JCP Bangladesh Metamodel

Expert reflection session

April 29, 2020

Joint Cooperation Programme

Bangladesh Netherlands

Knowledge development for a prosperous delta

Program

- Opening and introductions by chair William Oliemans
- Presentation progress Bangladesh Metamodel
  - Context (Marnix van der Vat, Deltares)
  - Network module (Md Shahadat Hossain, IWM)
  - Water balance and flood module (Kymo Slager, Deltares)
  - Agriculture water demand, production and food security (Judit Snetlage, WUR)
  - Dashboard (Md Mostafizur Rahman, CEGIS)

  15 minutes per topic for a concise presentation and questions, reflection and discussion (total 75 minutes)
- General reflection and recommendations (*30 minutes*)

JCP Bangladesh Metamodel

JCP: Joint Cooperation Program between CEGIS, IWM, Deltares and Wageningen University & Research sponsored by the Embassy of the Kingdom of the Netherlands

Goal: Long term knowledge sharing and capacity building, between Bangladesh and the Dutch knowledge institutes, in support of improved Integrated Water Resources Management (IWRM), Integrated Coastal Zone Management (ICZM), flood and drought management

Bangladesh Metamodel aims to provide quantitative decision support information to decision makers regarding the investment plan for BDP2100

What is a Metamodel?

- Simplified simulation
- Based on results of detailed, sectoral models
- Wide scope
- Short calculation time
- Less detail and accuracy in results
- No replacement for detailed models

Two different types of users

1. **As a planner at GED,**

- To analyze and assess the impact of proposed projects / programs (within SIBDP project) on water resources and socio-economic aspects,
- It can advise decision makers on input for the 8th 5-year plan and updating of the BDP2100 Investment Plans.

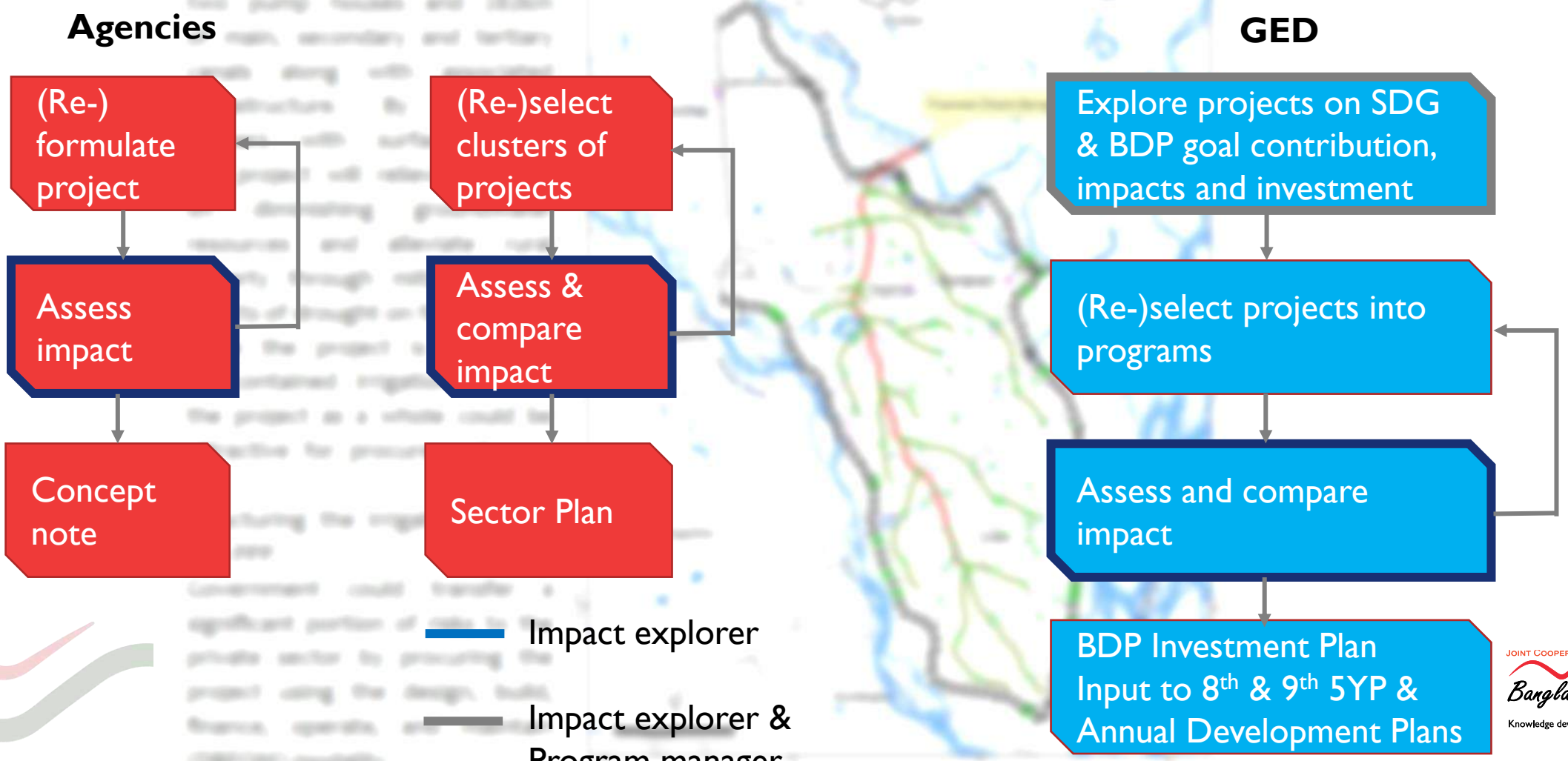
2. **As an officer at a Ministry or Agency,**

- To analyze and assess the project proposals and sectoral plans based on BDP2100 for their integrated impact own and other sectors,
- so that I can adapt projects and the sectoral plans to improve their impact and thereby the likelihood that they are included in the input from BDP2100 for the 8th 5-year plan and updating of the BDP2100 Investment Plans.

Use of the Metamodel

- Analyse impact of scenarios
  - Climate change & sea level rise
  - Socio-economic & land use
- Analyse impact of projects / programs
- Compare impact of different projects / programs
- Compare impact of projects / programs under different scenarios → robustness
- Analyse investment requirements of programs

Example of use of Metamodel for an investment project



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Indicators

Decision support indicators

- Flood damage
- (Poor) households affected by droughts, floods *and salinity*
- Crop production
- Food security
- *Displaced people due to disasters*
- *Habitat area suitable for protective species*
- *River navigability*
- *Rural access to safe drinking water*

All decision support indicators are linked to the SDGs and the BDP2100 Goals

Water system state indicators

- Annual flood duration
- Annual flood extent
- Dry season river flow
- Extreme flood extent
- GWL at end of dry season
- Waterlogged area
- *Area affected by salinity*
- *Environmental flow*

Indicators in italics will not (yet) be included in first version of the Metamodel

Objectives of the Network Module

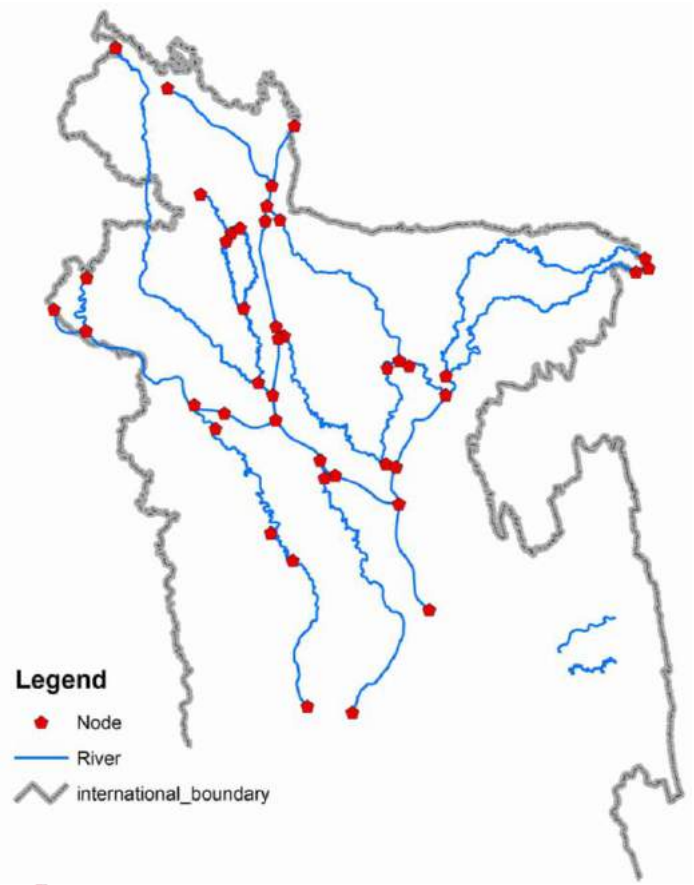
To describe transport of water through the major rivers of Bangladesh and generate necessary output for different module and parameter.

More Specifically:

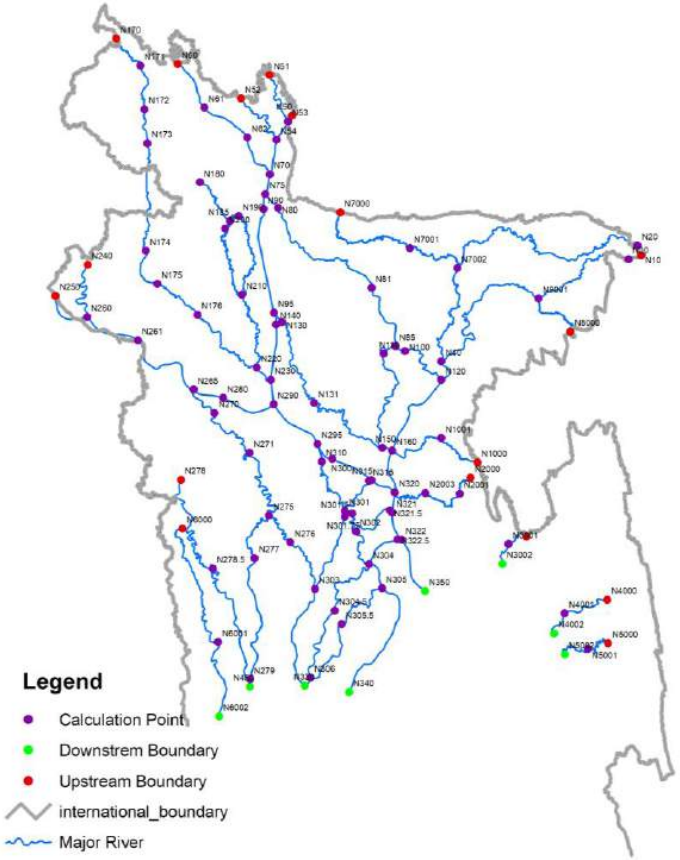
- Describing transport of water through the major rivers.
- To calculate discharge, water level , tidal range and salinity for all nodes.
- Generating outputs for other modules as per their requirement.

- River morpho dynamics is not include yet

Extent of Network Module



Version 0.2



Version 1.00

Input Data and Parameters

- Major River Network
- Network Distribution File: It contains necessary formula, water distribution strategies etc.
- Upstream boundary conditions (18 Boundaries)
- Downstream boundary conditions (8 Boundaries)

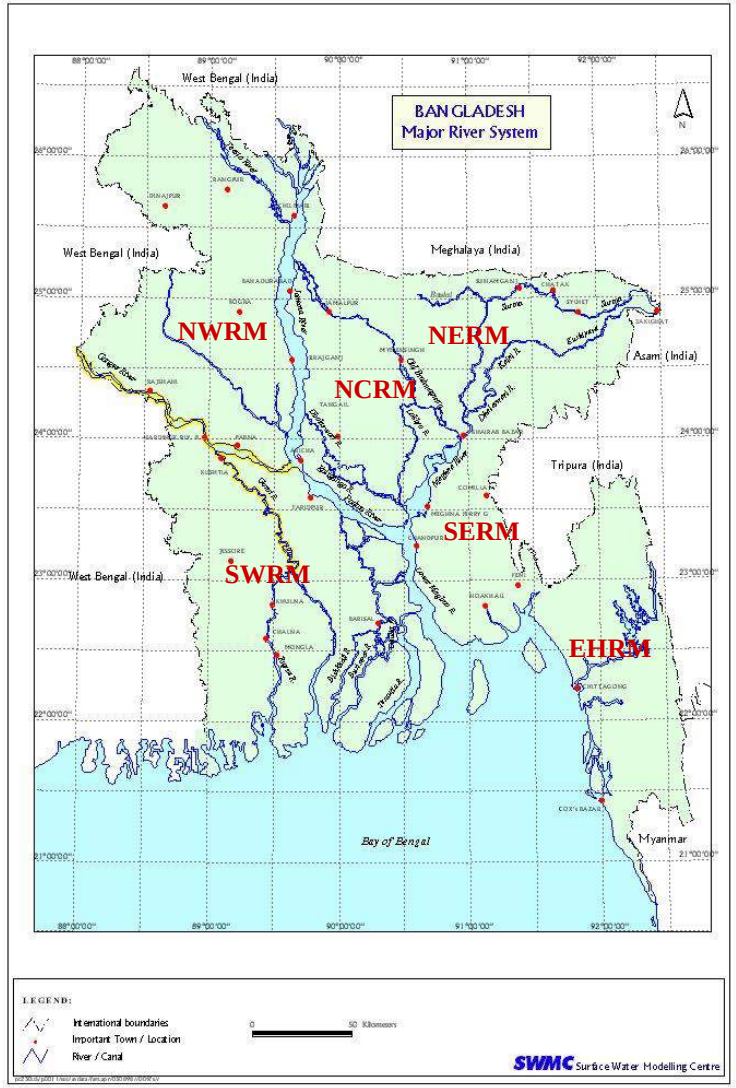
Decade (Ten Days Average) Discharge and Water Level Data as Boundary Condition

Time Span: 1985-2017

*All boundary data and bathymetry are based on IWM detail Region Model.

Historical Boundary Calculation

- IWM has historical rating curve at transboundary point (mainly major river).
- IWM use runoff from hydrological model as a boundary condition for small transboundary river
- In network module, all boundary data and calibration data have taken from IWM regional model



Six Regional Models of IWM

Formula Development

- To develop water distribution formula based on detail model at major bifurcation points
- To generate water level equation based upstream flow and downstream water level
- To calculate tidal range formula based on upstream flow and tidal water boundary
- To develop salinity formula based one upstream flow and tidal range

water level formula

$$h = \underbrace{h_{downstream} \times d_{node}}_{\text{Downstream control}} + \underbrace{h_{0,node} + \left(\frac{Q_{node}}{a_{node}}\right)^{\frac{1}{n}}}_{\text{Upstream control}}$$

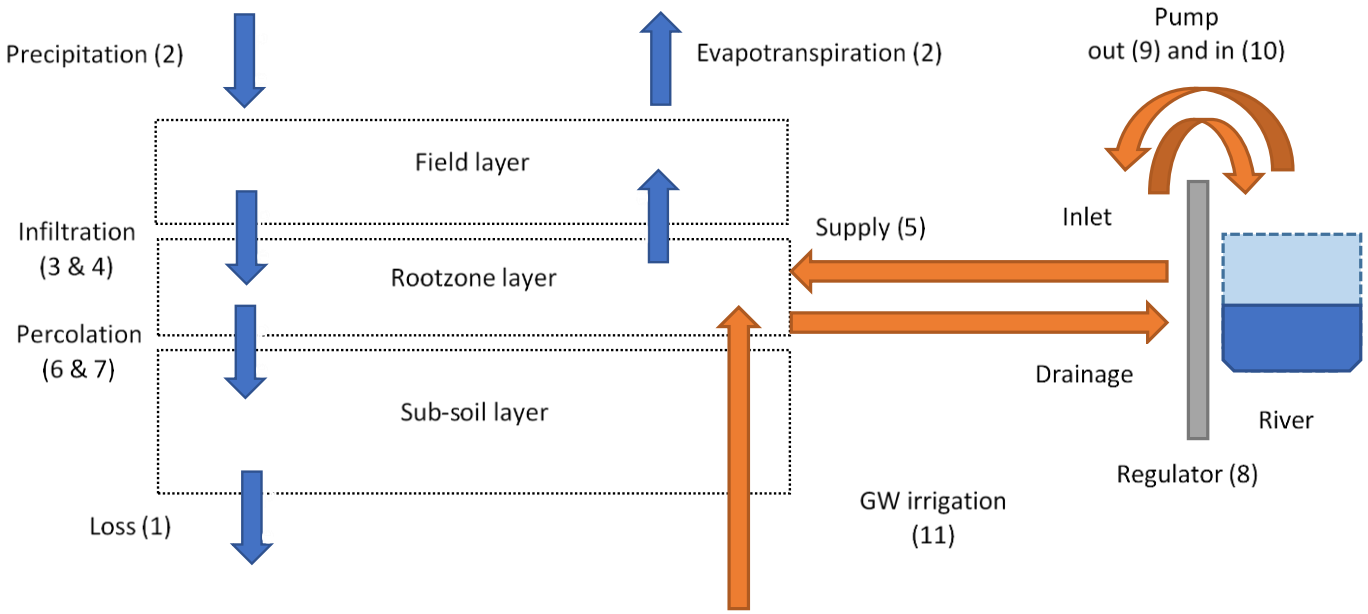
- Q_{node} is calculated in the discharge calculation
- $h_{downstream}$ is water level boundary condition
- $h_{0,node}$ comes from input network distribution table
- a_{node} comes from input network distribution table
- n_{node} comes from input network distribution table
- d_{node} comes from input network distribution table

Salinity and Tidal Range Calculation

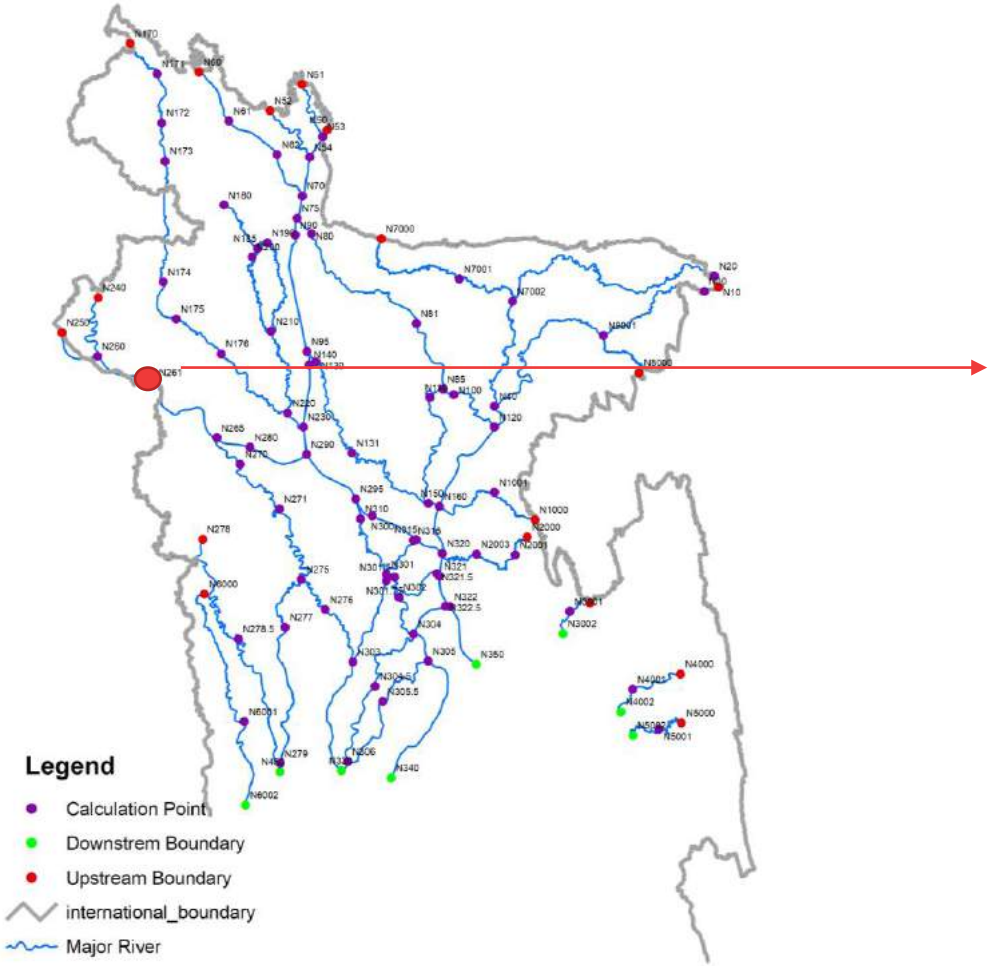
- Salinity is one of the major problem in the South West part of Bangladesh.
- Network module can calculate the salinity intrusion.
- Network module calculates tidal range at every node as an output differently because of network module's time step is 10 daily average and doesn't capture the tidal fluctuation.
- Salinity calibration is ongoing.

Water Exchange with Water Balance Module

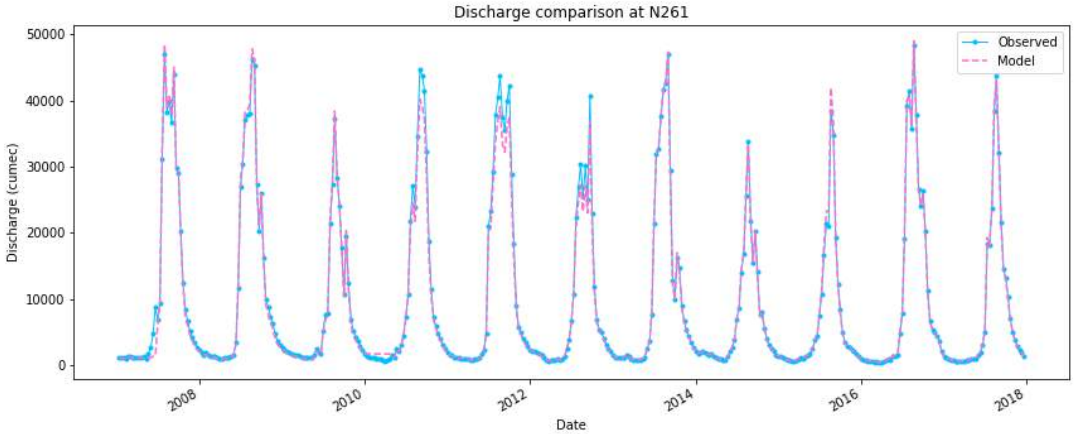
- Network module can exchange water based on water demand in different Upazilla by interacting with different module.
- In every time step network module is either take surplus water from WBM or provide water to WBM based on different sectoral requirement.

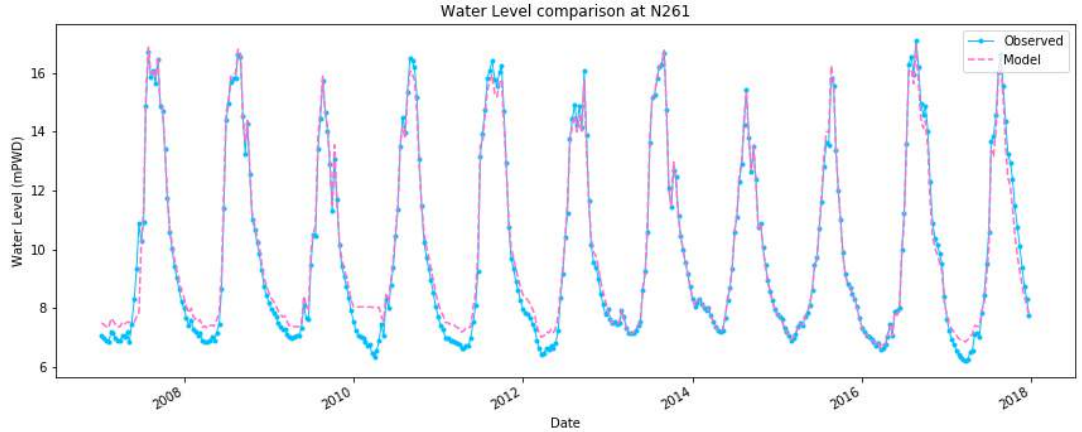


Calibration and Validation



Ganges River, Rajshahi

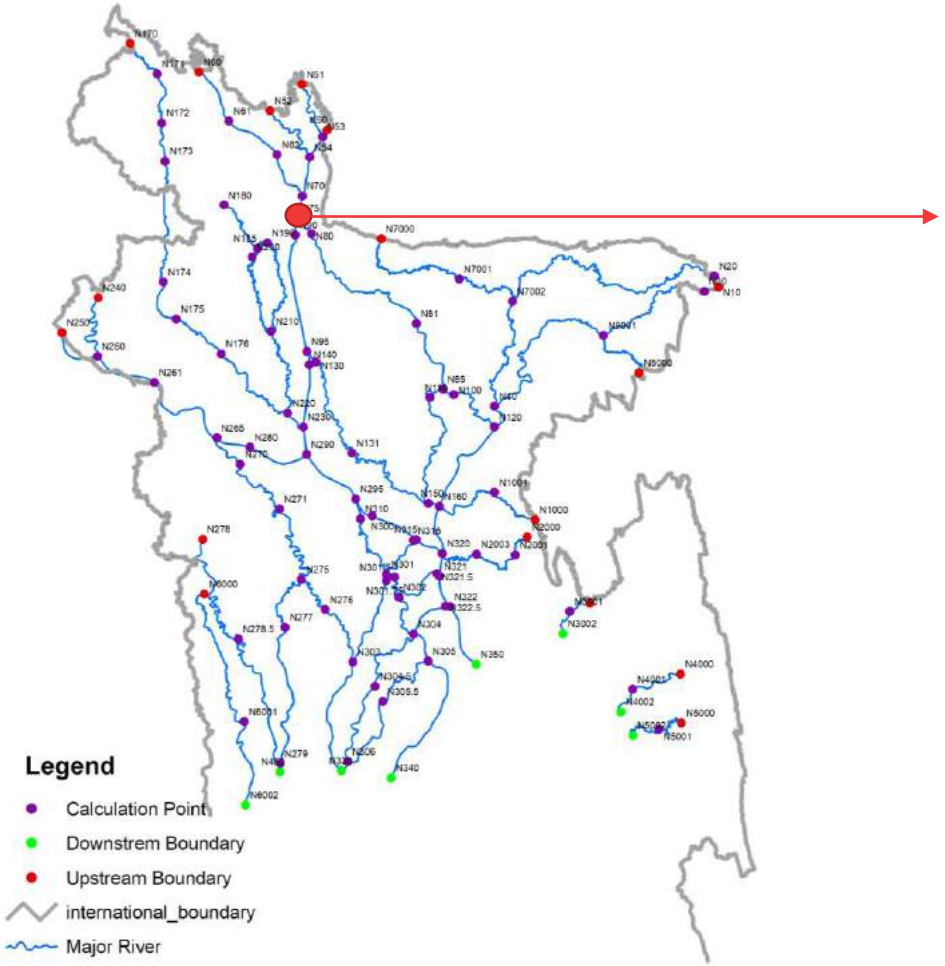




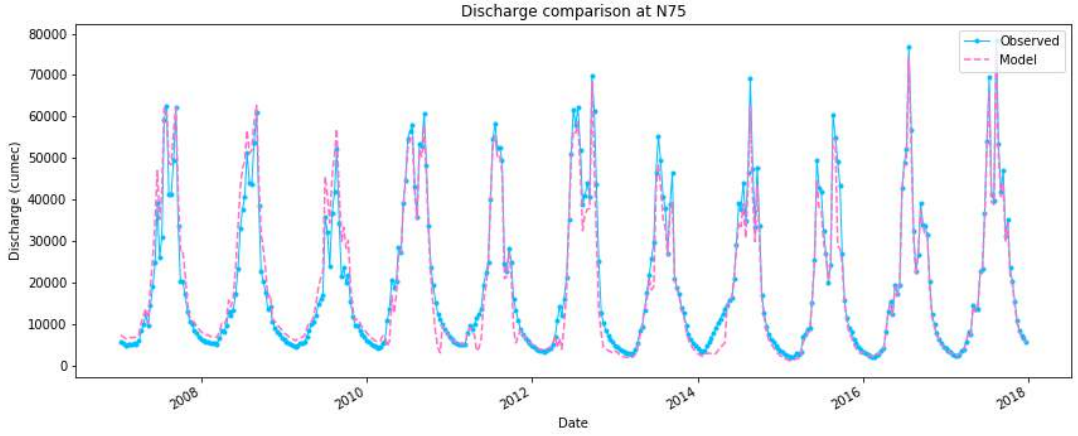
Item	NSE	PBAIS	R_square	RMSE	MAE	RSR	peakError
Discharge	0.99	2.65	0.99	1093.05	532.38	0.09	-603.66
Water Level	0.98	-1.34	0.99	0.43	0.30	0.14	0.20

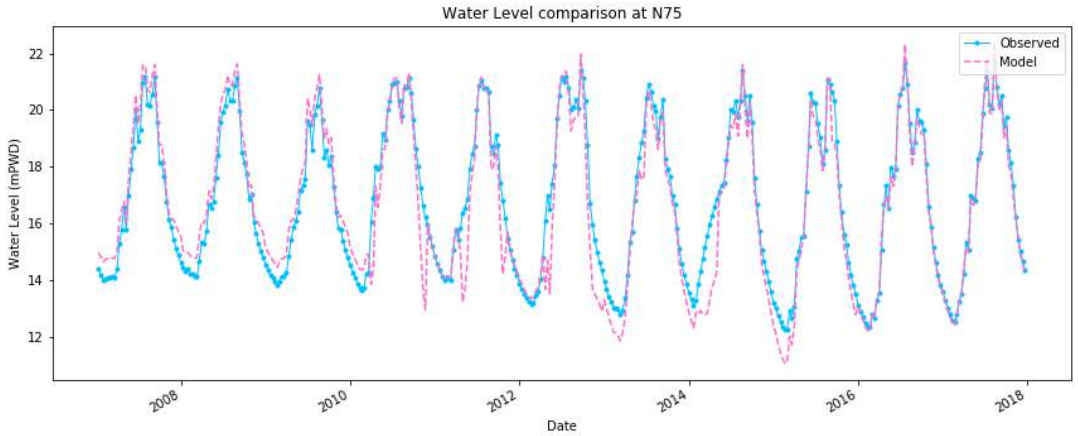
Observed-→ Detail Mike Region Model's Output

Calibration and Validation



Jamuna River, Bahadurabad

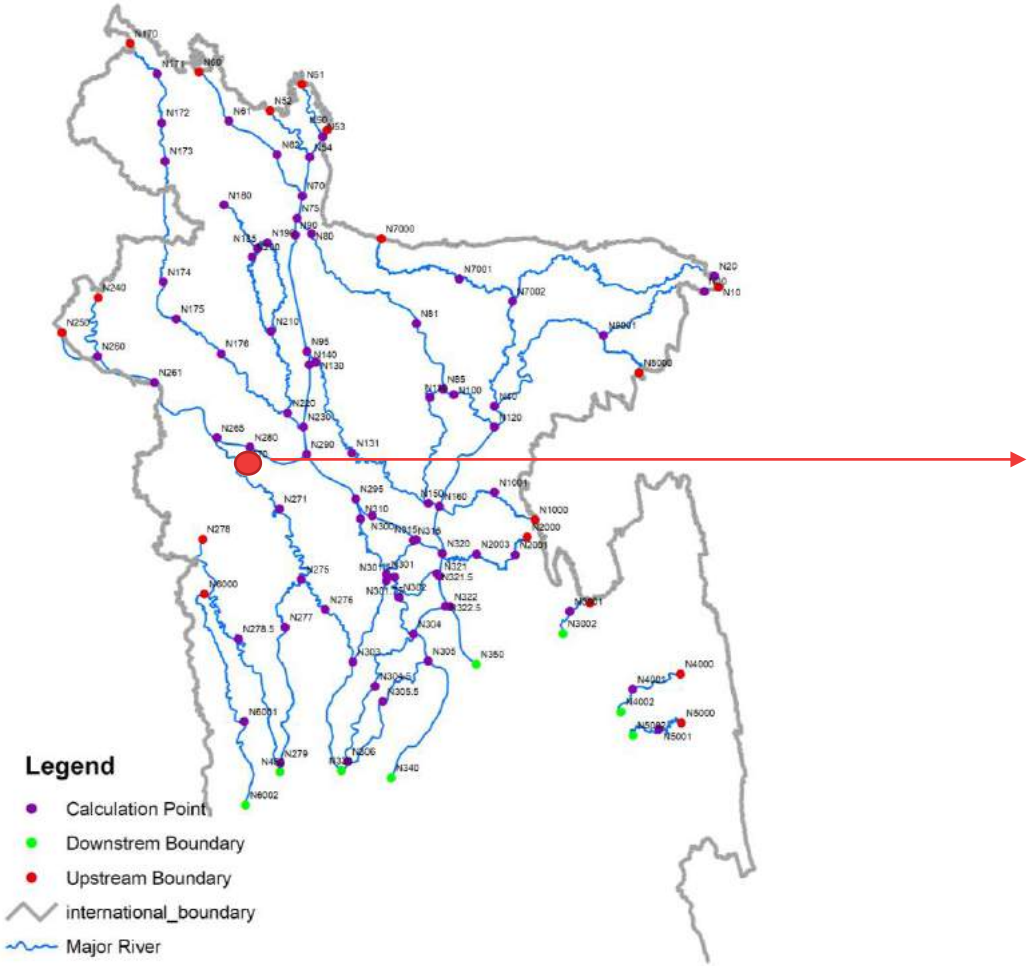




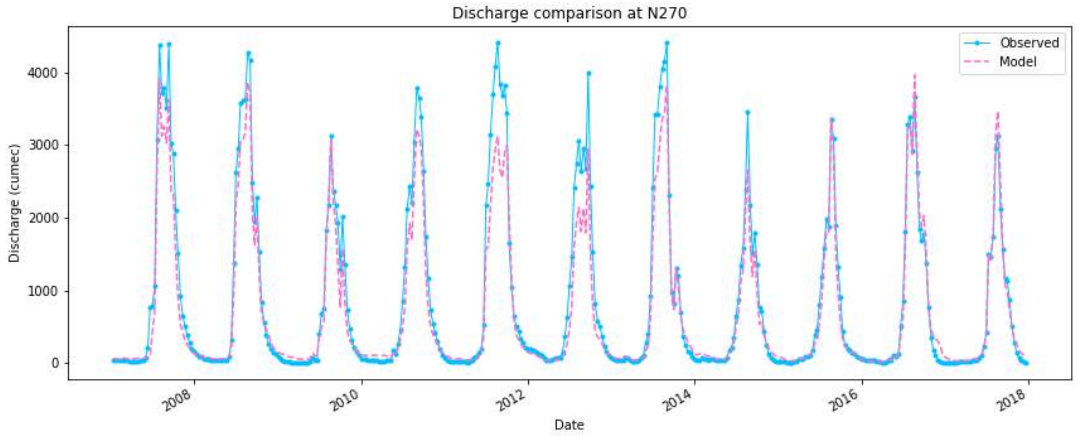
Item	NSE	PBAIS	R_square	RMSE	MAE	RSR	peakError
Discharge	0.95	2.28	0.95	4016.90	2690.40	0.23	2652.66
Water Level	0.91	1.07	0.92	0.82	0.58	0.31	-0.71

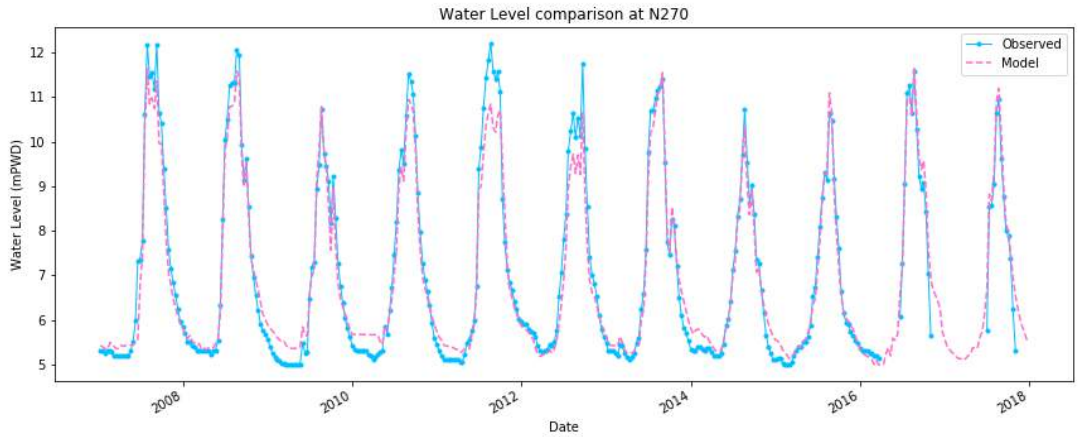
Observed-→ Detail Mike Region Model's Output

Calibration and Validation



Gorai River, Gorai Rail Bridge

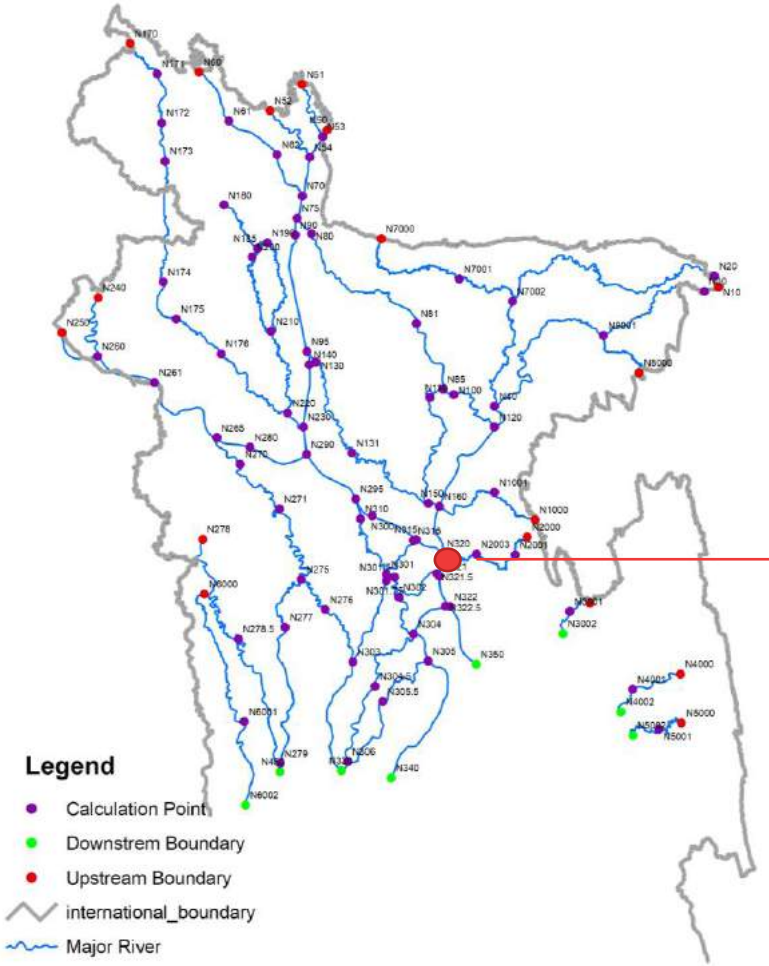




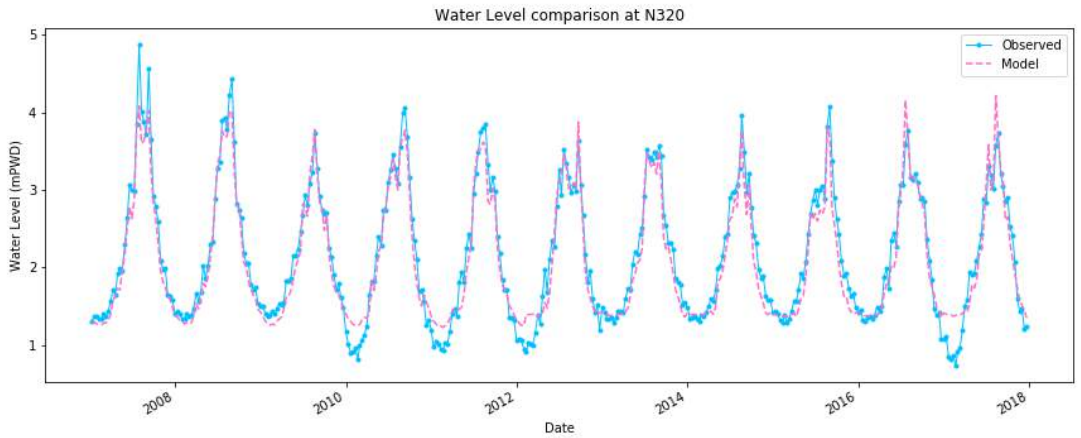
Item	NSE	PBAIS	R_square	RMSE	MAE	RSR	peakError
Discharge	0.93	14.69	0.97	305.53	178.89	0.26	1296.06
Water Level	0.96	0.37	0.97	0.40	0.31	0.19	1.37

Observed-→ Detail Mike Region Model's Output

Calibration and Validation



Meghna River, Chandpur



Item	NSE	PBAIS	R_square	RMSE	MAE	RSR	peakError
Water Level	0.94	3.30	0.95	0.22	0.17	0.25	0.80

Observed-→ Detail Mike Region Model's Output

Future Scenarios

BDP2100 has proposed 4 future scenarios:

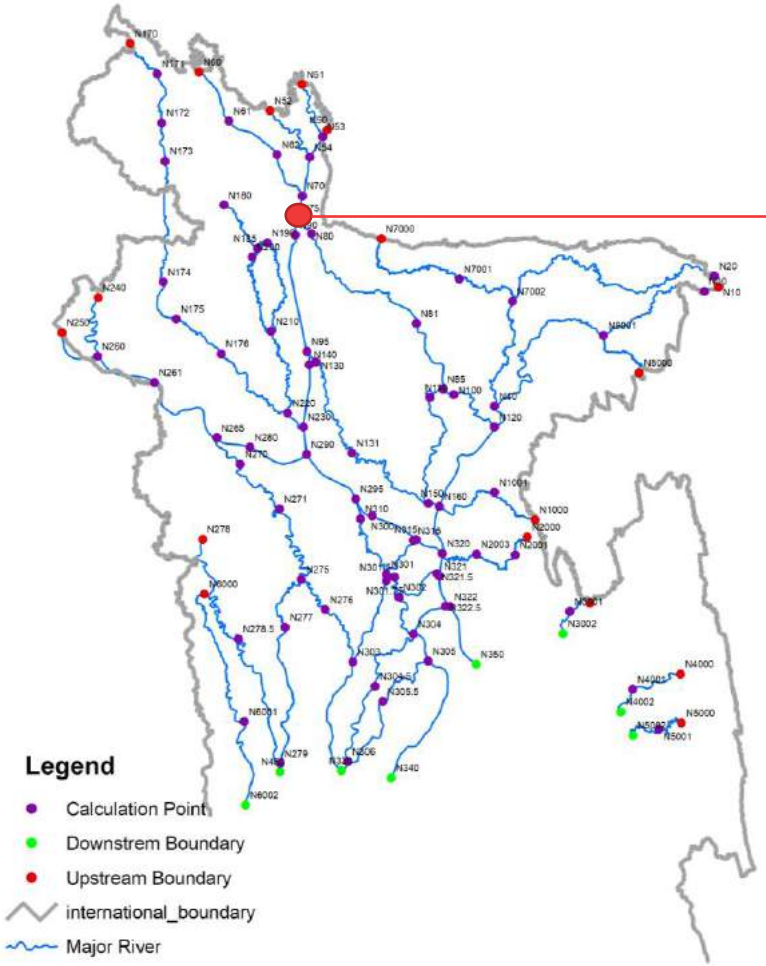
1. **Productive (low climate change, low socio-economic change)**
2. Resilient (high climate change, low socio-economic change)
3. Moderate (low climate change, high socio-economic change)
4. **Active (high climate change, high socio-economic change)**

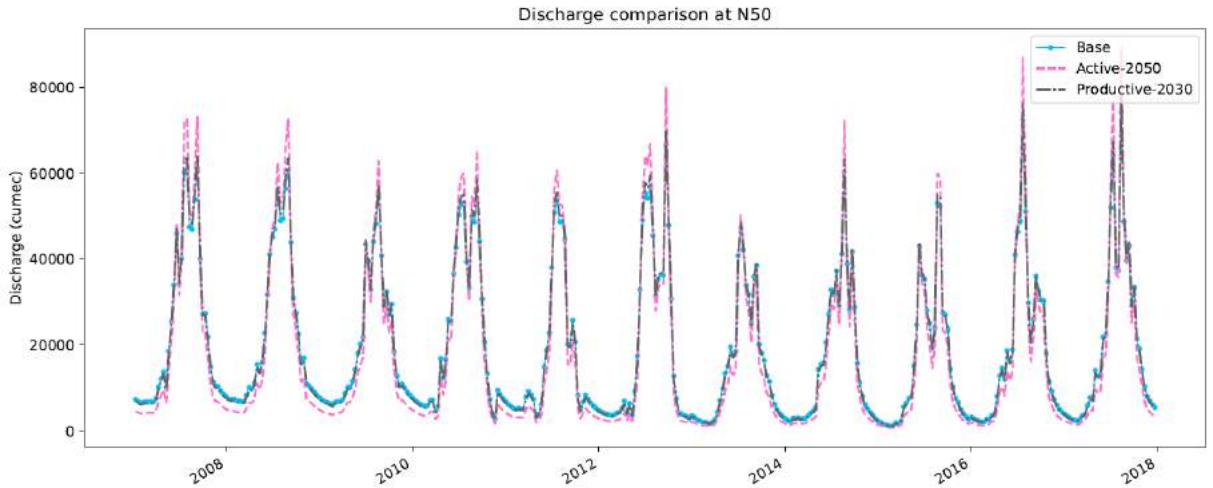
Every scenario is described for 3 future situations:

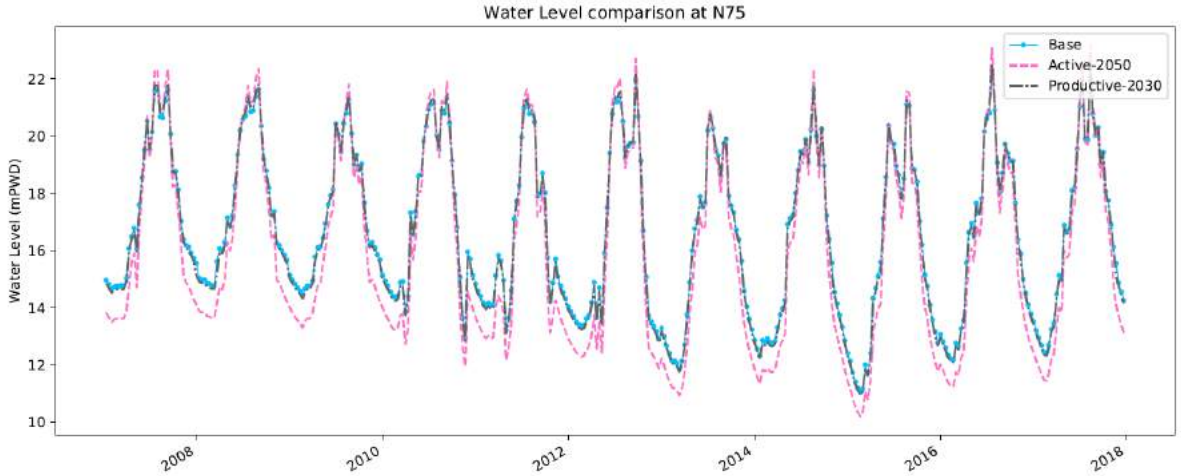
1. 2030
2. 2050
3. 2100

		Productive				Resilient				Moderate				Active			
		2015	2030	2050	2100	2015	2030	2050	2100	2015	2030	2050	2100	2015	2030	2050	2100
Sea level rise	Mean sea level rise		10-20	20-30	40-60		15-30	40-60	80-125		10-20	20-30	40-60		15-30	40-60	80-125
Temperature	Mean max. temperature degrees change	25	0.5	1	2	25	1.5	2	4	25	0.5	1	2	25	1.5	2	4
Monsoon rainfall	% change mean total monsoon (June-September) precipitation	1750	0	10%	15%	1750	15%	20%	40%	1750	0	10%	15%	1750	15%	20%	40%
Dry season rainfall	% change mean total dry season (December-February) precipitation	36	0	0	0	36	-10%	-10%	-20%	36	0	0	0	36	-10%	-10%	-20%
Peak discharge	% change of mean annual maximum at Hardinge Bridge	51130	15	20	30	51130	30	40	70	51130	15	20	30	51130	30	40	70
	% change of mean annual maximum at Bahadurabad	67490	5	10	15	67490	15	20	30	67490	5	10	15	67490	15	20	30
	% change of mean annual maximum at Bhairab bazar	13370	5	10	15	13370	15	20	30	13370	5	10	15	13370	15	20	30
Change average dry season flow	% change at Hardinge bridge	no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)			
	% change at Bahadurabad	3000	-5%	-15%	-30%	3000	-15%	-30%	-50%	3000	-10%	-25%	-40%	3000	-20%	-40%	-60%
Average dry season flow	m3/s at Hardinge bridge	no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)				no change (Controlled by Ganges Water Treaty)			
	m3/s at Bahadurabad	3000	2850	2550	2100	3000	2550	2100	1500	3000	2700	2250	1800	3000	2400	1800	1200

Future Scenarios' Effect on Different Stations

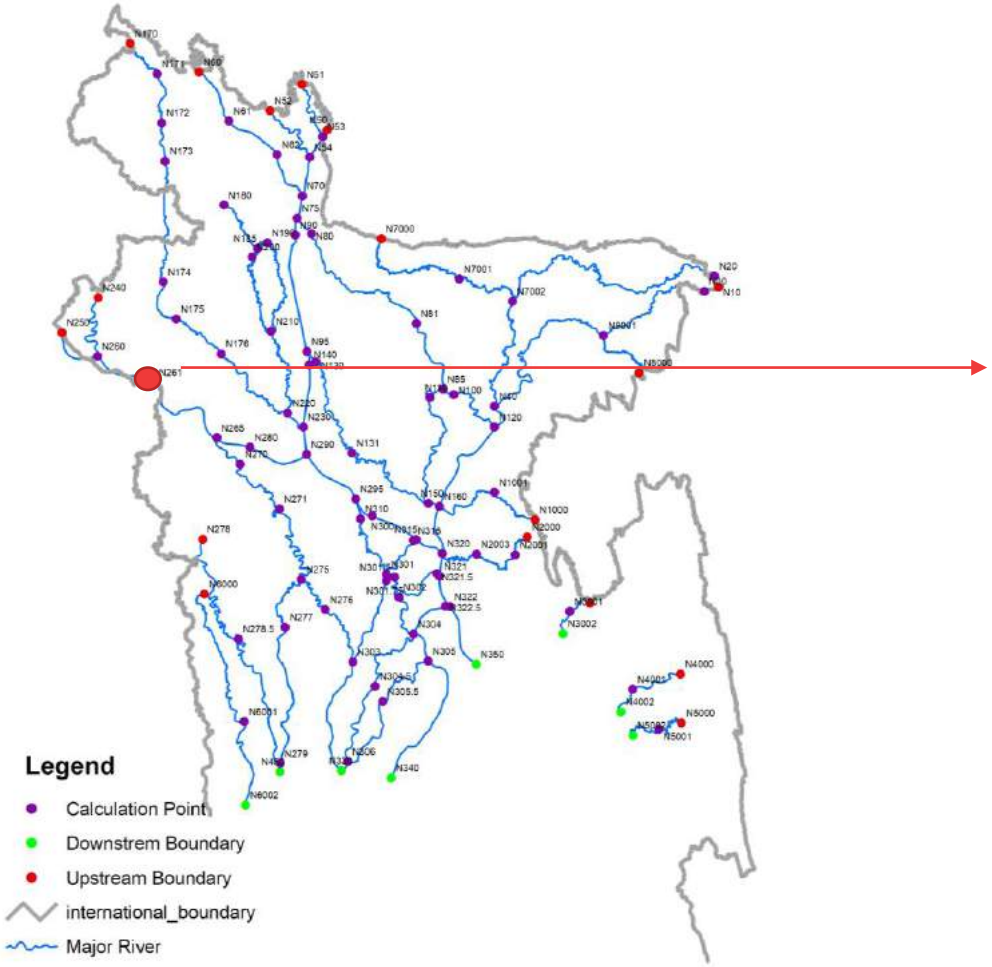


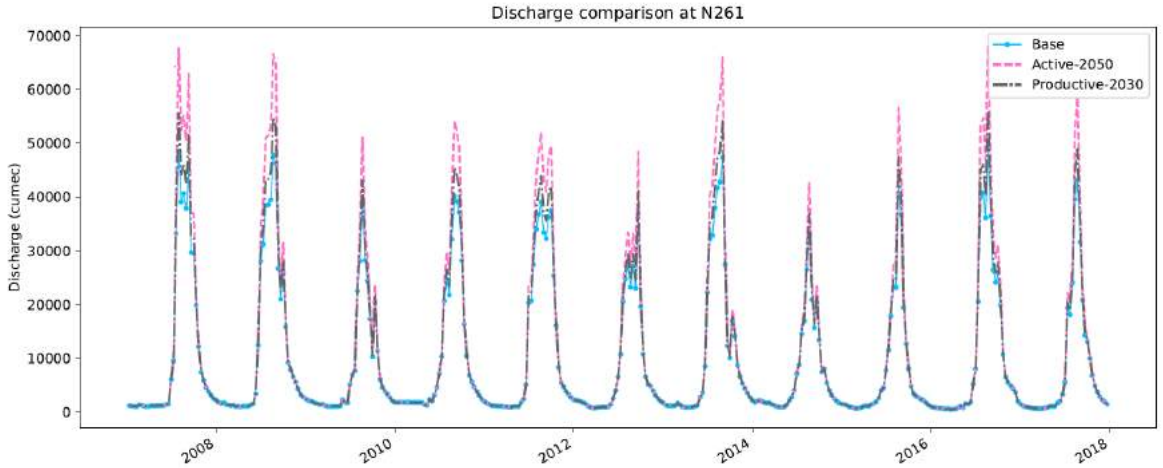


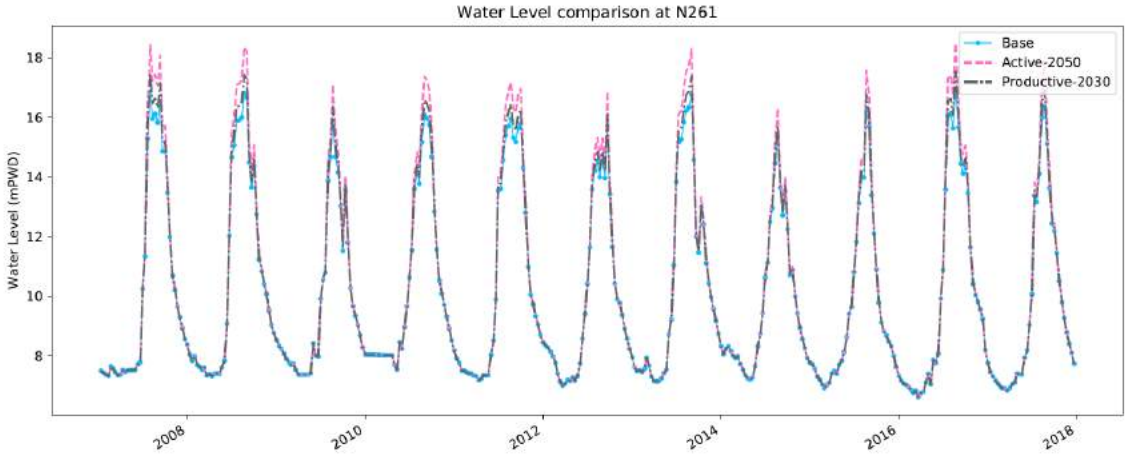


Jamuna River, Bahadurabad

Future Scenarios' Effect on Different Stations

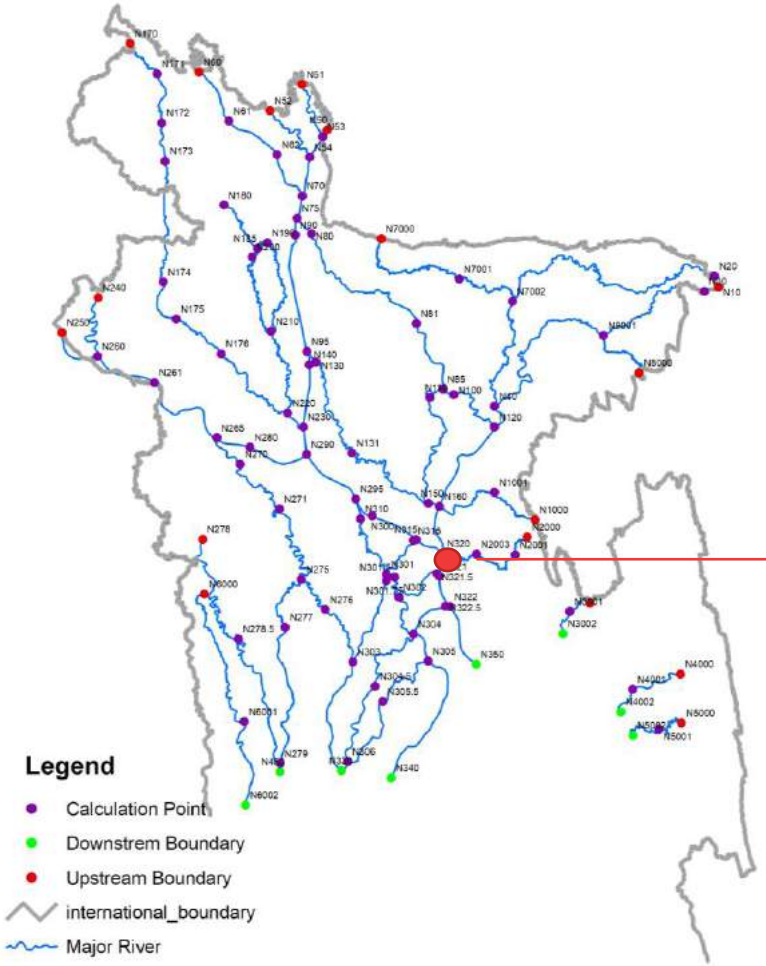




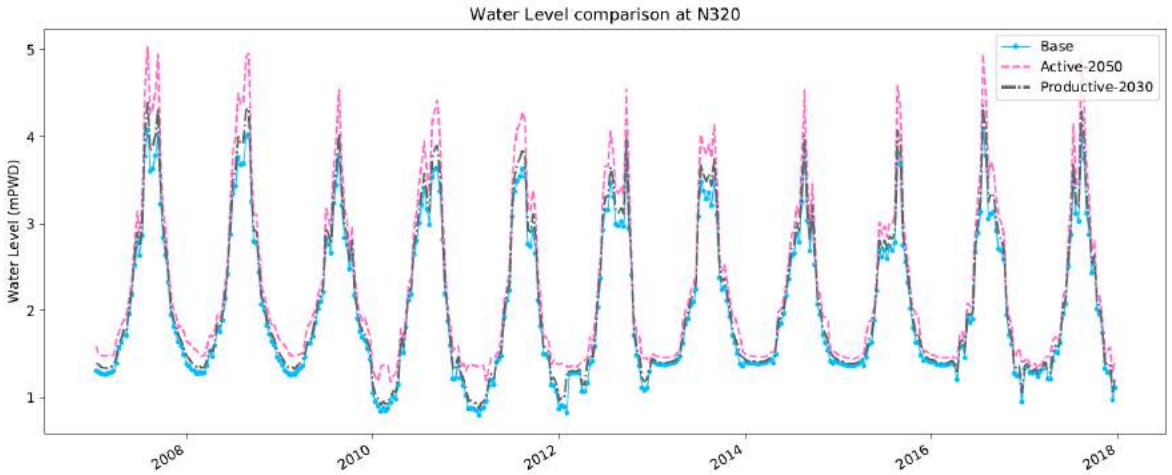


Ganges River, Rajshahi

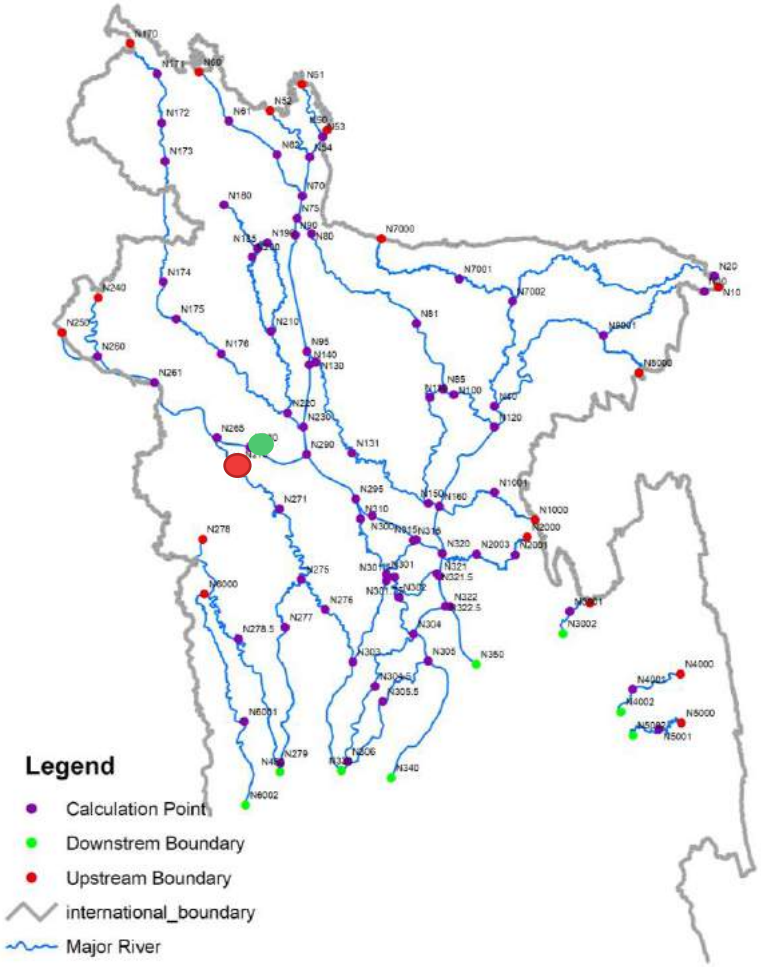
Future Scenarios' Effect on Different Stations



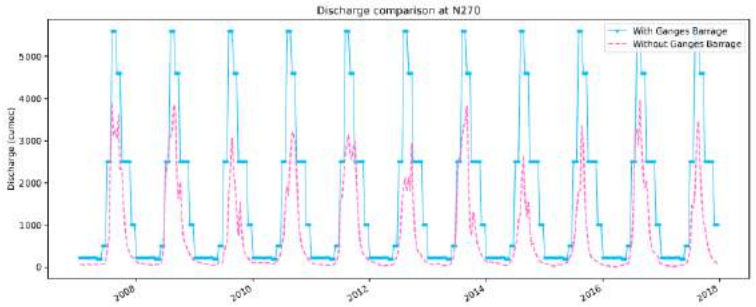
Meghna River, Chandpur

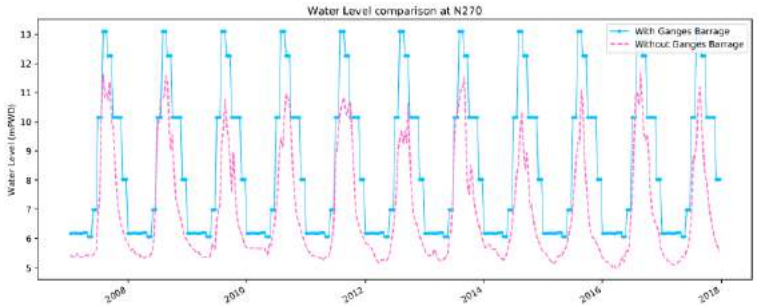


Ganges Barrage Project

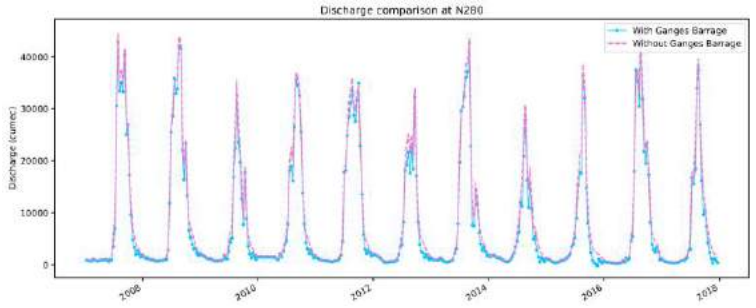


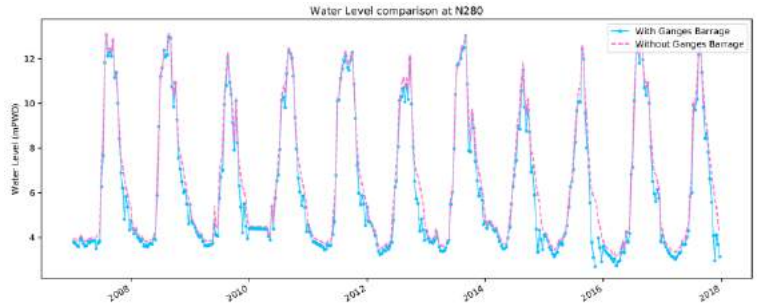
- Ganges barrage effect on Gorai River





- Ganges barrage effect at Downstream of Barrage on Padma River

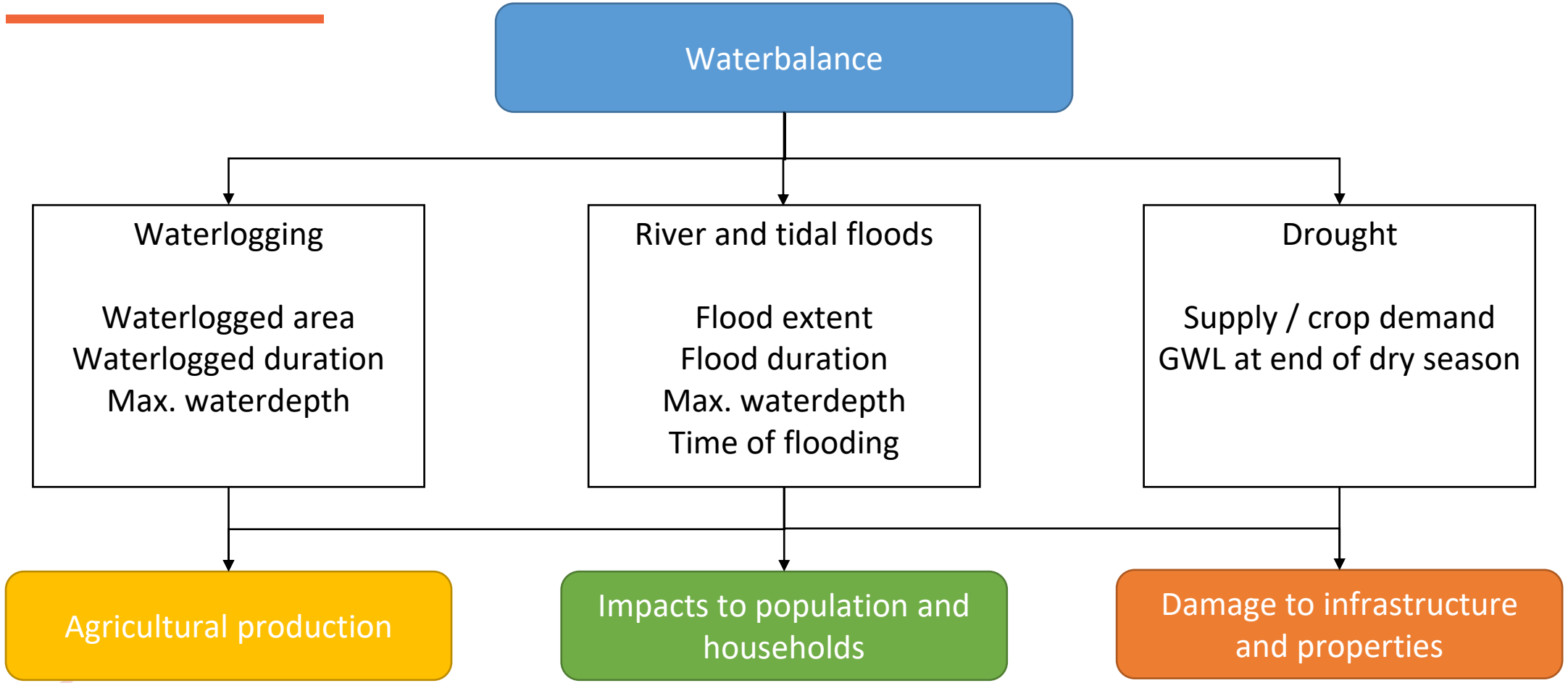




Experts' Opinion on:

- What should be included to improve the network Module?
- How to improve the network module results? Especially for small rivers where boundary data quality is poor?

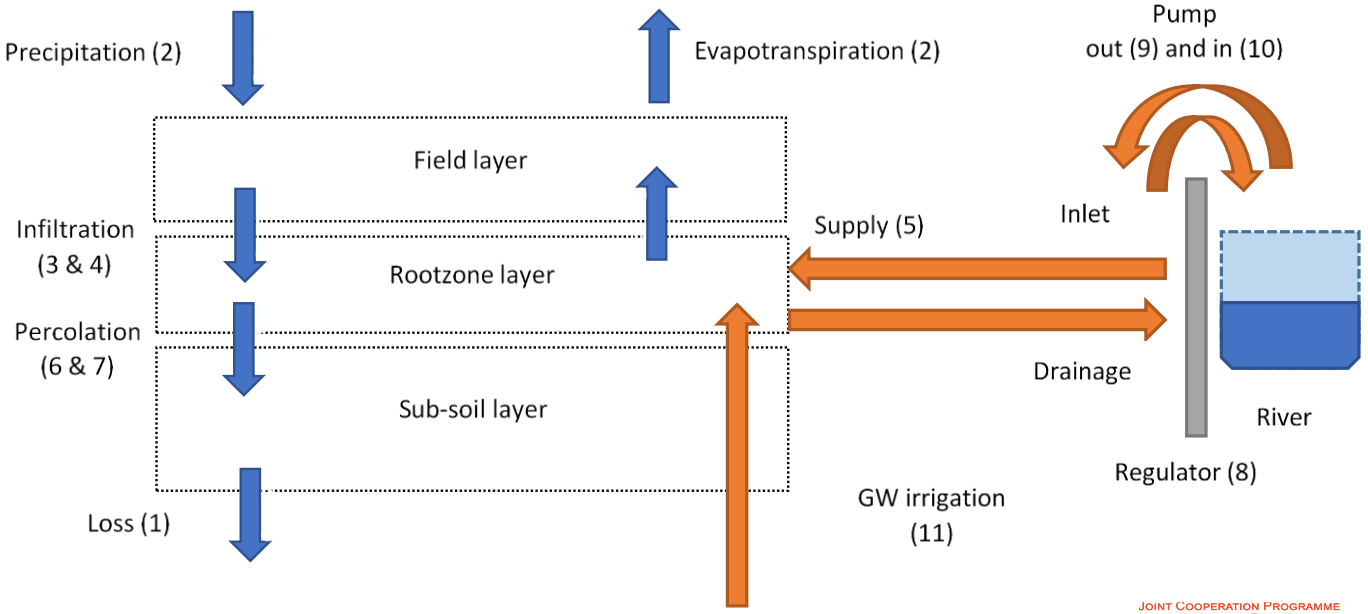
Main outputs of Waterbalance



Vertical waterbalance

- Three-layer vertical waterbalance per upazila (544)
- Divided in existing FCDI-project and non-project area
- For nine landtypes: F0 to F4, shrimp, forest, settlement and waterbodies

- Data sources (BDP2100 portal):
  - Administrative (BBS, 2011)
  - Land types and Soil (BARC, 1999)
  - Meteo (BMD, 2018)
  - FCDI-projects (BWDB, 2018)
  - DEM (WARPO, 2017)



Horizontal exchange

- Includes the main processes of SW exchange (gravity) between field and rivers:
  - Rainfall-runoff -> drainage (field to river)
  - Peak flows -> river/tidal floods of fields (river to field)
  - Inlet (and storage) of water in dry season
  - Large-scale pumped drainage and SW irrigation pumps (new projects)

- Bounded by flow capacity of internal water system (e.g. khals)
- In project areas: regulator dimensions and operation

Live demonstration of results for North-West region

Upazilas

District name

- 1004 Barguna
- 1006 Barisal
- 1009 Bhola
- 1042 Jhalokati
- 1078 Patuakhali
- 1079 Pirojpur
- 2003 Bandarban
- 2012 Brahamanbari
- 2013 Chandpu
- 2015 Chit
- 2019

Upazila name

- Select all
- 506909 Bar
- 506915
- 50

Landtypes

- Select all
- F0
- F1
- F2
- F3

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ject area

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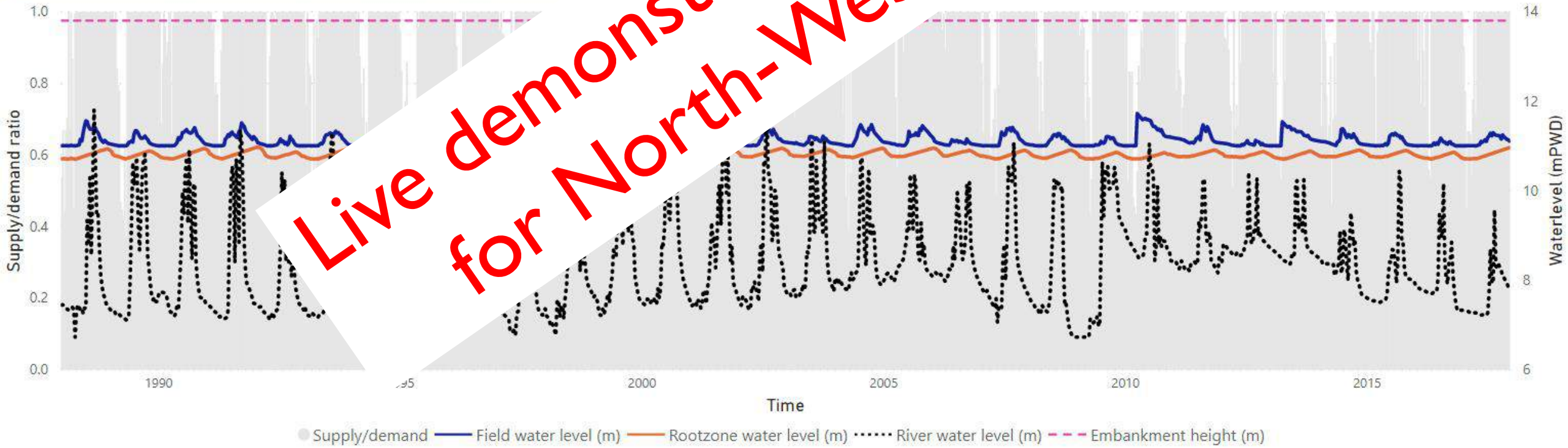
Sir



Flood Impact Module

Main objective:

To determine potential affected population and flood damage and losses to population, (poor) households and infrastructure, based on unit-loss method.

- Based on annual max. flood extent and depth from waterbalance
- Local vulnerability functions (N. Islam, BIDS)
- Exposure data from BBS and infrastructure owners (RHD, LGED, BWDB)

Future steps

- Further calibration on waterlogging, flooding and droughts
- Runs for impacts of climate change – future scenarios
- Runs for impacts of projects in Northwest hotspot
  - Improved water infrastructure (state, operation, maintenance)
  - Main river barrages
  - SW and GW irrigation schemes
  - River dredging
  - Improved soil management
  - Change of cropping patterns
- Salinity balance

Experts' Opinion on:

- Which further sources are available for waterbalance calibration?
- Any ideas on how to improve waterbalance (and network) for more hilly areas, incl. flash floods?

Agricultural Water Demand

-Explaining, calculating & considerations-

Goal: To estimate amount of water, need to meet water loss through evapotranspiration from crop land, forest land, fallow land, settlements and waterbodies

Crop water demand(m^3/decade) = (10 * EToi * Kci) / 1000 * Acrop * 10000

- 15 crops included in calculations (Yearbook of Agricultural Statistics - 2018)
- Based on DRAS model / FAO methods

Considerations

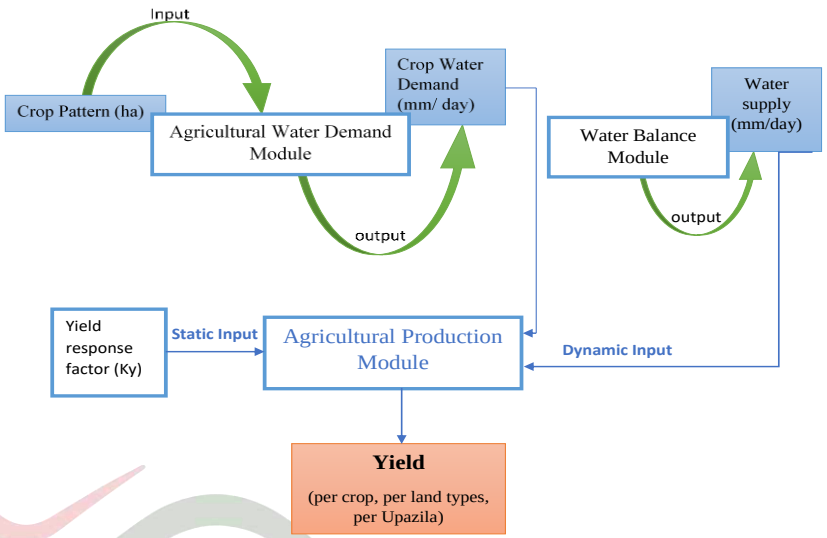
- Data used from 36 BMD weather stations
- Suitability of crops connected to landtype (F0, F1, F2, F3 and F4)

Agricultural production

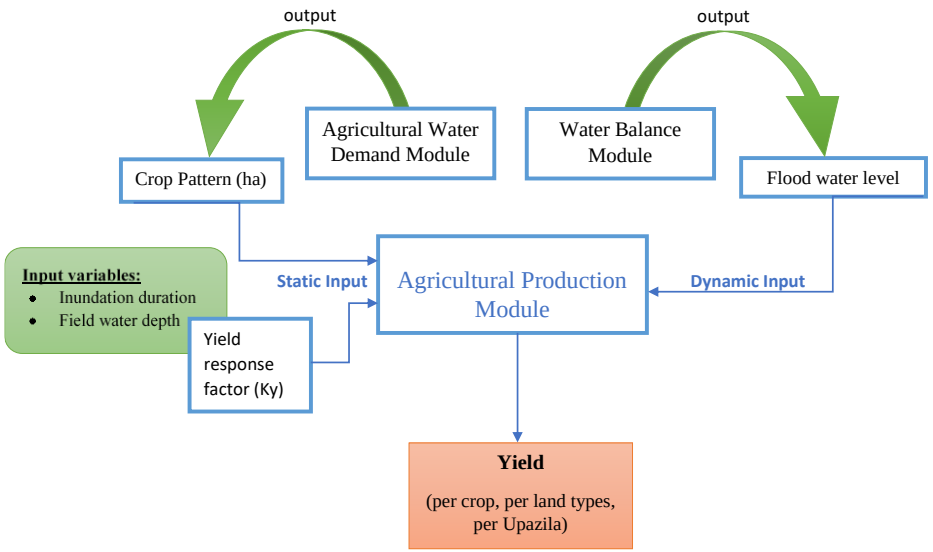
-Explaining-

- Goal: Agricultural production module will show indicated yield of 15 crops
- Agriculture production module requires inputs from other modules: water demand (water demand and cropping area) and water balance (water supply).
- The potential yield is (in this model version) restricted by flooding and drought damage.

Drought



Flood



Agricultural production

-Calculating-

Calculation actual yield

$Ya/Yp = 1 - Ky*\Sigma D/\Sigma S$

$Y = Ya * A$

Flood calculation explanation

The maximum value of ky during the planting period of a crop was taken to estimate the actual yield as below (FAO, 2012).

- $Ya/Yp = 1 - Ky$
- $Y = Ya * A$

Calibration

The ky value for flood is adjusted based on the yield in 2017, when the flood damage to Boro crops in the north east region was high. The ky value for drought is adjusted based on the yield in 2010

Agricultural production

-Considerations-

Future developments

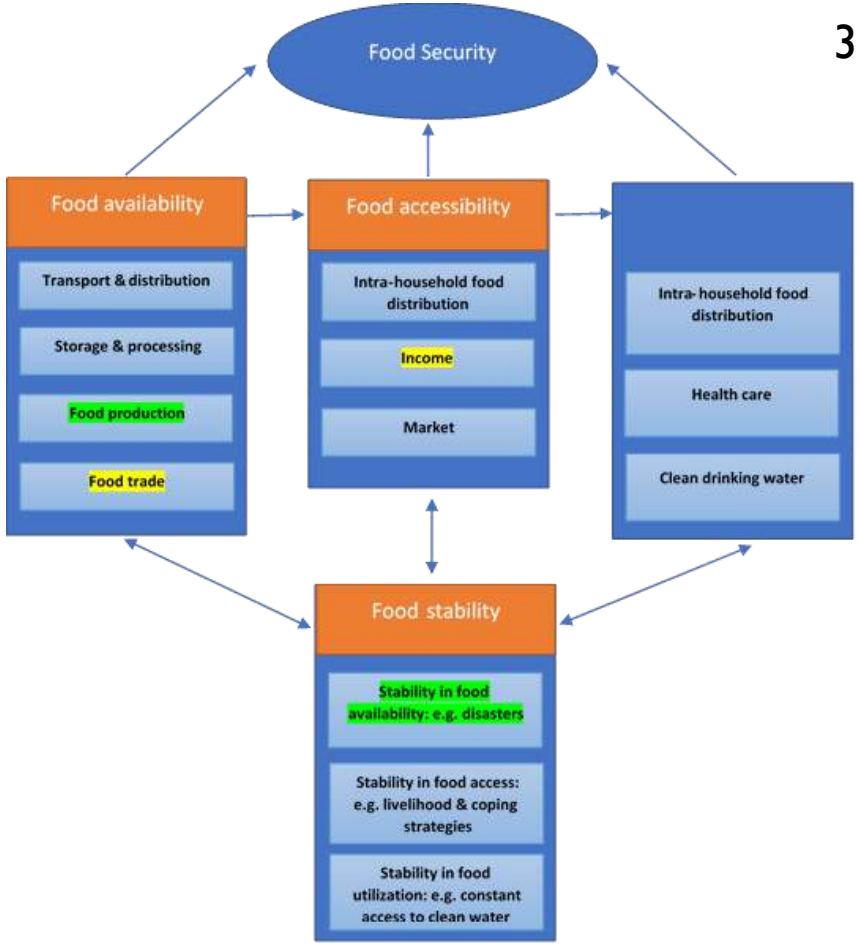
- Checking on a method combining flood, drought and salinity damage.
  - Current method is multiplying flood damage * drought damage = actual yield
  - Including salinity as damaging factor to the crop
- Calibration challenge
  - First wait on other modules calibration as agricultural production is connected to many other modules
  - Not all the crops are calibrated yet. This is now based on 6 crops of the total of 15 crops

Food security

-Explaining-

2 Determinants for food security

- Physical determinant which is the food flow: *Availability, Accessibility, Utilization*.
- Temporal determinant: Stability of food security and affects all three physical elements



Composite indicator for the metamodel

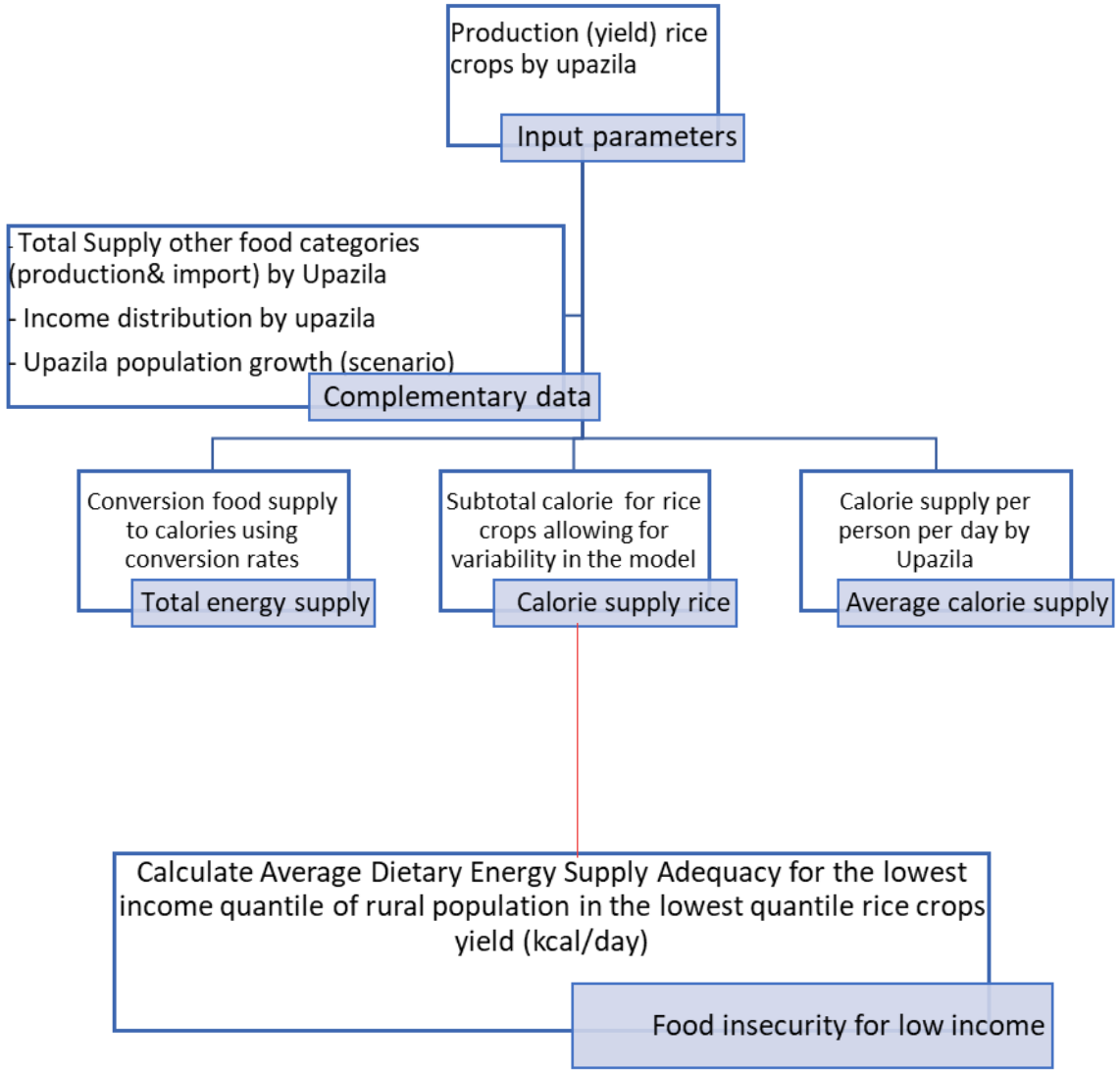
Food Security for Low Income

The Average Dietary Energy Supply Adequacy (ADESA) for the lowest income quartile of each Upazila for the lowest rice yield quantile

Food security

-calculations-

- Calculation steps →



Food security

-Considerations-

- **Inclusion of dimensions of the composite indicator**

In the module: *Availability, Accessibility and stability*

Not in module: *Utilization*.. Reason: No Direct link with metamodel.

- **Data requirement composite indicator**

requires available field-level data containing farmer's rice crops yields and income in the same array

Experts' Opinion on:

- Do you have suggestions on available/accessible detailed models of fisheries and/or livestock in Bangladesh?
- Are you aware of any national study and/or institute in Bangladesh that may contribute to the Food security indicators?

- More in general: are you aware of detailed models regarding ecosystem services and environmental flows in Bangladesh?
- Or river navigability?
- Or displacement due to disasters?

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JOINT COOPERATION PROGRAMME

Bangladesh-The Netherlands

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Web based dashboard link with JCP web site

Brief on Bangladesh Meta Mod

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and programs. Another important objective of the programme is to build capacity at different agencies in Bangladesh for developing, using and owning the Metamodel, and develop a structure to embed its maintenance and operation in an effective way.

BD METAMODEL

Sl. No.	Description	Data	Dashboard
1	SIBDP Program Manager	Data	Dashboard
2	Network module dashboard	Data	Dashboard
3	Impact explorer light	Data	Dashboard
4	Impact explorer full	Data	Dashboard

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Impact explorer

- Main interface to BDP Metamodel results
- To support GoB agencies to evaluate and compare calculated impacts of projects and programs on water and society.
- Used for viewing model results for future decision-making
- Development of Metamodel Engine and Database is under development; we now make use of dummy values to be able to discuss the main elements of the Metamodel

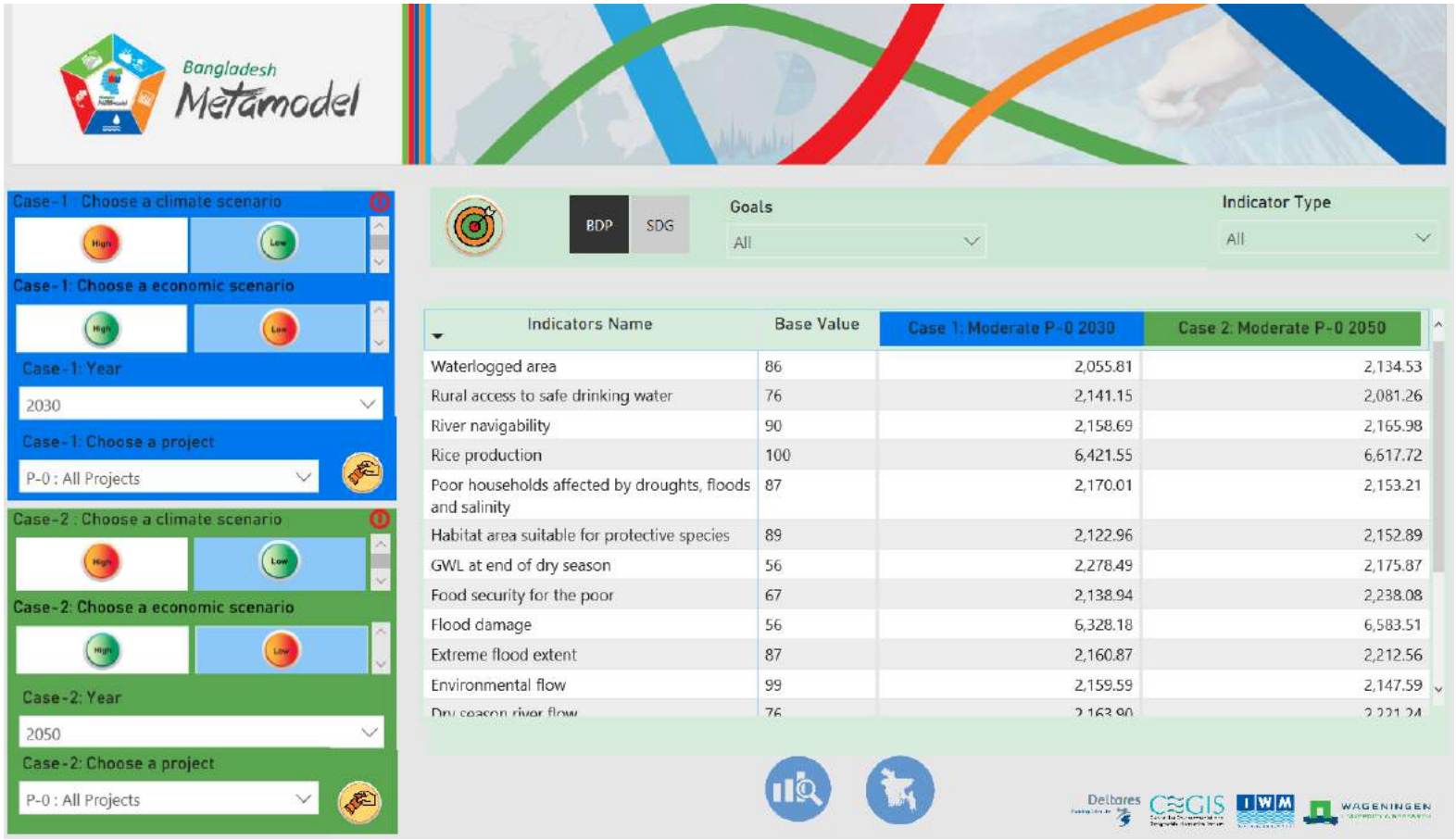
Impact explorer

Dashboard type:

- Main dashboard- compare model results
- Associate dashboard- Program Manager, Scenario description, Project explorer, map and graph viewer

With features:

- Filter/ slice elements (interactions)
  - Button Custom Visualization
  - Slicer for multiple scenarios
- Visualization graph and map
- Tooltip (detailed description)



Selection Panel

Viewer Panel

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Program Manager

Idea developed together with SIBDP to support the preparation of programs (= cluster of project)

By showing:

- Implementation pathway
- Total cost
- Annual cost
- Funding sources
- Contribution to BDP Goals

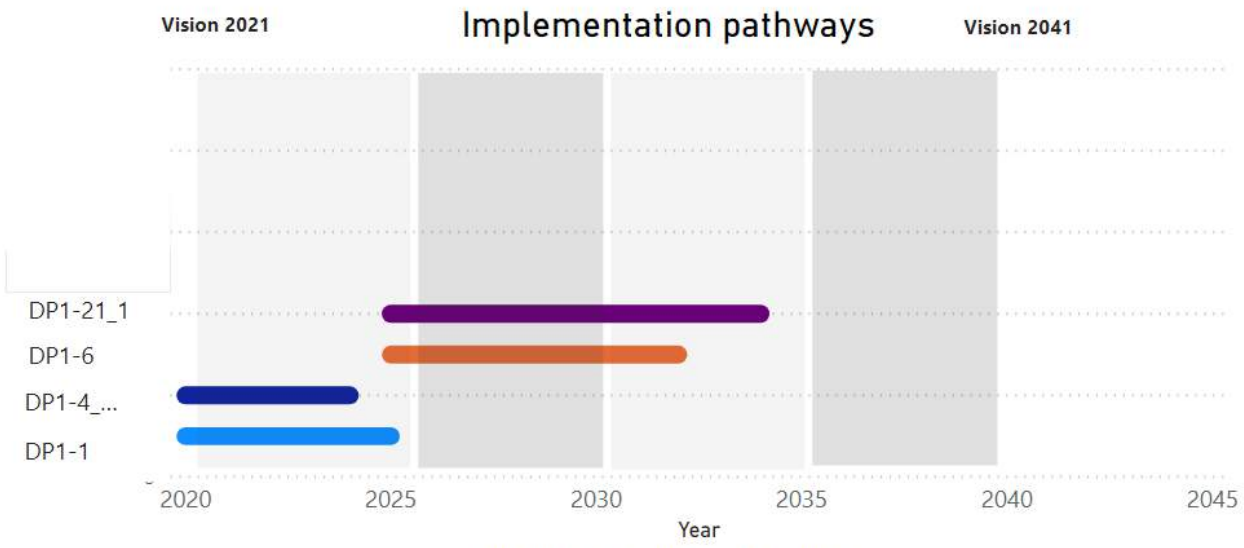
No new information, but combination and visualization of information from the BDP2100 investment plan

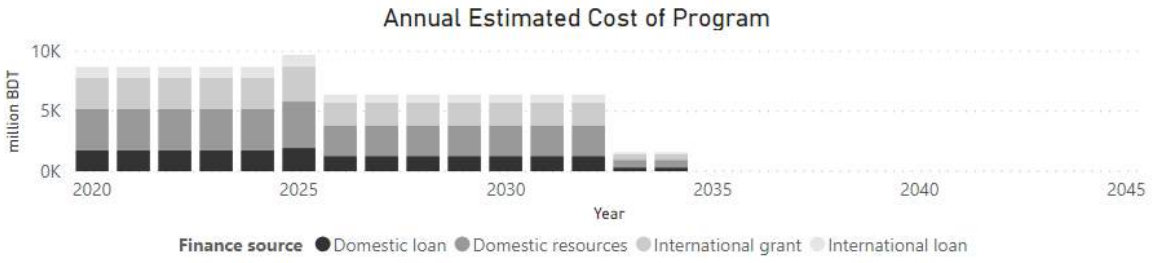
Program Manager

BDP 2100 Program Manager

BDP goals | Project info | Clear filter

		Start year
Project 1		
DP	DP1-1 North ...	2020
Project 2		
DP	DP1-4_1-5 K...	2020
Project 3		
DP	DP1-6 Teest...	2025
Project 4		
DP	DP1-21_1 Pr...	2025
Project 5		
		2020
Project 6		
		2020
Project 7		
		2020
Project 8		
		2020
Project 9		
		2020

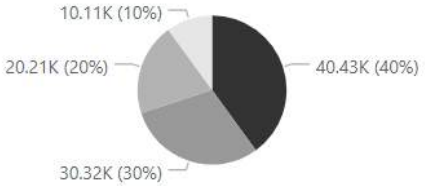




Total estimated project cost

101.07K

Million BDT



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Updated dashboards

- Versions of dashboards are published on and regularly updated at:

http://jcpbd.nl/bdpMetaModel.php