboratory. The test results are used for planning and designing of hydraulic structures like barrages, drainage channels, irrigation canals, flushing sluices, closures etc. Sediment testing results are also used in physical and mathematical model studies. In the chemical and water pollution laboratory, samples of surface and ground water are being analysed for using water in different purposes.

Test activities during 2022-2023 fiscal year

A total number of 655 samples including general suspended sediment, bulk suspended sediment, river bed and bank soil samples and water samples were received and tested in the sediment technology laboratory as well as chemical laboratory during the fiscal year 2022-2023. The general suspended sediment and bulk suspended sediment samples were collected by the field personnel of 4 (four) measurement divisions under the Surface Water Hydrology Circle-I of BWDB. The samples were collectedas a routine work by the Surface Water Hydrology Circle-I of BWDB. A total of 36 reports were published from this division during 2022-2023 fiscal year.

Category-wise list of samples with the clients

Sl. No.	Name of client	Category of samples	Nos. of samples received and tested
1	Surface Water Hydrology Circle-I of BWDB	General suspended sediment samples	100
2	Surface Water Hydrology Circle-I of BWDB	Bulk suspended sediment samples	190
3	Surface Water Hydrology Circle-I & II of BWDB	Silt samples	23
4	Others	Water samples and soil sample	342
	Total samples		655

Testing Facilities in Chemical and Water Pollution Laboratory

Chemical and Water Pollution laboratory is well equipped laboratory with modern instruments including Atomic Absorption Spectrometer, Spectrophotometer, Gas Chromatography-Mass Spectroscopy,portable Spectrophotometer, portable multi-parameter meter, Aquaculture testing kit, etc. Recently RRI has procured Particle size analyzer,Total Organic Carbon (TOC) analyzer, Carbon-Hydrogen-Nitrogen-Sulphur (CHNS) analyzer, Computerized Microscope Stemi 305andPortable Air Monitoring Systemwith rain gauge for Chemical Laboratory under Institutional Development and Capacity Building (IDCB) Project (Phase-II).These equipment are designed with cutting-edge technology and are ideal for a wide range of applications including environmental, materials, geological, food safety, clinical and petrochemicals purpose.

Portable Air Monitoring System with rain gauge (HAZ SCANNER, Model: HIM-600) is mainly used for EIA purpose. It is noticed that it is used specifically to determine Air particulate matters, humidity, temperature, wind speed with direction etc. Computerized Microscope Stemi 305 is used to determine shape & particle size of soil, bio-physical organism of water samples such as phytoplankton, Zoo plankton etc. Hach Spectrophotometer is used to detect substances such as Al, Ba, B, Cd, Cr, Mg, Fe, Cl, C, Ni, Fl, SO_4, etc. in soil, sediment and water samples. Hach portable colorimeter is used to detect substances in the field as Hach spectrometer does in the laboratory. Portable Multiparameter meter is used to determine pH, DO, EC, TDS, Salinity, etc. from the river. Aqua-culture kit is used to measure Ammonia, Cl^-, CO_2, Hardness, etc. Digital Turbidity meter can be used in this Laboratory to detect turbidity of water samples. TOC analyzer is used to determine the organic and inorganic carbon for water and wastewater samples in mg/l. Particle Size Analyzer is used to determine the particle size soil and sediment samples from 10 nm to 3500 mm. CHNS Analyzer is used to determine the percentage of soil, sediment and water samples.

Besides these, the following facilities also exist in the Chemical and Water Pollution laboratory:

Determination of p^H, arsenic, Salinity electrical conductivity, turbidity, free carbon di-oxide, bi-carbonate, sulphate, chloride, nitrate, sodium chloride, total solid content, hardness, calcium, magnesium, iron, silica, total dissolved solid, dissolved oxygen etc.

Recently procured equipment for Chemical Laboratory: (a) TOC Analyzer, (Shimadzu, Japan) (b) CHNS Analyzer with air purifier, (Perkin Elmer, UK)

Revenue earned from Sediment, Chemical and Water pollution division

A total of Tk. 746175.00 has been billed during the fiscal year 2022-2023 for testing of sediment samples. In total Tk. 465475.00 has been received in this fiscal year 2022-2023 and a total of Tk. 675178.00 is remaining unpaid up to June 2023 in which Tk. 445500.00 is in 2022-2023 fiscal year and remaining Tk. 229674.00 from previous fiscal years from different clients of BWDB and other organisation

Carl Zeiss Stemi 305 Microscope (left) and Portable Air Monitoring System with rain gauge (right) (HAZ SCANNER, Model: HIM-6000) used for environmental analysis

Environment Impact Assessment

Environment Impact Assessment (EIA) is a structured method used to analyse and understand the potential environmental effects that could occur from upcoming projects or activities. Also EIA plays a crucial role in protecting the environment and promoting sustainable development. By identifying potential impacts and proposing mitigating measures, it ensures that projects are designed and implemented in an environmentally responsible manner. In this 20023-24 fiscal year, two EIA study works have been conducted in RRI. One entitled EIA Study for the proposed Bridge at 6th km of Binapani–Kachua–Betagi–Mirjaganj––Patuakhali Highway (Z-8052) on the river by the RHD, another is Hydrological and Morphological Study with an EIA for Atul Nagar Ghat Bridge at 28th K.M. of Pirojpur – Nazirpur – Matibhanga – Patgati–Gonapara Highway (Z-7704) on the Kaliganga River under the Bridge Construction and Maintenance Circle of Roads and Highways Department.

Objectives of the EIA

The objectives of undertaking the Environmental Impact Assessment (EIA) of the proposed Bishkhali Bridge at 6th km of Binapani-Kachua-Betagi-Mirjaganj-Patuakhali Highway (Z-8052) on the Bishkhali river under RHD are to provide baseline data/information, to determine the likely potential environmental impacts (beneficial and adverse) associated with the project activities and to provide mitigation measures. The EIA identify impacts from the project implementation on physical, ecological, biological and socio-economic environment of the project area, and to propose measures to avoid, minimize, mitigate, and compensate such impacts. The specific objectives of the proposed EIA are-

- Assess the impacts on the physical environment (e.g., including meteorological, hydrological, geological components and processes etc.), biological environment (e.g., including flora, fauna, and ecosystems etc.), land use pattern, agriculture practices, cultural activities and Socio-economic environment related with the project activities;
- Public consultations with stakeholders regarding benefits, impacts, alternatives, mitigation measures and environmental management plans;
- Identify major issues that may arise as a result of the proposed project on physical, ecological, biological and socioeconomic environment of the project area and provide a quantitative or qualitative assessment of magnitude of each impact;
- Provide a methodology for prevention and mitigation of expected impacts due to the presence of the project.

Dhaka Laboratory

Dhaka Laboratory was established in October 2021 at 72 Green Road, Dhaka-1205. The laboratory is well-equipped and has the facilities to test soil, sand, sediment, water, and cement samples. The Specific Gravity, Natural Moisture Content, Sieve & Hydrometer Analysis, Unit Weight, Organic Content, Liquid Limit & Plastic Limit, etc. parameters of soil samples; Fineness Modulus (F.M.), Unit Weight, Specific Gravity, Organic Impurities of sand samples; Normal Consistency and Setting Time of cement samples; Sediment Concentration, Specific Gravity; Sieve & Hydrometer analysis of sediment samples; pH, Electrical Conductivity, Color (True or Apparent), Carbon-di-Oxide/Acidity, Carbonate/Bi-Carbonate, Alkalinity, Sulfate, Orthophosphate, Chloride, Fluoride, Chlorine Content Total/Free, Iodine Content, Bromine Content, Ammonia-Nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen, Salinity, Hardness, Ca-Hardness, Mg-Hardness, Turbidity, Total dissolved solid, Total solid content, Total Suspended/Insoluble Solids, Total Iron: UV-VIS, Ferrous Iron/Ferric Iron, Silica Content, Manganese: UV-VIS, Dissolved Oxygen, Chemical Oxygen Demand, Arsenic (Kit Method), etc. parameters of water samples can be determined in Dhaka Laboratory.

The important equipment of Dhaka Laboratory are HACH DR1900 Spectrophotometer, HACH DRB 200 Reactor, HACH HQ30D Multi-parameter, Duran Vacuum Filtration Device, Constance Force Convection Laboratory Oven 200°C and 300°C, Constance Muffle Furnace 1200°C, Controls Limit Device, Controls Sample Mixture, Controls Sieve Shaker and Set, Controls Compaction Device, Shimadzu Precision Balance, Kyowa Optical Microscope, Humboldt Setting Time Device, Cole-Parmer Micropipette, Soil Hydrometer, Magnetic Stirrer, Autoclave, Reagents, etc.

During the 2022-2023 fiscal year, Dhaka Laboratory tested 467 samples and published 12 reports. The total billed amount of those reports is 486,300.00 BDT, of which 111,975.00 BDT has been received from the client, and 374,325.00 BDT is due. The total collection of Dhaka Laboratory for 2022-2023 is 167,250.00 BDT, including the collections from previous dues. At the end of 2022-2023, the total dues of Dhaka Laboratory is 479,100.00 BDT.

Equipment of Dhaka Laboratory

Internship and Research program

Two students, Marzia Sultana Shefa and Suparna Sarker have completed their Internship and Research Program at Geotechnical Research Directorate of RRI in the fiscal year 2022-23 for partial fulfillment of their requirements of B. Sc degree at Environmental Science and Disaster Management (Honors) in the Patuakhali Science and Technology University. Dr. Fatima Rukshana, Principal Scientific Officer, have acted as an external supervisor of the students.

The students got an opportunity to enhance their academic learning through practical career related work experiences in RRI. During the internship program, the students mainly improved their skills and knowledge in working/ visiting at different laboratories including Soil Mechanics, Material Testing and Quality Control, Sediment, Chemical & Water Pollution and also different model areas in RRI. The students also learned about research methodologies and how to write a scientific reports and articles. Ms. Marzia worked at the Material Testing and Quality Control laboratory at ongoing testing projects. She also completed a research project entitled 'River Bank Erosion induced Human Displacement and its Consequences: A case study on Nalua Union, Bakerganj'. Ms. Suparna worked at the Sediment, Chemical and Environmental laboratory about the Analyses of suspended sediment samples in the Ganges, Gorai – Madhumati, Arial khan and Kirtinasha River of ongoing project from BWDB. She conducted a research project entitled 'Water Pollution Status of Kirtankhola River: A Lab Based Physiochemical Study.

Figure: Marzia Sultana Shefa, operating Concrete Crushing Machine for measuring compressive trength of the blocks at the Material Testing and Quality Control lab

Figure: Suparna Sarker, weighing the amount of suspended sediment for determining sediment concentration at the Sediment lab

ADMINISTRATION AND FINANCE

This Directorate consists of several sections namely, i) Establishment, ii) Accounts & Audit, iii. Public Relation & Photography, iv) Library, v) Estate & Security and vi) Store. The other activities include procurement, operation & maintenance of physical facilities.

Activities of Administration & Finance Directorate

The activities of Administration & Finance Directorate include overall administration of RRI, establishment, human resources development, financial management, photography, public relations, internal security, storing of materials, plantation, arrangement of different kinds of training, publications of annual reports, journal, newsletters etc. The approved and existing manpower employing in this institute is 257 and 161 respectively. The details of manpower are given in the following table as shown below:

Class-wise approved and existing manpower in RRI

Sl. No.	Class	Approved manpower	Existing manpower
1	1st Class	68	38
2	2nd Class	03	02
3	3rd Class	119	78
4	4th Class	64	46
	Total	257	164

This directorate also collects a number of books both from home and abroad, journals, research reports, newsletter and many other publications every year for library. Many researchers, students and teachers from different institutions use this library for their necessary documents. The total number of reading materials (including books, journal, newsletter reports and publications) is 16139 nos. and the total expenditure under this directorate during the fiscal year 2021-22 is 1831.76 lakh.

Total collection of items in the Library

Sl. No.	Description	Collection in 2022-2023	Total
1	Books	51	2600
2	Journal	3	2671
3	Reports	83	5770
4	Other publications	5	5239
	Total	142	16280

Total expenditure in establishment

Sl. No.	Description	Amount (Tk. In lakh)
1	Officers' salary	281.87
2	Staff salary	331.71
3	Allowances	395.98

4	Supply and services	253.22
5	Capital expenditure	270.83
	Total	1251.74

Other activities

In addition to the above activities, this directorate also provides technical support services to the other directorates and divisions. This directorate is also responsible for procurement, operation & maintenance, and mechanical & electrical works of physical facilities. The work completed by operation and maintenance, and mechanical and electrical section during the fiscal year 2021-22 is outlined below.

Works executed by Operation and Maintenance (Civil Engineering)

Repair and maintenance of different office buildings such as administration, medical centre, mosque, ansar camp as well as residential buildings. The repair and maintenance works include stripping of old plaster and replacing by new plaster works, white washing, plastic painting, synthetic enamel painting to window gratings, door polishing, woodwork in door frames and replacing of glass panes in window shatters and replacing of doors under establishment budget.

- ✓ Purchase & replacing of plumbing materials of different buildings with new ones.
- ✓ Purchase of stationery, plumbing, and construction materials for general use as well as model use.
- ✓ Cleaning of water tank in all office and residential buildings.
- ✓ Cleaning and maintenance of surface drain of RRI campus.

Works executed by Mechanical Section

- ✓ Installation, repair & maintenance of pump, motors, tailgates, gate valves, foot valves, model bridges etc.
- ✓ Repair and maintenance of mechanical tools.
- ✓ Repair, fitting & fixing of grill, window etc at residential and office buildings.
- ✓ Repair and maintenance of all the vehicles of RRI.
- ✓ Purchase of raw materials for mechanical workshop of RRI.
- ✓ Repair and maintenance of photocopy machines, air cooler and refrigerators.

Works executed by Electrical Section

- ✓ Purchased of fuel & batteries for generator.
- ✓ Routine maintenance of computer, printers, UPS, IPS and other electronic equipment.
- ✓ Purchased of computer accessories, electrical materials.
- ✓ Purchased of electric wires of different sizes.
- ✓ Electrification in the model area.

A staff is being awarded as “Staff of the Month” by Honarable Director General

RESEARCH AND DEVELOPMENT

Research plays a significant role to improve the quality of lives of the people and also the socio-economic development of the country. Quick and effective decision making by proper use of information contributes for upliftment of the society. Researches in the field of hydraulics, geo-technical and environmental engineering carry great importance for the development of water resources of the country. In view of the above mentioned facts, RRI takes up research projects every year. The two directorates of RRI, namely Hydraulic Research and Geo-technical Research conduct research and development activities in their respective fields. These activities are briefly described in this chapter.

Two research works have been conducted in 2021-2022 fiscal year, of which one is completed and other three are carried out at present fiscal year. Completed research work entitled "Assessment of Eco-hydrological characteristics and water quality of Surma River in Sylhet Bangladesh" and "Assessment of Morphometric Parameters, Environmental flow and Bio-physical aquatic status of Bakkhali River Basin" under Geo-technical Research Directorate.

Research projects

a) "Assessment of Morphometric Parameters, Environmental flow and Bio-physical aquatic status of Bakkhali River Basin"

Research Information

Duration: From September, 2022 to June, 2023
Total Expenditure: 6,93,652/-(Six Lac Ninety Three Thousand Six Hundred Fifty Two Taka only)
Funding: RRI Research Head (GoB)

Introduction

Water resource management is a grave challenge today particularly in areas deficient in water resources. Optimum utilization of surface and groundwater, their storage and conservation are the core issues concerning water resource management. Watersheds have long been the considered hydrological units for management of land and water resources however; diverse soil conditions, changing land use pattern and differing topographic characteristics have necessitated the need to have micro level hydrological units for their better planning, management and optimum utilization.

Hypsometric analysis of a watershed is important for integrated planning and management of watershed resources. Hurtrez et al (1999) stated that a watershed is stabilized with convex hypsometric curves and un-stabilized (susceptible to erosion) with concave hypsometric curves. In recent years, a number of studies have been conducted by various researchers in different part of the world on estimation of erosion status of watersheds or river basins using hypsometric (area-altitude) analysis and watershed morphometric parameters (Sharma et al 2016, Kandpal et al 2018a, Singh and Singh 2018, Malik et al 2019a) Anurag Malik and Anil Kumar (2019).

The management and allocation of water requires addressing elementary ecological issues to achieve sustainability. Hence, there is a growing demand to conserve ecosystems and strike a balance regarding water sharing between the ecosystem and human needs. Over 60% of rivers in the world are influenced by hydrological fluctuations and flow characteristics (Shahriar Shams et al, 2021)

Environmental flow (E-flow) is the minimum amount of flow which focuses not only on the quantity but also on the quality and occurrence of water flow required to sustain the aquatic ecosystem. E-flows are emerging as a new concept particularly for water resources planners, developers and policymakers of developing countries and its application and enforcement is a major challenge (Shams & Matin, 2014) due to lack of awareness among the public. Growing intervention on river flow through damming often causes lowering flow below ecological minima and it is of great concern. In the last few decades, environmental flow appraisal has obtained priority. Many scholars have quantified ecological flow across the globe intending to flow reinstatement and long term supervision of the river, riparian ecosystem and the livelihood of the stakeholders (Tamal Kanti Saha, 2022).

Among these techniques Range of Variability Approach (Richter et al.1997), Flow Duration Curve Analysis (Tharme 2003) are frequently used techniques are present. The application of the Global Environmental Flow Calculator for calculating environmental flow for diverse ecological management classes is one of the signposts in this progress (Smakhtin and Anputhas 2006; Salik et al. 2016; Abdi and Yasi 2015). If all the existing methods are taken into consideration and categorized, there are four types i.e. (1) Hydrological or historic flow methods (2) Habitat methods (3) Hydraulic methods and (4) Holistic methods. Hydrological or historic

flow methods are based on the records of the historical flow regime. Tennant (1976) method, for example, determines the EF as a percentage of the average annual flow. Hydraulic methods are dealt with the hydraulic geometry of a channel. Collings(1974) method is a customary one that defines the minimum flow based on the relationship between discharge and wetted perimeter. Habitat methods are based on the physical habitats simulation concerning flow. The stream-flow incremental methodology suggested by Bovee (1998) is a quite good example of this group. Holistic methods focus on water resource management about the riverine ecosystem as a whole. Precise estimation of eco-flow can extend an appropriate scope for restoration of the river and riparian ecosystem. So, this task is quite essential. In the developed nations, such work has been done affluently but there is an acute dearth of such work in the developing nations (Pal and Talukdar 2020). A clear report about the flow condition and ecological needs of each river should be in hand of the concerned policy makers for designing and implementing suitable strategies for its restoration and prevention.

Objectives

The Research objective is to address this research and policy gap and shed light on challenges, opportunities and measures for implementing environmental flows in the Bakkhali river. The target audience for this research study is scientists, natural resources managers, decision-makers and land, water, and environmental advocates who are interested in better understanding both technical and socio-political conditions for integrating environmental flows into existing water governance and management practices.

The followings are the specific objectives of the study-

- Morphological analysis of Bakkhali River
- Morphometric characterization of Bakkhali River Basin/Watershed
- Sub-watershed prioritization according to linear and areal parameters to predict soil erodibility
- Assessment of perennial property of Bakkhali river
- Assessment of Instream Flow requirement (IFR) of Bakkhali River at available discharge data station
- Water quality analysis
- Eco-biological analysis

Study Area

A number of small streams originating from the Cox's Bazar Sadar, Ramu of Cox's Bazar District and Naikhongchhari of Bandarban district form the river Bakkhali. It flows through Naikhongchhari and Ramu of Cox's Bazar district and falls into the Moheshkhali channel of the Bay of Bengal. This river is relatively wide compared to other rivers of the Cox's Bazar district and has a length of about 67 km. The Bakkhali river estuary has a semidiurnal tidal regime. Its hydrology is also heavily influenced by monsoon wind. The tidal range varied between 0.07 m and 4.42 m during neap and spring tide respectively. The Study area is situated in 46Q UTM zone. It lies between 2,356,716 mN to 2,390,716 mN and 390,005 mE to 438,620 mE (Figure 1). Its total drainage area is 571.52 km^2.

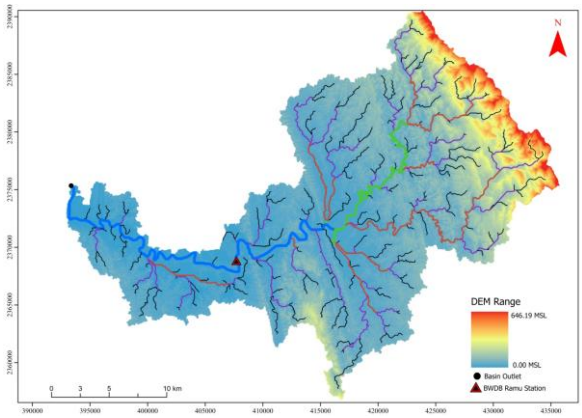


Figure: Study area

Materials and methods

Our methodology combines a literature review with the multidisciplinary topics, which includes environmental, and hydrological research in the basin. We focused on three questions: (1) What is the current status of knowledge about environmental flows and their relation to ecosystem and human water needs in the Bakkhali River? (2) In what ways do current water governance frameworks in the basin appear to support or hinder the establishment of environmental flows? (3) Are there policies or practices that have implemented environmental flows, and what lessons can be learned from those experiences for a more widespread implementation in the basin? We address these questions by considering the Rio Grande/Bravo as a whole basin.

In this study, freely available 30 meter resolution, COP-DEM obtained from http https://portal.opentopography.org/datasets had been used. In order to deduce various morphometric parameters first stream network, watershed and subwatersheds boundaries were delineated using ArcGIS Pro 2.7.0.Spatial Analyst extension was used in ArcGIS Pro 2.7.0. To create stream network, initially the sinks were removed from DEM by filling them. The filled DEM was then used for acquiring flow direction and flow accumulation. Using this flow accumulation drainage network was generated by giving a threshold of 1000 pixels, it is a user defined value to determine minimum contributing area needed to form and maintain a channel. The stream network

thus derived was ordered using Strahler's method of stream ordering.

Watershed and sub-watershed boundaries were delineated using the pour point with fifth-order stream as threshold. The various morphometric parameters viz. linear, areal and relief were calculated using the standard formulae (Table 1). The entire watershed was divided into 1 km by 1 km grid to compute and obtain grid-wise values of drainage density, ruggedness index, dissection index, relative relief etc. These were interpolated and mapped using Inverse Distance Weighing Interpolation Method.

Results and Discussions

Hierarchical Structure of Bakkhali Basin

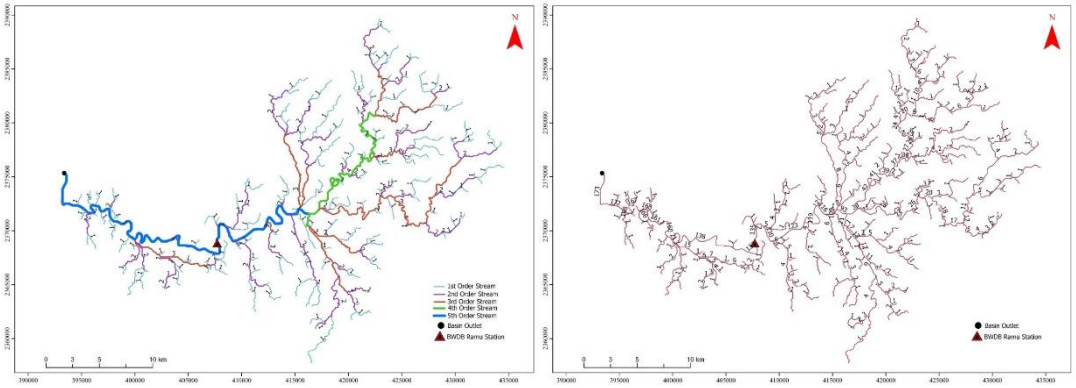


Figure: Hierarchical Structure of Bakkhali Basin according to Strahler and Shreve Method Method

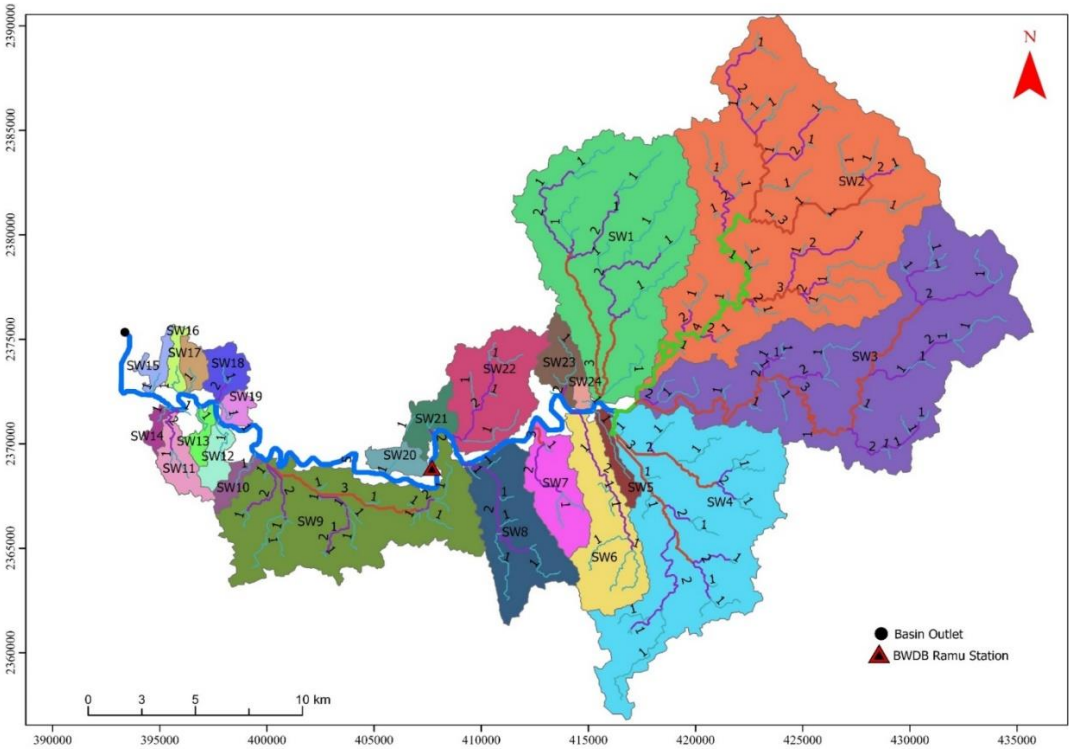


Figure: Sub-watersheds of Bakkhali Basin

Table: Area, Perimeter, Stream order, Stream number and Basin Length of sub-watersheds

Sub-watershed	Area (km^2)	Perimeter (km)	Percentage of total basin area	Basin Length (km)	Number of Streams in each Order				
					1	2	3	4	5
SW1	72.32	44.68	12.65	22.42	15	5	2	1	
SW2	131.77	68.22	23.06	34.91	42	12	3	1	
SW3	98.58	66.03	17.25	35.46	23	7	1		
SW4	72.38	58.18	12.67	20.85	21	5	2	1	
SW9	49.87	50.94	8.73	13.81	21	5	1		
Bakkhali Basin	571.52	196.87	100.00	77.40	173	35	7	3	1

Table: Length of streams for different watersheds

Sub-watersheds	Length of 1st Order Stream (km)	Length of 2nd Order Stream (km)	Length of 3rd Order Stream (km)	Length of 4th Order Stream (km)	Length of 5th Order Stream (km)	Total Length of all Streams (km)
SW1	32.33	20.51	12.77	0.23		65.84
SW2	57.78	28.96	18.47	20.49		125.70
SW3	34.87	22.57	27.74			85.18
SW4	30.55	17.98	14.16	1.50		64.18
SW9	21.65	12.57	8.47			42.68
Bakkhali Basin	248.52	133.43	83.26	23.74	42.50	531.44

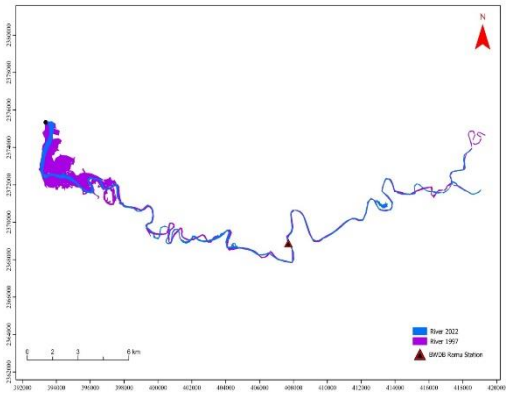


Figure: Planform analysis of Bakkhali River for main channel

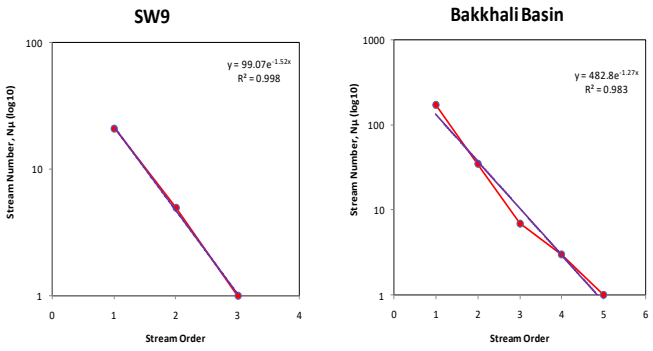


Figure: Relationship between Stream number and Order

Hypsometric and Flow Duration Analysis of Bakkhali River

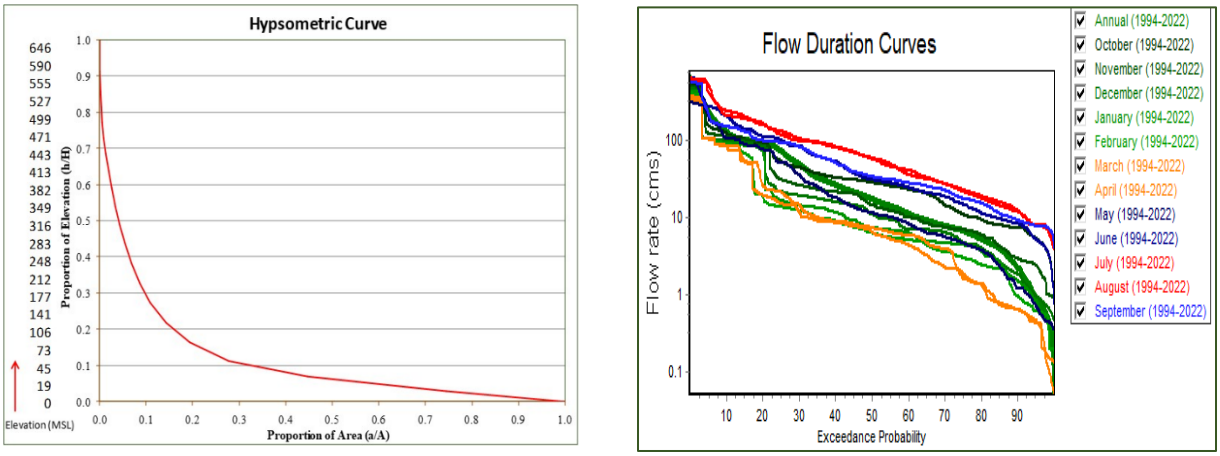


Figure: Hypsometric Curve and Flow Duration Curve of Bakkhali Basin

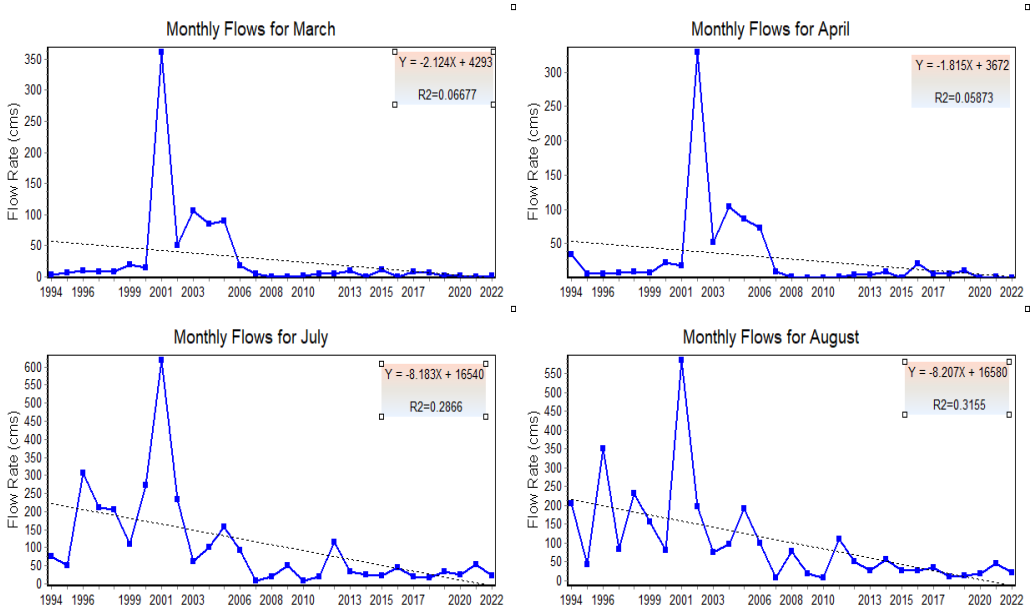


Figure: Monthly Flows

Water Quality

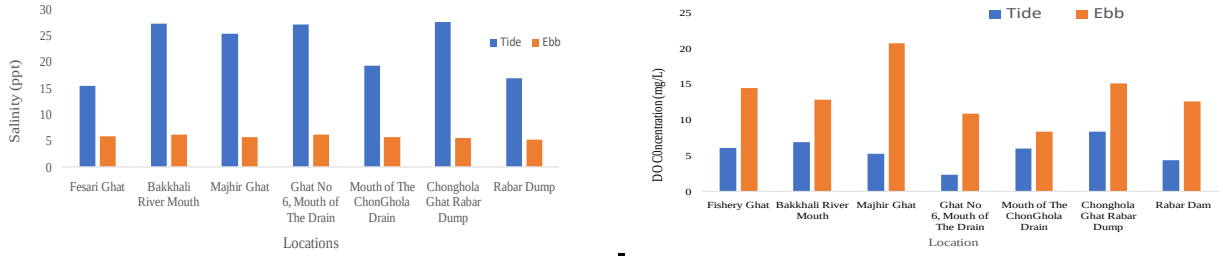


Figure: Salinity and DO concentration during Ebb and Tide

Conclusion

- According to hypsometric Analysis Bakkhali River is in old age stage.
- BakkhaliRiver is Meandering river with sinuosity index 2.17.
- Among the sub-watersheds SW-9 ranked 1 in terms of soil erosion that is it needs high priority.
- Stream order and number show high coefficient of determination for exponential regression analysis.
- According to discharge dependable values it is observed that Q_{100} exist for round the year for the analysis period (1995-2023) indicating Bakkhali is a perennial river.
- From the monthly flow duration curves it has been observed that the Months July and August shows the highest discharge dependable values.
- From the monthly flow duration curves it has also been observed that the Months March and April shows the lowest discharge dependable values.
- It is observed that mean annual flow of Bakkhli river varies from 28.57 m^3/s to 103.79 m^3/s.
- From the setting of instream flow requirement (IFR) using MAF it has been seen that the month Juluy, August, September and October of High Flow Season has the 'Optimum' habitat quality.
- From the setting of instream flow requirement (IFR) of MAF it has been seen that the month of Low Flow Season has the 'Optimum' 'Outstanding' habitat quality. The remaining months of Low Flow Season shows the 'Fair' habitat quality.
- Annual extreme water conditions like 1, 3, 7, 30, 90 day maximum show decreasing trend.
- All annual extreme water conditions like 1, 3, 7, 30 day minimum show decreasing trend.

Recommendations

- Since Bakkhali river is a hilly river, it's basin relief is high (646 m) and simultaneously it's a meandering river. Therefore any intervention on the river needs scientific analysis.

- From the findings it is observed that environmental flow of the river is a decreasing trend. Further research is required to find the causes behind the declining of environmental flow.

(b) The research program "Assessment of Eco-hydrological characteristics and water quality of Surma River in Sylhet Bangladesh" started on 31 August'2023 and completed on June 2023

Research Information

Duration: From August' 2022 to June' 2023
Total Expenditure: 11,68,735/-(Eleven Lac Sixty Eight Thousand Seven Hundred Thirty Five Taka only)
Funding: RRI Research Head (GoB)

Study Area

Five sampling stations along the Surma River at Sylhet in Bangladesh were selected.

Objectives of the Study

- To determine the phytoplankton communities that growing on the river and their seasonal distribution.
- To observe the seasonal changes of water quality parameters such as air and water temperature, Secchi depth, TDS, EC, pH, DO, SRS, SRP, TSS, anions ($NO2^-$, $NO3^-$, $PO43^-$, $SO42^-$, Cl^-, Fl^-), cations (NH4+, Na+, K+, Ca2+, Mg2+, Mn2+)
- Determination of Hydro-biological Characteristics of river water i.e. test for Chlorophyll a (chl-a), Phaeopigment (PP), Phytoplankton diversity, Benthic Diatom etc.
- To determine degree of contamination at different seasons and to comment on quality of the river water.
- To draw the implication and to provide the suggestions for actions to reduce contamination

Description of Research Activities and Findings

The Study Area is from Sylhet-Jaflong Bypass Bridge, a point before Sylhet town upto Temukhi Bridge, though sample from a point Tuker Bazar during dry season was collected.
The Surma originates in the hills of Shillong and Meghalaya of India. The main source is barak river, which has a considerable catchment in the ridge and valley terrain of Naga-Manipur hills bordering Myanmar. From its source in the Manipur Hills near Mao Songsang, the river is known as the Barak River. At the border with Bangladesh, the river divides with the northern branch being called the Surma River and the southern the Kushiyara River. This is where the

river enters the Sylhet Depression which forms the Surma Basin. Surma is the longest river of Bangladesh. The river Surma after originating from the bifurcation of the Barak river at Amalshid runs towards west through Sylhet until it meets the Balui river and collects inflow from the 56% area of the Surma basin which occupies most of the southern slope of Shillong Platueau and receives world's highest rainfall. The Kushiyara receives tributaries from the Sylhet Hills and Tripura Hills to the south, the principal one from the Tripura Hills being the Manu. The Kushiyara is also known as the Kalni River after it is joined by a major offshoot from the Surma. When the Surma and the Kushiyara finally rejoin in Kishoreganj District above Bhairab Bazar, the river is known as the Meghna River. The Surma is a meandering and dynamic river. It has travelled 215 km inside Bangladesh from the Indian boundary up to Sunamganj district

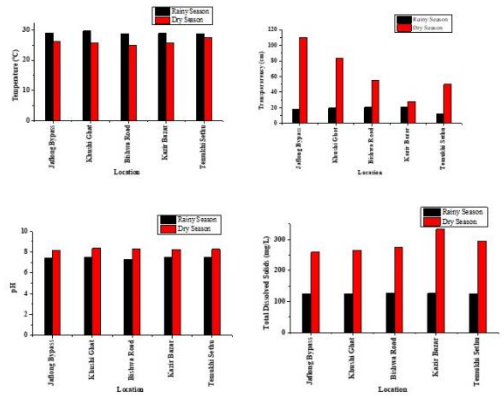
Between Surma and Kushiyara, there lies a complex basin area comprised of depressions (haors). Most of the Surma system falls in the Haor basin, where the line of drainage is not clear or well defined. In the piedmont tract from Durgapur to Jaintiapur, the network of streams and channels overflows in the rainy season and creates vast sheets of water which connect the haors with the rivers.

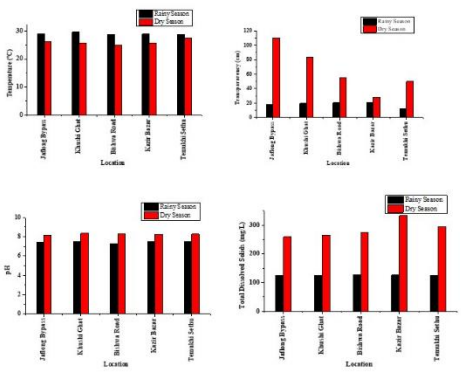
Sample Collection from Kazir Bazar Bridge area, Monsoon.

Sample Collection from Kean Bridge area. Monsoon.

Polluted water during dry season at Kazir Bazar Bridge area

Pollution source during dry season at Kazir Bazar Bridge area





List of newly identified phytoplankton from Surma river in Sylhet for the first time in Bangladesh

Class	Phytoplankton identified		References
Bacillariophyceae	Gomphonema quadripuntatum var. hastatum	Cymbella prostata	Bogopocam, 1951
	Eunotia bilunaris var. mucophila	Rhizosolenia longiseta	Hustedt, 1930; Germain, 1981
Chlorophyceae	Hydrianum diogenes	S. insignis	Huber-Pestalozzi, 1972
	Scenedesmus armatus var. bicaudatus		
Euglenophyceae	Euglena hyalina	P. bacillifera	Huber-Pestalozzi, 1955
	Hyalophacus ocellatus	P. gigas Dacunha	
	Phacus aenigmaticus Drez	P. pseudoplatelea	
	Trachelomonas scraba var. labiata		
	Trachelomonas spiculifera	T. umbilicopora	
Cyanophyceae	Anabaena flos-aquae f. lemmermanni	Hydrocoleum turfosum Woronichin	Starmach, 1966
	Oscillatoria mougeotii (Kützing) Forti f. clathrata Skuja	O. obliquaeacuminata	Starmach, 1966; Desikachary, 1959

Number of species recorded from different classes of algae as phytoplankton from the Surma River.

Class	No. of species	Percentage
Cyanophyceae	13	11.02%
Chlorophyceae	19	16.10%
Euglenophyceae	31	26.27%
Bacillariophyceae	45	38.15%
Cryptophyceae	6	5.08%
Chrysophyceae	2	1.69%
Dinophyceae	2	1.69%
Total	118	100%

Number of genera recorded from different classes of algae as phytoplankton from the Surma River.

Class	No. of genera	Percentage
Cyanophyceae	8	14.54%
Chlorophyceae	16	29.09%
Euglenophyceae	7	12.73%
Bacillariophyceae	19	34.54%
Cryptophyceae	3	5.54%
Chrysophyceae	1	1.82%
Dinophyceae	1	1.82%
Total	55	100%

List of Phytoplanktons identified from the Surma River in Sylhet

Class	Phytoplankton identified		
Bacillariophyceae	Amphora ovalis	Gomphonema parvulum	Pinnularia gibba var. parva
	Amphora veneta	Gyrosigma sp.	Pinnularia microstauron
	Achnanthes sp.	Melosira granulata	Pinnularia stauroptera var. semivruciata
	Coscinodiscus lacustris	Melosira granulata var. angustissima	Rhizosolenia sp.
	Coscinodiscus tumidus	Navicula anglica	Stauroneis anceps
	Cyclotella kuetzingiana	Navicula cincta	Surirella moelleriana
	Cyclotella meneghiniana	Navicula pupula	Surirella ovata
	Cymbella stuxburgii	Neidium sp.	Surirella robusta
	Deploneis ovalis	Nitzschia acicularis	Surirella robusta var. splendida
	Eunotia sp.	Nitzschia clausii	Surirella tenera
	Fragillaria crotonensis	Nitzschia fruiticosa	Synedra acus
	Fragillaria virescens	Nitzschia gracilis	Synedra rumpens
	Gomphonema gracile	Nitzschia longissima	Synedra tabulata
	Gomphonema lanceolatum	Nitzschia subrostrata	Synedra ulna
	Gomphonema subtile	Pinnularia gibba	Synedra ulna var. oxyrhynchus

Conclusion

- Data on 27 physicochemical and biological variables recorded during the present investigation showed an almost clear picture about the river.
- A total of 118 species of phytoplankton under 55 genera belonging to 7 different algal classes have been found.
- Highest number of genera as well as species were obtained from the class Bacillariophyceae (38.15% of the total species).
- Physicochemical variables were present in optimum level indicating that the water of the river is of good quality.
- From the data obtained on physicochemical parameters, the water quality of the Surma River is fairly good in order to sustain life
- and also water is in a condition to be used for different purposes.
- Sylhet-Jaflong Bypass Bridge, a point before Sylhet town after which pollution started especially during dry season. After Kean Bridge pollution increase during dry season. From Kazir Bazar Bridge to Temukhi Bridge pollution is maximum during dry season.
- Though overall water quality of Surma river near Sylhet town is good but during dry season DO value near Kazir Bazar Bridge is almost zero and BOD value is too high which is dangerous for live and environment. Immediate measure is needed.
- Number of new phytoplankton identified from Surma river in Sylhet for the first time in Bangladesh

BUILDING OF HUMAN CAPITAL

RRI has been putting special emphasis to human resources development since its establishment in order to achieve its goals as mandated by the Government of the People's Republic of Bangladesh. Scientists and engineers are working at RRI whose efforts are being put with a view to reach the research standard through innovation of new technologies and ideas in the related fields of activities. RRI is a relatively new organisation of this kind of research in the country. As the technologies of the disciplines concerned are fast developing, the necessity of higher studies and advanced on the job training of the research personnel in the academic and research institutions of similar activities at home and abroad (especially in developed countries) has strongly been highlighted in order that it can keep them abreast of the latest development in the related fields of research. Some of the RRI personnel attended higher studies and training program both at home and abroad.

RRI scientists and officers participated in different trainings and workshops during the 2021-2022 fiscal year at RRI and outside of RRI. The title and duration of these training programs and seminars were as the following:

A view of the in-house training

List of training RRI officers attained in 2022-23.

Sl. No	Title of the training / Seminar	Duration
1	Workshop on formulation of action plans to meet potential challenges of Fourth Industrial Revolution under e-Governance and Innovation Action Plan	14-09-2022
2	Two days training on preparation of financial statements	29-09-2022
3	Training on Right to information Act 2009 and its rules, regulations and self-initiated disclosure of information	29-09-2022
4	Workshop on personal Ledger Account creation and Automatic Fund release using online platform	19-10-2022

Sl. No	Title of the training / Seminar	Duration
5	Training on implementation of e-Governance and Innovation Action plan 2022-23	15-11-2022
6	Training on water Resources Management in line with National Environmental Policy 2018	05-12-2022
7	Training on review of water Bangladesh Delta Plan 2100	01-02-2023
8	Training on Integrated research: Perspective water Resources Management	06-02-2023
9	Workshop on Built Water Strong in South Asia CEGIS	28-01-2023
10	Training on Objective, Strategy, Approaching of Bangladesh Delta Plan BARD, Cumilla	29-01-23 to 01-02-23
17	Training on EFT management for RRI	02-03-2023
18	Training on National Integrity Strategy (NIS)	20-03-2023
20	Training on Right to Information to Manage Official Information	
21	Training course on ICT for office management, RPATC, Dhaka	30-1122 to 26-01-23
22	Training on Cyber Security, MOWR	25-05-2023
23	Training on definition of river and determination of number of rivers, The National Conservation for Protection of river	
24	Training on ADP/RADP Management System (AMS)	11-06-23 to 12-06-23
26	Workshop on Two decades of Haor and wet land Impacts of Climate Change and future of our Haor Region.	19-06-2023
27	Training on SDG	12-06-2023

53 th BOG meeting of is being held presided over by Honourable State Minister, MoWR

FINANCIAL MANAGEMENT

River Research Institute is a national organization having mandate of a statutory Public Authority under the Ministry of Water Resources, Government of the People's Republic of Bangladesh. The annual expenses are being borne by its own income and some grant from the Government revenue budget.

The main sources of RRI's own income are revenue received from model studies (physical and mathematical model), and geo-technical testing fee (testing of soil, concrete, water and sediment sample). Detailed budgetary information (income and expenditure) for the fiscal year 2020-2021 and 2021-2022 are given hereafter–

Earnings and Expenses for the fiscal year 2022-2023

Earnings		Expenses	
Items	**Taka (Lakh)**	**Items**	**Taka (Lakh)**
Govt. grant	1643.85	Establishment: Officers salary 282.93 Staff salary 402.52 Allowances 439.85 Supply and services 329.91 Retirement benefit assistance 150.06 Research Grant 34.57 Capital expenditure 20.74 Refund of non-expended money 35.32	1493.61
Model study	263.63	Model study	186.45
Geotechnical testing fee	15.95	Geotechnical testing	8.17
Others	34.18	Surplus (+)	62.72
Total	**1957.61**	**Total**	**1750.95**

Earnings and Expenses for the fiscal year 2021-2022

Earnings		Expenses	
Items	**Taka (Lakh)**	**Items**	**Taka (Lakh)**
Govt. grant	1695.90	Establishment: • Officers salary 282.93 • Staff salary 402.52 • Allowances 439.85 • Supply and services 329.91 • Retirement benefit assistance 150.06 • Research Grant 34.57 • Capital expenditure 20.74 • Refund of non-expended money 35.32	1695.90
Model study	59.74	Model study	57.09
Geotechnical testing fee	23.41	Geotechnical testing	14.08
Others	52.71	Surplus (+)	64.69
Total	**1831.76**	**Total**	**1831.76**

Earnings and Expenses for the fiscal year 2020-2021

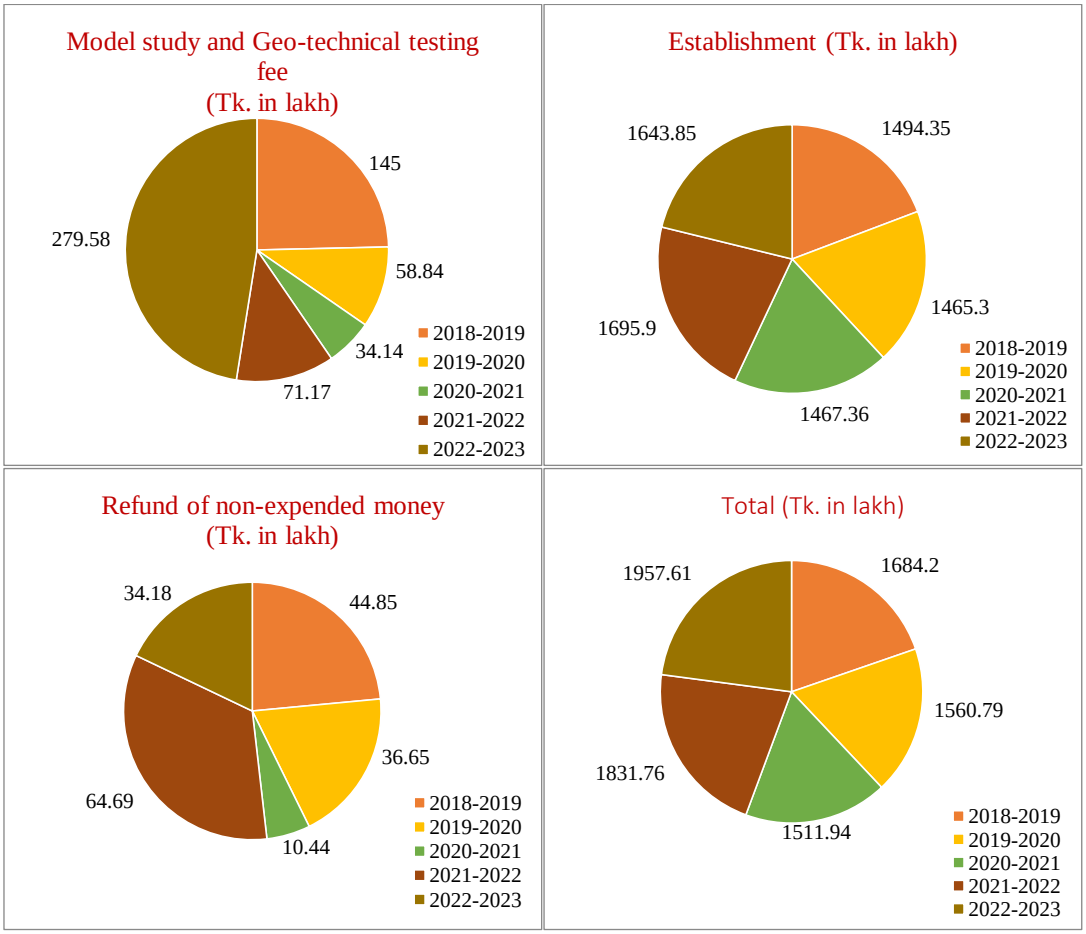
Earnings		Expenses	
Items	**Taka (Lakh)**	**Items**	**Taka (Lakh)**
Govt. grant	1477.80	Establishment: Officers salary 236.25 Staff salary 364.83 Allowances 554.16 Supply and services 210.99 Capital expenditure 101.13 Refund of non-expended money 10.44	1477.80
Model study	45.07	Model study	18.15
Geotechnical testing fee	38.71	Geotechnical testing	15.99
Others	43.47	Surplus (+)	93.11
Total	**1605.05**	**Total**	**1605.05**

Significant features of RRI's earnings, expenses and closing balance in recent years (last 5 years) are given here.

Scenario of earnings for last five years

Sl. No.	Sources of income	Total (Tk. in lakh)				
		2018-2019	**2019-2020**	**2020-2021**	**2021-2022**	**2022-2023**
1	Model study & geo-technical testing fee	226.65	85.17	83.78	59.74	279.58
2	Govt. grant	1539.20	1465.3	1477.80	1695.90	1643.85
3	Others	29.27	38.21	43.47	76.12	34.18
	Total	**1795.12**	**1588.68**	**1605.05**	**1831.76**	**1957.61**

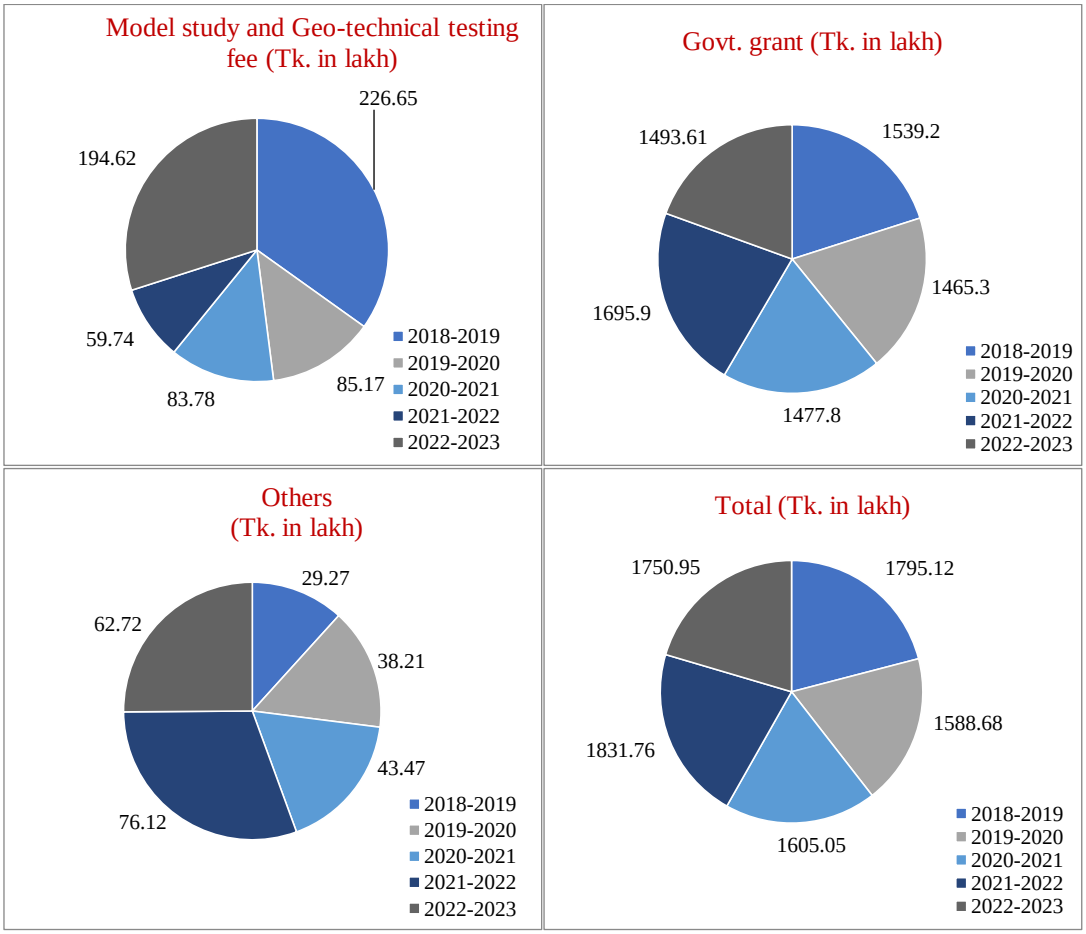
Graphical representation of scenario of earnings for last five years



Scenario of expenses for last five years

Sl. No.	Description	Total (Tk. in lakh)				
		2018-2019	2019-2020	2020-2021	2021-22	2022-2023
1	Model study and Geo-technical testing.	145.00	58.84	34.14	71.17	194.62
2	Establishment	1494.35	1465.3	1467.36	1695.90	1493.61
3	Refund of non-expended money	44.85	36.65	10.44	64.69	62.72
	Total	**1652.71**	**1560.79**	**1511.94**	**1831.76**	**1750.95**

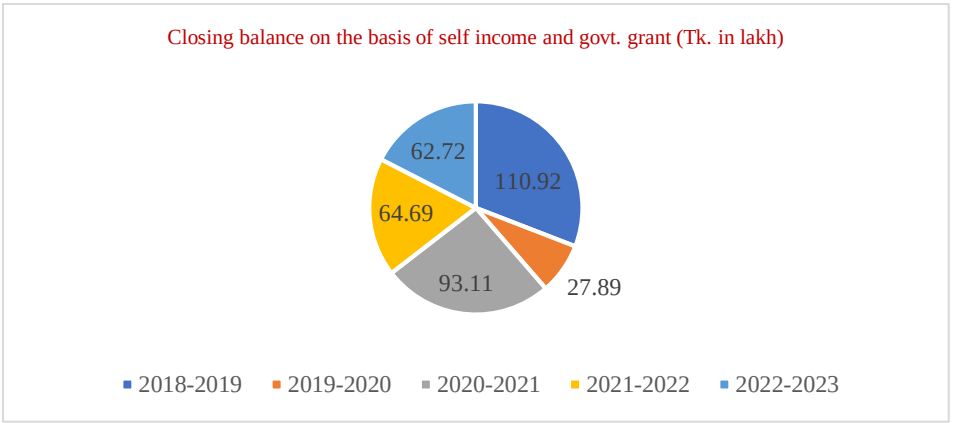
Graphical representation of scenario of expenses for last five years



Scenario of closing balance for last five years

Sl. No.	Description	Total (Tk. in lakh)				
		2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
1	Closing balance on the basis of self-earnings and govt. grant	(+) 110.92	(+) 27.89	(+) 93.11	(+) 64.69	(+) 62.72

NB: (+) indicates surplus.



FUTURE PROSPECTS AND PLANNING

Since its establishment as a national organization with distinct mandates for rendering services to deal with river related problems and to devise economic and sustainable solutions to the problem RRI has been discharging its responsibilities using established facilities and available man power. At the beginning, the main focus was physical modelling and soil and material testing mainly to support planning and design of different water infrastructures and Bangladesh Water Development Board (BWDB) was the main client. With the passage of time physical modelling technology has been applied to address wide range of river related issues namely sediment management at the off-take, river restoration, bridge and barrage hydraulics, river dredging etc. However, the application of physical modelling technology was very limited for tidal and coastal systems due to lack of required modelling facilities. In order to meet the growing need for comprehensive and multidisciplinary studies RRI adopted mathematical modelling technology in 2007 as a tool for conducting model studies side by side physical modelling technology. At the same time a number of RRI engineers and scientists pursued higher education in different disciplines and many of them are trained at home and abroad to enable RRI to carry out multidisciplinary studies. Under an institutional development and capacity building project a number of sophisticated equipment were procured to upgrade testing facilities. However, some facilities are yet to be established to carry out all mandated activities as well as to deal with new challenges and emerging issues in water sector. With this end in view the second phase of institutional development and capacity building project has begun in the financial year 2017-18.

For RRI to function as a pioneering organization in water sector and to cope with the increasing demand of the time in the competitive market; institutional development, instrumentation, sustainable technology and highly trained manpower are very essential to enhance the standard of service to international level. From this point of view the following future development prospects are important to be mentioned:

Now-a-days, Information Technology (IT) has become a very useful tool for research and studies, sound management and transparent administration in the world. RRI has to encounter this new challenge to meet the demand for quality services.

RRI has already established a network system by connecting all the activities of this institute. For this RRI has completed all the installations and collected software, hardware and networking components required. By this time, LAN is working at RRI. A complete wing (manpower & logistics) wing will be required to govern the IT sector in RRI.

Two Material Testing and Quality Control field laboratories at Bogura and Barisal have already been established. A liaison office is situated at 72, Green Road, Dhaka. In the liaison office soil, building materials, sediment & water samples are being received from BWDB and other Govt, Semi-Govt, NGOs and consulting firms. There is system for bringing the collected samples to RRI headquarter in Faridpur within a short period of time to complete the tests in due time. The test results are furnished to the clients in report form to execute the work of the projects in scheduled time. RRI is contemplating to establish field laboratory in all district headquarters of the country to make its services easily available.

RRI has already established well-equipped Math Model LAB with internet facilities and uninterrupted power supply required to support mathematical modelling. However, existing facilities need to be expanded and upgraded by purchasing more computers and accessories, installing updated modelling softwares, introducing modelling in new areas and imparting training to the modellers. Some of the needs are expected to be fulfilled under the on-going IDCB project. It is understood that in order to further expand the RRI mathematical modelling services a full-fledged Math Model LAB has to be established in Dhaka.

RRI successfully completed the physical model studies of some of the biggest projects of Bangladesh namely Bangabandhu Railway Bridge Project, Paira Bridge Project, Bangabandhu Bridge Project, Padma Multipurpose Bridge Project, Ganges Barrage Project, Gorai River Restoration Project, Arial Khan Roadway Bridge Project, 3rdKarnafullyRoadway Bridge Project, Kushtia Town Protection Project etc. However, due to lack of needed facilities RRI could not do much in physical modelling of coastal systems. Initiatives have already been taken to establish the tidal and coastal modelling facilities and to train scientists in this field.

RRI may act as a focal institution of its peripheral region to investigate regional water resources problems. A monitoring cell may be established at RRI to monitor the natural hazards like flood, draught, bank erosion, earthquake etc. As a focal institution, RRI may provide consultancy services to the Government, Local Authority of any organizations or may directly advise the beneficiaries to take precautionary measures against those hazards.
RRI is working in collaboration with BUET and is willing to work with similar foreign institutions like CWPRS (India), DHI (Denmark), Delft Hydraulics

(The Netherlands), HR Wallingford (UK), NHC (Canada), SMEC (Australia), LHI (Sri Lanka) etc. Efforts are being made by RRI to start joint venture/bi-lateral study/research projects with these similar international institutions.

More opportunities should be extended for RRI research personnel for imparting higher studies leading to MS/Ph D degree and other advanced on-job training. There should also have enough scope for RRI officials to participate in the national/international seminar, symposium, congress, workshop etc.

It can be mentioned here that though RRI is primarily catering the needs for national agencies, with the gradual development of manpower and technology, the institute will fulfil the demands for international bodies and organizations in future.

ANNEXURES

Padma Multipurpose Bridge

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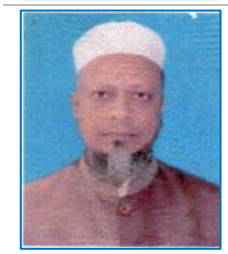

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Note: Sequence of the officials in the list has been maintained in accordance with the official gazette of the Government of the People's Republic of Bangladesh published on February 9, 2020.

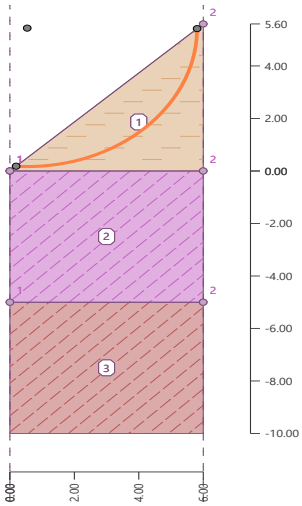
ABBREVIATIONS AND ELABORATIONS

A	AD	Assistant Director
	ADB	Asian Development Bank
	AFPM	Active Flood Plan Management
	A & F	Administration and Finance
	AIT	Asian Institute of Technology
	ASTM	American Society for Testing Materials
	ASO	Assistant Scientific Officer
B	B.A	Bachelor of Arts
	BAU	Bangladesh Agricultural University
	BARD	Bangladesh Academy for Rural Development
	BCA	Bangladesh Crystallographic Association
	BCL	Bangladesh Consultant Limited
	BCSIR	Bangladesh Council of Scientific and Industrial Research
	BIAM	Bangladesh Institute for Administrative Management
	BIM	BIM Bangladesh Institute of Management
	BIT	Bangladesh Institute of Technology
	BIWTA	Bangladesh Inland Water Transport Authority
	BIWTC	Bangladesh Inland Water Transport Corporation
	BoG	Board of Governors
	BPATC	Bangladesh Public Administration Training Centre
	BPI	Bangladesh Photographic Institute
	BPS	Bangladesh Physical Society
	BRRP	Buriganga River Restoration Project
	BUET	Bangladesh University of Engineering & Technology
	BWDB	Bangladesh Water Development Board
C	CBM	Concrete Block Mats
	CBR	California Bearing Ratio
	CC	Certificate Course
	CCFGIS	Certificate Course on Fundamentals on Geographic Information System
	CCFRS	Certificate Course on Fundamentals on Remote Sensing
	CCPGIS	Certificate Course on Professional Geographic Information System
	CERP	Coastal Embankment Rehabilitation Project
	CEGIS	Centre of Environmental and Geographic Information Services
	CPT	Cone Penetration Test
	CPU	Central Processing Unit
	CPTU	Central Procurement Training Unit
	CSO	Chief Scientific Officer
	CT	Concrete Technician
	CUET	Chittagong University of Engineering & Technology
	CWPRS	Central Water and Power Research Station
	CZEM	Coastal Zone Engineering and Management
D	DDC	Design Development Consultants Limited
	DC	Deputy Commissioner
	DD	Deputy Director
	DG	Director General
	DHI	Danish Hydraulic Institute
	DIFPP	Dhaka Integrated Flood Protection Project
	Dip.	Diploma
	DPP	Development Project Proforma
	D/S	Downstream
	DU	Dhaka University
E	EC	Electrical Conductivity
	EEE	Electrical & Electronics Engineering
	EGIS	Environmental and Geographic Information Service
	EGB	East Guide Bund

	EIA	Environmental Impact Assessment
	EMP	Environmental Management Plan
E	ESIA	Environmental impact statement
	ENGG.	Engineering
F	FAP	Flood Action Plan
	FCDI	Flood Control, Drainage & Irrigation
	F-IEB	Fellow of the Institution of Engineers, Bangladesh
	FM	Fineness Modulus
	FPM	Farm Power and Machinery
G	GBSP	Ganges Barrage Study Project
	GDP	Gross Development Profit
	GeoSRF	Geospatial Science & Research Foundation
	GHH	Ground Water Hydrology
	GIS	Geographic Information System
	GO	Government Order
	GoB	Government of Bangladesh
	GR	Geotechnical Research
	GRRP	Gorai River Restoration Project
	GWC	Ground Water Circle
H	Hons	Honours
	HP	Horse Power
	HR	Hydraulic Research
	HRL	Hydraulic Research Laboratory
	HS	Hojung Solutions
I	IAD	Integrated Agricultural Development
	IBAIS	International Business Administration and Information System
	ICDDRB	International Centre for Diarrheal Disease Research and Rehabilitation, Bangladesh
	IDCB	Institutional Development and Capacity Building
	IEB	Institution of Engineers, Bangladesh
	IHE	International Institute for Infrastructural, Hydraulic and Environmental Engineering
	IIT	Indian Institute of Technology
	IMED	Implementation, Monitoring and Evaluation Department
	IRD	Integrated Rural Development
	ITC	International Institute for Aerospace Survey and Earth Sciences
	IUSS	International Union of Soil Science
	IWFM	Institute of Water and Flood Modelling
	IWM	Institute of Water Modelling
	IWRM	Integrated Water Resources Management
J	JOCL	Japan Overseas Consultants Limited.
	JU	Jahangirnagar University
	JnU	Jagannath University
K	KUET	Khulna University of Engineering & Technology
	KUL	Katholic University of Leuven
	KVA	Kilo Volt Ampere
L	LA	Laboratory Attendant
	LAB	Laboratory
	LGB	Left Guide Bund
	LHI	Lanka Hydraulic Institute
	LLB	Bachelor of Law
	LM	Life Member
	LOI	Letter of Intent
	LT	Laboratory Technician
	LTU	La Trobe University
M	M.A	Master of Arts
	M-ASCE	Member of American Society of Civil Engineer
	M-BAAS	Member of Bangladesh Association for Advancement of Science

M	MBA	Master of Business Administration
	M-BCS	Member of Bangladesh Computer Society
	M-BES	Member of Bangladesh Environmental Society
	MC	Main Consultant/Moisture Content
	M-IEB	Member of the Institution of Engineers, Bangladesh
	MIS	Management Information System
	M-JSCE	Member of Japan Society of Civil Engineers
	MLSS	Member of the Lower Class Subordinate
	M-NOAMI	Member of National Oceanographic and Maritime Institute
	MoU	Memorandum of Understanding
	MoWR	Ministry of Water Resources
	MP	Member of the Parliament
	MPA	Mongla Port Authority
	MS	Mild Steel
	M.S/M.Sc.	Master of Science
	M. Phil.	Master of Philosophy
N	NHC	North Hydraulic Consultants Limited
	NMC	Natural Moisture Content
	NU	National University
	NAHRIM	National Hydraulic Research Institute Malaysia
	NHC	North Hydraulic Consultants Limited
	NOAMI	National Oceanographic and Maritime Institute
O	O & M	Operation & Maintenance
	OTM	Open Tendering Method
P	PABX	Public Automatic Branch Exchange
	PATC	Public Administration Training Centre
	PC	Personal Computer
	PD	Project Director
	PGD	Post Graduate Diploma
	PGT	Post Graduate Training
	PhD	Doctor of Philosophy
	PLOI	Provisional Letter of Intent
	PPM	Parts per Million
	PS	Private Secretary
	PSO	Principal Scientific Officer
	PU	Prime University
	PWD	Public Works Department
R	RAC	Regional Accounts Centre
	RDPP	Revised Development Project Proforma
	REBRFM	Research on the Effect of Bandalling on River Flow and Morphology
	RFQ	Request for Quotation
	RGB	Right Guide Bund
	RHD	Roads & Highways Department
	RPATC	Regional Public Administration Training Centre
	RRI	River Research Institute
	RS	Remote Sensing
	RTW	River Training Work
	RU	Rajshahi University
	RUET	Rajshahi University of Engineering & Technology
S	SAE	Sub-Assistant Engineer
	SICT	Support to Information and Communication Technology
	SMEC	Snowy Mountain Engineering Corporation
	SO	Scientific Officer
	SRNDP	Southwest Road Network Development Project
	SSD	Submerged Soil Density
	SSO	Senior Scientific Officer
	SSFCDI	Small Scale Flood Control, Drainage & Irrigation

	ST	Soil Technician
	SWH	Surface Water Hydrology
	SWMC	Surface Water Modelling Centre
T	TDS	Total Dissolved Solids
	ToR	Terms of Reference
	TU	Technical University
U	UAV	Unmanned Aerial Vehicle
	UGC	University Grant Commission
	UK	United Kingdom
	UNESCO	United Nations Educational, Scientific and Cultural Organization
	UPM	University Putra Malaysia
	U/S	Upstream
	USA	United States of America
	USV	Unmanned Surface Vehicle
	UTM	Universal Testing Machine
W	WR	Water Resources
	WRD	Water Resources Development
	WRDP	Water Resources Development Project
	WRE	Water Resources Engineering
	WRM	Water Resources Management
	WRS	Water Resources Survey



Professional staff in 2022-23

Directorate	DIR	CSO	PSO	SSO	SO	TOTAL
Hydraulic Research	-	1	2	6	2	11
Geotechnical Research	-	1	3	5	1	10
Administration and Finance	1	-	2	3	1	7
Total	1	2	7	14	4	28

DIR: Director, CSO: Chief Scientific Officer, PSO: Principal Scientific Officer, SSO: Senior Scientific Officer, SO: Scientific Officer

Directorate-wise total employee in 2022-23

Directorates	1st Class	2nd Class	3rd Class	4th Class	TOTAL
Hydraulic Research	11	-	13	12	36
Geotechnical Research	10	-	33	14	57
Administration and Finance	13	01	33	31	78
Total	34	01	79	57	171

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