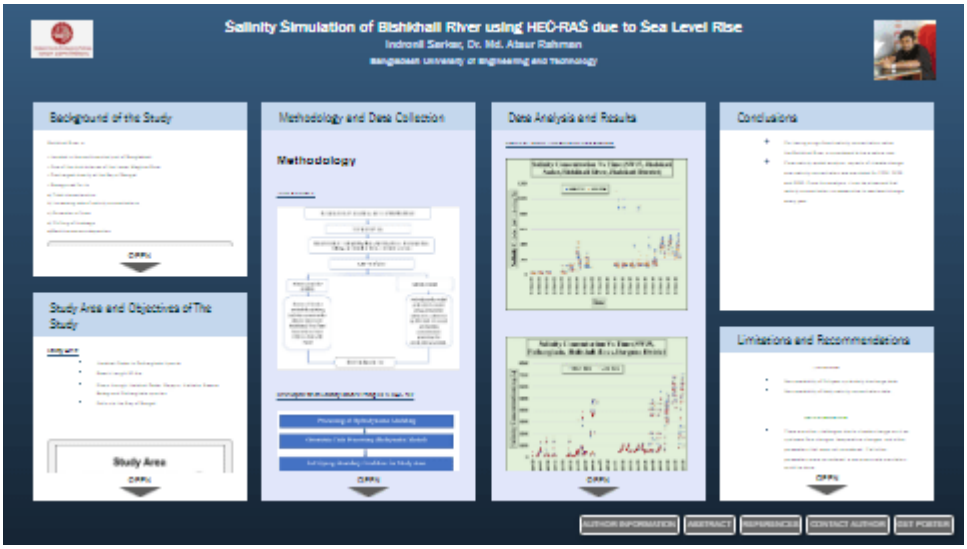
Salinity Simulation of Bishkhali River using HEC-RAS due to Sea Level Rise



Indronil Sarkar, Dr. Md. Ataur Rahman

Bangladesh University of Engineering and Technology

PRESENTED AT:

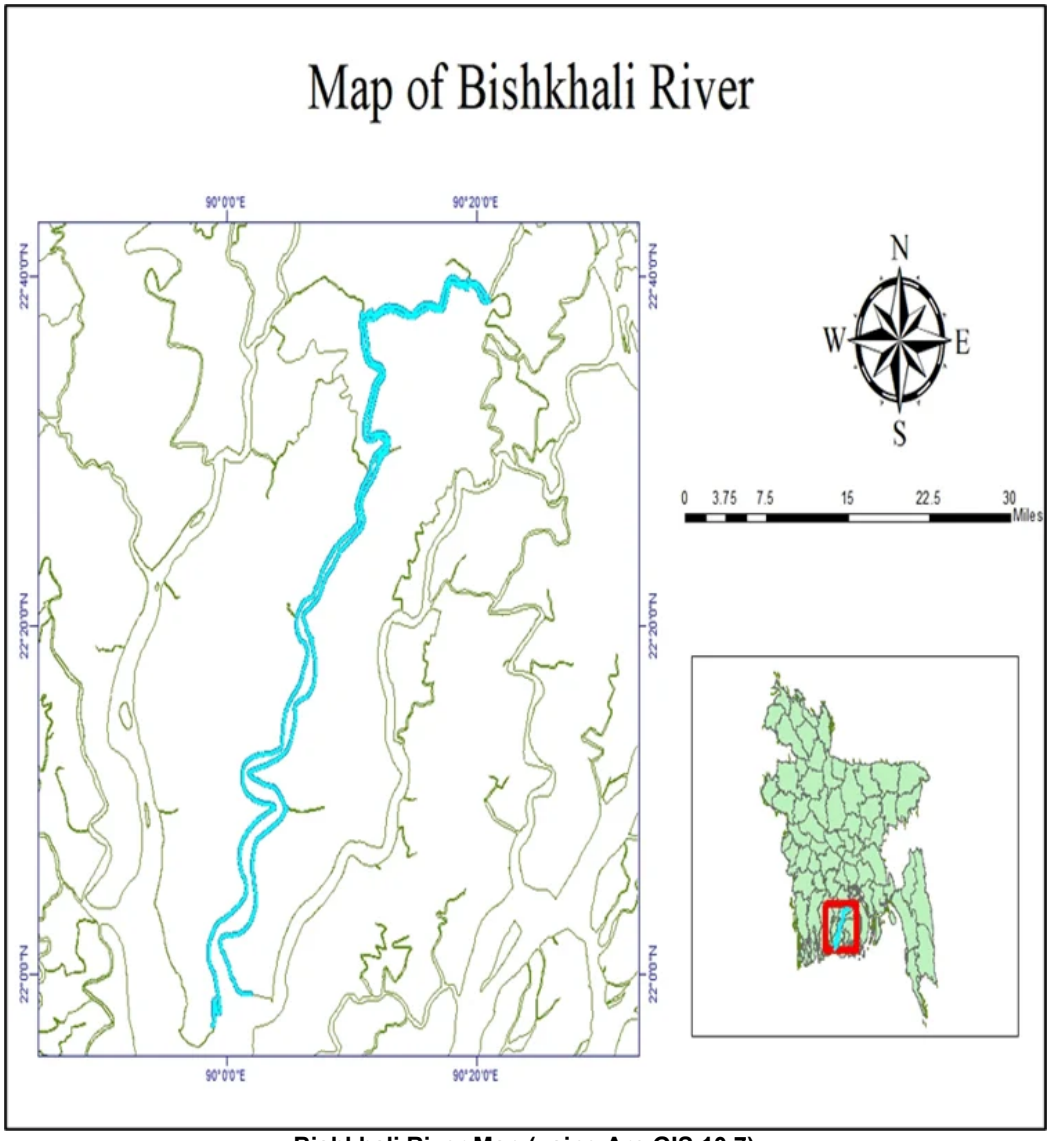
AGU FALL MEETING
Chicago, IL & Online Everywhere
12–16 December 2022
SCIENCE LEADS THE FUTURE

BACKGROUND OF THE STUDY

Bishkhali River is

- Located in the south-central part of Bangladesh.
- One of the distributaries of the Lower Meghna River
- Discharged directly at the Bay of Bengal
- Recognized for its

a) Tidal characteristics
b) Increasing rate of salinity concentrations
c) Formation of bars
d) Shifting of thalwegs
e)Bankline erosion-deposition



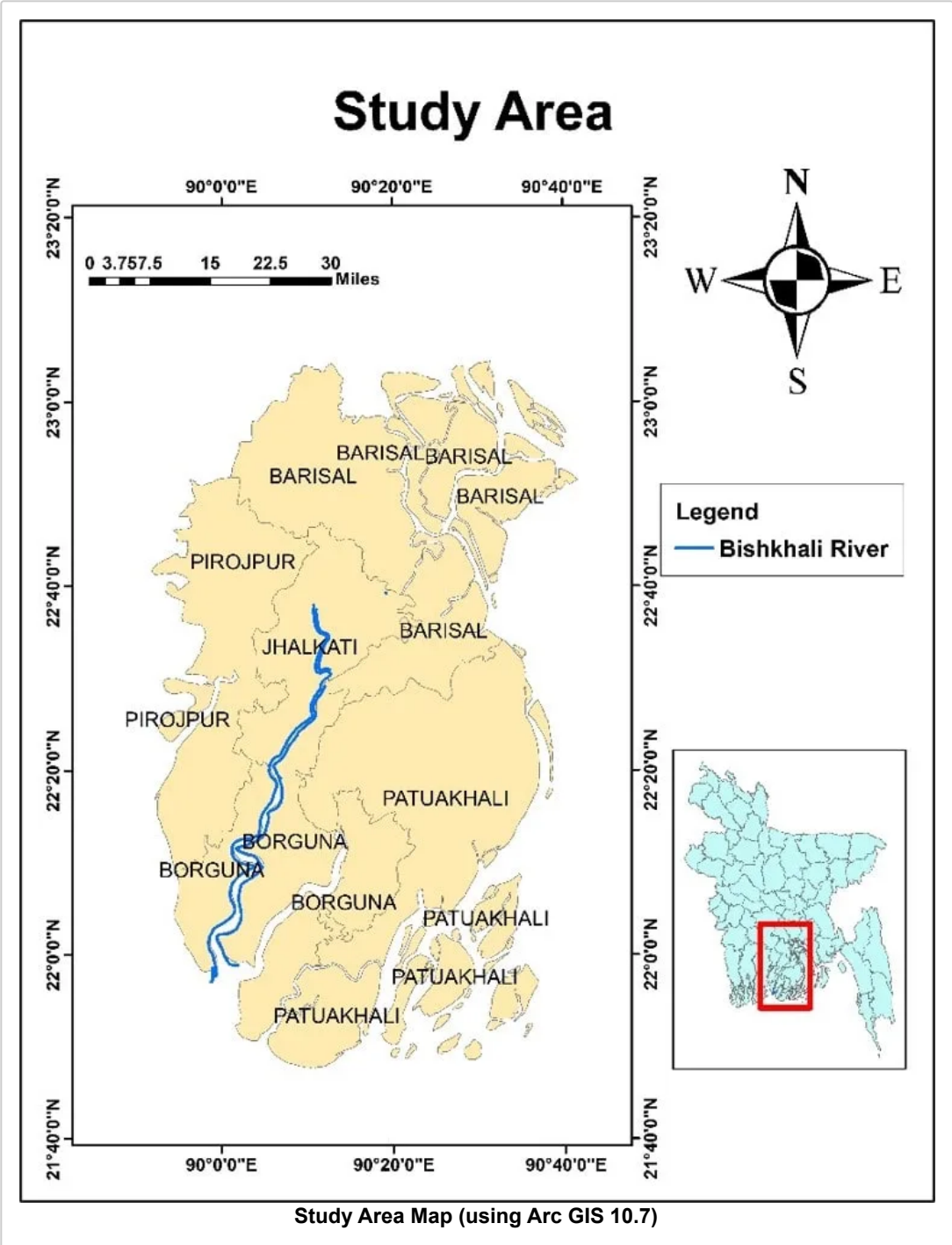
Bishkhali River Map (using Arc GIS 10.7)

(Source: Google Image)

STUDY AREA AND OBJECTIVES OF THE STUDY

Study Area:

- Jhalokati Sadar to Patharghata Upazila.
- Reach Length 93 Km.
- Flows through Jhalokati Sadar, Rajapur, Kathalia, Bamna, Betagi and Patharghata upazilas.
- Falls into the Bay of Bengal.



Study Area Map (using Arc GIS 10.7)

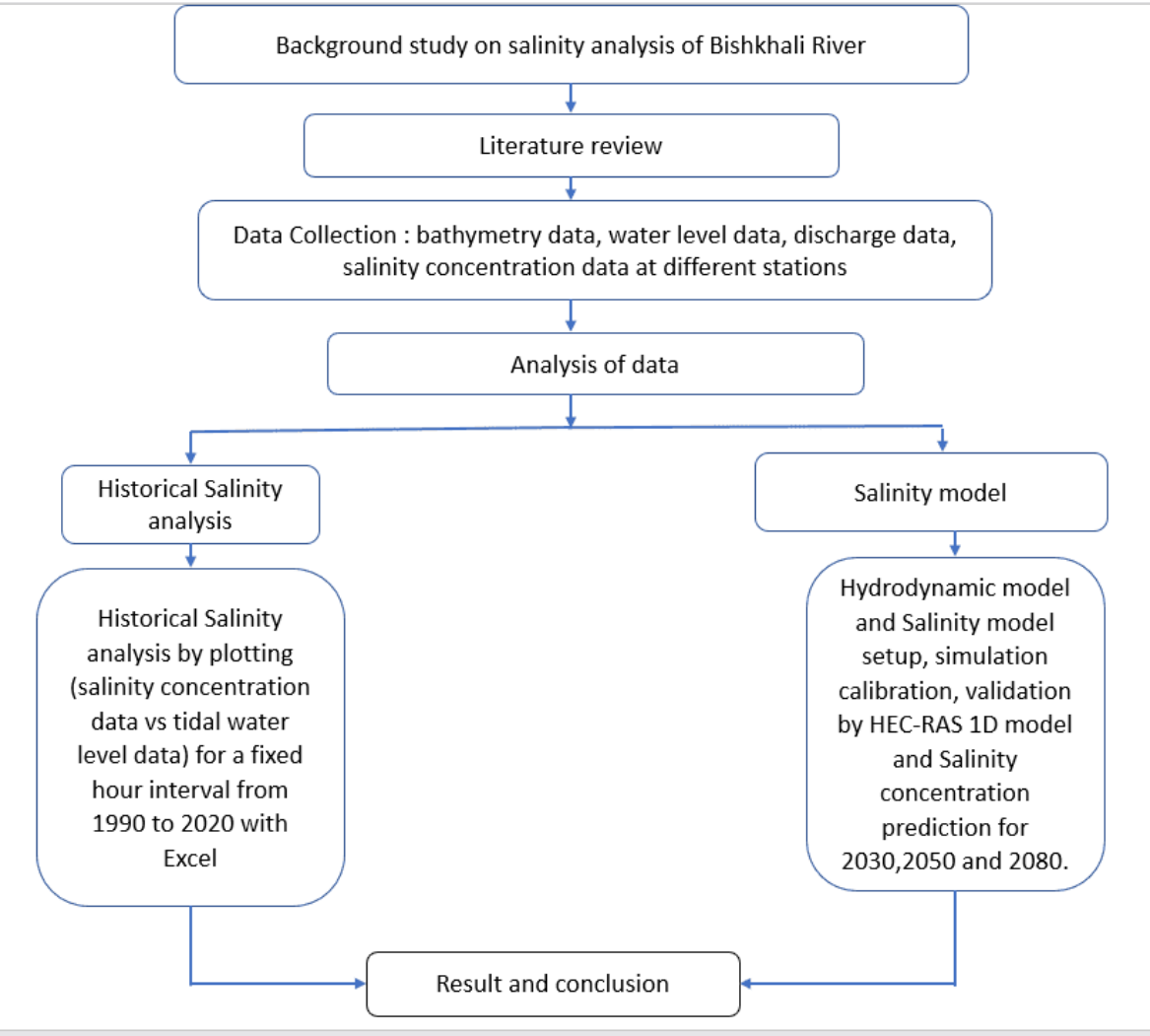
Objectives of the Study:

- To perform salinity analysis at different locations of the Bishkhali River using historical salinity concentration data.
- To develop a salinity model using the HEC-RAS 1D model for the Bishkhali River and assess the salinity condition under different scenarios.

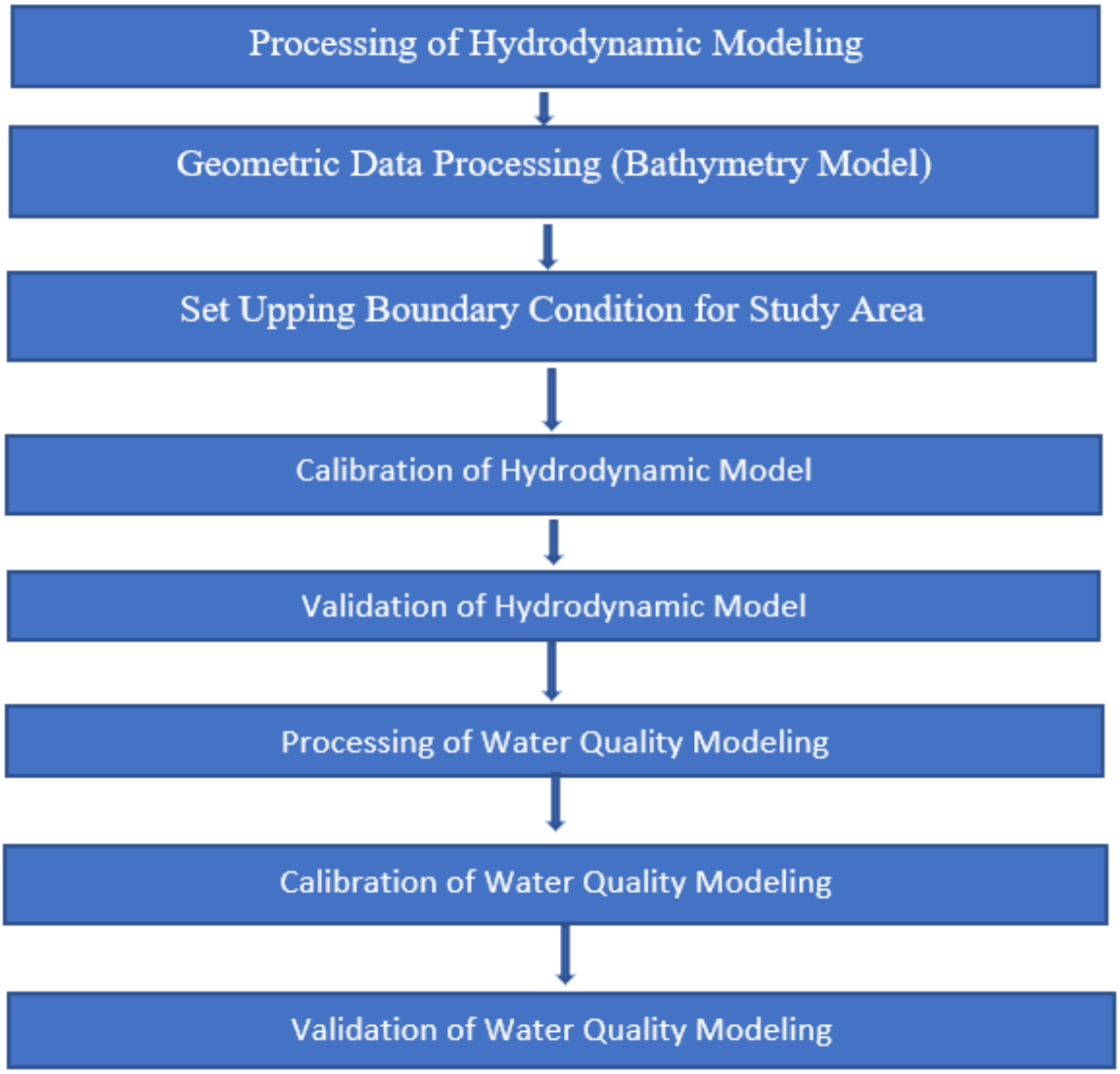
METHODOLOGY AND DATA COLLECTION

Methodology

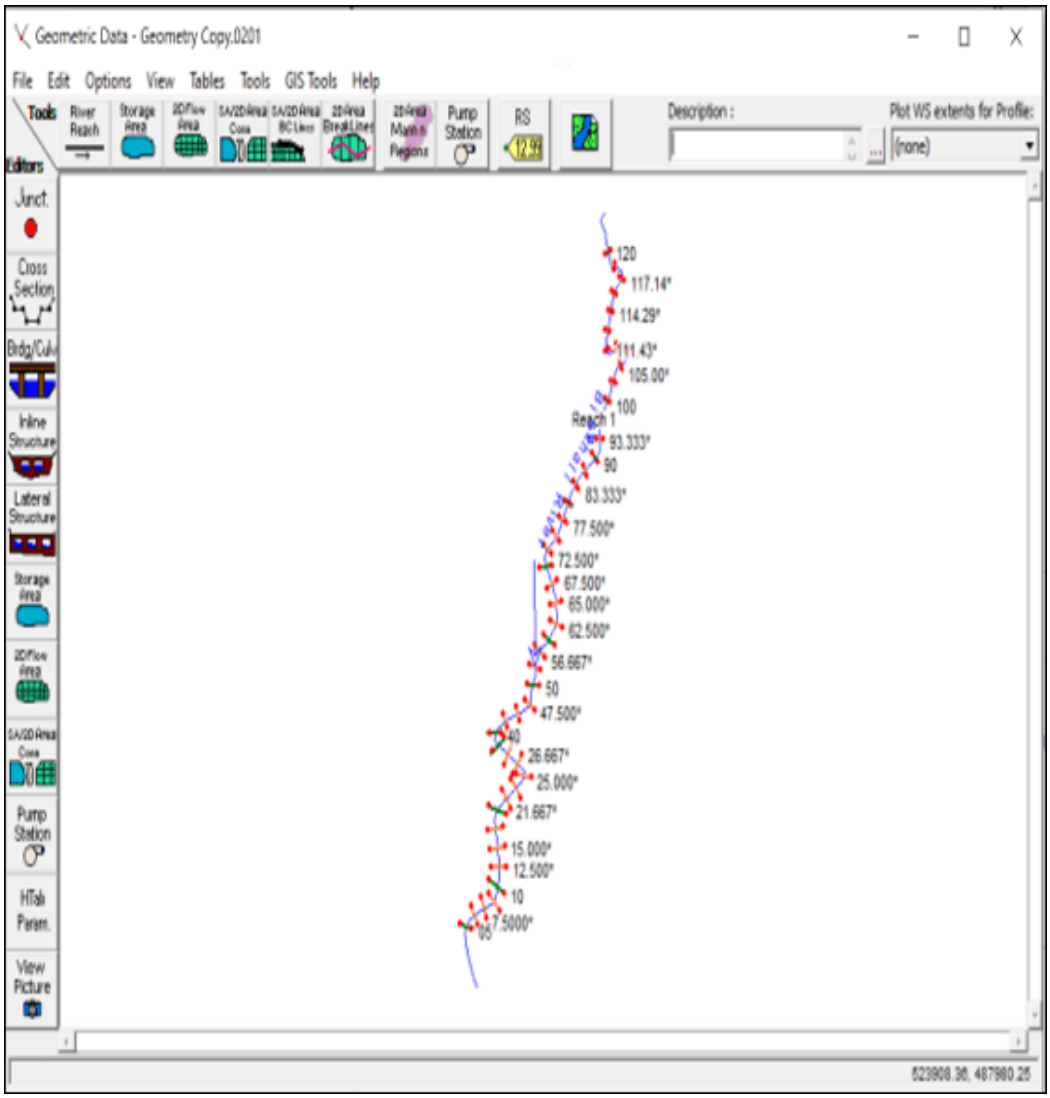
Study Approach:



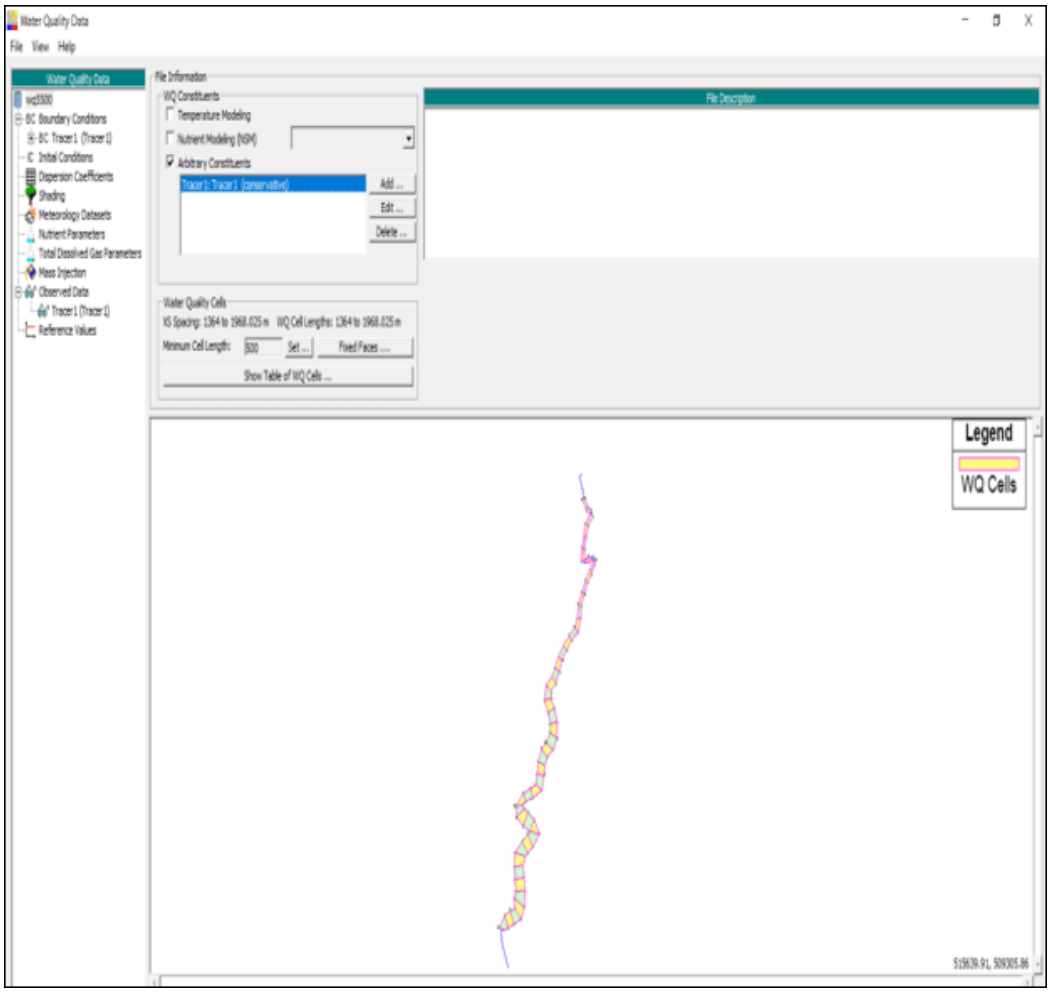
Development of Salinity Model Using HEC-RAS-1D:


Processing of Hydrodynamic Modeling
Geometric Data Processing (Bathymetry Model)
Set Upping Boundary Condition for Study Area
Calibration of Hydrodynamic Model
Validation of Hydrodynamic Model
Processing of Water Quality Modeling
Calibration of Water Quality Modeling
Validation of Water Quality Modeling

Model Set-up:



Hydrodynamic model set-up using HEC-RAS



Water quality model set-up using HEC-RAS

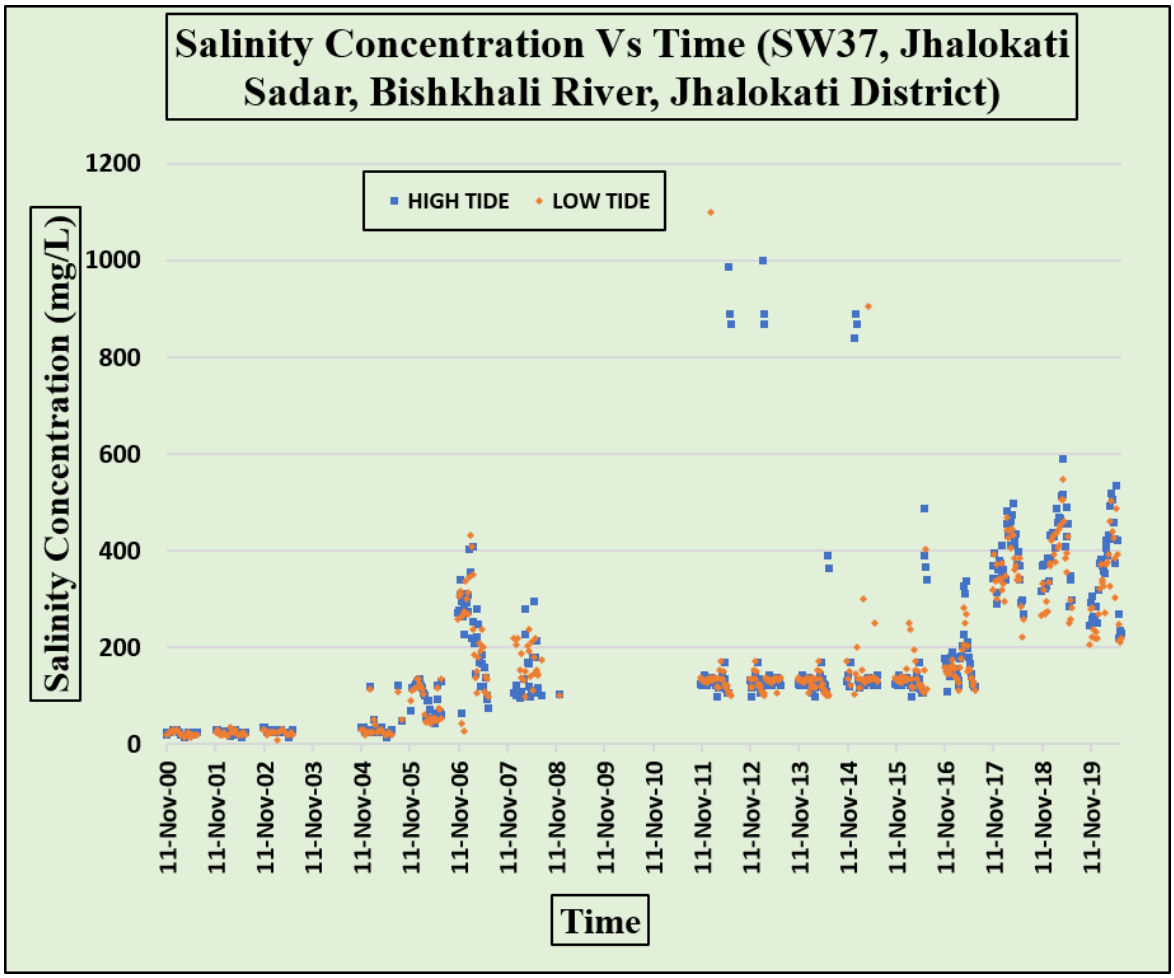
Data Collection

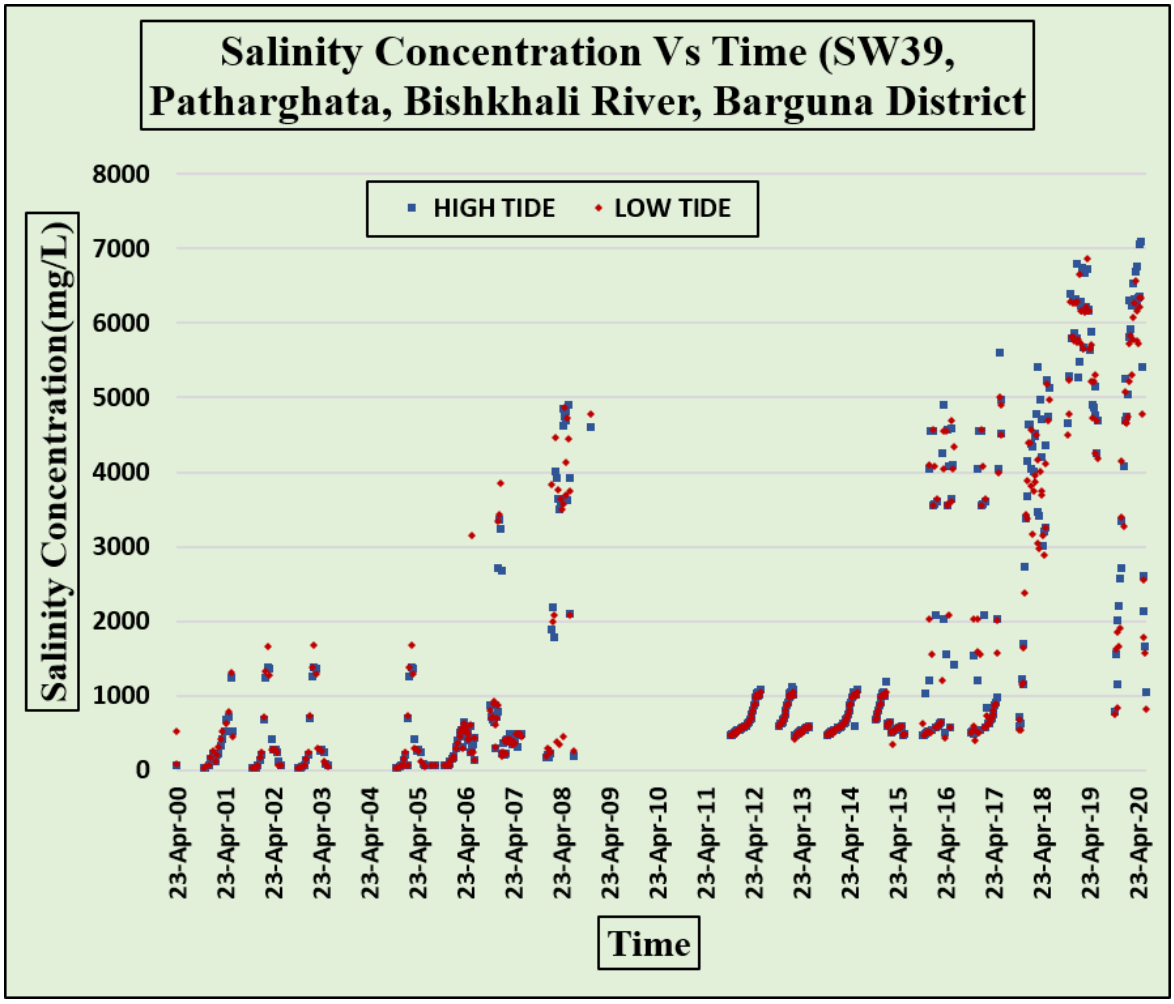
Data Type	Location	Data Source	BWDB Station ID	Period (Year)
Satellite Images	Bishkhali River	USGS (30m resolution)	-	(1995-2020)
Bathymetry Data	Bishkhali River	BWDB	RMBIS 5 to RMBIS 16	(1995-2020)
Water Level	Bishkhali River	BWDB	SW37 to SW39	(1995-2020)
Discharge	Bishkhali River	Tertiary Data Sources	-	(1983 & 2011)
Salinity Data	Bishkhali River	BWDB	SW37 to SW39	(2000-2020)

BWDB Stations

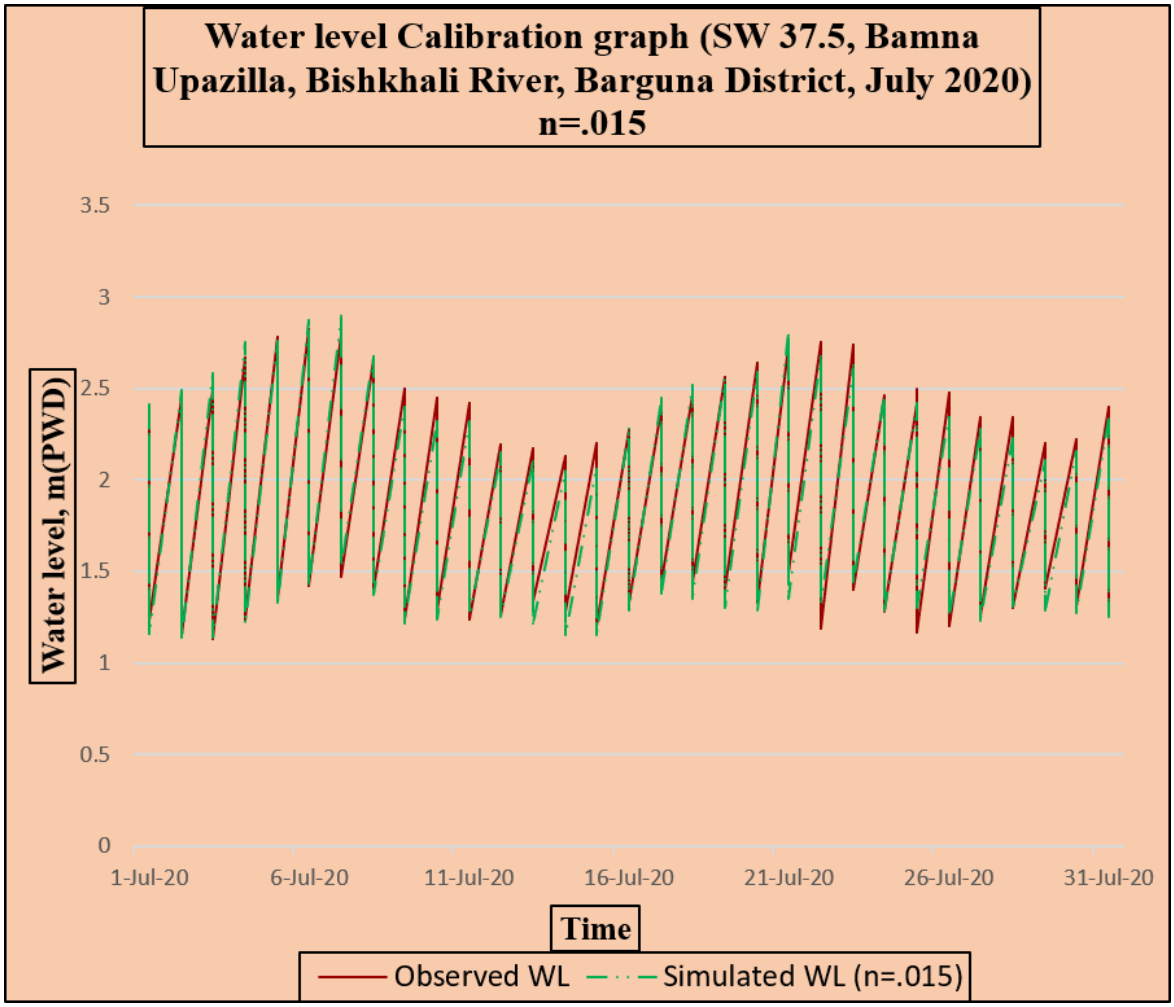
DATA ANALYSIS AND RESULTS

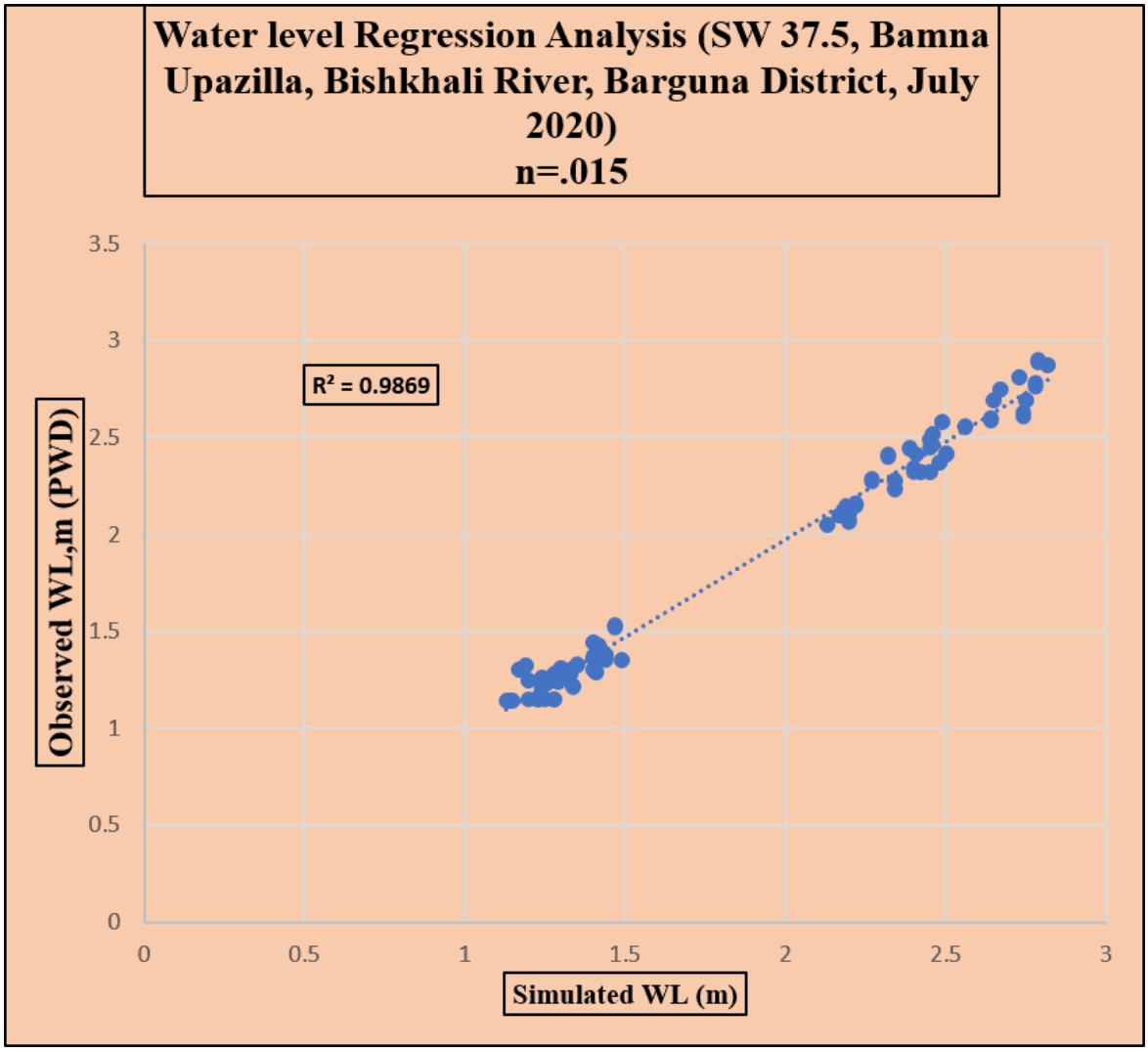
Historical Salinity Concentration Data Analysis:



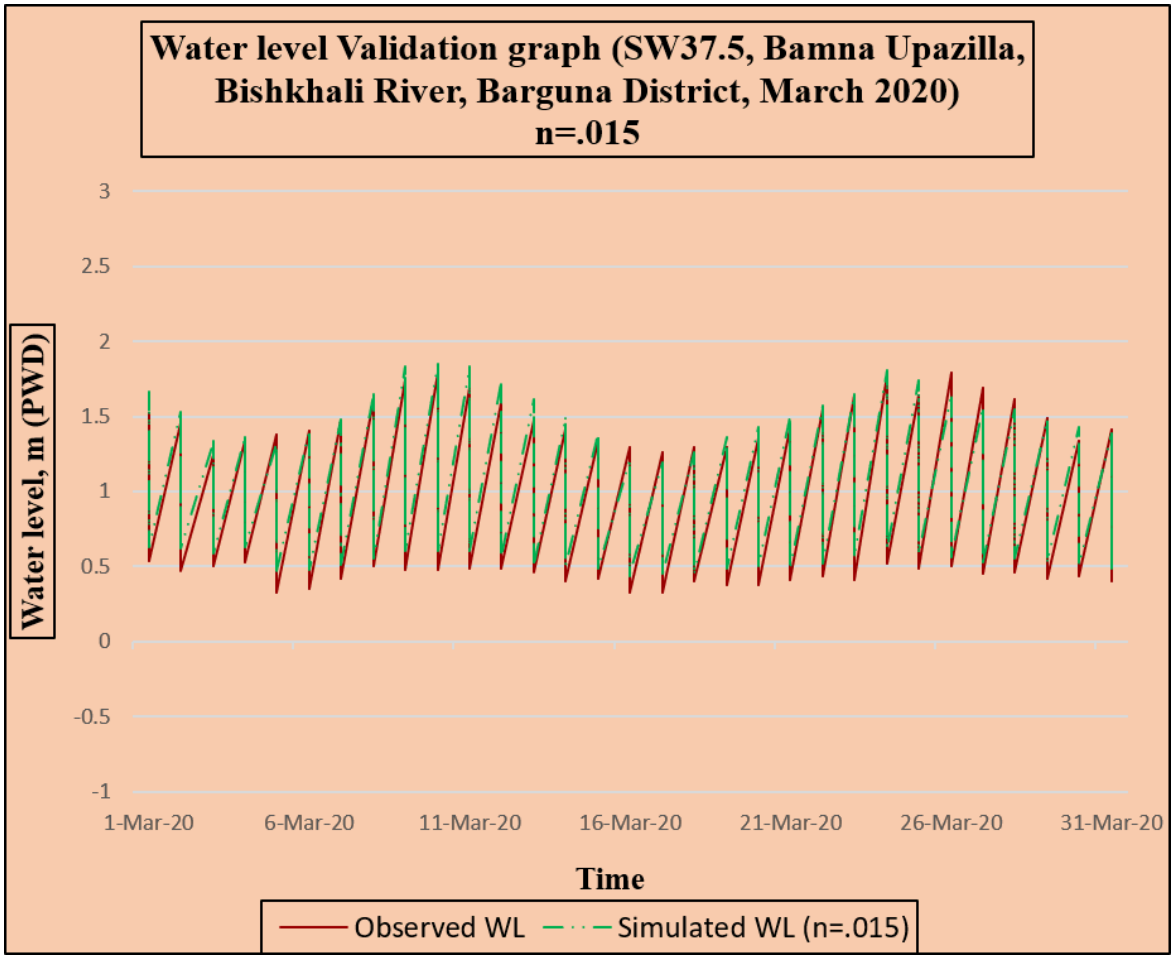


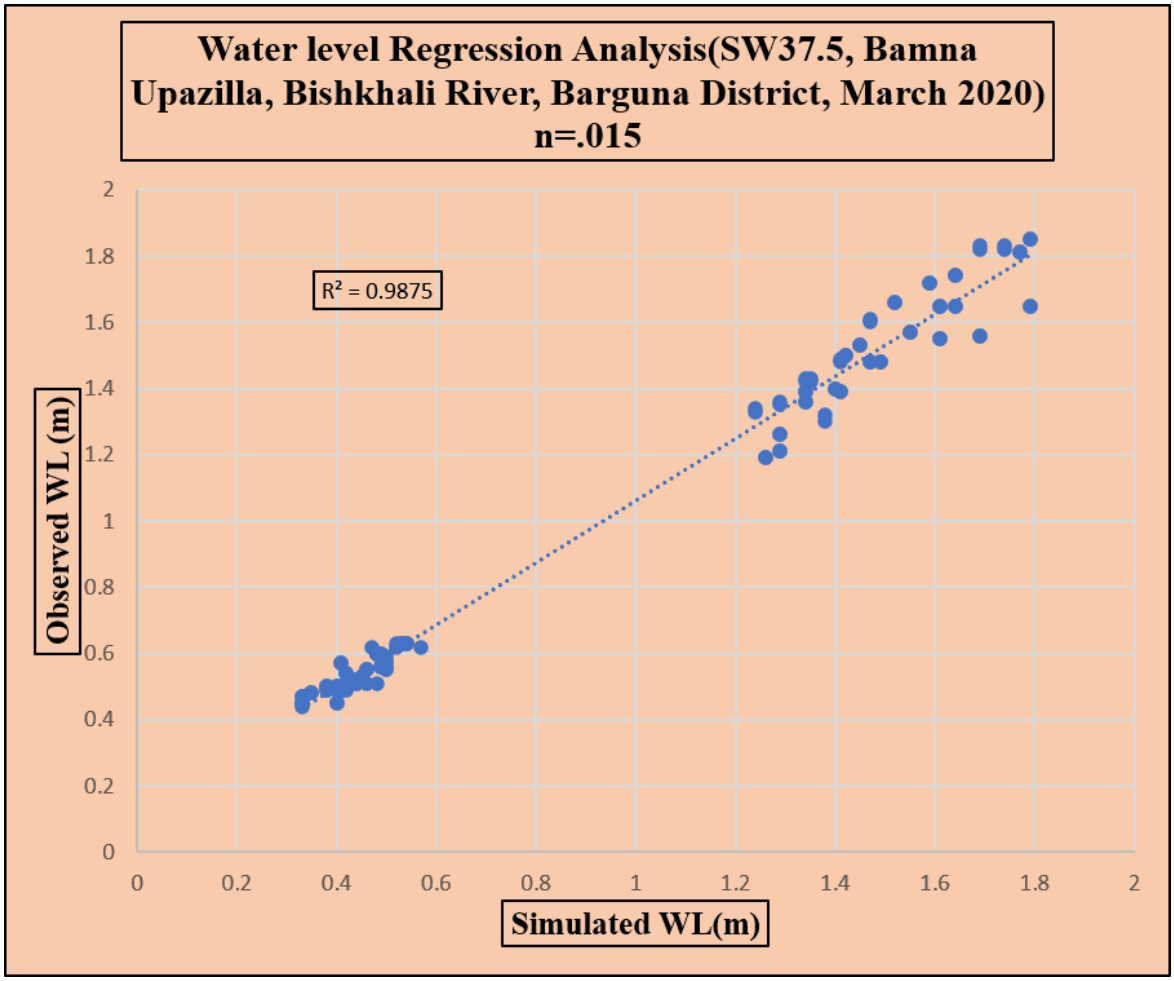
Calibration of Hydrodynamic Model at Bamna Upazila (SW37.5) for July 2020:


Water level Calibration graph (SW 37.5, Bamna Upazilla, Bishkhali River, Barguna District, July 2020) n=.015
Water level, m(PWD)
3.5
3
2.5
2
1.5
1
0.5
0
1-Jul-20
6-Jul-20
11-Jul-20
16-Jul-20
21-Jul-20
26-Jul-20
31-Jul-20
Time
Observed WL
Simulated WL (n=.015)

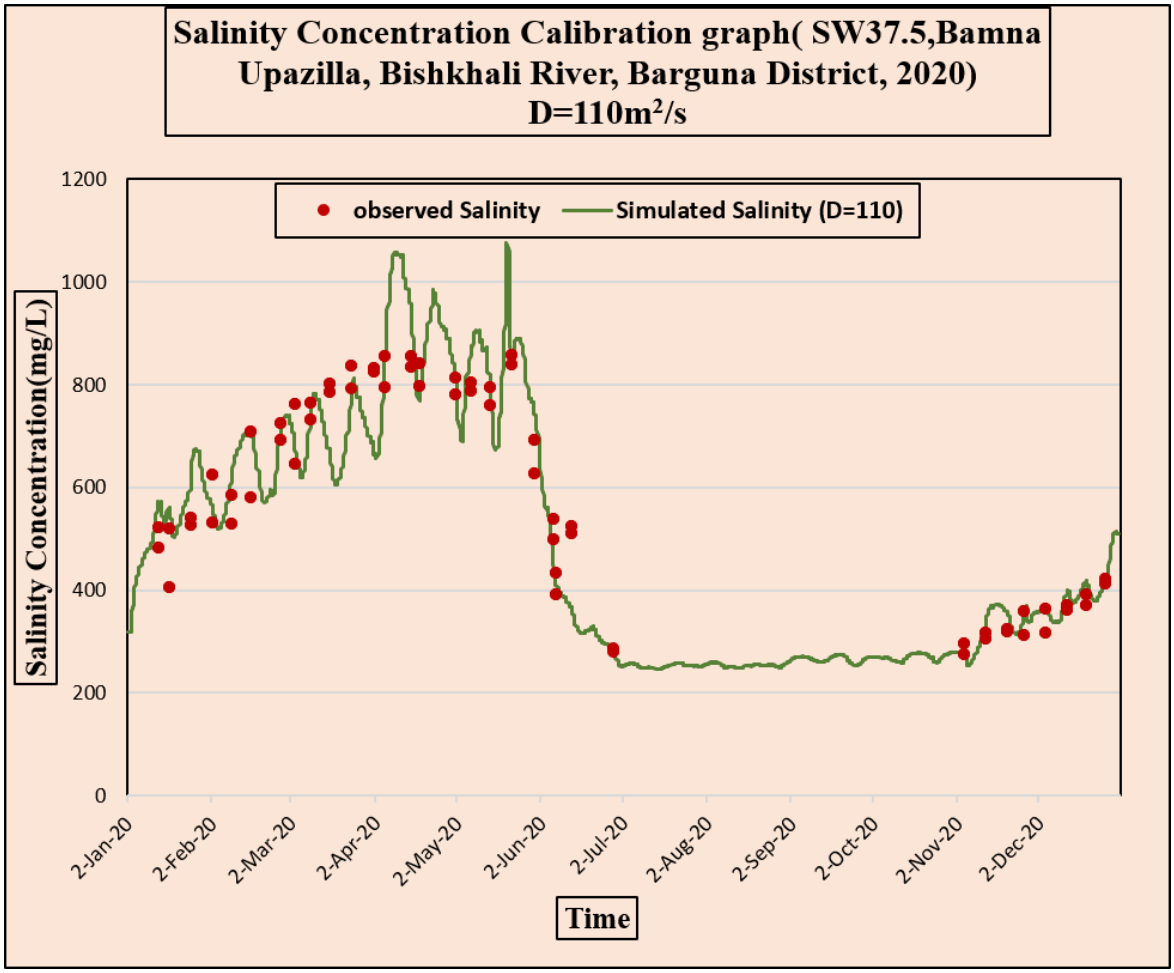


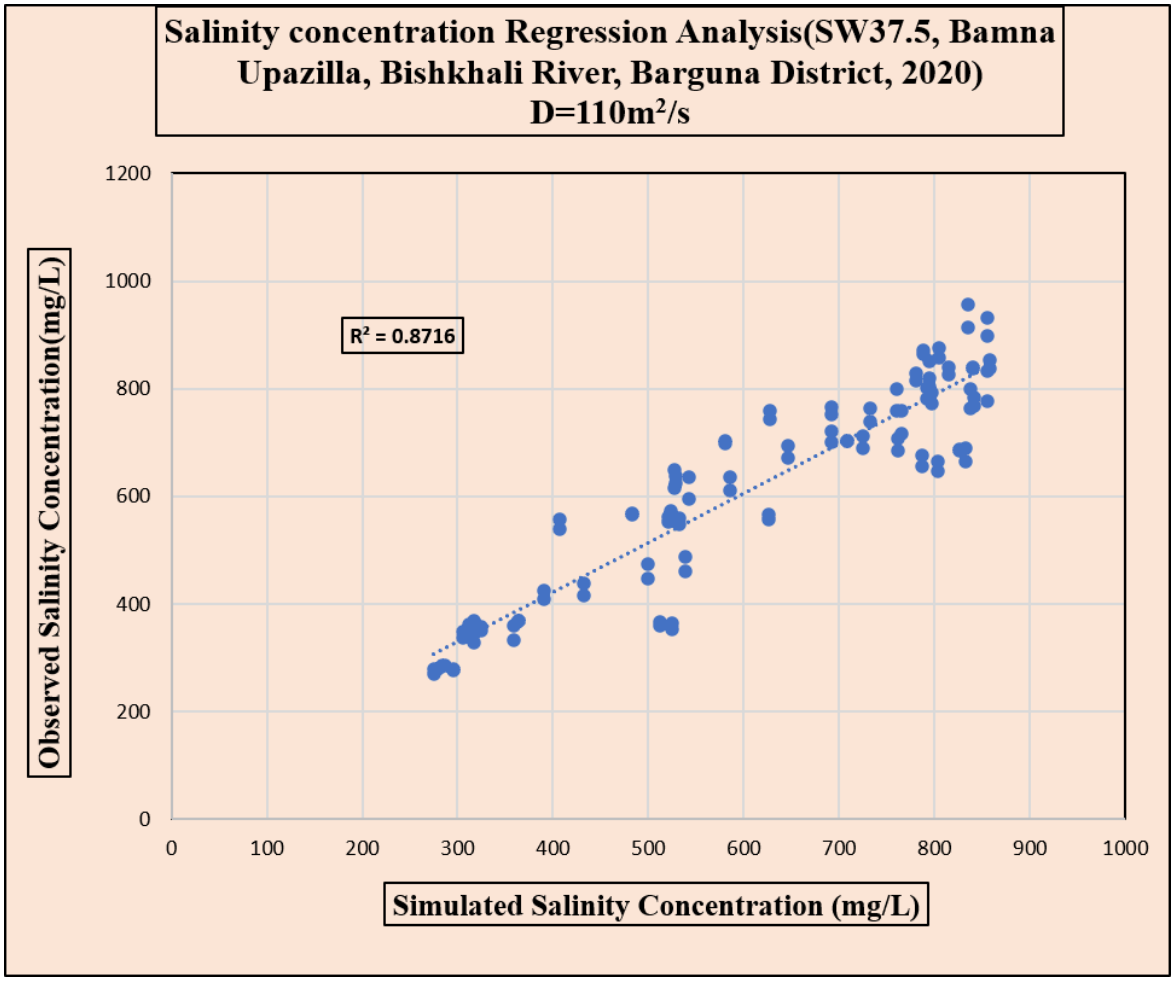
Validation of Hydrodynamic Model at Bamna Upazila (SW37.5) for March 2020:


Water level Validation graph (SW37.5, Bamna Upazilla, Bishkhali River, Barguna District, March 2020)
n=.015
Water level, m (PWD)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
1-Mar-20
6-Mar-20
11-Mar-20
16-Mar-20
21-Mar-20
26-Mar-20
31-Mar-20
Time
Observed WL
Simulated WL (n=.015)

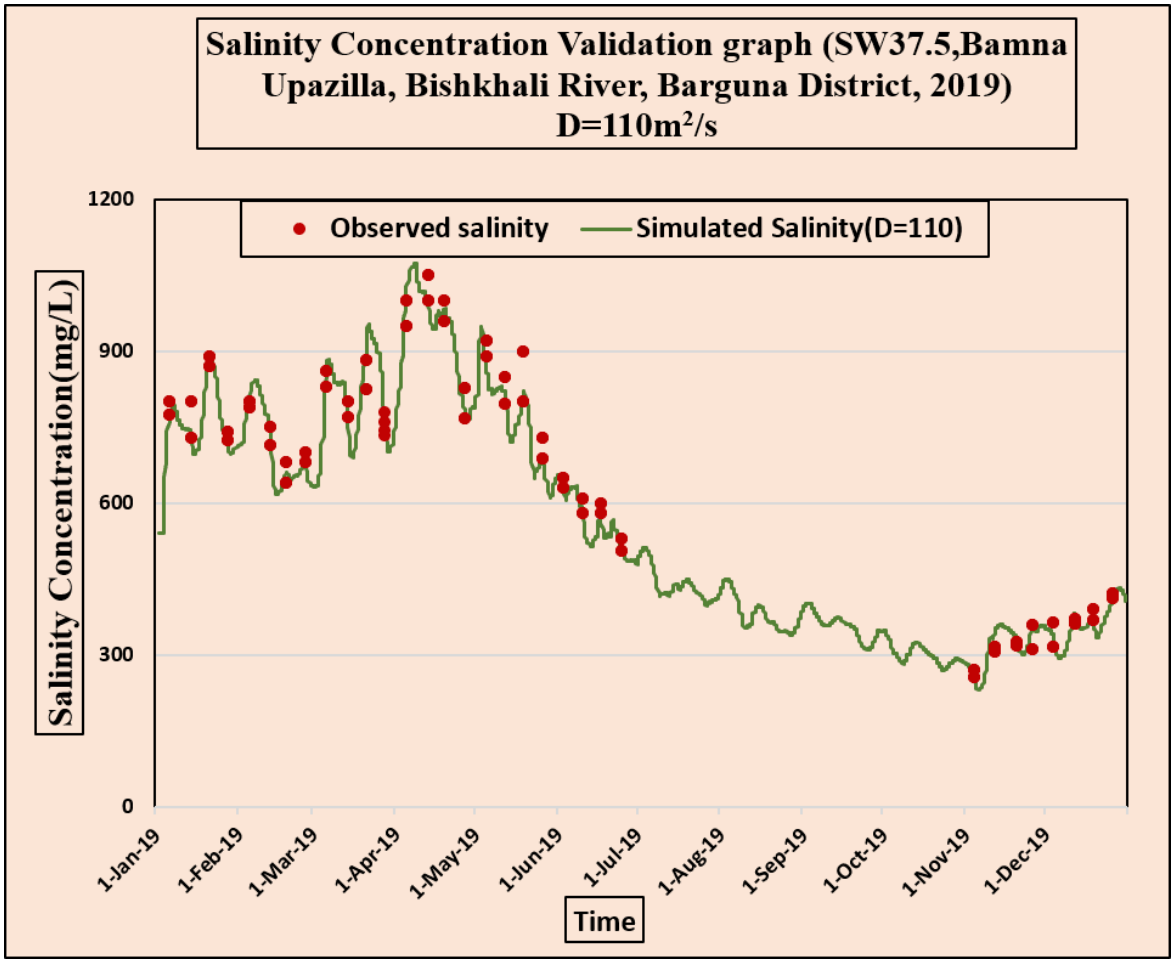


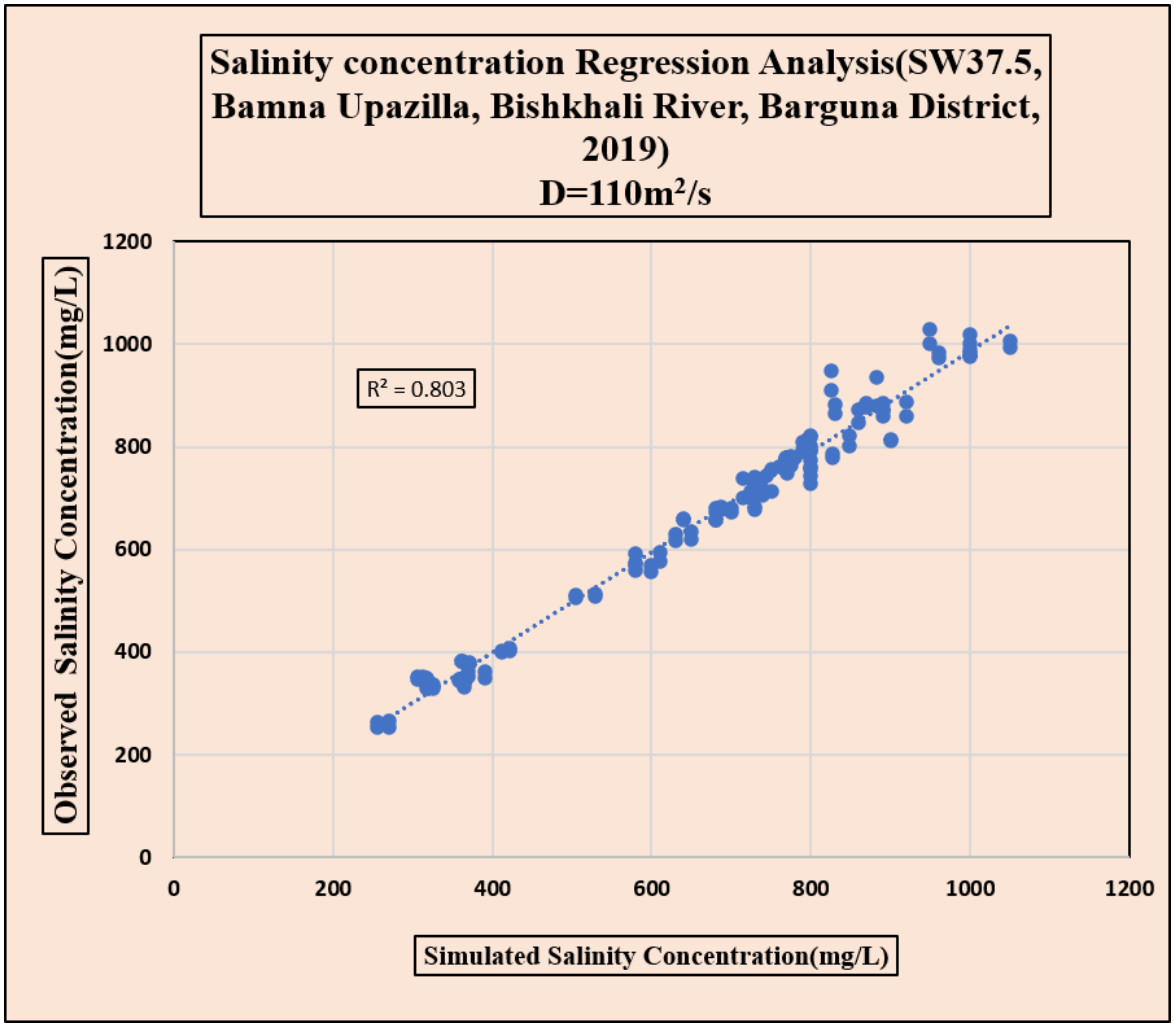
Calibration of Salinity Model at Bamna Upazila (SW37.5) for 2020:


Salinity Concentration Calibration graph(SW37.5,Bamna Upazilla, Bishkhali River, Barguna District, 2020)
D=110m²/s
observed Salinity
Simulated Salinity (D=110)
Salinity Concentration(mg/L)
1200
1000
800
600
400
200
0
2-Jan-20
2-Feb-20
2-Mar-20
2-Apr-20
2-May-20
2-Jun-20
2-Jul-20
2-Aug-20
2-Sep-20
2-Oct-20
2-Nov-20
2-Dec-20
Time

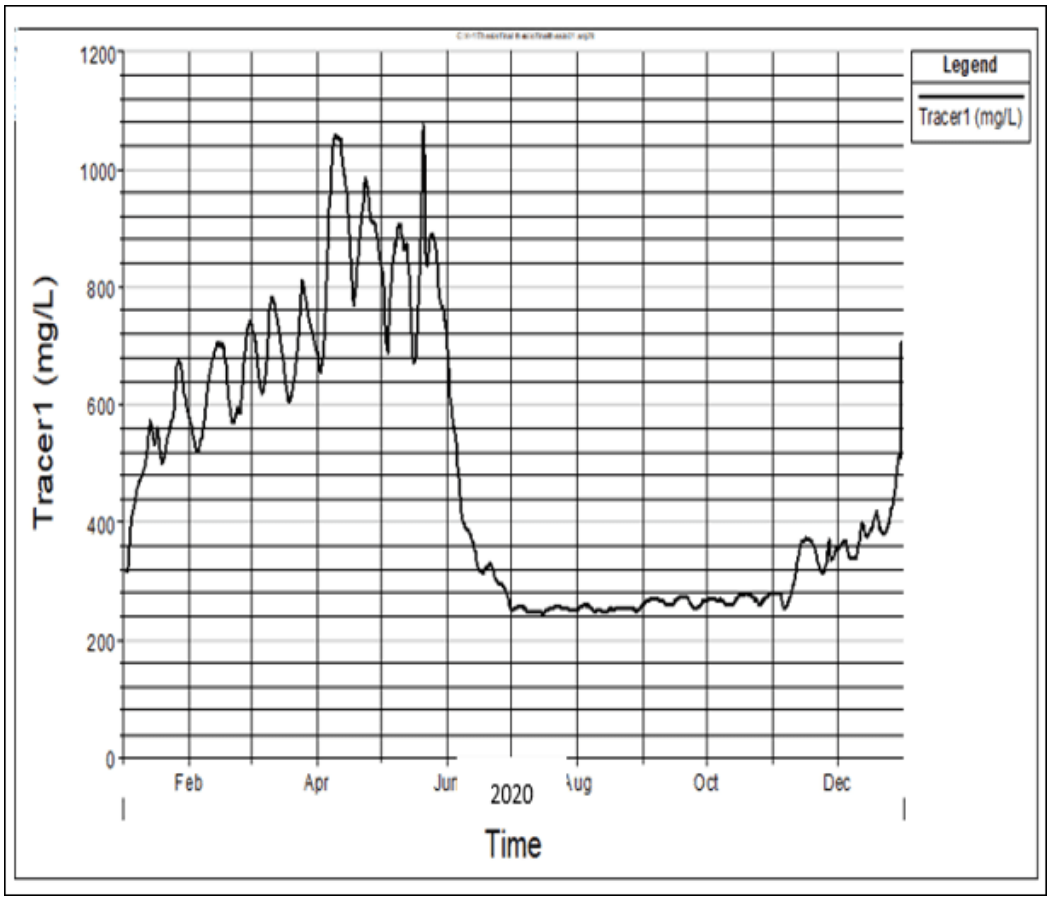


Validation of Salinity Model at Bamna Upazila (SW37.5) for 2019:

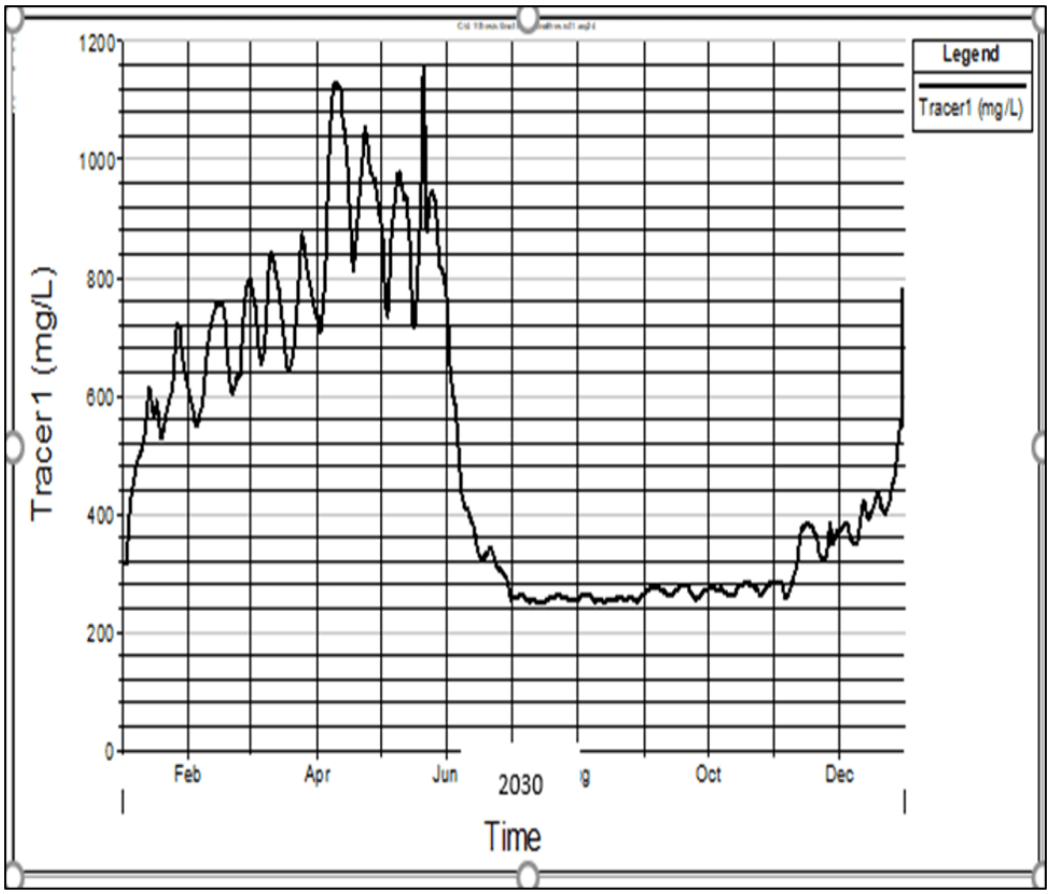

Salinity Concentration Validation graph (SW37.5,Bamna Upazilla, Bishkhali River, Barguna District, 2019)
D=110m²/s
Observed salinity
Simulated Salinity(D=110)
Salinity Concentration(mg/L)
1200
900
600
300
0
1-Jan-19
1-Feb-19
1-Mar-19
1-Apr-19
1-May-19
1-Jun-19
1-Jul-19
1-Aug-19
1-Sep-19
1-Oct-19
1-Nov-19
1-Dec-19
Time



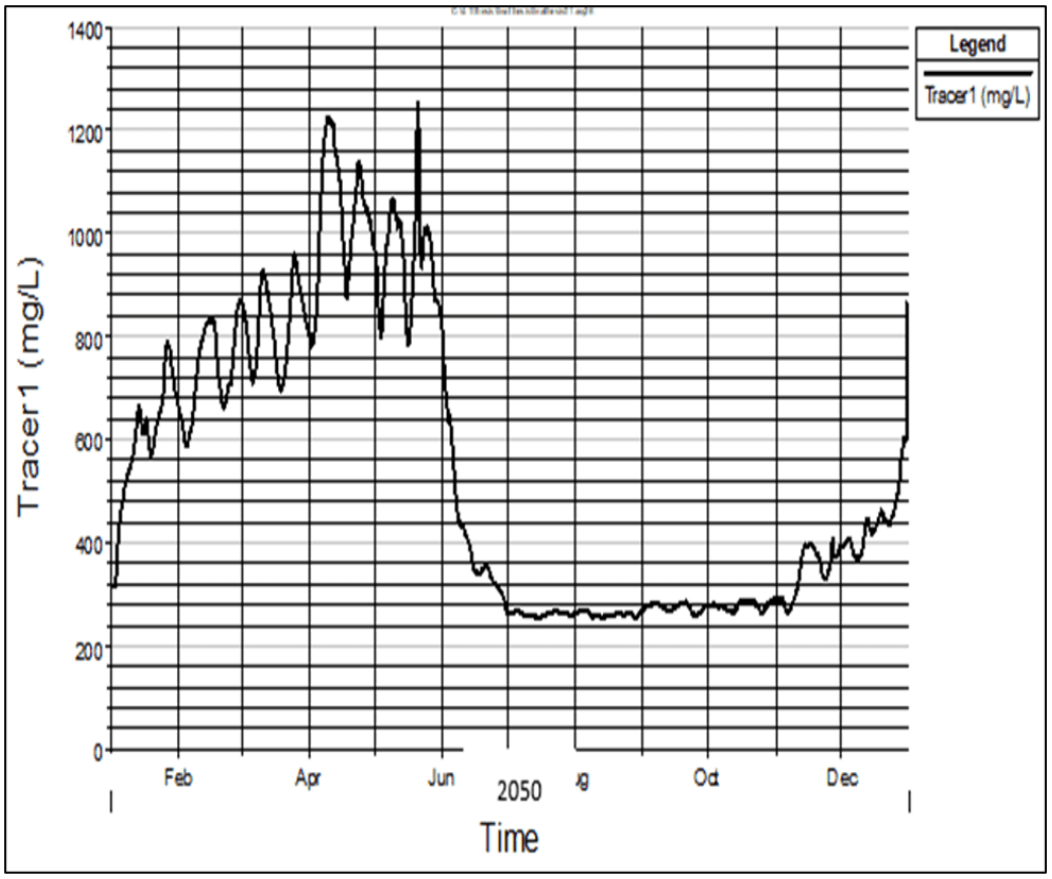
Salinity Analysis for Different Scenarios at Bamna Upazila (SW37.5) due to Sea level rise:


Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
1200
1000
800
600
400
200
0
Feb
Apr
Jun
Aug
Oct
Dec
2020
Time

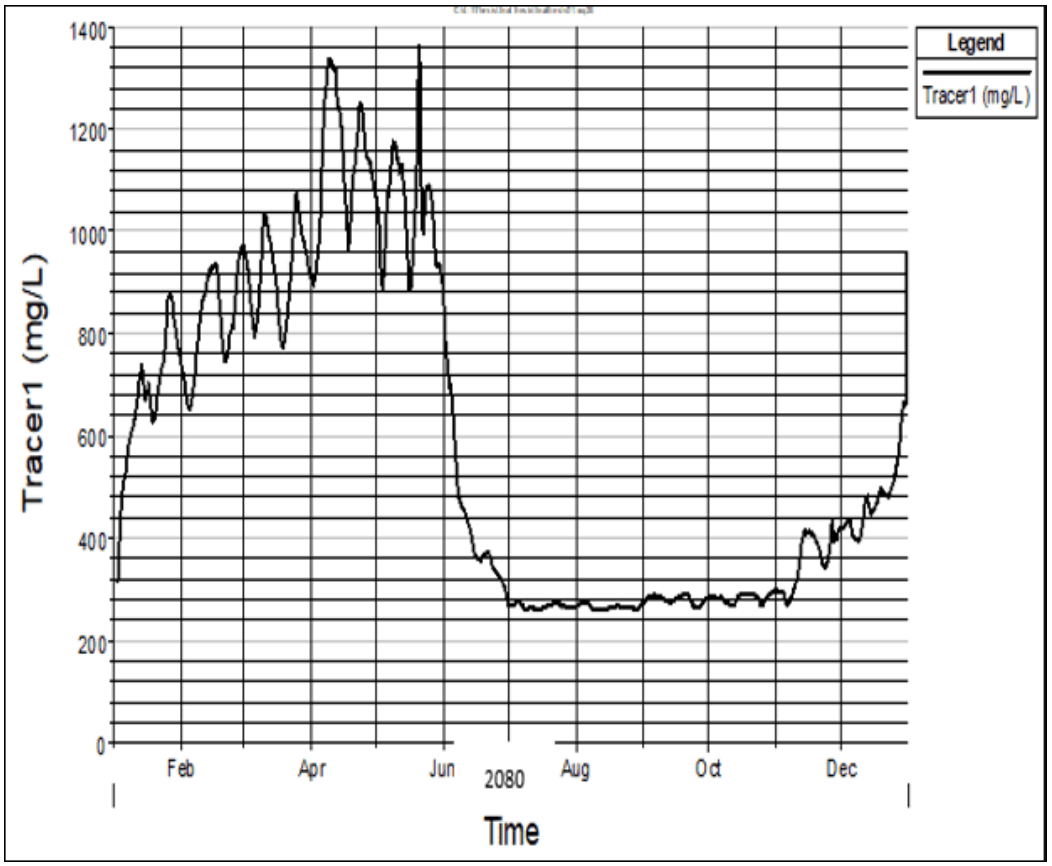
2020


Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
1200
1000
800
600
400
200
0
Feb
Apr
Jun
2030
Oct
Dec
Time

2030

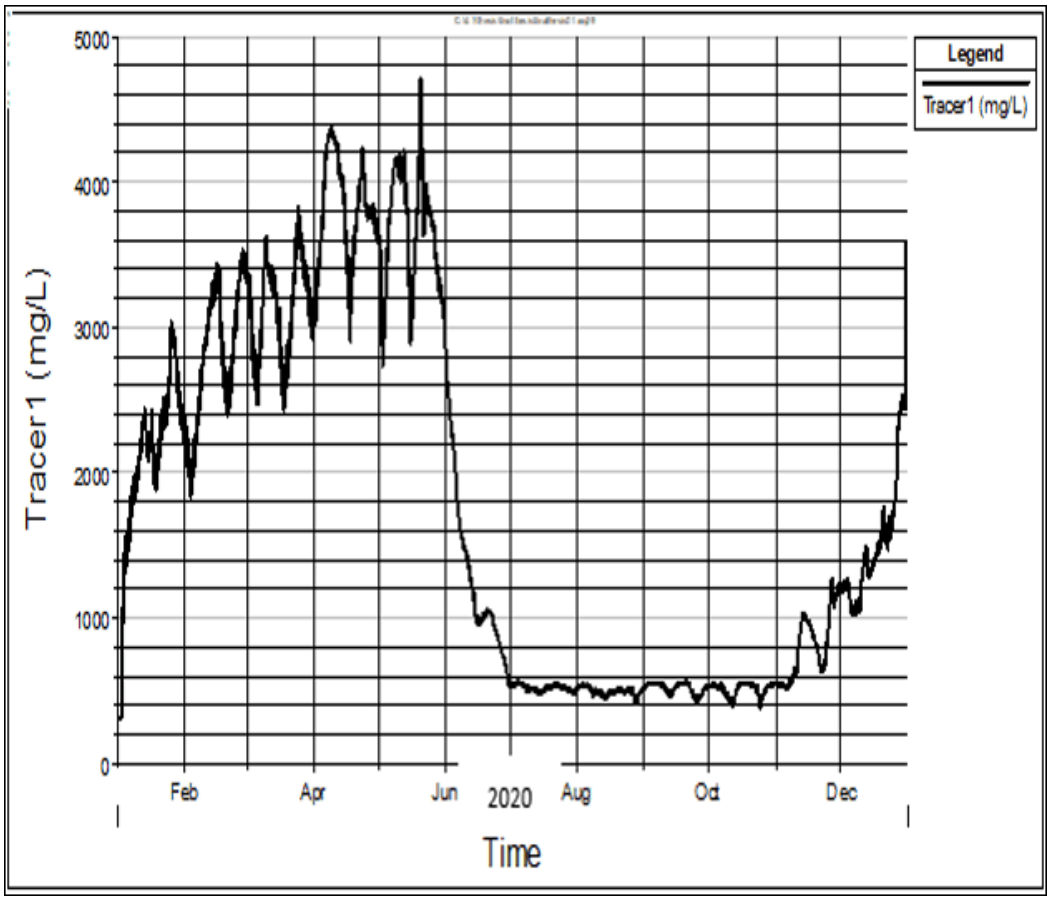

Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
1400
1200
1000
800
600
400
200
0
Feb
Apr
Jun
2050
Aug
Oct
Dec
Time

2050

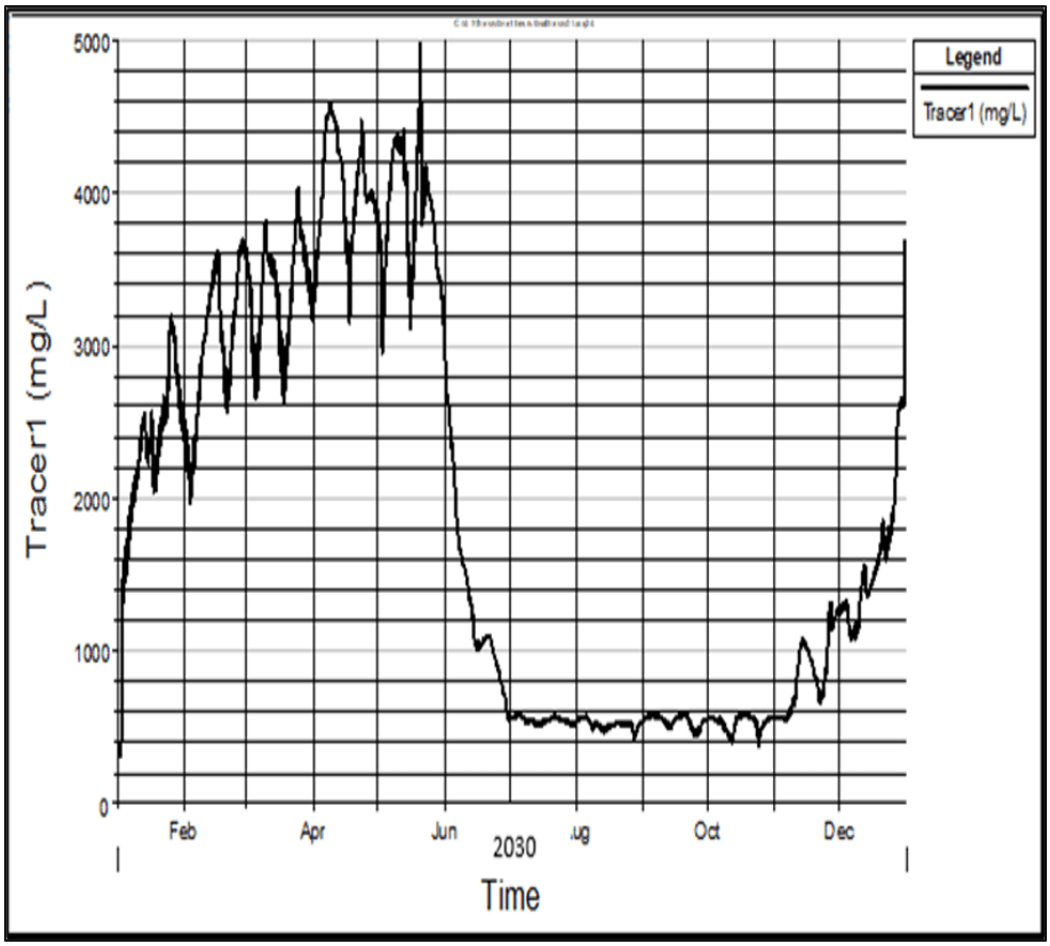


2080

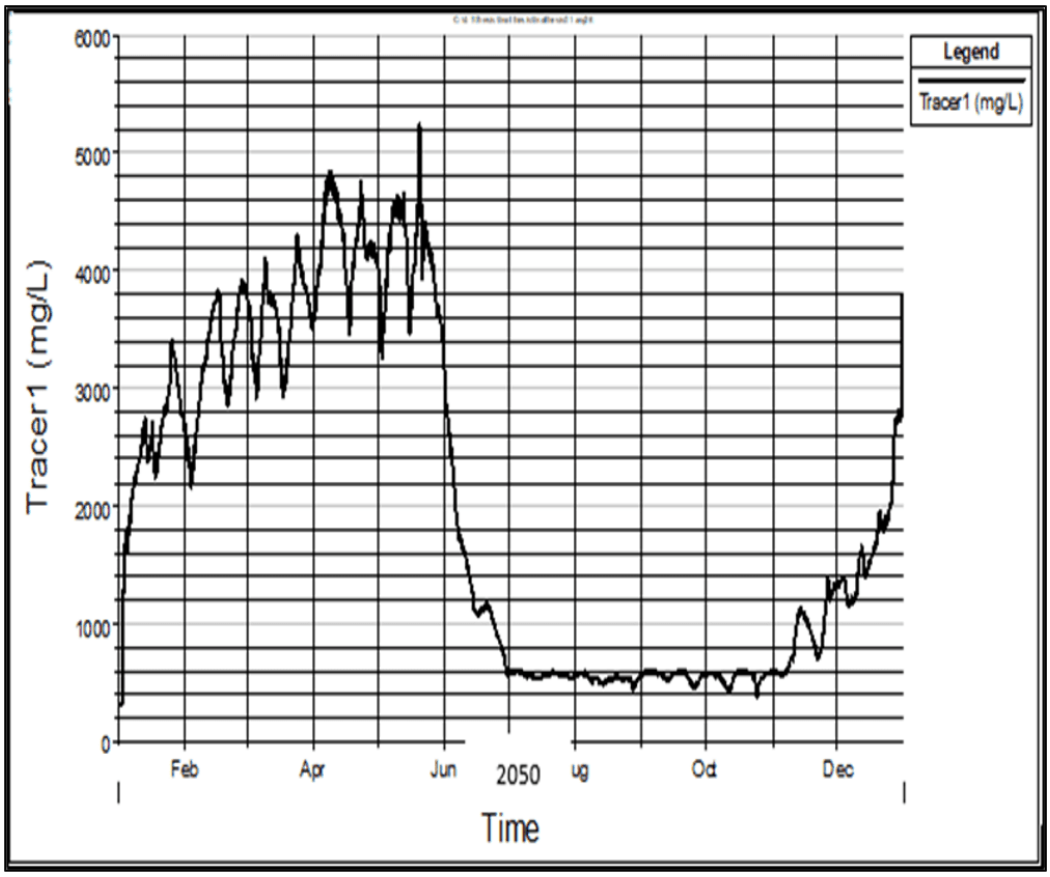
Salinity Analysis for Different Scenarios at Betagi Upazila (SW38) due to Sea level rise:


Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
5000
4000
3000
2000
1000
0
Feb
Apr
Jun
2020
Aug
Oct
Dec
Time

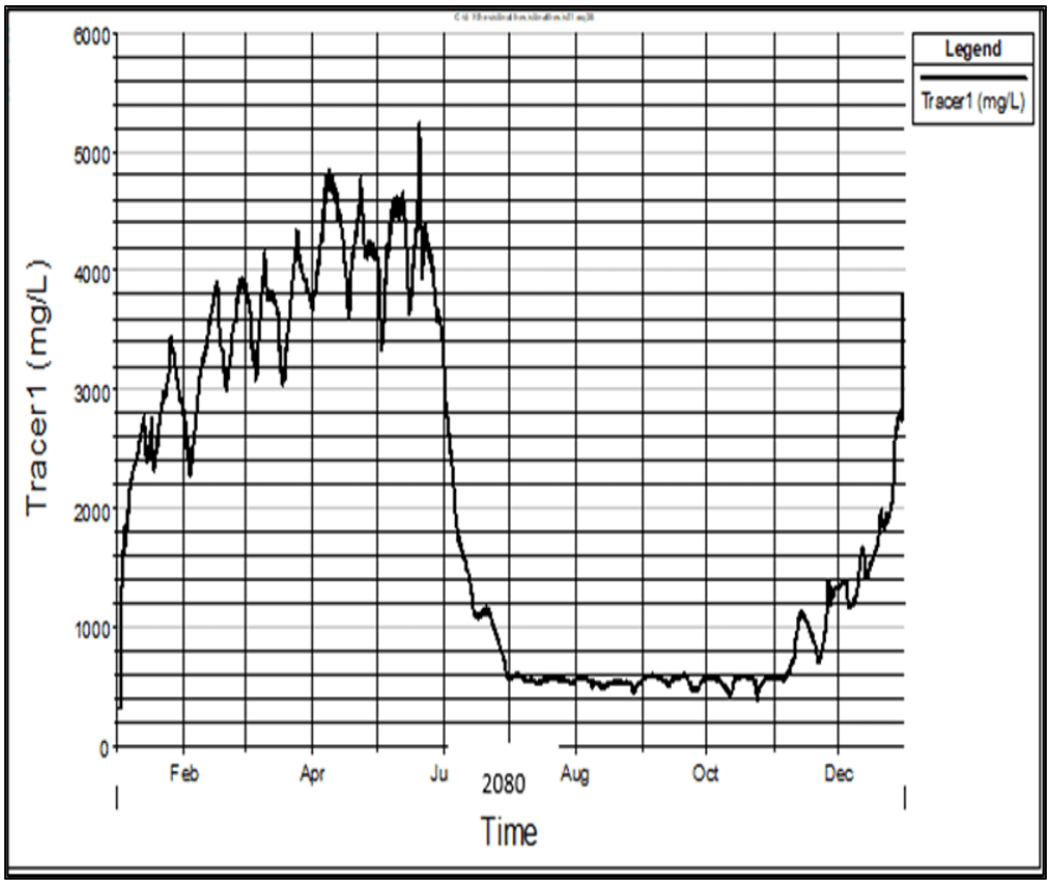
2020


Legend
Tracer1 (mg/L)
5000
4000
3000
2000
1000
0
Tracer1 (mg/L)
Feb
Apr
Jun
Aug
Oct
Dec
2030
Time

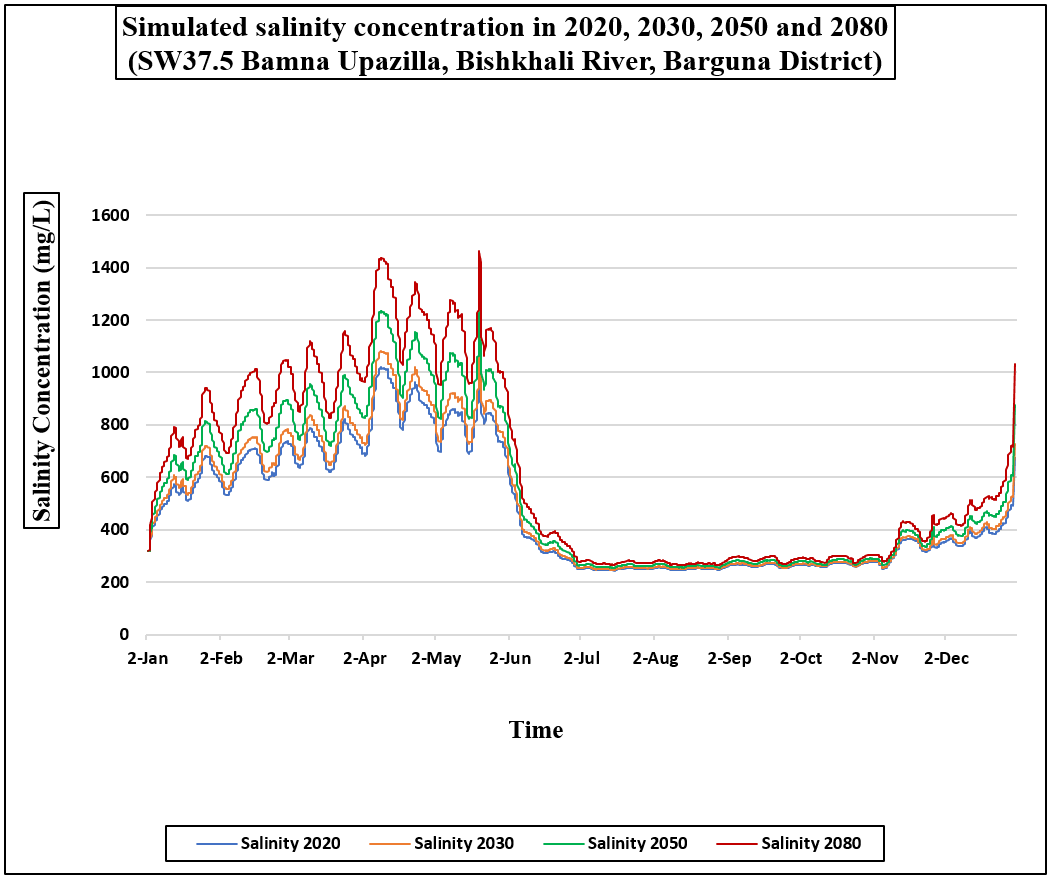
2030


Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
6000
5000
4000
3000
2000
1000
0
Feb
Apr
Jun
2050
ug
Oct
Dec
Time

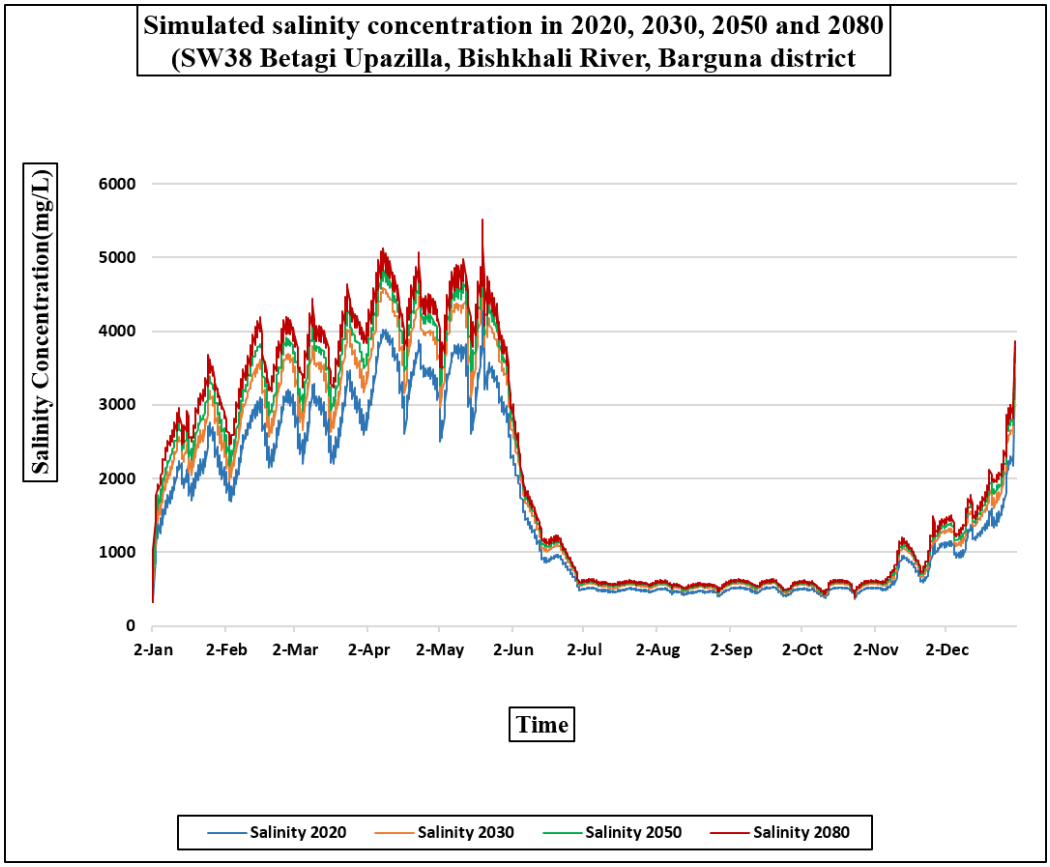
2050


Legend
Tracer1 (mg/L)
Tracer1 (mg/L)
6000
5000
4000
3000
2000
1000
0
Feb
Apr
Ju
2080
Aug
Oct
Dec
Time

2080



Simulated Salinity Concentration in 2020, 2030, 2050, and 2080 (SW37.5 Bamna Upazilla, Bishkhali River, Barguna District)



Simulated Salinity Concentration in 2020, 2030, 2050, and 2080 (SW38 Betagi Upazilla, Bishkhali River, Barguna District)

Year	Percentage Increase (Bamna Upazilla)	Percentage Increase (Betagi Upazilla)
2030	9.45%	15.77%
2050	18.44%	23.99%
2080	28.48%	31.84%

Salinity concentration increased in 2030, 2050, and 2080 in percentage for both Bamna Upazilla and Betagi Upazilla

CONCLUSIONS

- For having a significant salinity concentration value, the Bishkhali River is considered to be a saline river.
- From salinity model analysis, impacts of climate change over salinity concentration are simulated for 2030, 2050, and 2080. From this analysis, it can be observed that salinity concentration increases due to sea level change every year.

LIMITATIONS AND RECOMMENDATIONS

Limitations

- Non-availability of full-year cycle daily discharge data.
- Non-availability of daily salinity concentration data.

Recommendations

- There are other challenges due to climate change such as upstream flow changes, temperature changes, and other parameters that were not considered. If all other parameters were considered, a more accurate simulation could be done.
- This study is limited to the impact of the main branch only. For better results, its other tributary, and distributary branches should be considered.
- If calibration and validation were done both in the hydrodynamic model and the water quality model during different seasons, we would have got a more appropriate value.
- Different Manning's 'n' can be used for right, bed and left bank.

AUTHOR INFORMATION

Indronil Sarkar

Indronil Sarkar is a graduate student from the Bangladesh University of Engineering Technology. He is currently working as a Research Assistant at the Institute of Water and Flood Management. His work involves the use of software like HEC-RAS and GIS. He is keen to do work on Water Quality, River Morphology and Land Use, and Land Cover change. He is also interested to explore in the application of Machine Learning to predict different Hydrologic and Hydrodynamic parameters under different conditions.

email: indrorahul7777@gmail.com

1616007@wre.buet.ac.bd

Dr. Md. Ataur Rahman

Dr. Md. Ataur Rahman is currently working as a professor at the Department of Water Resources Engineering, Bangladesh University of Engineering and Technology. His field of work involves Coastal Engineering, Coastal Zone Management, Irrigation and Water Management, Hydraulics, and Hydraulic Structures.

email: mataur@wre.buet.ac.bd

ABSTRACT

Bishkhali River is one of the major Rivers in the south-central region of Bangladesh, which originates from Sugandha River and falls into the Bay of Bengal. It passes through Barishal, Jhalokati, and Barguna districts. This River plays a vital role to ensure the supply of fresh water for agricultural and household purposes for the local people. Moreover, The River provides inland navigational facilities to many people. For having a connection with the Bay of Bengal, The River has some tidal characteristics and an increasing trend of salinity concentration. In this study, salinity model is developed by using HEC-RAS model with the help of different types of data which were collected from BWDB (Bangladesh Water Development Board) and other Tertiary data sources. The hydrodynamic model is calibrated and validated using the water level data of July 2020 and March 2020 respectively. Model simulated water level values showed good agreement with the observed water level values for Manning's roughness coefficient as 0.015. Then, water quality model is calibrated and validated using the salinity concentration data of 2020 and 2019 respectively. For water quality model calibration and validation, the value of dispersion coefficient is 110m^2/s which gives an approximate match between observed salinity concentration data and model simulated salinity concentration data. After developing salinity model, salinity concentrations have been predicted for 2030, 2050, and 2080 at Bamna and Betagi Upazilas due to sea level rise. The percentage increase in salinity concentration in 2030, 2050, and 2080 by considering 2020 as the base year are 9.45%, 18.44%, and 28.48% respectively at Bamna Upazila. For Betagi Upazila these percentages are 15.77%, 23.99%, and 31.84% in 2030, 2050, and 2080 respectively. This research will help the local authorities to ensure the suitability of The River water for agricultural and household purposes in upcoming years and to take other necessary steps against sea level rise impacts.

REFERENCES

(1)Sarwar, M., 2013. Sea-level rise along the coast of Bangladesh, in: Disaster Risk Reduction Approaches in Bangladesh. Springer, pp. 217–231.

(2)Rahman, S., Sarkar, M.R.H., Mia, M.Y., 2017. Spatial and temporal variation of soil and water salinity in the South-Western and South-Central Coastal Region of Bangladesh. Irrigation and Drainage 66, 854–871.

(3)Uddin, M.N., Haque, A., 2010. Salinity response in south-west coastal region of Bangladesh due to hydraulic and hydrologic parameters. Int. J. Sustain. Agril. Tech 6, 01–07.

(4)www.bishkhaliriver.org.