Metamodel for BDP 2100

Presented by:

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&

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Deltares, Netherlands

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Technical Support from JCP Bangladesh Metamodel Team with four institutions: Deltares, WUR, IWM, CEGIS

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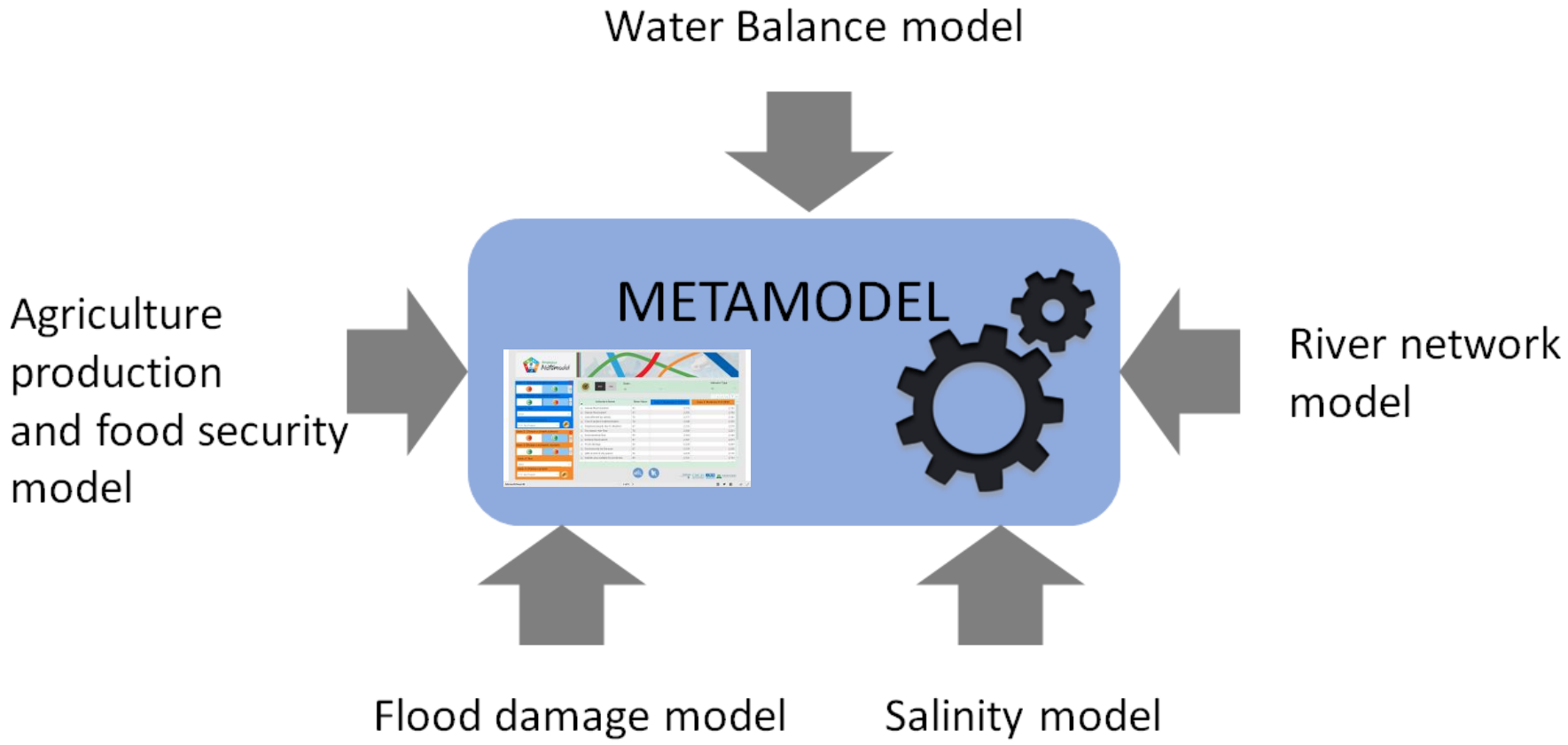
Contents

1. Short overview on progress of Bangladesh Metamodel developments and recent consultations
2. Impacts of BDP2100 climate change scenarios
3. Impacts of projects / programs in Atrai – Hurasagar Basin
4. Impacts of projects / programs in Kurigram district*
5. Considerations
6. Future planning

* Not in this presentation

What is a metamodel?

Metamodel: A model of models



Metamodel: In short

- 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

Participatory model development – Recent consultations

- Internal SIBDP progress meeting (8-4-2020)
- Expert reflection session 1(29-4-2020)
- GED meeting (7-5-2020)
- End User meeting (13-5-2020)
- Expert reflection session II on Agriculture and Food security (9-7-2020)
- Expert reflection session II on Water & Climate change (16-7-2020)
- Internal SIBDP technical progress meeting (13-7-2020)

(To be) planned:

- Structured interviews with agencies (July/August)
- GED meeting (July/early August)

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Brief on Bangladesh Meta Model

The main objective of the Metamodel is to support adaptive delta planning (IWRM and ICZM) by key stakeholders such as the General Economics Division, Ministry of Water Resources and others in investment planning and integrated assessment. The Bangladesh Meta model is developed in close collaboration with the project "Support to the Implementation of the Bangladesh Delta Plan 2100 (SIBDP2100)", which will provide advisory support to the GED. The Bangladesh Metamodel will be developed to support the formulation, analysis and evaluation of alternative projects 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.

BDP Metamodel Data and Dashboard

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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How can the metamodel be used?

Two different types of users

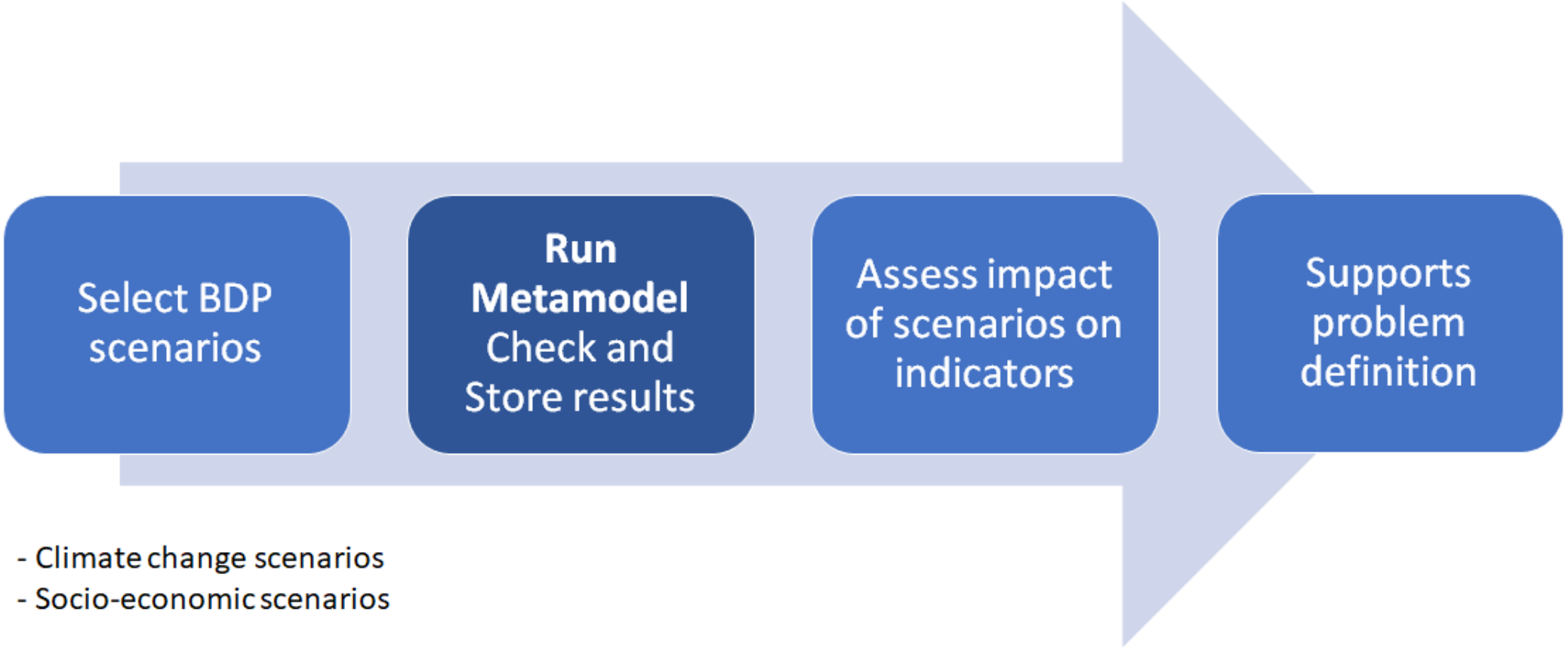
1. **As a planner at GED,**

- To analyze and assess the impact of proposed projects / programs (within BDP 2100) 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.

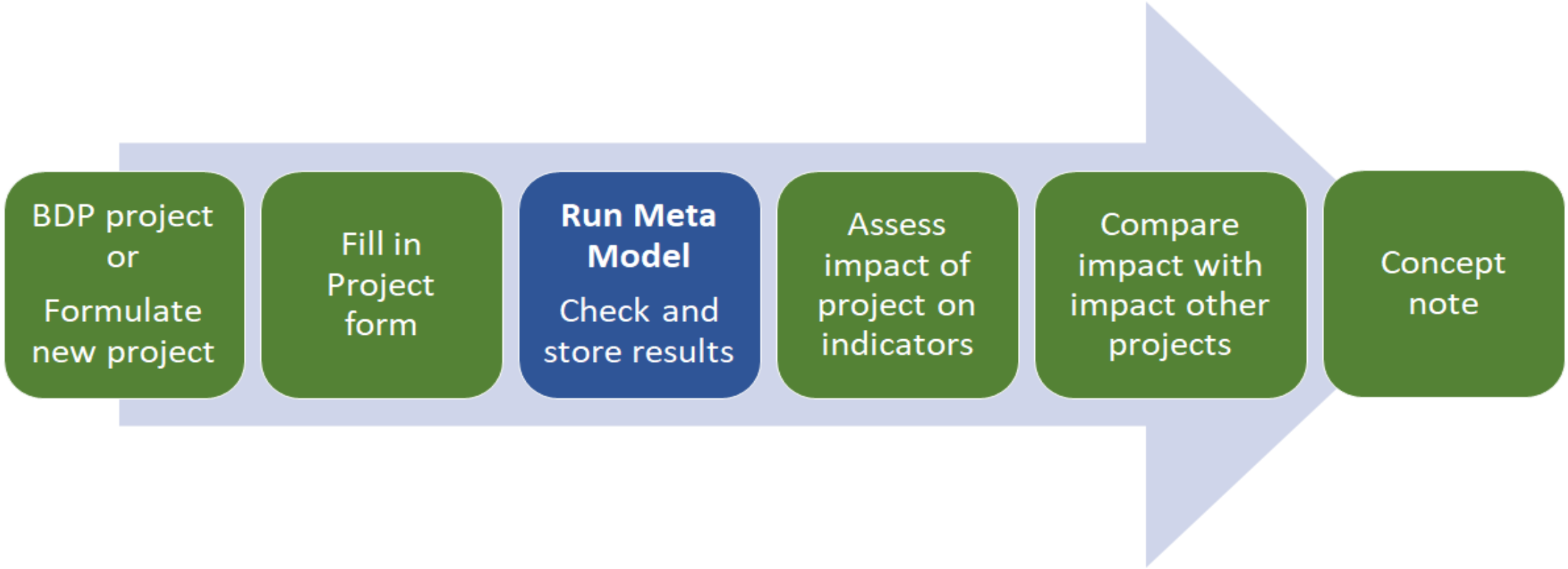
2. **As an officer at a Ministry or Agency,**

- 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 metamodel: Scenario exploration



Use of metamodel: Impact of projects



Project information form

Project information form

This project information form is used to collect information on the projects that are going to be included in the Bangladesh Metamodel.

Some of the information will be background information and project characteristics, but since the Metamodel is a numerical model we need to feed numerical data into the model.

It may be difficult to assess a detailed, correct value for those parameters. However, we ask to assess the values is good as possible as this will significantly improve model results obtained with the model.

This questionnaire is developed by:
Willem van Deursen, Deltares (willem.vandeursen@deltares.nl)

Please enter your name and the institute you work for?

Your answer

Please enter the name of the project?

Your answer

Please enter the total project area [ha]

Your answer

Please enter the net project area [ha]

Your answer

Please check components that are planned in the project

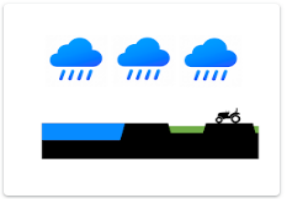
☐ Interventions to improve drainage

☐ Interventions to improve flood protection

☐ Interventions to increase groundwater irrigation

☐ Interventions to increase surface water irrigation

☐ Interventions to increase protection of population against flood



☐ Interventions to increase protection of property against flood damage

☐ Interventions in the main network

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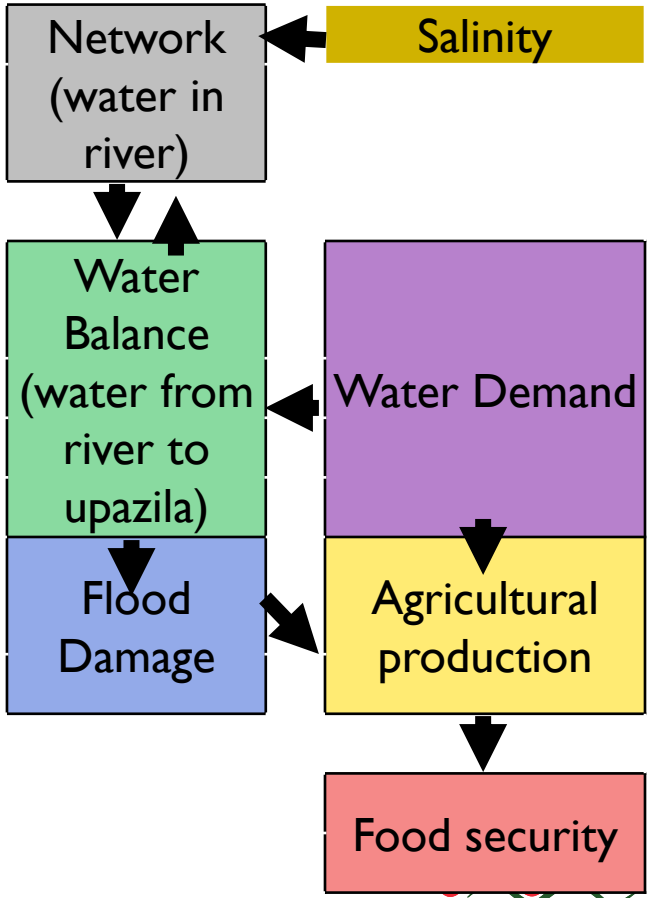
Metamodel indicators

All decision support indicators are linked to the SDGs and the BDP2100 Goals
Color represent modules
* Results in progress

State Indicators	Decision Support Indicators
Environmental flow (m^3/s)*	Annual rainfall damage (Taka)
Dry season river flow (m^3/s)	River navigability (km/class)*
Annual flood extent (km^2)	Rural access to safe drinking water (%)*
Annual flood duration (month)	Habitat area suitable for protective species (km^2)*
Extreme flood extent (km^2)	
Waterlogged area (km^2)	
GWL at end of dry season (m)	
Flood damage (Taka)	Poor households affected by droughts, floods and salinity (%)*
	Displaced people due to disasters (%)*
	Rice production (Ton)
	Food security for the poor (%)
Area affected by salinity (km2)*	Cost of project implementation (Taka)

* Under development

Metamodel engine module workflow



Bangladesh Metamodel

Case-1 : Senario Year

2030

Case-1 : Choose a climate scenario

High | Low

Case-1: Choose a economic scenario

High | Low

Project List

DP1-3 : Revitalization and Restorati...

Case-2 : Senario Year

2050

Case-2 : Choose a climate scenario

High | Low

Case-2: Choose a economic scenario

High | Low

Project List

DP1-3 : Revitalization and Restorati...

BDP | SDG

Goal Name: All

Indicator Type: All

Division: All

Indicators	Reference Value : Year 2020	Case-1	Case-2
Annual rainfall damage (Taka)	534532187	4,096,069.78	4,046,839.19
Flood damage (Taka)	75417833	1,002,191.45	736,714.48
Waterlogged area (km2)	21487	21,747.41	21,036.92
Extreme flood extent (km2)	11842	13,963.17	11,843.53
Rice production (Ton)	4570	9,277.99	9,630.34
Annual flood extent (km2)	9381	9,152.64	7,993.04
Dry season river flow (m3/s)	771	555.15	614.20
Annual flood duration (month)	394	32.96	32.58
GWL at end of dry season (m)	-423	25.39	-94.99
Poor households affected by droughts, floods and salinity (%)	1	1.51	1.48
Food security for the poor (%)	53		

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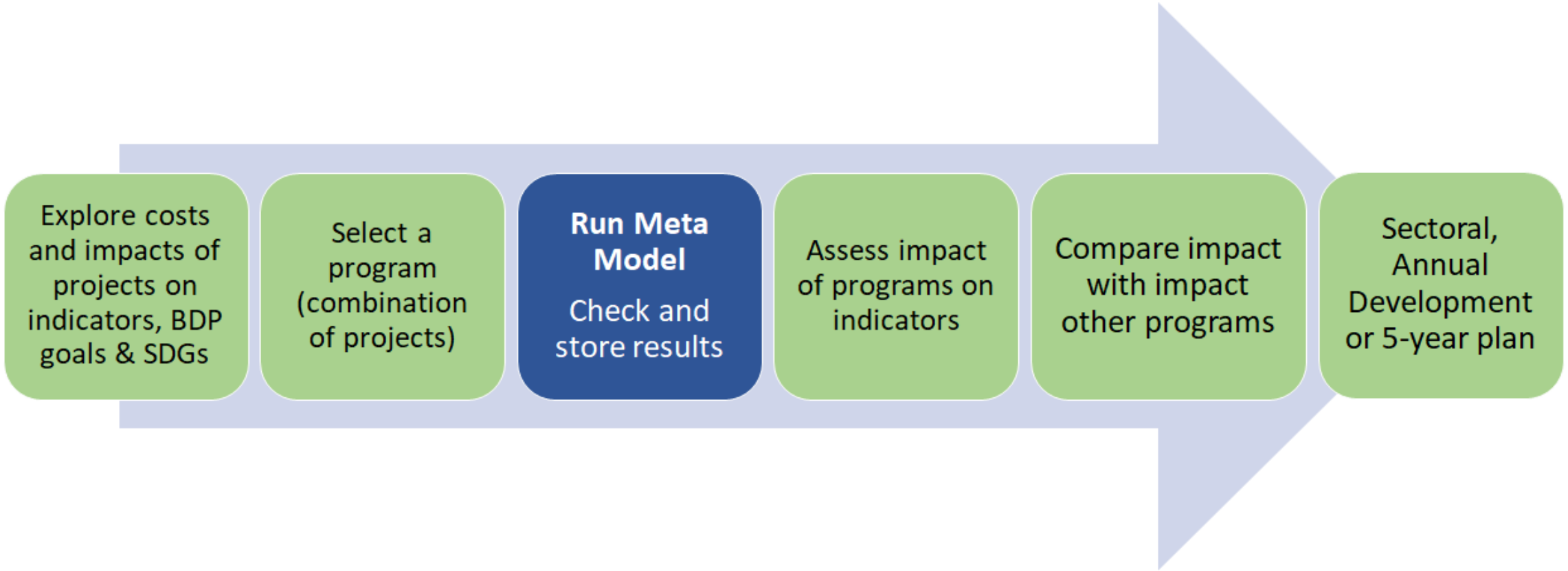
Use of metamodel: Impact of programs

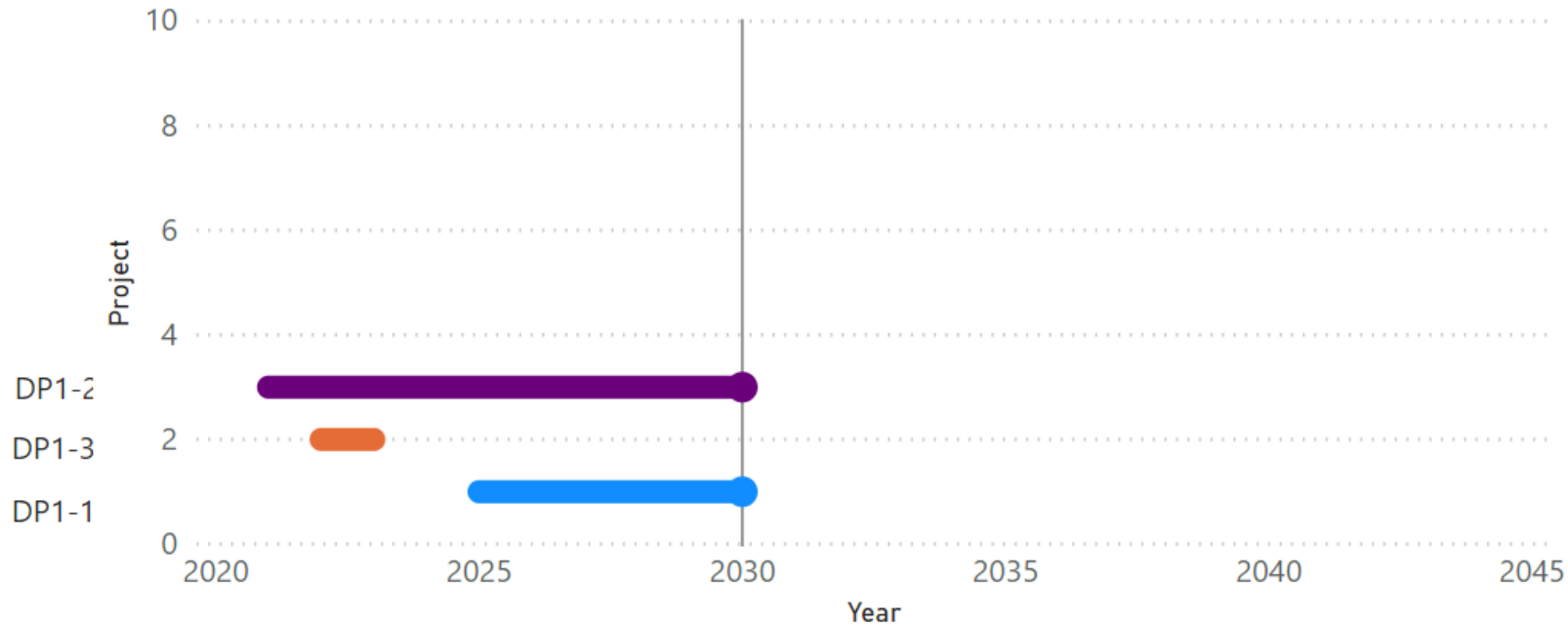


BDP 2100 Program Manager

BDP goals | Project info | Clear filter

			Start year
Project 1	DP	DP1-1 North...	2025
Project 2	DP	DP1-3 Revit...	2022
Project 3	DP	DP1-21_1 P...	2021
Project 4			2020
Project 5			2020
Project 6			2020
Project 7			2020
Project 8			2020
Project 9			2020

Implementation pathways



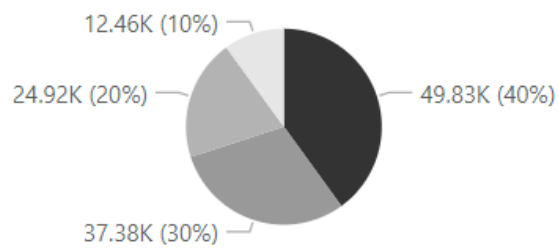
Annual Estimated Cost of Program

Finance source Domestic loan | Domestic resources | International grant | International loan

Total estimated project cost

124.59K

Million BDT



Bangladesh Metamodel

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DP1-3 : Revitalization and Restorati...

Case-2 : Senario Year

2050

Case-2 : Choose a climate scenario

High | Low

Case-2: Choose a economic scenario

High | Low

Project List

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Poor households affected by droughts, floods and salinity (%)	1	1.51	1.48
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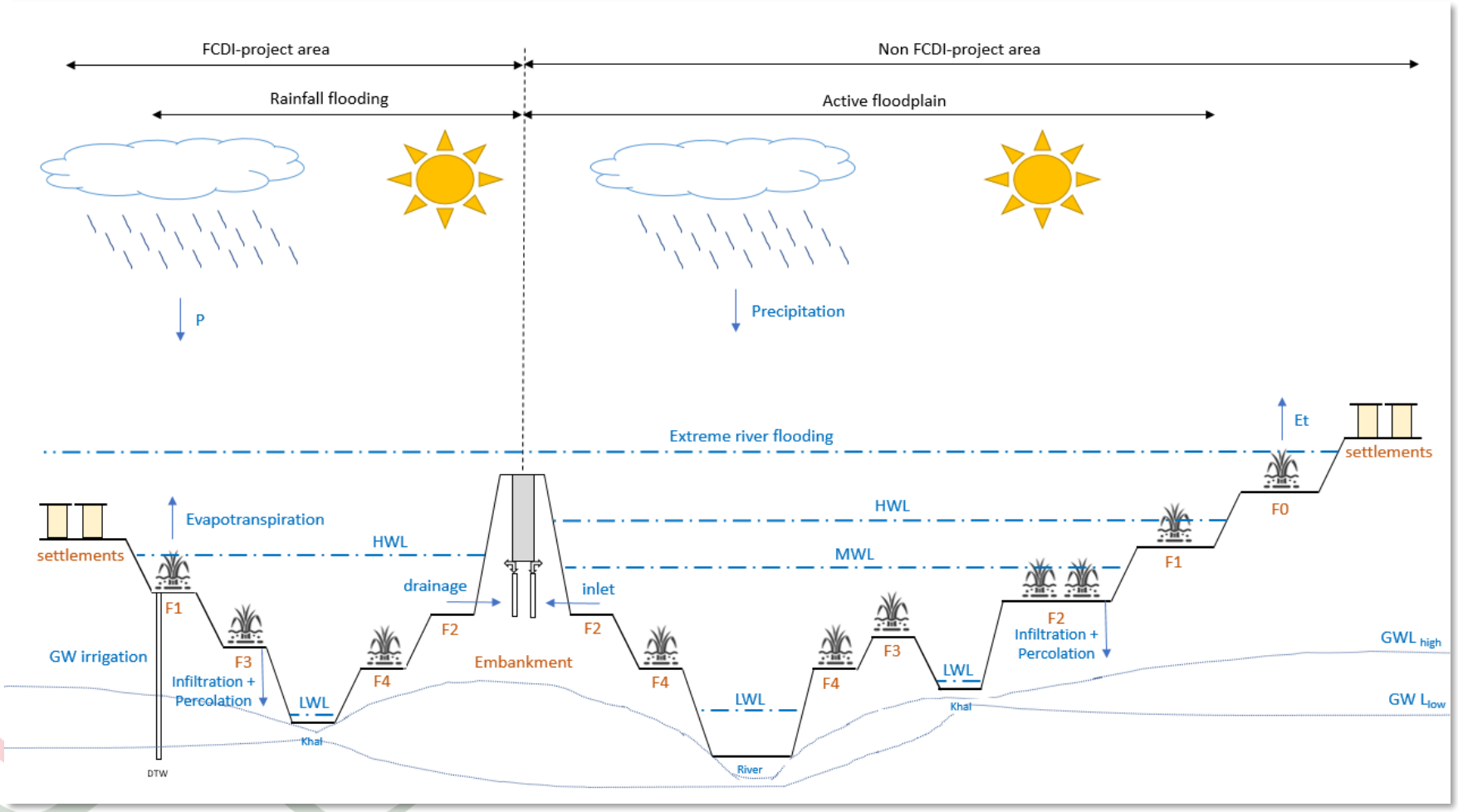
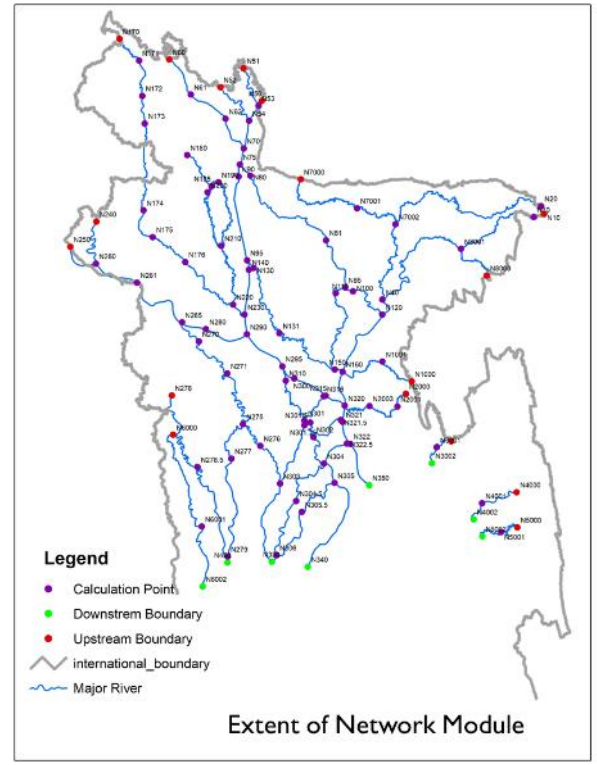
How does the metamodel work? (and first results)

Water distribution





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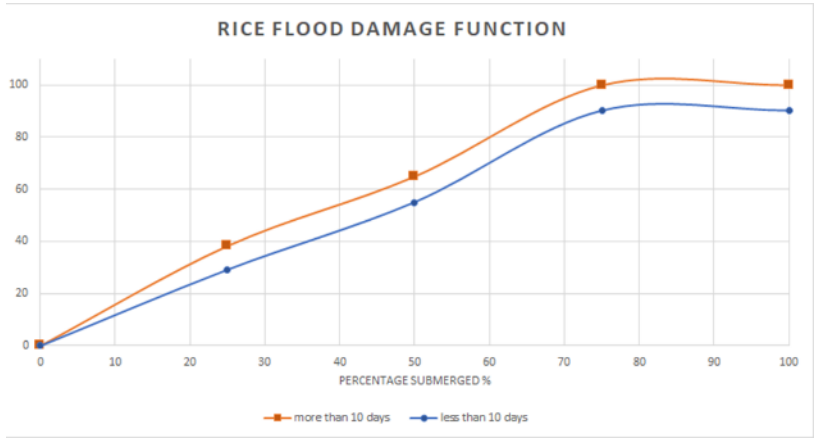
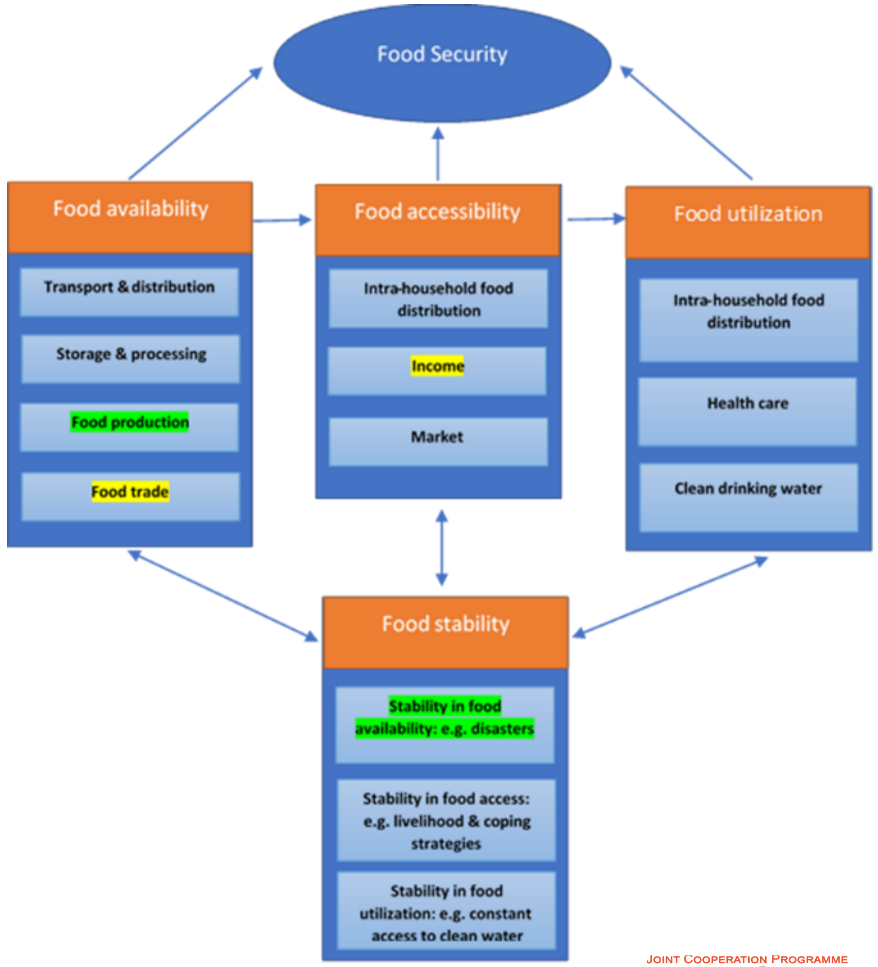
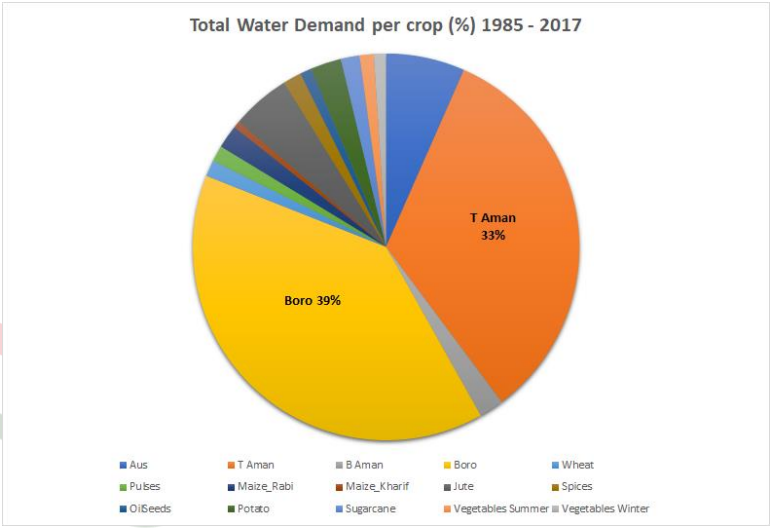
Agricultural water demand, production and food security



Source: Hussain (1995)





Source: Output MM, Penman-Monteith

Sources: FAO, BARI, BMD, BARC, MPO, DSAT, Agricultural yearbook

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Main results of Metamodel v.1

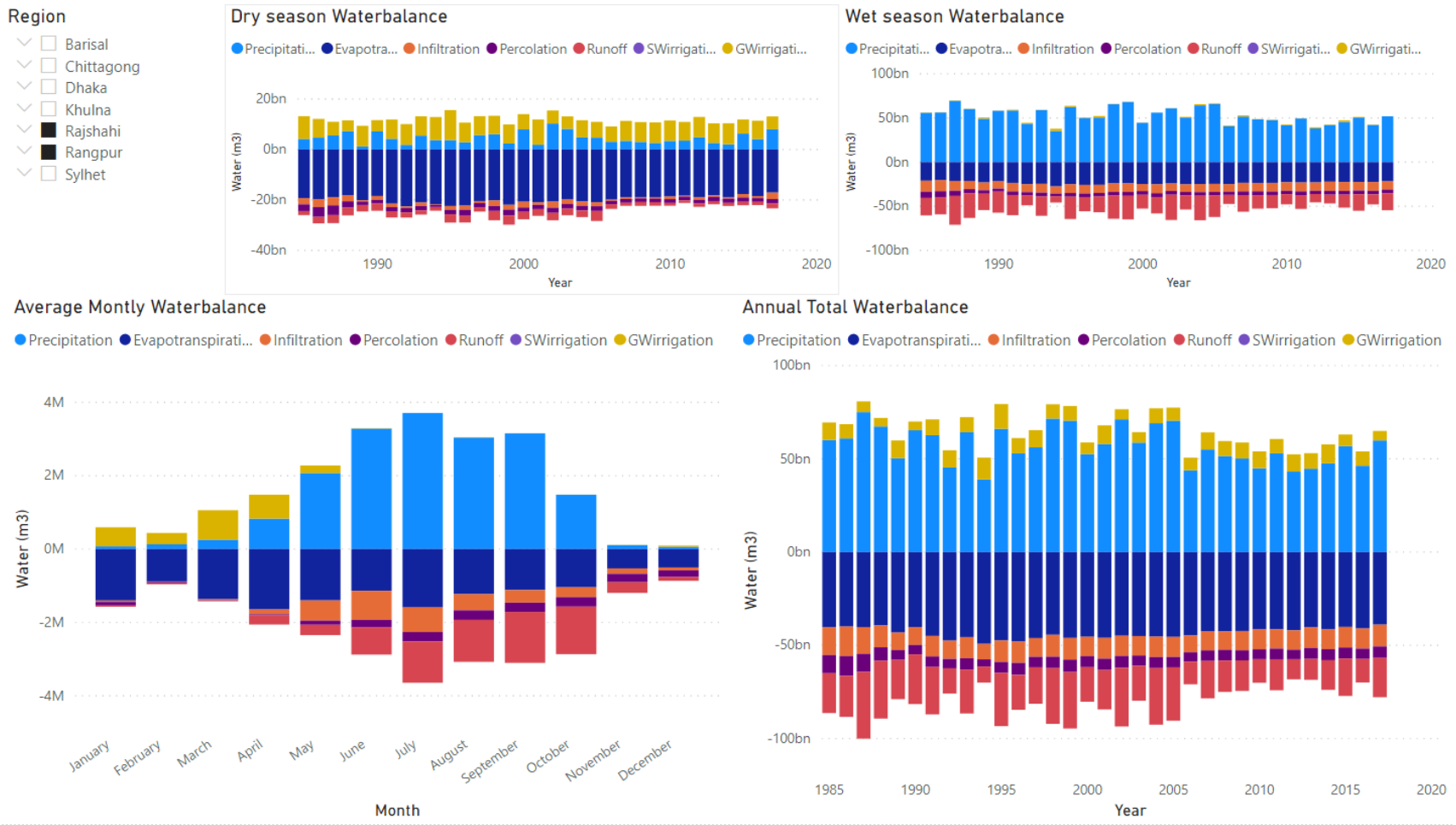
Based on the most actual and complete data and nation-wide detailed models available in Bangladesh:

- National waterbalance, incl. river network
- National impact models: flood damage, agricultural production, food security, …
- National BDP2100 project database

- First version of a metamodel and impact explorer to analyse and compare impacts of scenarios, projects and programs on water resources and socio-economic aspects.
- To be used in combination with SIBDP Program Manager to analyse investment requirements of programs.

- Well established capacity in CEGIS and IWM!

Example output: national water balance (extract North-West)



<u>Main observations:</u>

I. Clear seasonal diff
II. Large annual variation
III. Residual moisture supplemented by GW irrigation in beginning of dry season

Available for every hotspot, division, and district in Bangladesh (currently calibrated for NW-region)

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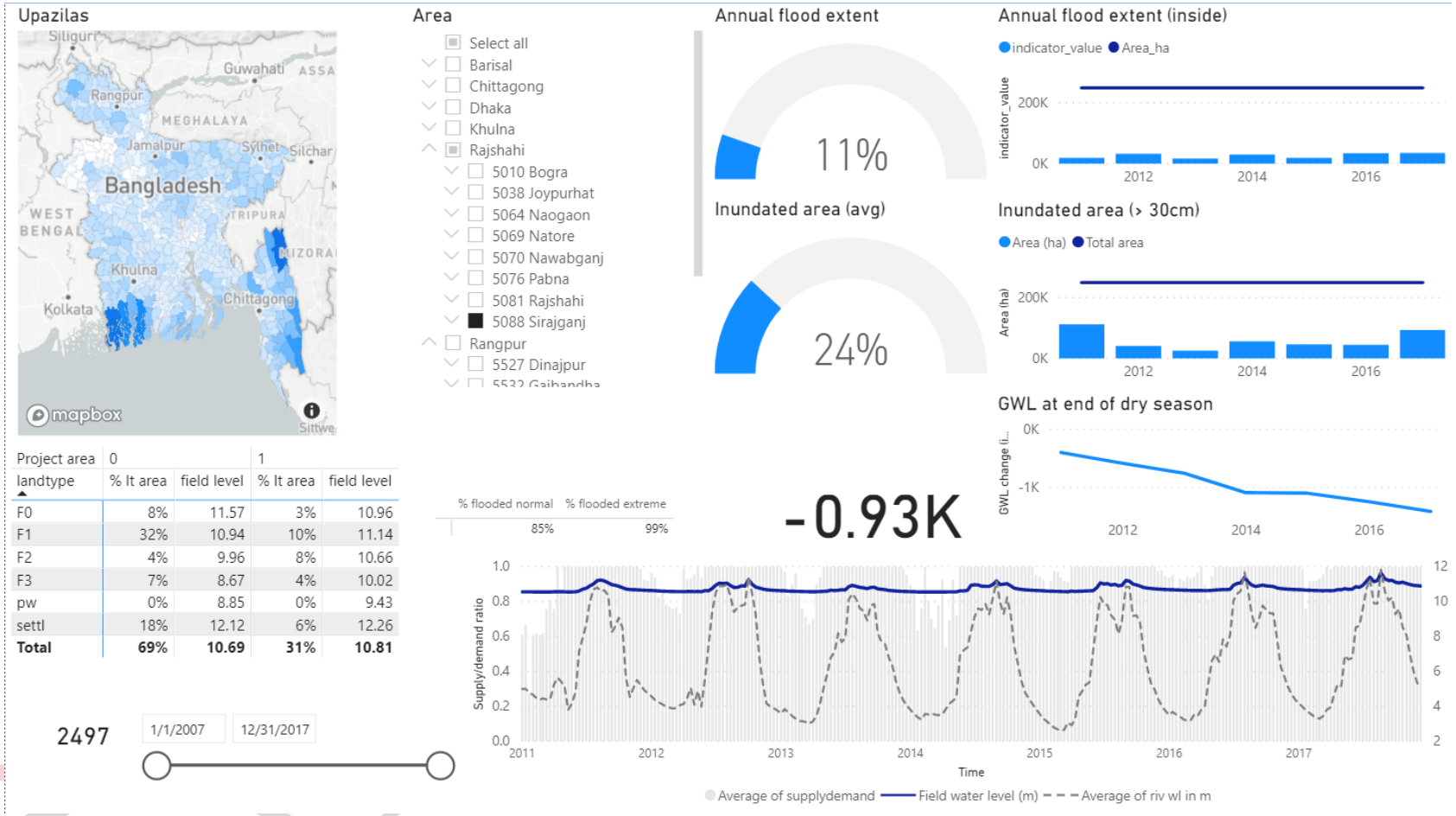
Example output: flooding and drought characteristics



Main observations:

I. Large annual variation
II. Distinction in river floods and rainfall floods
III. Timing and duration of floods inside/outside embankments
IV. Crop water supply-demand ratio ~100%

Available for every district in Bangladesh (currently calibrated for NW-region)

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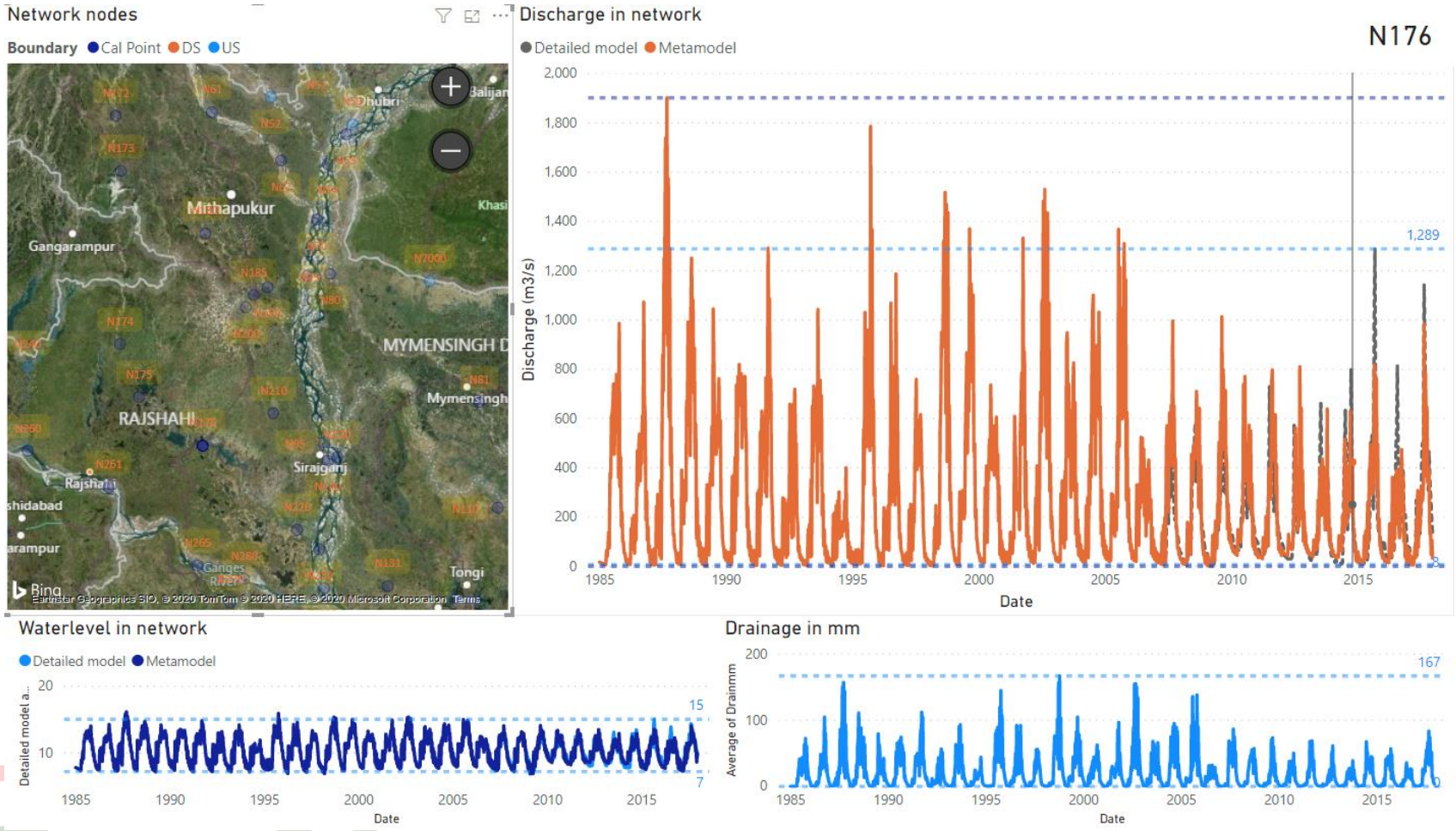
Example output: modelled discharges and waterlevels in main rivers



Output available for all major rivers in Bangladesh

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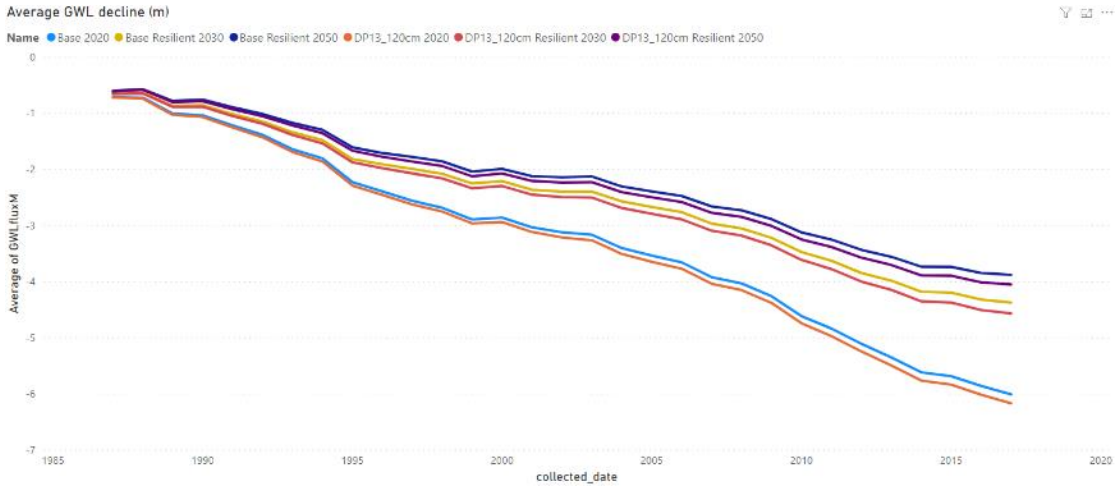
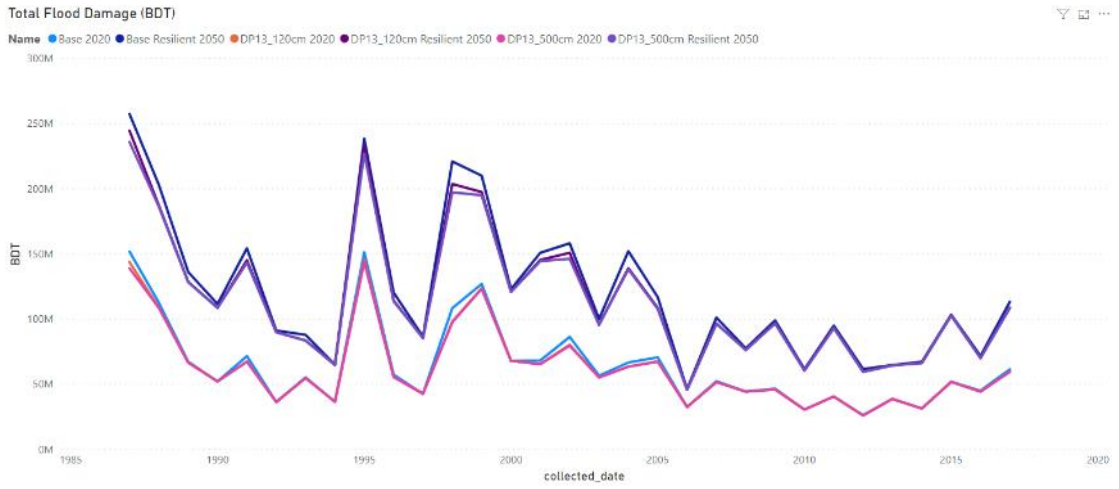
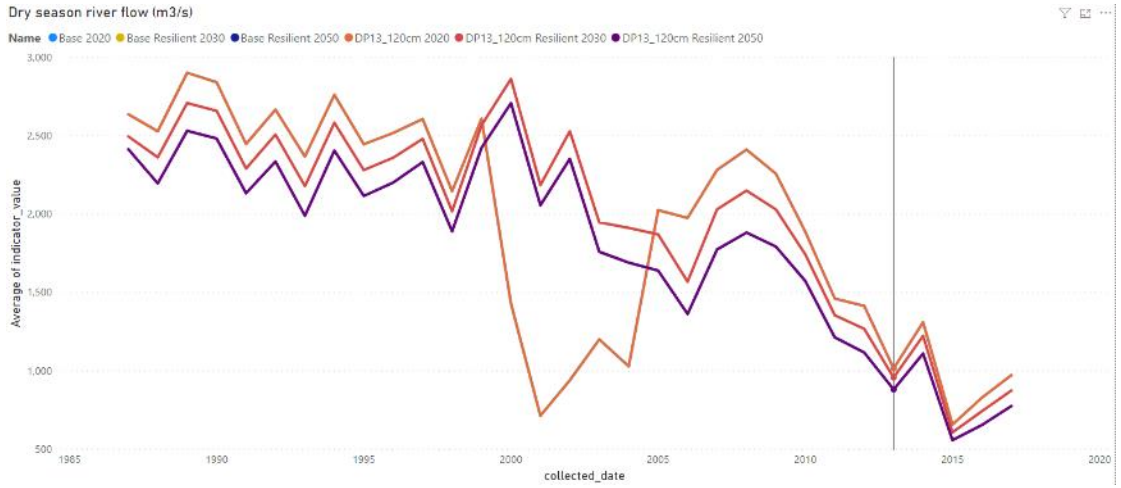
Example output: temporal and spatial distribution for different indicators







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Scorecard BDP2100 climate change scenarios for NW-region

Scenario		Base	Productive		Resilient		Moderate		Active	
Climate situation		2020	2030	2050	2030	2050	2030	2050	2030	2050
Climate characteristics										
Sea level rise	cm	n/a	10 - 20	20 - 30	15 - 30	40 - 60	10 - 20	20 - 30	15 - 30	40 - 60
Temperature rise*	˚C	n/a	0.5	1	1.5	2	0.5	1	1.5	2
Monsoon rainfall change	%	n/a	0	10	15	20	0	10	15	20
Dry season rainfall change	%	n/a	0	0	-10	-10	0	0	-10	-10
Peak discharge change	%	n/a	5 - 15	10 -20	15 - 30	20 - 40	5 - 15	10 - 20	15 - 30	20 - 40
Low flow discharge change	%	n/a	-5	-15	-15	-30	-10	-25	-20	-40
Decision support indicators										
Annual flood damage (infrastructure, housing, etc.)	crore BDT	6.4	15%	37%	59%	88%	14%	37%	59%	88%
Poor households affected by droughts and floods		522	7%	37%	59%	81%	7%	37%	59%	81%
Annual rice crop production (T aman, Boro, Aus)	Mtonnes	10.4	-1%	-3%	-5%	-7%	0%	-3%	-5%	-7%
Food security for the poor: dietary energy supply	calories/day	n/a	-22%	-28%	-25%	-31%	-22%	-28%	-25%	-31%
Water system state indicators										
Total flood extent	% of area	29%	8%	13%	21%	28%	8%	12%	21%	28%
Extreme flood extent	% of area	47%	17%	22%	53%	64%	17%	22%	53%	64%
Flood duration	days	114	1%	9%	12%	15%	1%	9%	12%	15%
Dry season river flow (Atrai Basin)	m3/s	25	7%	0%	0%	-10%	4%	-7%	-3%	-17%
GWL decline per year	cm	9	-3%	-16%	-22%	-30%	-3%	-16%	-22%	-29%

* effect on reference evapotranspiration

Main observations:

1. Much wetter in monsoon
2. Larger & longer annual floods, more extreme floods
3. Positive for GWL
4. Dry season low river flow in Atrai basin decrease

Preliminary result need to be verified!
Excluding economic development scenarios!

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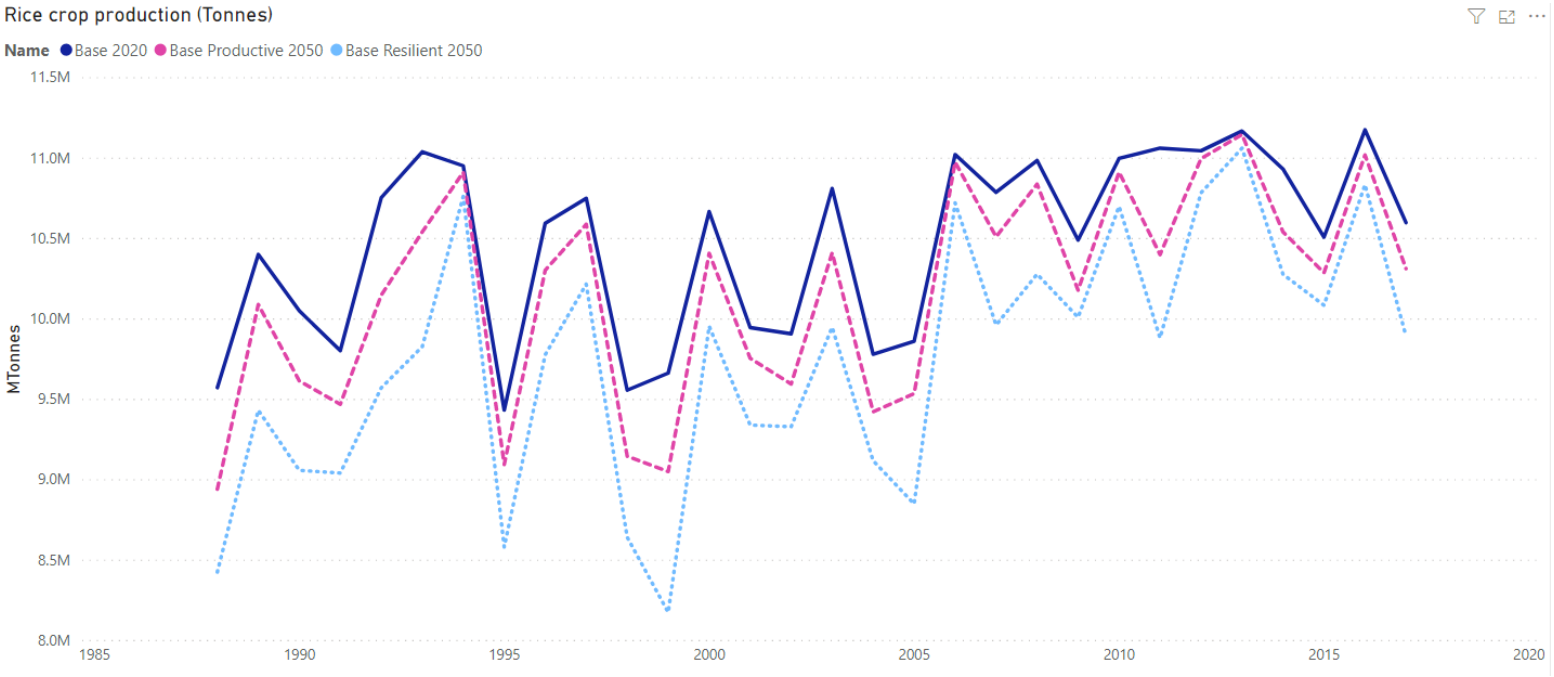
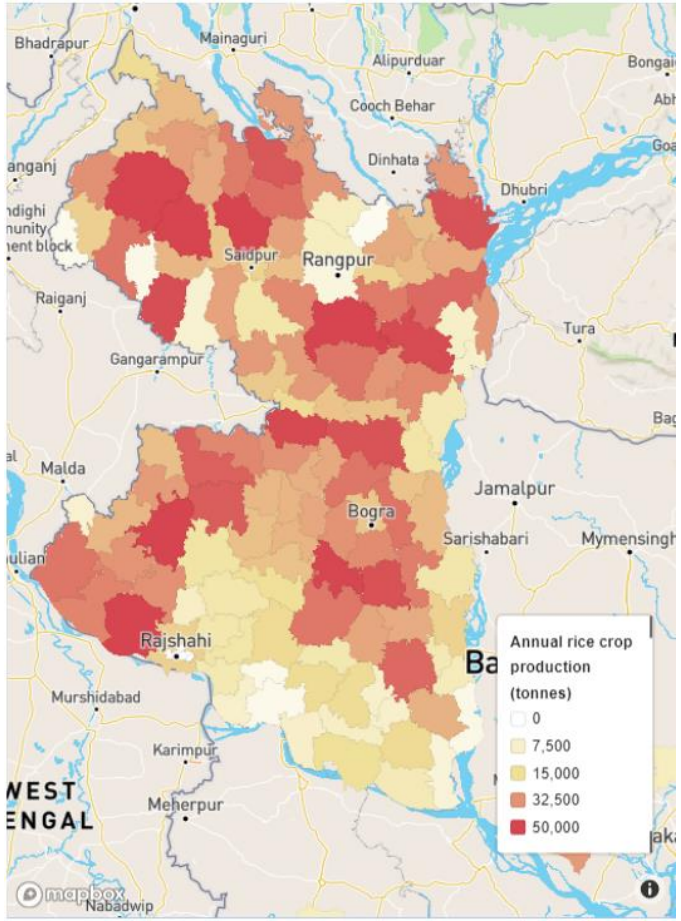
Impacts BDP2100 climate change scenarios in time and space





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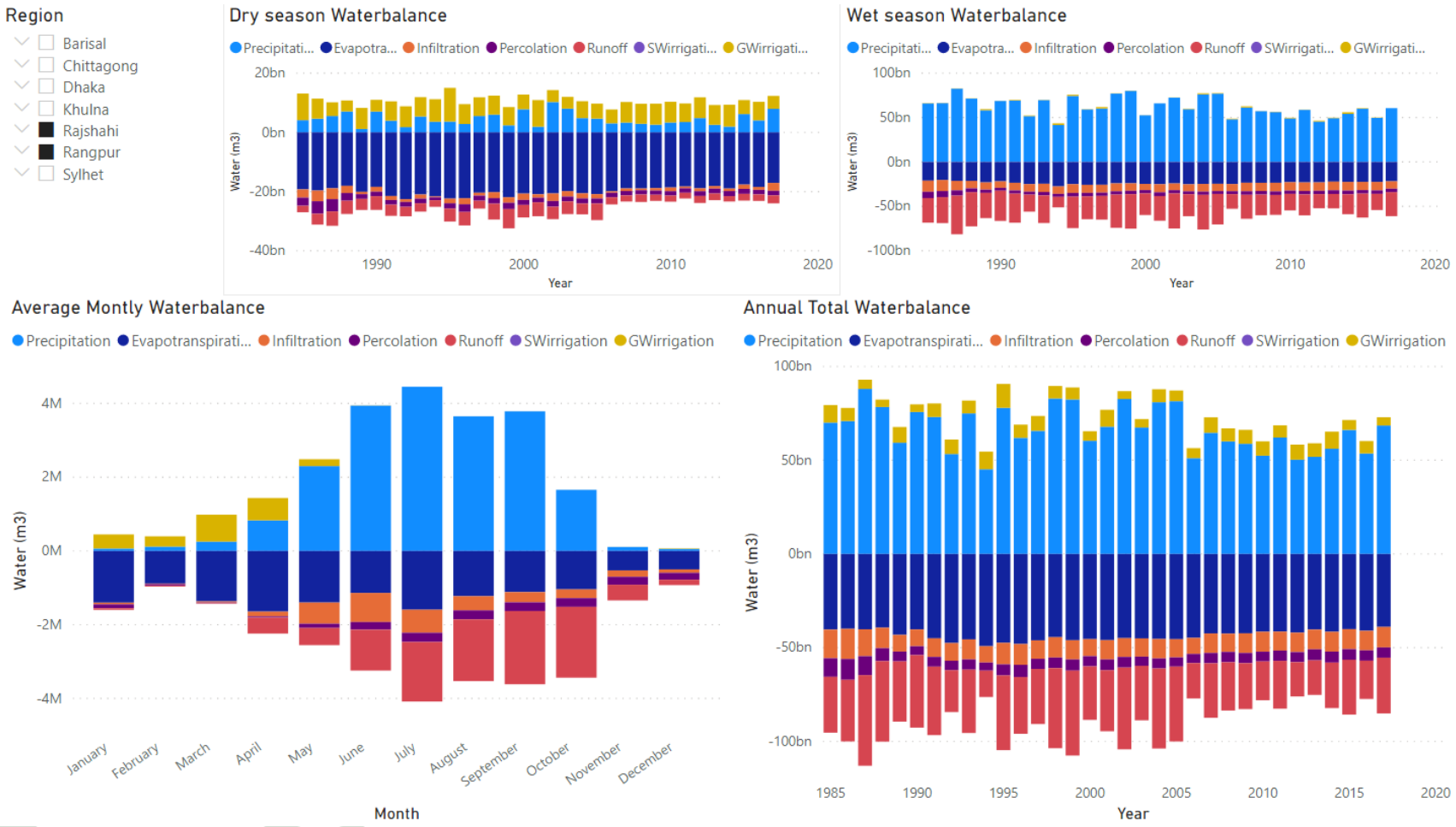
Impacts of BDP2100 climate change scenarios



Main observations:

1. More rainfall -> more runoff
2. Slightly less GW irrigation + more percolation

To do:

Visualize river inflow/outflow

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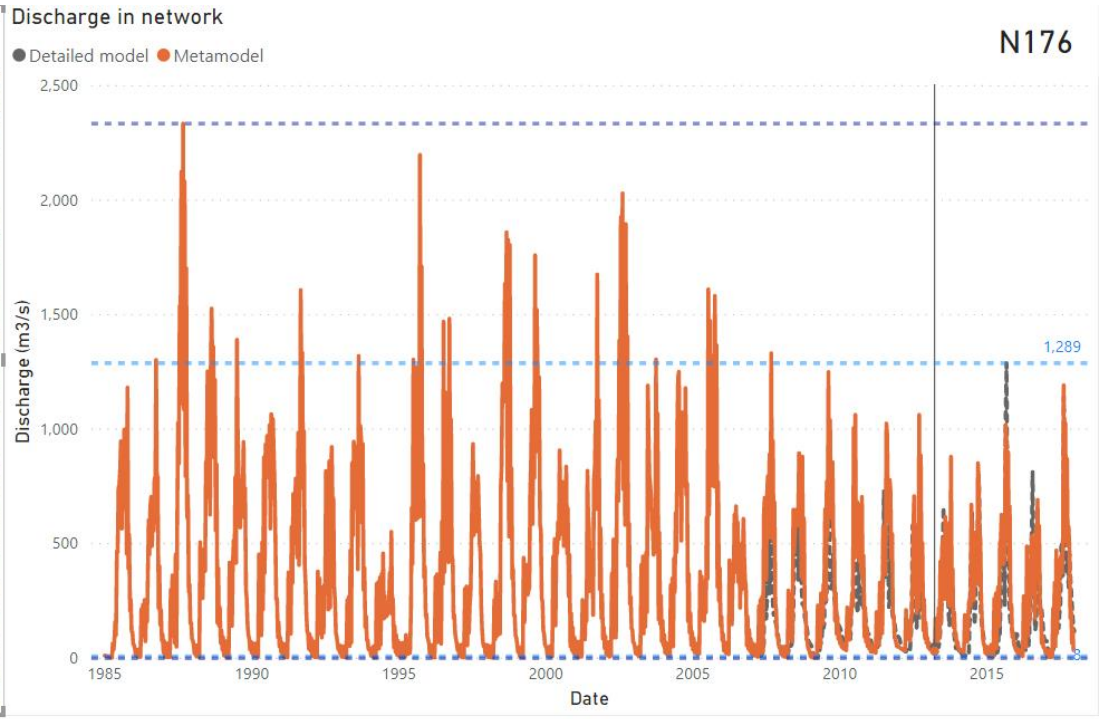
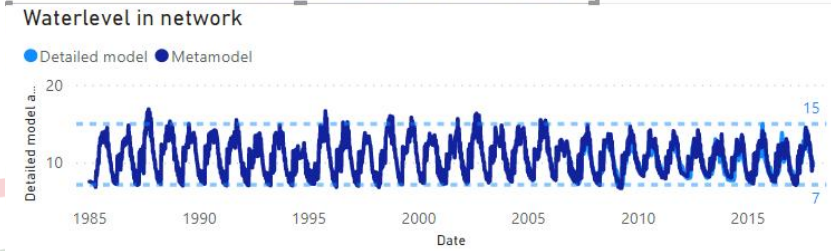
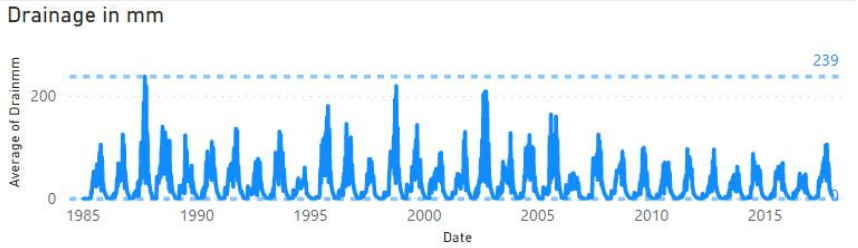
Impacts of climate change on river discharge







Main observations:

1. Higher peak flows
2. More drainage from fields

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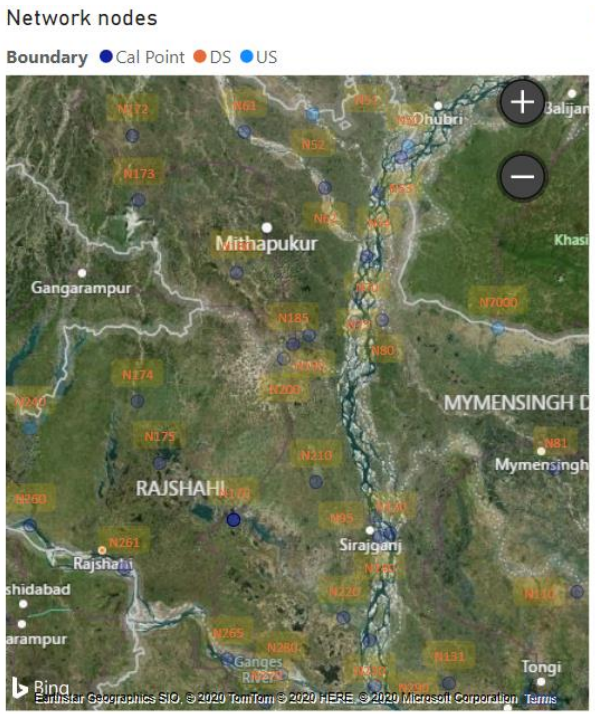
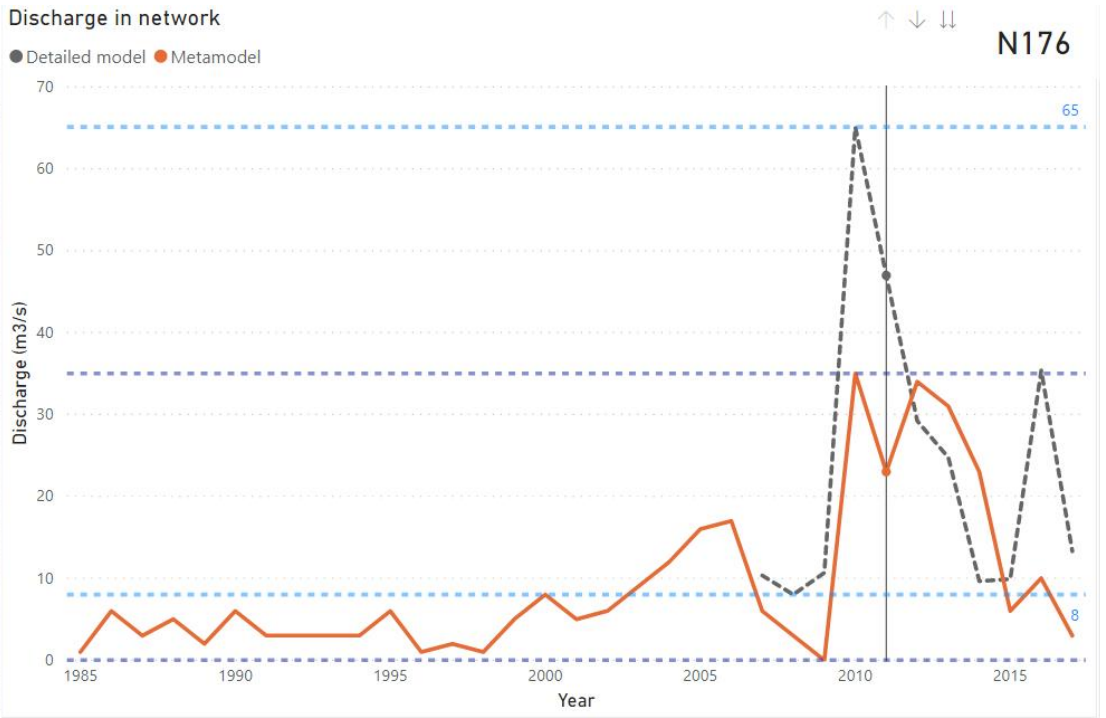
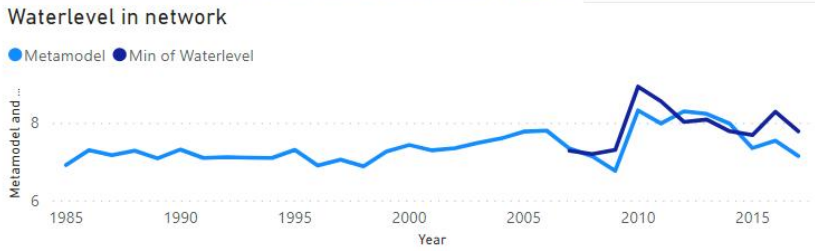
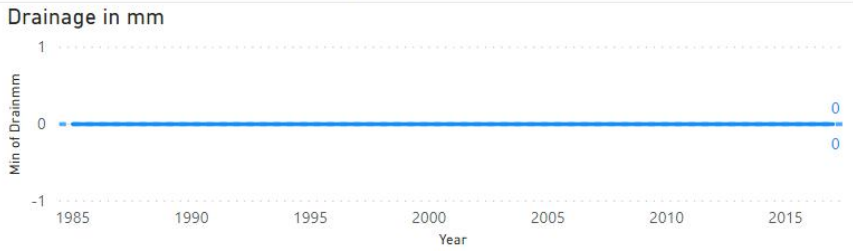
Impact of climate change on low flow river discharge









Main observations:

1. Declining dry season river flows

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Preliminary conclusions – Impacts of climate change on NW

- The area becomes **much wetter** in the wet season, a **bit drier** in the dry season
- Leads to larger flood extents, flood depths with little bit longer duration
- Mainly leads to potentially **more flood damage** to infra and buildings, slightly more to rice crops
- Poor households will be increasingly affected and the dietary energy supply will go down
- Groundwater levels will **rise**, GW extraction remain stable, dry season water levels go down
- Drought damage to crops does not change substantially

- No change in signal in timing of floods, as these are not included in the scenarios using the delta method

Issues in Atrai – Hurasagar Basin

Siltation of main rivers Atrai and Hurasagar

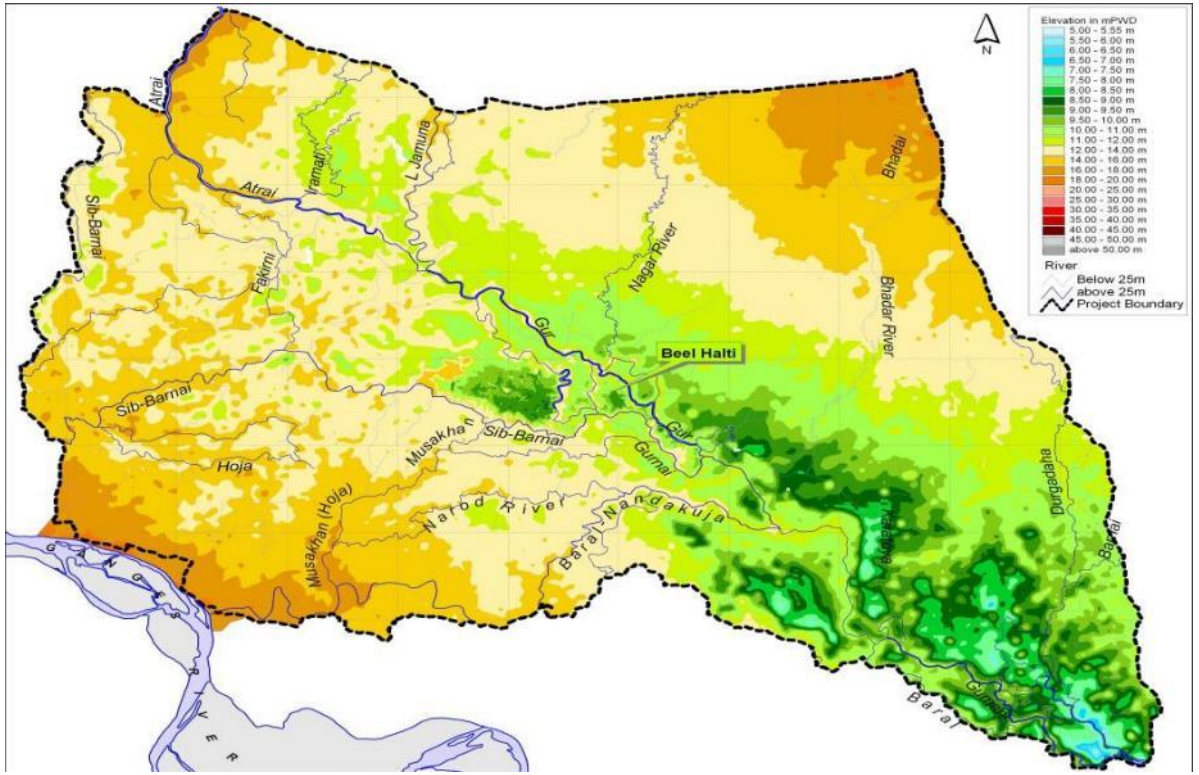
↓

Impeding navigation & erosion of river banks, increased flooding

FCD-projects (1980s)

↓

Decreasing agriculture yield
Decreasing fisheries
Loss of floodplains & wetland
Cuts/breaches embankments
Closure of navigation routes



Source: Mathematical modelling for IWRM Chalan Beel incl. Beel Halti (IWM, 2005)

BDP2100 note: increased flooding may also be caused by impediments to drainage due to unplanned infrastructure

Suggested SIBDP projects in Atrai – Hurasagar Basin

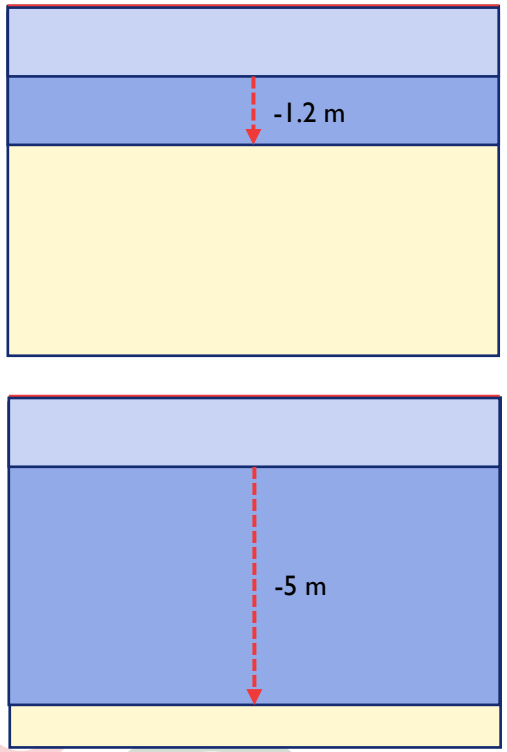
- **Revitalization & restoration of Hurasagar and Atrai rivers (DP 1.3)**
  - Dredging the Hurasagar and Atrai Rivers to increase discharge capacity and navigability
  - 30 km river bank protection works along Atrai River to protect growth-centers against erosion

- **Revitalization and restoration of Beel Halti / Chalan Beel (DP 1.2)**
  - Option 5a) main public cuts with structures & closing all breaches, excavation Sib river, large structures -> low height embankments, + b) with additional FCD for Beel Halti area

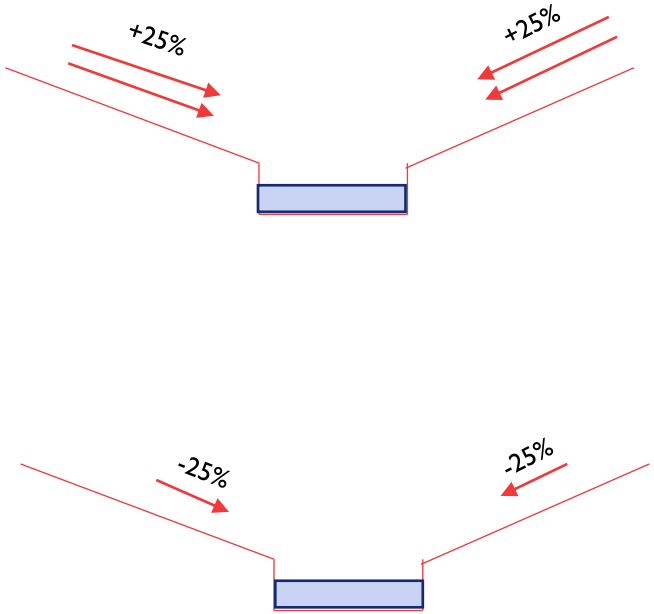
- **Implementation of rationalized water related interventions in Hurasagar basin (DP 1.21)**
  - Program with measures: Infrastructure, knowledge, institutional

Interventions modelled

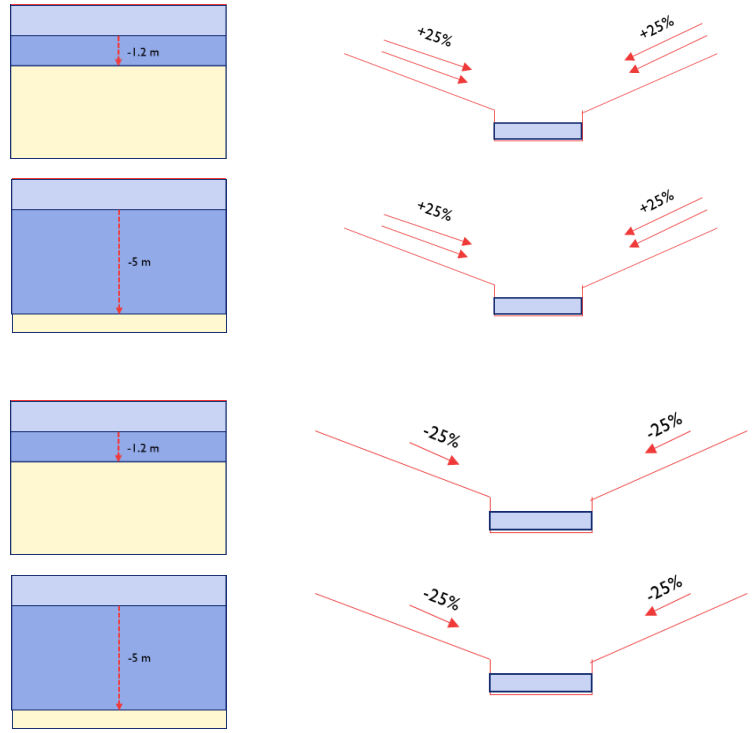
Dredging (DP 1.3)



Drainage capacity (DP 1.2)



Combined (DP 1.3 + 1.2)



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Impacts of projects in Atrai – Hurasagar Basin

Project		Base		DP 1.3a		DP 1.3b		DP 1.2a		DP 1.2b		DP1.3 + DP 1.2	
Rajshahi division		Without project		Revitalization Atrai and Hurasagar		Revitalization Atrai and Hurasagar		Revitalization Beel Halti		Revitalization Beel Halti			
Option				Dredging - 1.20m		Dredging - 5.00m		Drainage capacity +25%		Drainage capacity - 25%		Dredging - 1.20m + Drainage capacity + 25%	
BDP2100 scenario - Resilient		2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Decision support indicators													
Annual flood damage (infrastructure, housing, etc.)	crore BDT	77	148%	-8%	127%	-9%	123%	-7%	148%	27%	201%	-15%	39%
Poor households affected by droughts and floods		522	116%	-14%	90%	-17%	83%	-21%	116%	63%	216%	-36%	-1%
Annual rice crop production (T aman, Boro, Aus)	Mtonnes	89	-6%	2%	-4%	3%	-2%	1%	-6%	-1%	-9%	3%	1%
Food security for the poor: dietary energy supply	calories/day	n/a	-27%	2%	-25%	3%	-23%	1%	-27%	-1%	-29%	3%	-21%
River navigability*	km/class	n/a	--	++	-	++	-	0	++	0	+	++	+
Rural access to safe drinking water*	%	n/a	0	0	0	0	0	0	0	0	0	0	0
Habitat area suitable for protective species*	km2	n/a	+	0	+	0	+	0	0	0	0	0	+
Displaced people due to disasters*	%	n/a	--	0	-	0	-	0	-	0	-	0	-
Water system state indicators													
Total flood extent	% of area	21%	51%	-18%	27%	-33%	5%	1%	51%	-1%	48%	-18%	5%
Extreme flood extent	% of area	34%	124%	-9%	64%	-34%	37%	0%	124%	-2%	123%	-9%	31%
Flood duration	days	85	25%	-1%	26%	-7%	25%	-6%	25%	7%	27%	-8%	10%
Dry season river flow (Atrai Basin)	m3/s	25	-5%	0%	-5%	0%	-5%	0%	-5%	0%	-5%	0%	-3%
GWL decline per year	cm	9	-32%	3%	-29%	4%	-26%	10%	-32%	-13%	-48%	13%	-3%
Waterlogged area*	km2	n/a	++	-	++	-	0	0	+	0	+	0	0
Environmental flow*	m3/s	n/a	-	0	-	0	-	0	--	0	--	0	-
Area affected by salinity*	km2	n/a	0	0	0	0	0	0	0	0	0	0	0
Financial indicators													
Cost of project implementation	mill BDT	0		112800		112800		78603		78603		152100	
Cost of project maintenance	mill BDT	0		32400		32400		0		0		32400	
Total cost	mill BDT	0		145200		145200		78603		78603		184500	

* not yet quantified; expert opinion

Main observations:

1. Dredging + improved drainage improves flood situation for the short term
2. Negative impact on GWL decline per year
3. None of the calculated measures is robust for extreme climate change situation

Note: the role of sediment is not included

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Considerations / recommendations

- Define project characteristics in close connection to SIBDP & project leads
- Verification with line agencies on project descriptions / configurations / BMM results
- Training & capacity building
- Publications & outreach

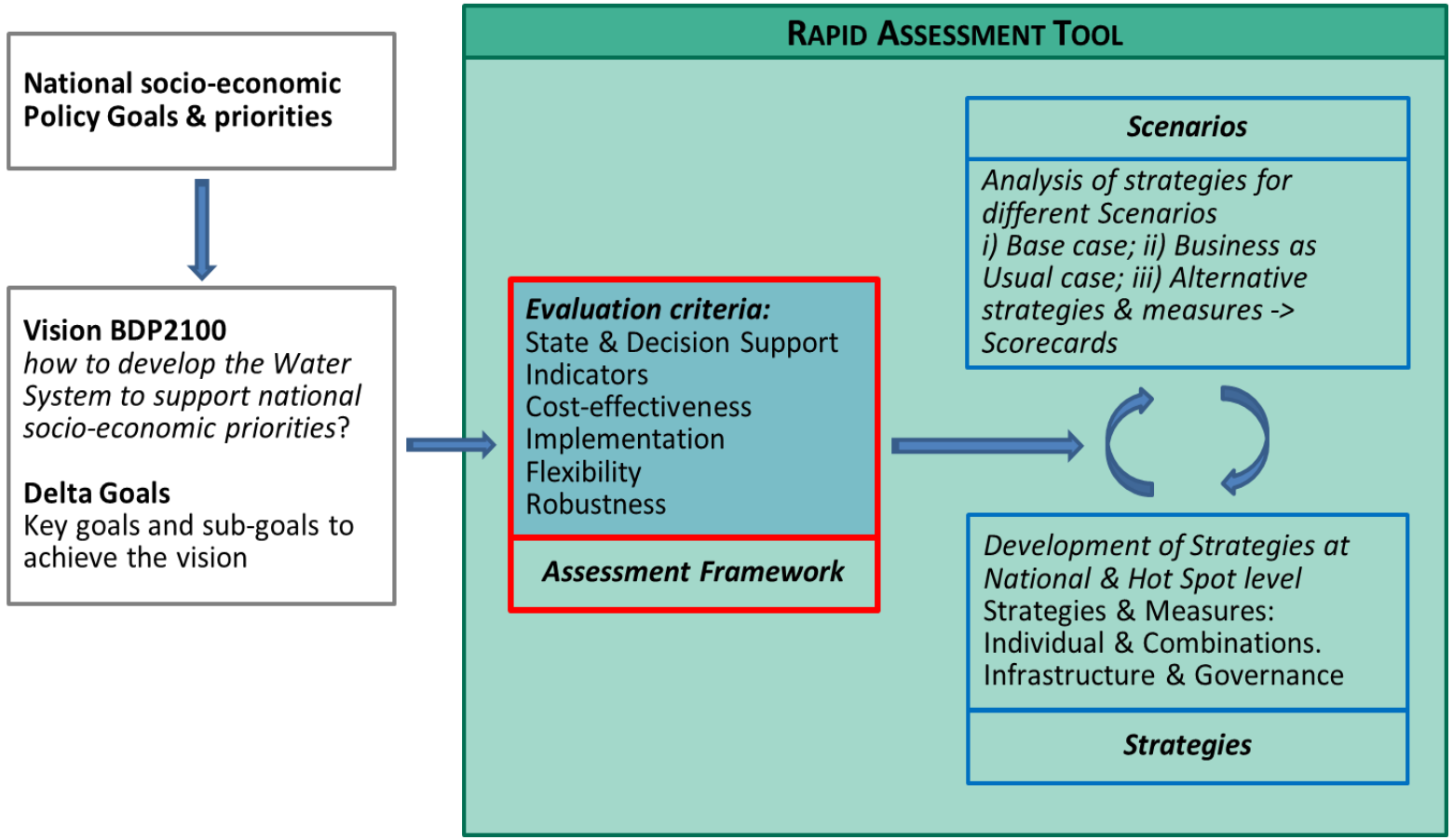
Planning Q3 and Q4 2020

- Drafting Metamodel results for NW-region (July – August)
- Focus on Coastal zone (July – September)
  - Project descriptions and configurations
  - Including SW salinization
  - Including additional modules (Fisheries, Navigation, Ecosystem functioning)
- Expert reflection session(s) on Coastal zone (September)
- SIBDP & GED meetings on Coastal zone (September / October 2020)
- Expert reflection session(s) on other regions (Q4 2020)
- SIBDP & GED meetings on other regions (Q4 2020 / Q1 2021)

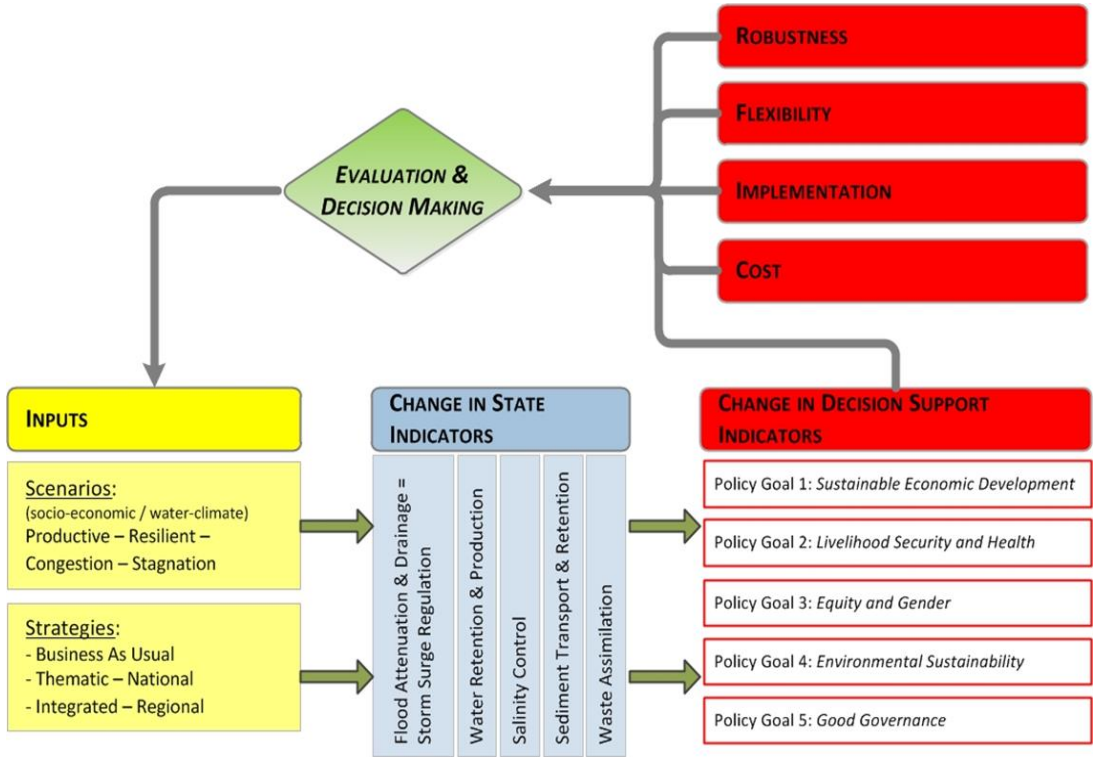
Use of results in decision support framework

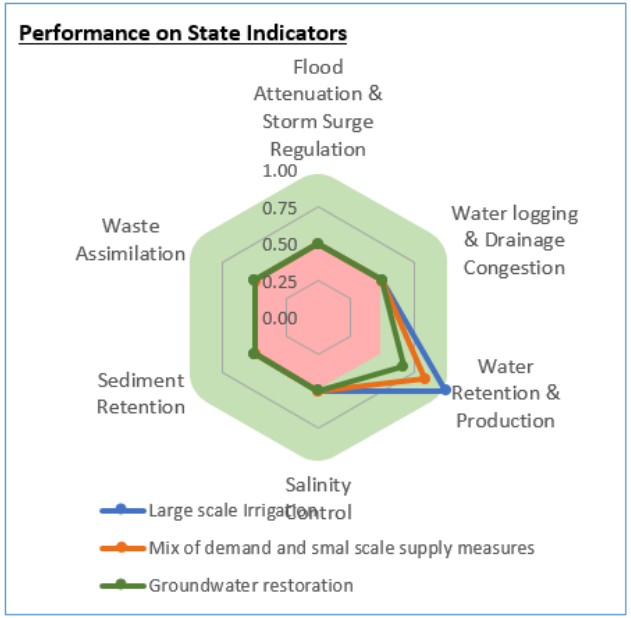
- The metamodel provides a rich source of quantitative information on the impact of scenarios and projects.
- Not all the impacts of projects can easily be quantified (such as inequality)
- There is a need for an additional decision support framework

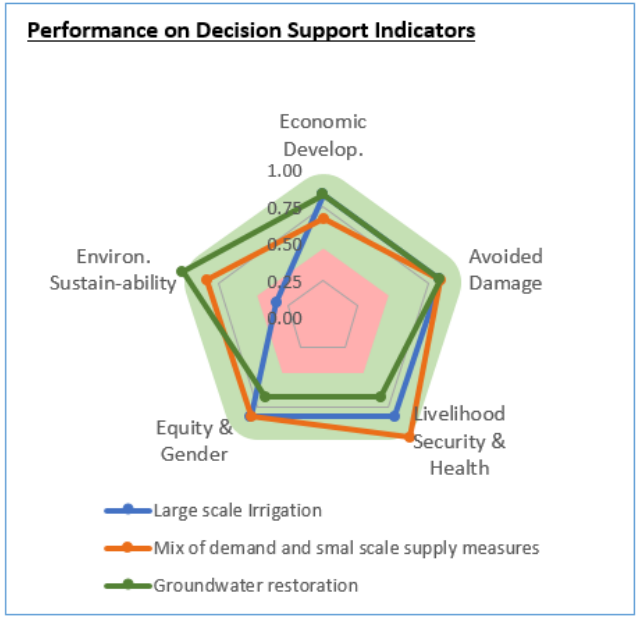
BDP2100 – Rapid assessment framework

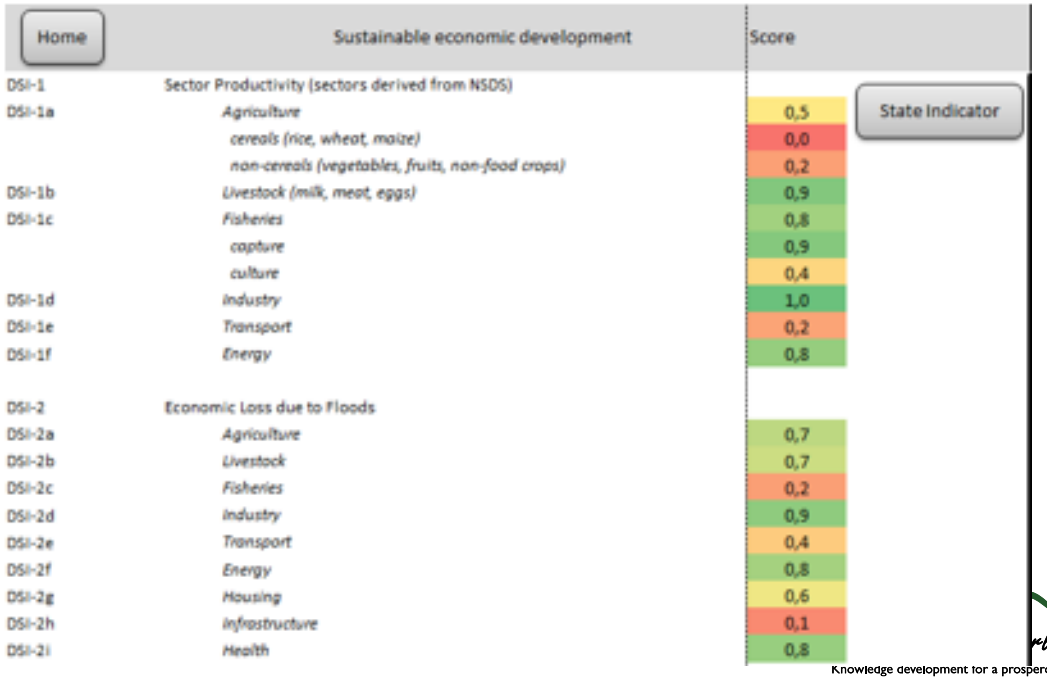


BDP2100 rapid assessment framework









Assessment frameworks?

- The assessment framework in the BDP2100 was mainly based on qualitative scoring.
- Now we have more quantitative information available (metamodel)
- What kind of decision support frameworks can be used?

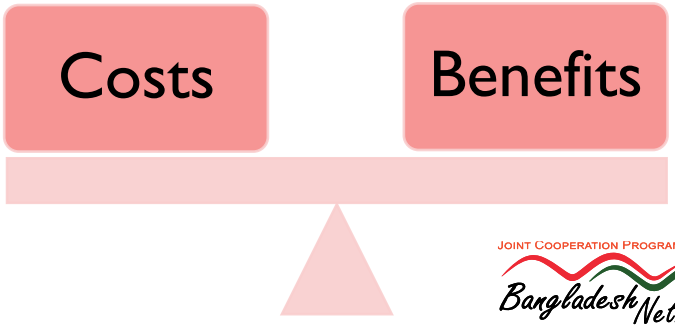
Decision support frameworks

Which project to select based on the costs and effects?

Example monetization:
Water quality
↓
Impact on health of people
↓
Reduction in productivity and increase health care costs
(both expressed in taka)

<u>Cost-benefit analysis</u>
- Grounded in welfare theory
- Monetization of all effects
- Final result: Benefit-Cost Ratio, Net Present Value or Internal Rate of Return

<u>Multi-criteria analysis</u>
- Grounded in operation research
- Evaluates a multitude of qualitative and quantitative impacts and criteria
- Final result: Comparable score (dimensionless unit)



How could a MCA be set-up?

Method: Weighted summation

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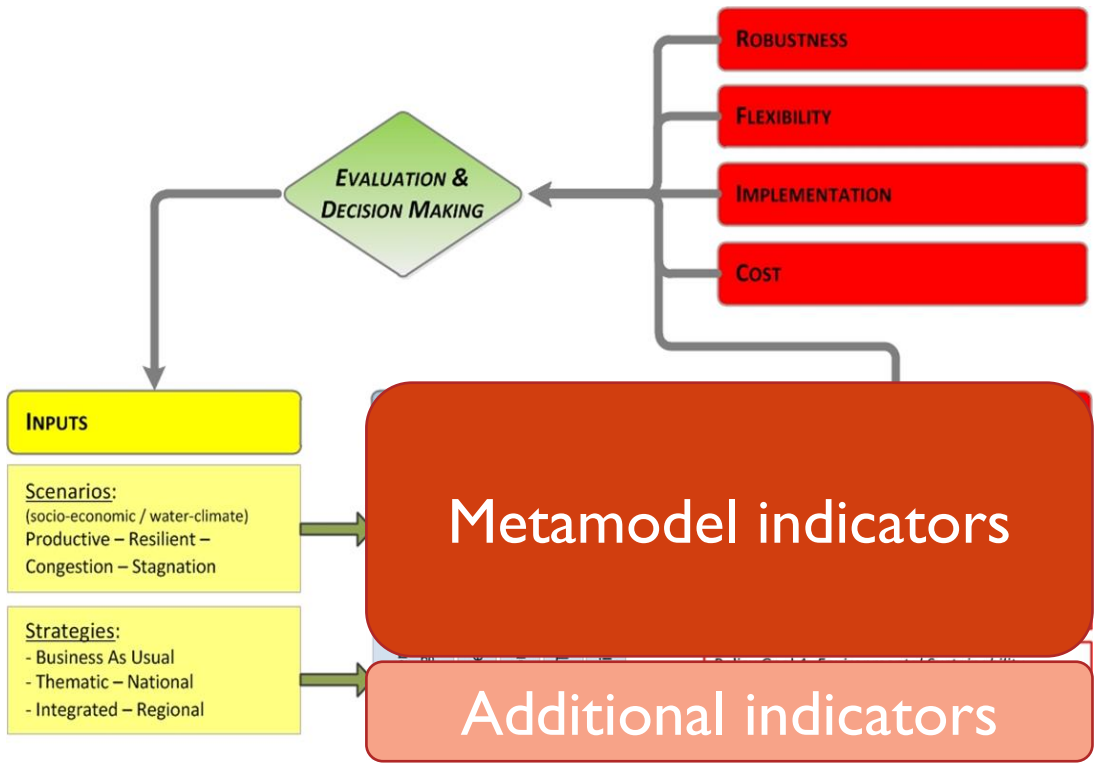
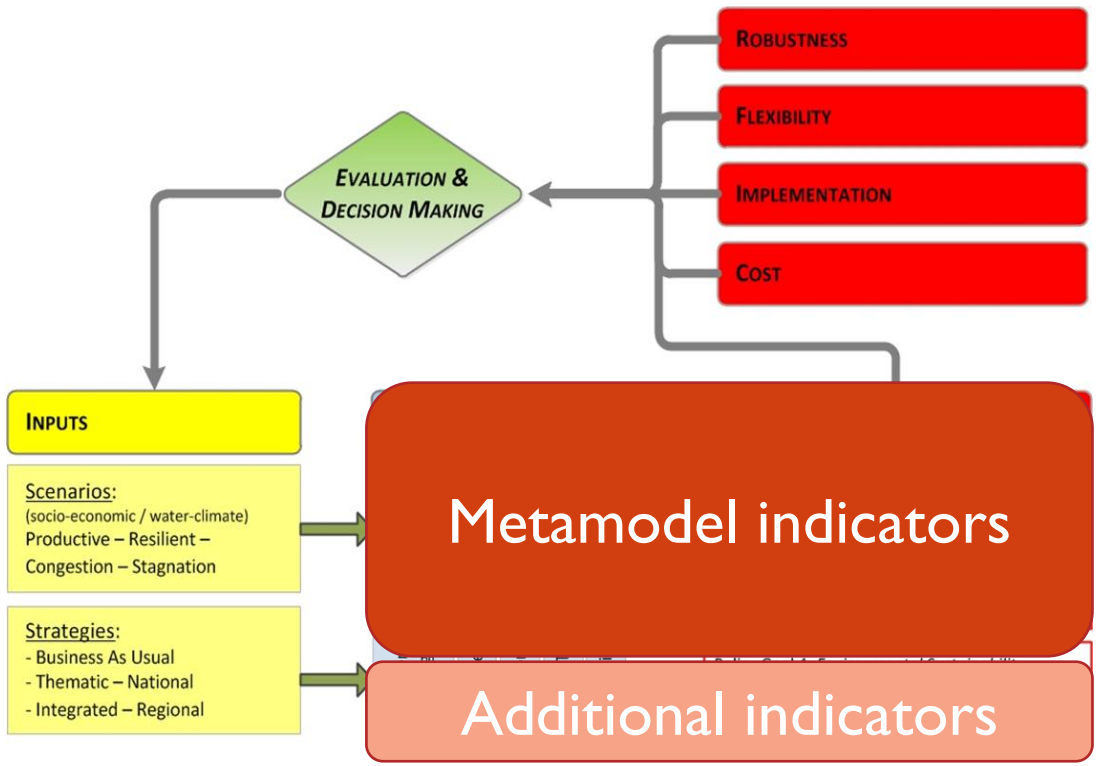
Indicator selection – Use of Metamodel indicators



METAMODEL INDICATORS	
Water system indicators	
	Annual river flood duration
	Extreme river flood extent
	Coastal flood extent
	Waterlogged area
	Dry season river flow
	Ground water level at end of dry season
	Area affected by salinity
Environmental indicators	
	Environmental flow
Economic impact indicators	
	Flood damage
	Crop production
	Fish production
	River navigability
Social impact indicators	
	Food security
	Households affected by droughts, floods and salinity
	Displaced people due to disasters
	Access to safe drinking water
Other indicators	
	Investment costs
	Operation and maintenance costs

Indicator selection – Use of other indicators



INDICATOR	
Water system indicators	
	Annual flash floods
	River bank erosion
Environmental indicators	
	Biodiversity
	Red list species
	Restoration of natural habitats
	Water quality in water bodies
	Water quality in rivers
Economic impact indicators	
	Inequality (in flood, salinity and drought damages)
	Employment – short term
	Employment – long term
	Economic growth
	Poverty
Social impact indicators	
	Access to sanitation
	Health
ADM indicators	
	Flexibility
	Reconciliation
	Robustness
	Innovative
	Holistic
Other indicators	
	Cost recovery potential
	Societal support
	Inclusiveness
	Impact on institutional capacity

How could a MCA look like - Standardization

Indicators	Unit	Baseline (current situation)		
		Without project	Project 1	Project 2
Indicator 1	Million Taka	30	25	20
Indicator 2	%	34	30	32
Indicator X	Score	0	-2	1

Standardize scores

Indicators	Unit	Baseline (current situation)		
		Without project	Project 1	Project X
Indicator 1	Million Taka	0	0.5	1
Indicator 2	%	0	1	0.5
Indicator X	Score	0.5	0.3	0.6

Calculation final score (example)

Weight	Indicators	Unit	Baseline (current situation)					
			Without project		Project 1		Project X	
40	Indicator 1	Million Taka	0	**0**	0.5	**20**	1	**40**
10	Indicator 2	%	0	**0**	1	**10**	0.5	**5**
50	Indicator X	Score	0.5	**25**	0.3	**15**	0.6	**30**
TOTAL			**25**		**45**		**75**	

Considerations

Requirements

- Qualitative scoring → Expert judgement
- Weighting → Involvement of policy makers

How will a MCA be used?