Bangladesh Metamodel

Database and Dashboard

1.1 Database

The database is used for storing geospatial data and model output results. A database named PostgreSQL is used in metamodel which is completely open source. Azure cloud is used as a database server and also a data gateway is used to synchronize data from the database to the main dashboard. Finally, a Mapbox API server is used for storing administrative boundaries information.

The following information is stored in the azure database:

- List of indicators information.
- Scenarios information
- Administrator boundaries Information
- Model run information
- Model output results

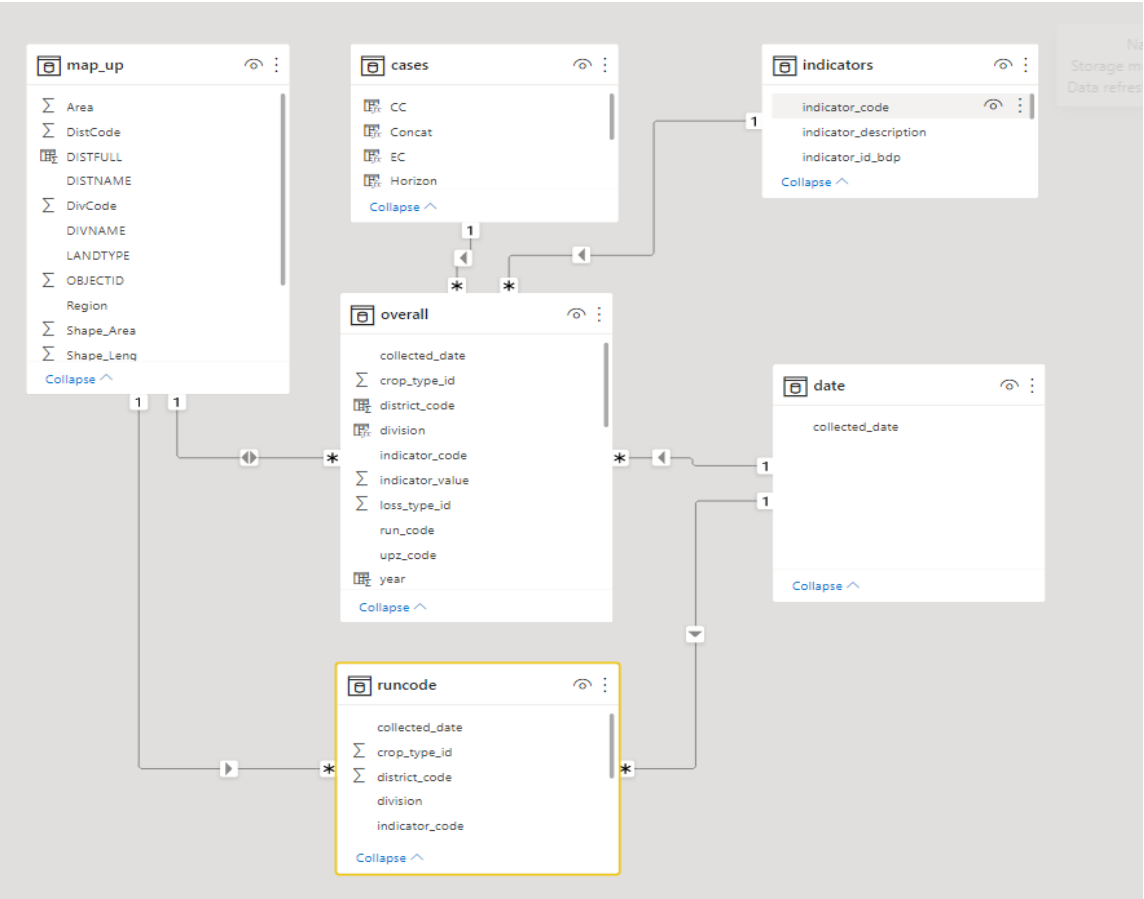


Figure 1: ER-Diagram of Metamodel

Here are 33 indicators for 9 climatic and socio-economic scenarios including the base year, 2030, and 2050. Some database table information is given below:

Table 1: List of Scenarios

SL	Name	Short Description
1	Base 2020	Base Scenario
2	Resilient 2030	Resilient 2030 (Climate Change High and Economic Change High
3	Resilient 2050	Resilient 2050 (Climate Change High and Economic Change High)
4	Active 2030	Active 2030 (Climate Change High and Economic Change Low)
5	Active 2050	Active 2050 (Climate Change High and Economic Change Low)
6	Productive 2030	Productive 2030 (Climate Change Low and Economic Change High)
7	Productive 2050	Productive 2050 (Climate Change Low and Economic Change High
8	Moderate 2030	Moderate 2030 (Climate ChangeLow and Economic Change Low)
9	Moderate 2050	Moderate 2050 (Climate ChangeLow and Economic Change Low)

Table 2: List of Indicators

Indicator Code	**Indicator Name**	**Indicator Description**	**Units**	**type**
I-1	Rice production	Total average rice production in (metric) tonnes per year for the 30 years time hydro-meteorological time series. In this indicator the production of four major rice crops are summed: HYV Boro, T.Aman, B.Aman and T.Aus. The production is calculated following FAO's Cropwat methodology, using BBS'agricultural areas and production per district in 2017 and crop yield reduction factors due to flood and drought losses.	tonnes/year	DSI
I-2	Damage due to river and rainfall floods	Average annual rainfall and river flood damage to major infrastructure, buildings and embankments. Based on Bangladeshi depth-damage functions and assumptions on average densities and land heights of the different land type categories (RHD and BARC) per upazila. Flooding depth of settlements is used as reference. Flood damage to	crore BDT/year	DSI

		crops is not included here, but as a separate indicator.		
I-3	Food security for the poor	Food security is expressed as the average energy intake per day for a 20-percentile poor household (in kcal/day/person). The minimum daily intake is 2100 kcal/day/person. The indicator is calculated based on the four pillars of food security (FAO, 2000): availability, access, stability and quality. The calculation uses national and divisional statistics and crop production (as output of agricultural production module). The indicator value is influenced through change in crop production and change in access via the BDP2100 scenarios.	Kcal/day/person	DSI
I-4	Rural population with safe drinking water access	Not (yet) available in Metamodel.	%	DSI
I-5	Poor population affected by river and rainfall floods	This indicator describes the average number of poor people, located in flood-affected areas, with water depths higher than 50 cm. Since the spatial distribution of poor people within upazilas is not known, the ratio of poor people to total population is used. NB. Affected population to Drought and Salinity is not yet included in the Metamodel.	Persons/year	DSI
I-6	Displaced people due to disasters	Not (yet) available in Metamodel.	%	DSI
I-7	Habitat area suitable for protective species	Not (yet) available in Metamodel.	ha	DSI
I-8	River navigability	Not (yet) available in Metamodel.	km/class	DSI
I-9	Cost of project implementation	Based on input in concept notes of the projects.	crore BDT	DSI
I-10	River flood extent	Average annual maximum area flooded from rivers (overbank flow, overtopping embankments). The area	ha/year	SI

		of each upazila more than 30 cm below the adjoining river water level is considered flooded and part of this extent.		
I-11	Flood duration	Average annual maximum number of consecutive decades that any of the landtypes within an upazila is flooded by rainfall and river flooding for more than 30 cm.	days/year	SI
I-12	Extreme river flood extent	Maximum area flooded from rivers in extreme flood years (~1/30 year flood waterlevel).	ha/year	SI
I-13	Waterlogged area	Average annual maximum area flooded with a longer duration from rainfall and rivers. The indicator is calculated as the sum of areas which are congested for more than 4 weeks, for more than 1.2 m.	ha/year	SI
I-14	Dry season river flow	The average minimum annual discharge at the most representative river location for each district, division, region or the country.	m3/s	SI
I-15	Sustainable groundwater use	Average annual groundwater level change. The GWL change is relative to measured groundwater levels (BADC) in 2011 and averaged over the selected area.	cm/year	SI
I-16	Area affected by salinity	Not (yet) available in Metamodel.	ha	SI
I-17	Environmental flow	Not (yet) available in Metamodel.	-	SI
I-18	Damage due to river floods	Average annual river flood damage to major infrastructure, buildings and embankments. Based on Bangladeshi depth-damage functions and assumptions on average densities and land heights of the different land type categories (RHD and BARC) per upazila. Flooding depth of settlements is used as reference. Flood damage to crops is not included here.	crore BDT/year	DSI
I-19	Rainfall and river flood extent	Average annual maximum area flooded from rainfall and rivers. The area of	ha/year	SI

		each upazila with water depths deeper than 30 cm is considered flooded and part of this extent. As such, this include agricultural cropped areas in the monsoon season.		
I-20	Rice crop yield loss due to river and rainfall floods	Estimated rice crop yield loss due to river and rainfall floods. In this indicator the yield loss to four major rice crops are summed: HYV Boro, T.Aman, B.Aman and T.Aus. Yield loss is estimated by applying standardized crop reduction factors given depth-duration-damage functions (CEGIS, 2019).	Tonnes/year	DSI
I-21	Rice crop yield loss due to drought	Average annual rice crop yield loss due drought. In this indicator the yield loss to four major rice crops are summed: HYV Boro, T.Aman, B.Aman and T.Aus. Yield loss is estimated by applying FAO crop reduction functions given water demand and water supply (DRASS, CEGIS, 2019).	Tonnes/year	DSI
I-22	Wheat production	Average annual wheat production. The production is estimated following a simplified crop model (based on FAO Cropwat), using agricultural areas and production per district in 2017 (BBS), and crop yield reduction factors due to drought losses.	Tonnes/year	DSI
I-23	Agricultural damage due to river and rainfall floods	Estimated annual rainfall and river flood damage to rice crops. Based on Bangladeshi depth-damage functions.	crore BDT/year	DSI
I-24	Population affected due to river and rainfall floods	Affected population due to annual rainfall and river floods.	Persons/year	DSI
I-25	Damaging rainfall and river flood extent	Areas flooded for more than 1.20m	ha/year	SI
I-26	Volume irrigated from SW		m3/year	SI
I-27	Volume irrigated from GW		m3/year	SI
I-28	Volume percolated to GW		m3/year	SI

I-29	Dry season river flow per district		m3/s	SI
I-30	Dry season river flow per division		m3/s	SI
I-31	Maize Production		tonnes/year	SI
I-40	River Fish Production		MT/year	DSI
I-41	Ilish Production		MT/year	DSI

*SI: State indicator

*DSI: Decision Supports indicator

1.1.1 Data Getaway

Power BI Data Gateway is the software required to access data from the on-premises network. The request always goes through a Gateway to access the on-premises data from a cloud. For fast and secure data transfer between on-premises, installing a gateway on servers where data is present is preferred.

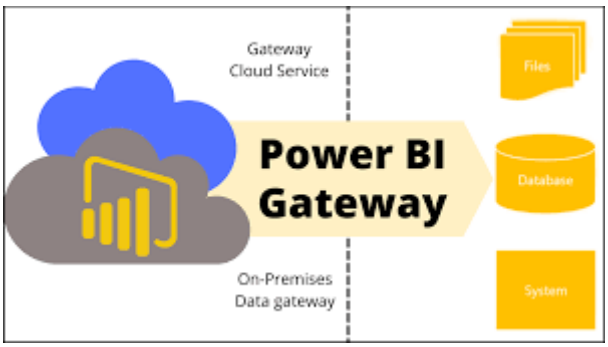


Figure: Data gateway

The purpose of the gateway is to access the present data in the main dashboard. When we update data from the database server it is automatically updated into the main dashboard.

1.1.2 Mapbox Datasets API

Using the Datasets API involves interacting with two types of objects: **datasets** and **features**. Datasets contain one or more collections of GeoJSON features. It published District and Upazila boundaries shape file in the Mapbox API server and called it from the main dashboard to visualize administrative boundaries in the main dashboard.

We used the following information to connect the Mapbox API to the main dashboard map.

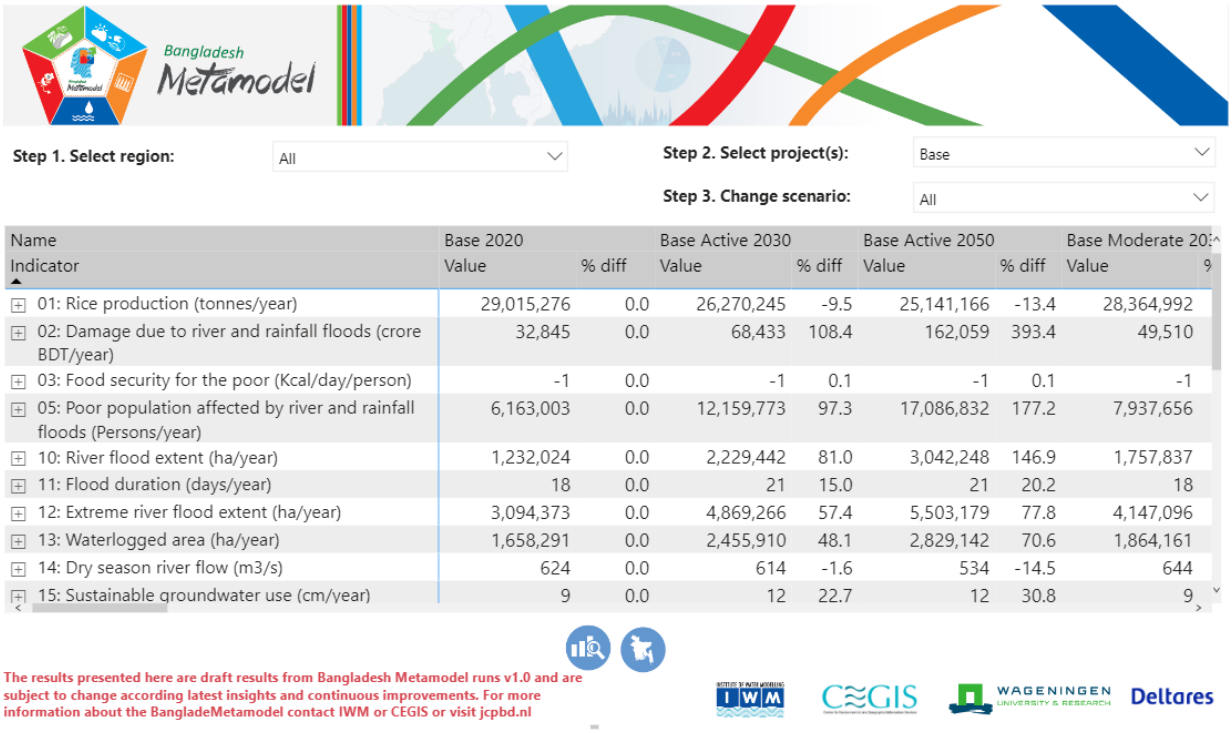
Access Token:
pk.eyJ1IjoibW9zaGl1cmNzZSIsImEiOiJjazE0Z3R3eHowaW1xM21weW9lc283ODR5In0.CVXnj83FaFxqx897botGig
Mpabox API url: https://api.mapbox.com
Vector Tiles: mapbox://moshiurcse.aqaaquqb
Source Layer Name:upazilaWGS_String-cnz9qe
Vecotr Property: THACODE

1.2 Dashboard

Dashboard is an interface that can visualize model outputs data to evaluate calculated impacts of projects on water and other sectors. It is also used for viewing model output results for future decision-making at the planning level. It can compare indicator values for a selected combination (Project, scenarios, and time) in different formats like table charts and, maps.

Microsoft Power BI and its Dax language are used for developing the main dashboard. Power BI is data and analytics reporting tool that visualizes raw data to present actionable information.

Dashboard link: https://www.bdp2100kp.gov.bd/metamodel/



Name	Base 2020		Base Active 2030		Base Active 2050		Base Moderate 20
Indicator	Value	% diff	Value	% diff	Value	% diff	Value
01: Rice production (tonnes/year)	29,015,276	0.0	26,270,245	-9.5	25,141,166	-13.4	28,364,992
02: Damage due to river and rainfall floods (crore BDT/year)	32,845	0.0	68,433	108.4	162,059	393.4	49,510
03: Food security for the poor (Kcal/day/person)	-1	0.0	-1	0.1	-1	0.1	-1
05: Poor population affected by river and rainfall floods (Persons/year)	6,163,003	0.0	12,159,773	97.3	17,086,832	177.2	7,937,656
10: River flood extent (ha/year)	1,232,024	0.0	2,229,442	81.0	3,042,248	146.9	1,757,837
11: Flood duration (days/year)	18	0.0	21	15.0	21	20.2	18
12: Extreme river flood extent (ha/year)	3,094,373	0.0	4,869,266	57.4	5,503,179	77.8	4,147,096
13: Waterlogged area (ha/year)	1,658,291	0.0	2,455,910	48.1	2,829,142	70.6	1,864,161
14: Dry season river flow (m3/s)	624	0.0	614	-1.6	534	-14.5	644
15: Sustainable groundwater use (cm/year)	9	0.0	12	22.7	12	30.8	9

Figure 2: Main Dashboard

Steps for using the dashboard

Step-1: Select Region from the dropdown list

Step-2: Select the project from the dropdown list to compare it with the base condition

Step-3: Select Scenario from the dropdown list to compare with base 2020

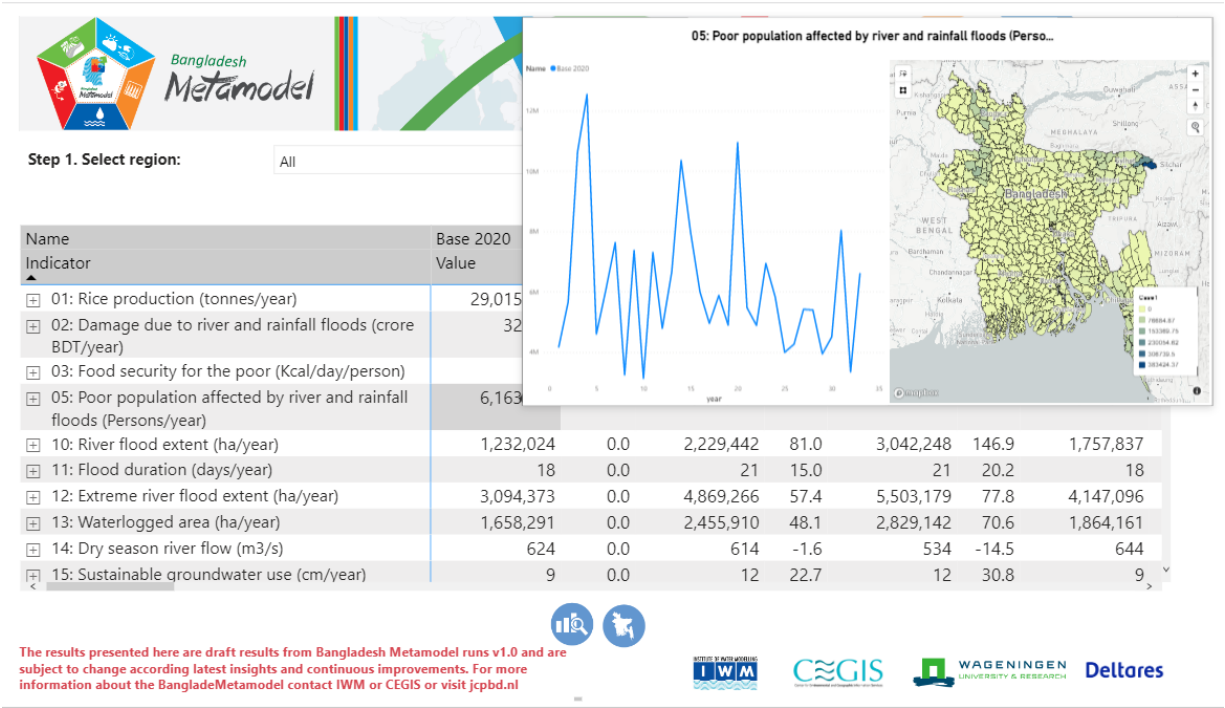


Figure 3: All region dashboards with tooltip

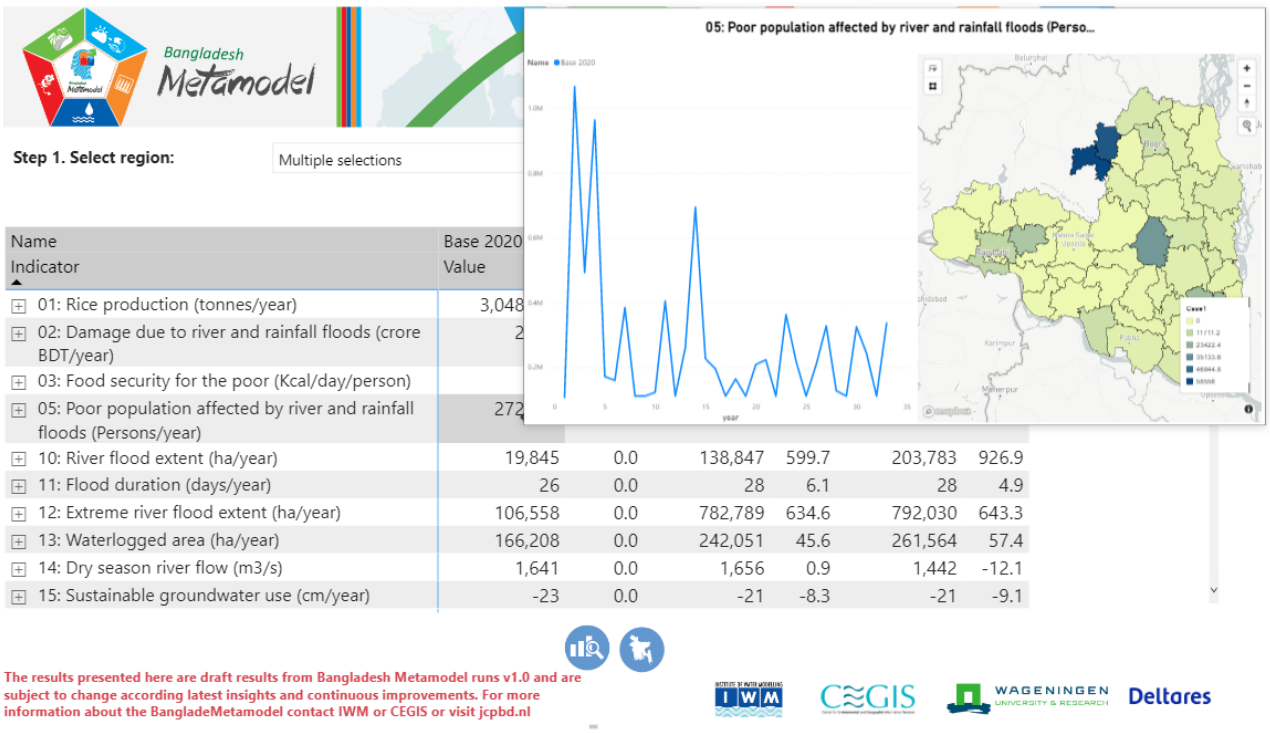


Figure 4: Selected region dashboard with tooltip

1.2.1 Compare the result in the graph

To compare results in a graph, the user has to select multiple project scenarios from the dropdown list by pressing ctrl on the keyboard.

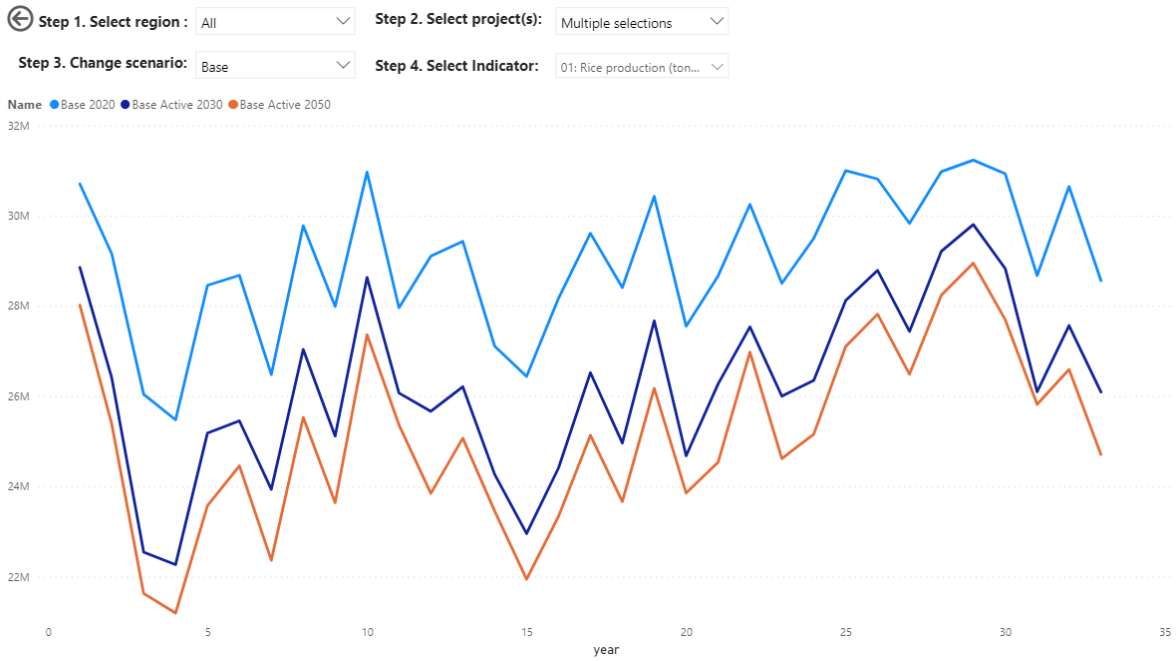


Figure 5: Compare Results in Graph

1.2.2 Compare results in a map

To compare results in a map, the user has to select Project and indicator for both maps.

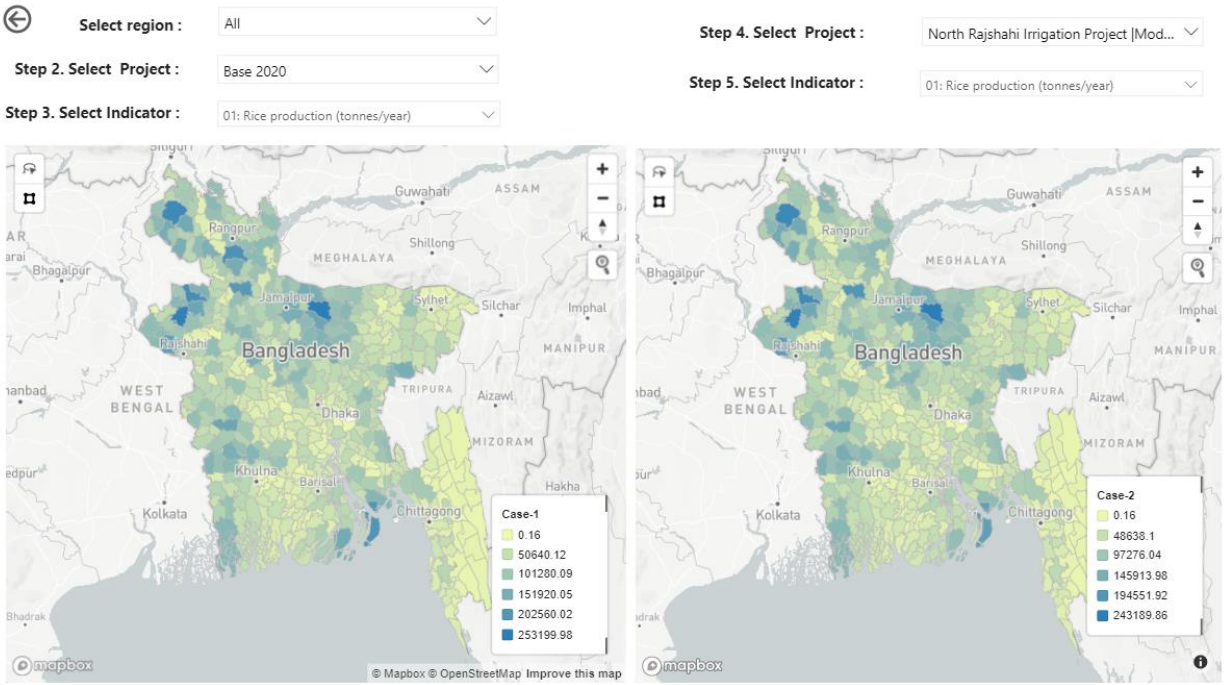


Figure 6: Map Comparison for all Regions

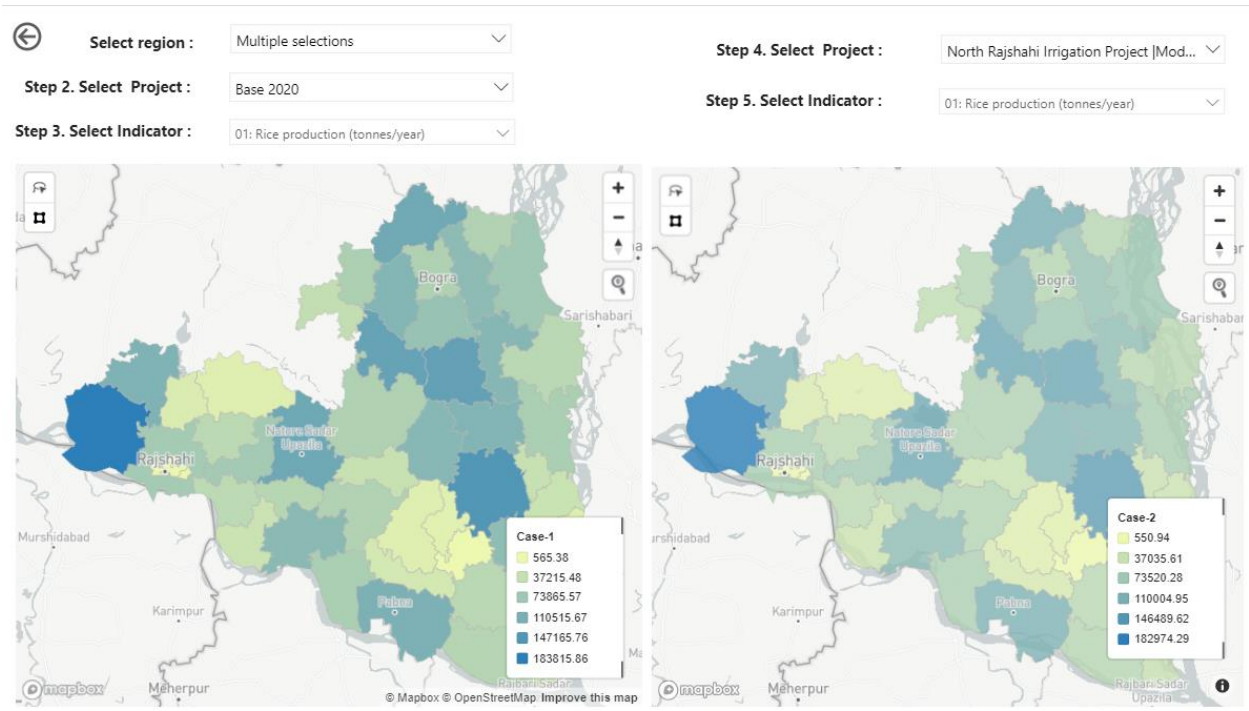


Figure 7: Map Comparison for Selected Region

1.2.3 Data Analysis Expressions (DAX) Language

DAX is a programming language that is used throughout Microsoft Power BI for creating calculated columns, measures, and custom tables. It is a collection of functions, operators, and constants that can be used in a formula, or expression, to calculate and return one or more values. We use the following DAX code to develop the main dashboard.

The following code is used to aggregate the result of indicator values spatially and average them annually. Depending on the type of indicators, there are 3 different approach to aggregate the indicator values spatially.

```
aggregate = IF(NOT(
ISBLANK
(CALCULATE(AVERAGE(overall[indicator_value_Core]),
filter (overall,
overall[indicator_code] = "I-15")))),
[get_slops],
IF(ISBLANK
(CALCULATE(AVERAGE(overall[indicator_value_Core]),
filter (overall,
overall[indicator_code] = "I-3" ||
overall[indicator_code] = "I-11" |
 overall[indicator_code] = "I-29" ||
overall[indicator_code] = "I-30" ||
overall[indicator_code] = "I-14"
))),
```

There are 3 types of spatial aggregation:

Aggregation type 1: Sum of resulting annual indicator values from different upazila. This is relevant for part of indicators, such as rice production or damage due to flooding

```
aggregation_temporal_spatial_type1 =
averagex(DISTINCT('date'[collected_date]),calculate(sum(overall[indicator_value_Core])))
```

Aggregation type 2: Average of resulting annual indicator values from different upazila. This is relevant for part of indicators, such as flood duration.

```
aggregation_temporal_spatial_type2 = AVERAGE('overall'[indicator_value_Core])
```

Aggregation type 3: Average increase of resulting annual indicator values from different upazila. This is relevant for part of indicators, such as increase or decrease in groundwater level. The length of the year depends on the years selected by users:

```
get_slops = (CALCULATE(average(overall[indicator_value_Core]), FILTER(overall,
overall[collected_date]=max(overall[collected_date])))-
CALCULATE(average(overall[indicator_value_Core]), FILTER(overall,
overall[collected_date]=min(overall[collected_date])))) / ((max(overall[collected_date])-
min(overall[collected_date])) +1 )
```

```
year = overall[collected_date] - 1984
```

Some indicators value is converted into crore using the following code:

```
indicator_value_crore = IF((overall[indicator_code]=="I-2" ||
overall[indicator_code]=="I-9" ||
overall[indicator_code]=="I-18" ||
overall[indicator_code]=="I-23") ,
overall[indicator_value]/10000000,overall[indicator_value])
```

Table 3: Aggregation of Indicators

Indicator Code	Indicator Name	Units	Spatial aggregation	Temporal aggregation	Covert unit (in dashboard)
I-1	Rice production	tonnes/year	Sum	Average	
I-2	Damage due to river and rainfall floods	crore BDT/year	Sum	Average	to crore
I-3	Food security for the poor	Kcal/day/person	Average	Average	
I-4	Rural population with safe drinking water access	%	Sum	Average	
I-5	Poor population affected by river and rainfall floods	Persons/year	Sum	Average	
I-6	Displaced people due to disasters	%	Sum	Average	
I-7	Habitat area suitable for protective species	ha	Sum	Average	
I-8	River navigability	km/class	Sum	Average	
I-9	Cost of project implementation	crore BDT	Sum	Average	to crore
I-10	River flood extent	ha/year	Sum	Average	
I-11	Flood duration	days/year	Average	Average	
I-12	Extreme river flood extent	ha/year	Sum	Average	
I-13	Waterlogged area	ha/year	Sum	Average	
I-14	Dry season river flow	m3/s	Average	Average	
I-15	Sustainable groundwater use	cm/year	Average increase in a year	Average	
I-16	Area affected by salinity	ha	Sum	Average	
I-17	Environmental flow	-	Sum	Average	

I-18	Damage due to river floods	crore BDT/year	Sum	Average	to crore
I-19	Rainfall and river flood extent	ha/year	Sum	Average	
I-20	Rice crop yield loss due to river and rainfall floods	Tonnes/year	Sum	Average	
I-21	Rice crop yield loss due to drought	Tonnes/year	Sum	Average	
I-22	Wheat production	Tonnes/year	Sum	Average	
I-23	Agricultural damage due to river and rainfall floods	crore BDT/year	Sum	Average	to crore
I-24	Population affected due to river and rainfall floods	Persons/year	Sum	Average	
I-25	Damaging rainfall and river flood extent	ha/year	Sum	Average	
I-26	Volume irrigated from SW	m3/year	Sum	Average	
I-27	Volume irrigated from GW	m3/year	Sum	Average	
I-28	Volume percolated to GW	m3/year	Sum	Average	
I-29	Dry season river flow per district	m3/s	Average	Average	
I-30	Dry season river flow per division	m3/s	Average	Average	
I-31	Maize Production	tonnes/year	Sum	Average	
I-40	River Fish Production	MT/year	Sum	Average	
I-41	Ilish Production	MT/year	Sum	Average	

To set the base case the following Dax code is used:

```
ReferenceValue = CALCULATE([aggregate],
FILTER(overall,overall[run_code]==SELECTEDVALUE('baseCase'[Run_code])))
```

To show multiple cases selected by the users, these function below is used:

```
Case1 = CALCULATE([aggregate],

FILTER(overall,overall[run_code]=SELECTEDVALUE('Filter'[Run_code])))
```

The difference (in %) between reference case and case selected by users:

```
Case1(%) = ([Case1]-[ReferenceValue])/[ReferenceValue]*100
%avg = averagex(DISTINCT(overall[district_code]),[Case1(%)])
```