

# Application of Geospatial Technologies in Developing Climate Change Adaptation Tracking Mechanism (ATM) in Bangladesh

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# BANGLADESH HAZARD PROFILE



## **DROUGHT**

Affects 2.3 m ha crop land. Loss of grazing fields, dried up ponds, water shortage. In 2006, reduced food grains by 1 million tons.

## **FLASH FLOOD**

Damages standing crops, infrastructures and facilities. Unpredictable, uncertain.

## **FLOOD**

Inundates 20% (normal years) to 75% of land area during monsoon, increases river erosion, breaches embankments, damages infrastructures. Loss of crops, fisheries, livestock, biodiversity.

## **SALINITY INTRUSION**

Damages biodiversity, crop lands, livelihoods, safe water sources. Spreading intrusion from 0.75 to 1.5 m ha (2009); 53% of coastal area affected. Projected displacement: 6-8 million people by 2050

## **CYCLONE**

Remains the deadliest, most destructive hazard. Recurring events, lingering aftermath, complex recovery. Improved preparedness (CPP, shelters, embankments).

## **AND**

**CLIMATE CHANGE HAZARDS, EARTHQUAKES, FIRE BREAKOUTS, INFRASTRUCTURE COLLAPSES, ETC.**

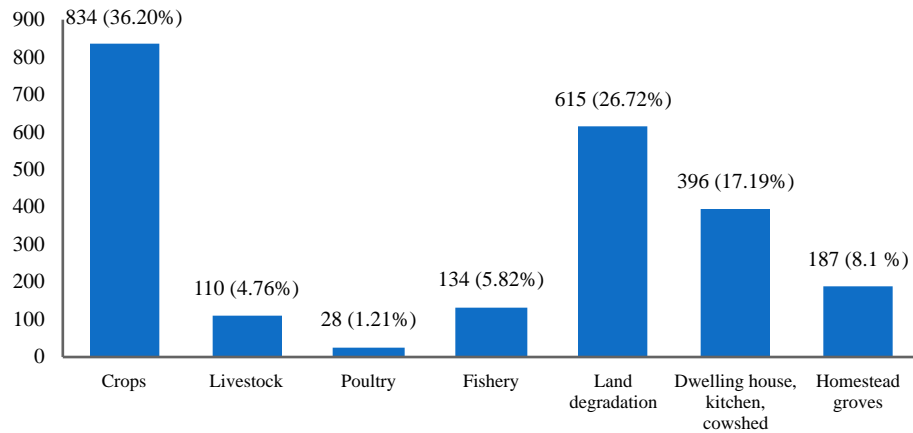


Figure: Loss and damage caused by disasters (2009-2015) in different sectors (figures in million USD). Source: BBS 2015.

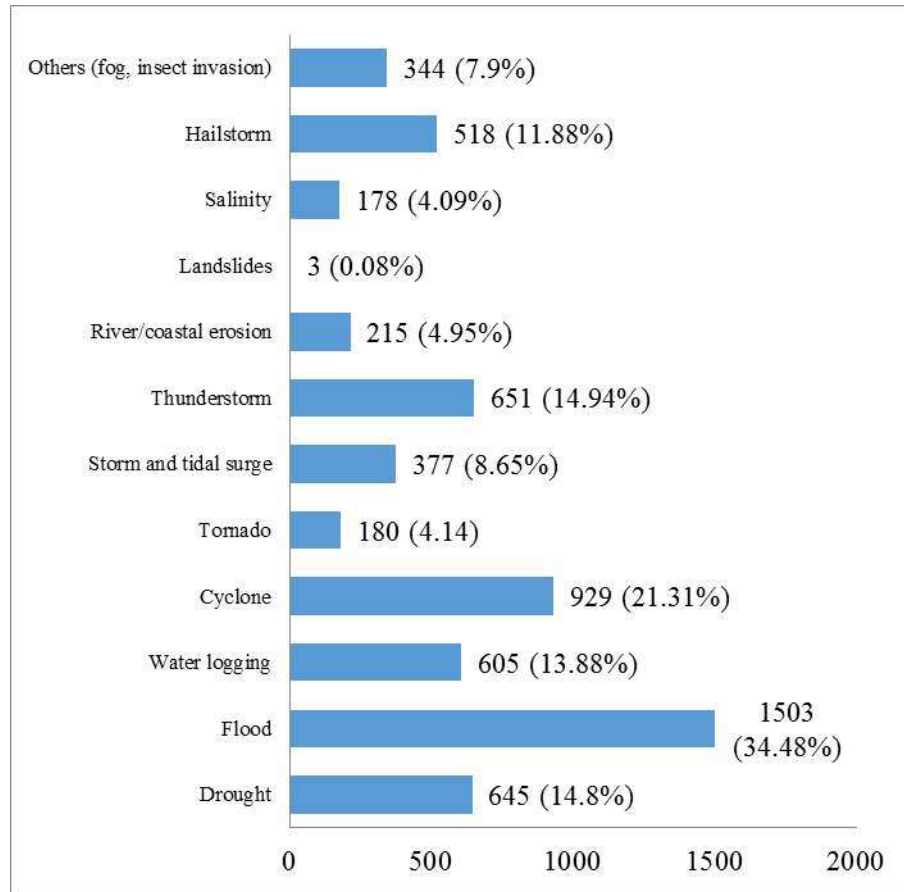


Figure 9: Number of affected people from various types of disasters drawn from the sample population (BBS 2015).

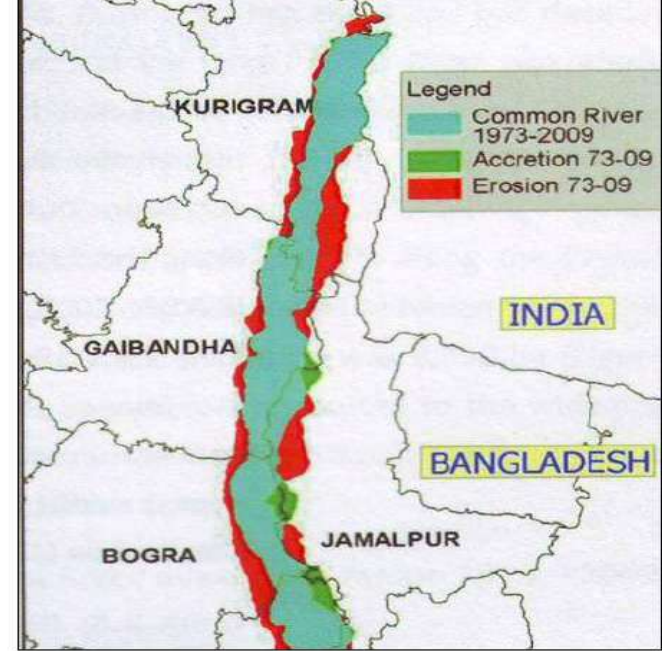




Figure: Physical context of Chouhali study site, Sirajgonj district.



Physical context of Chilmari study site, Kurigram district.

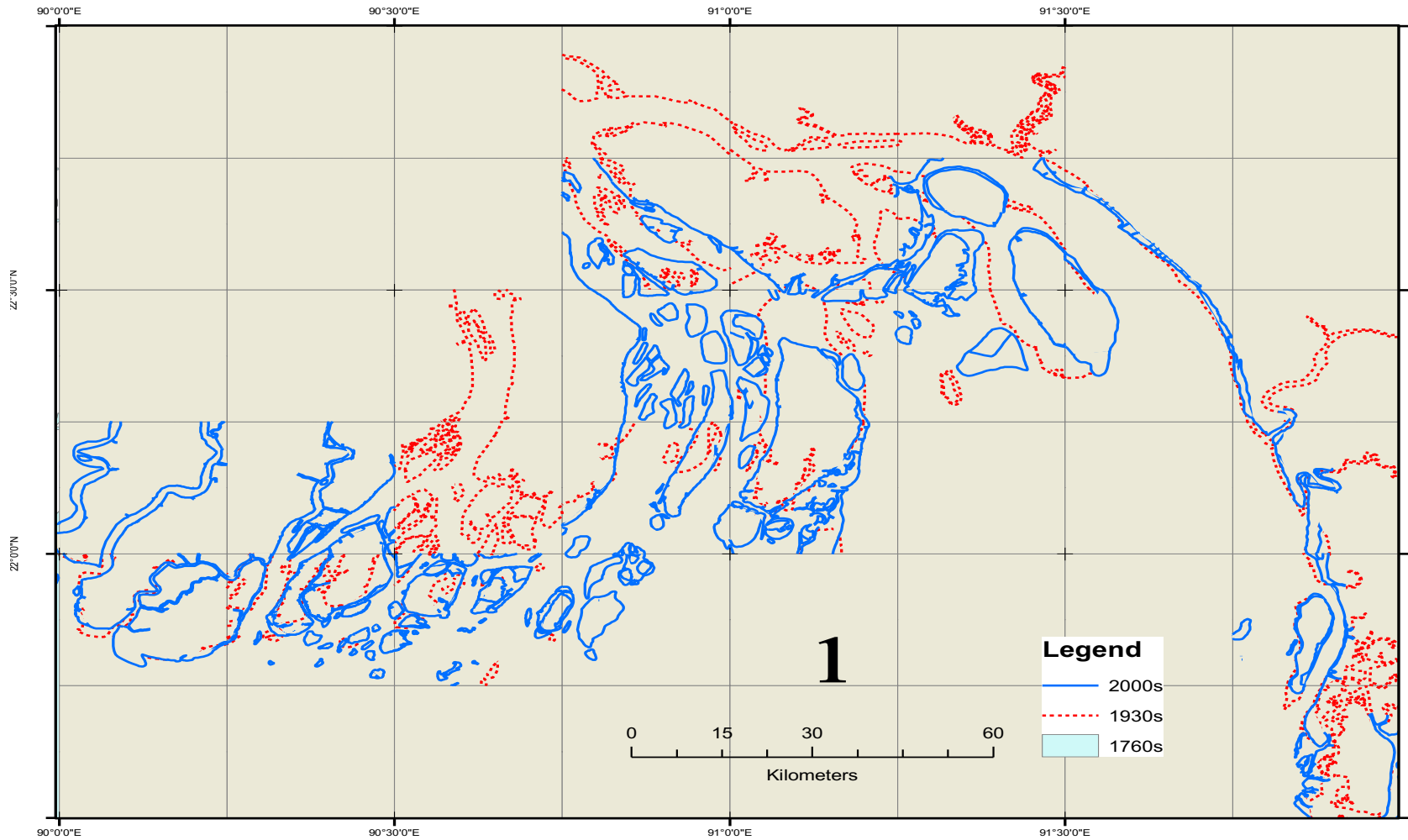
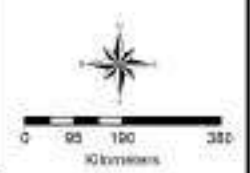
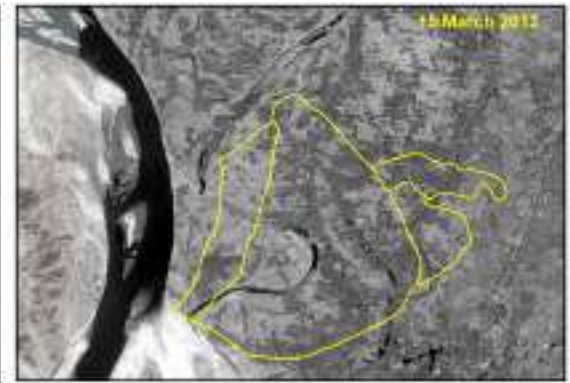
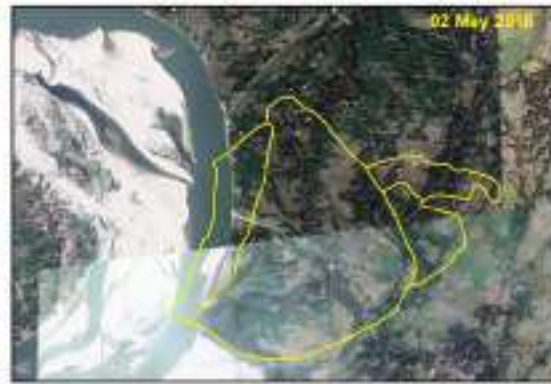
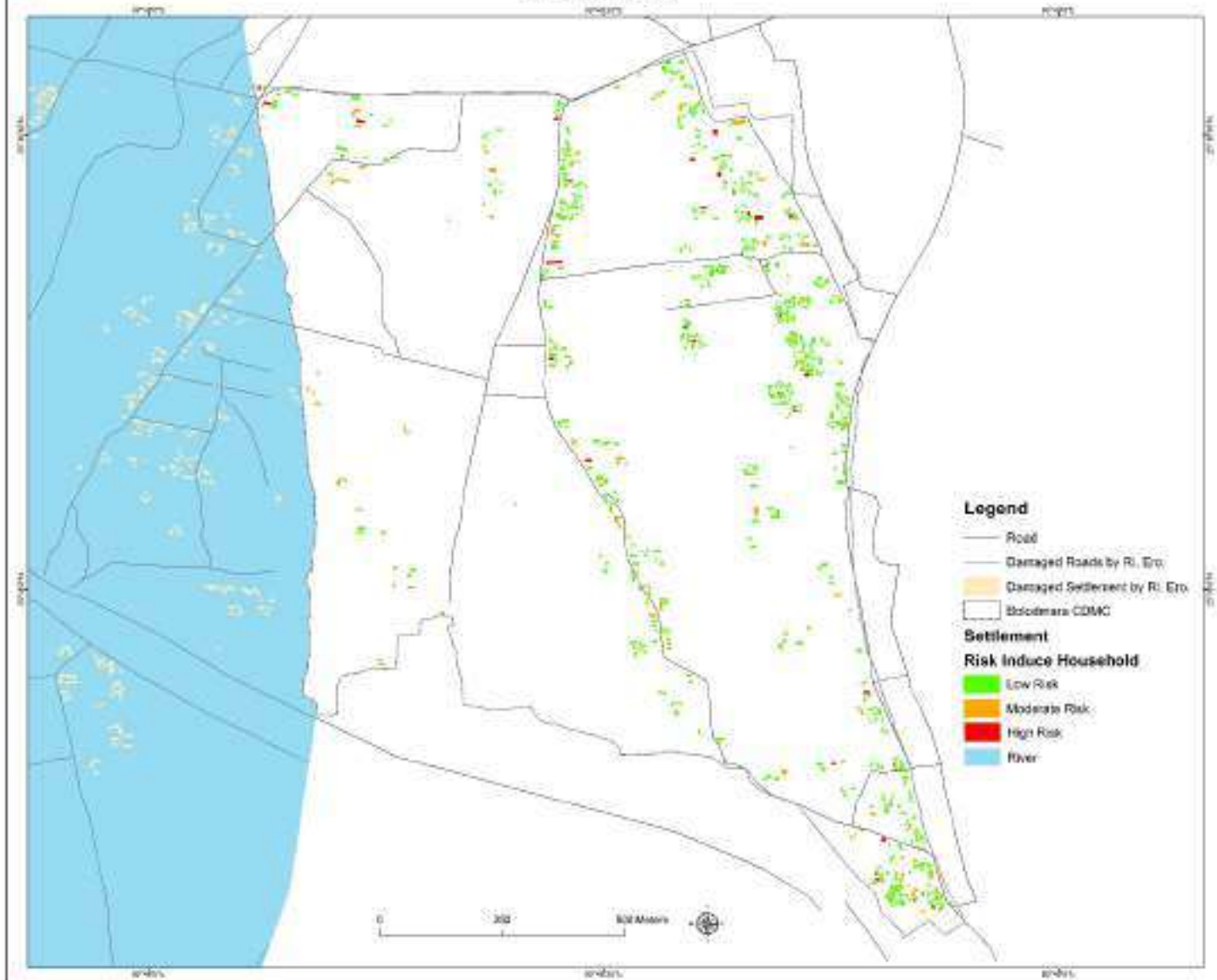


Figure 9: Block wise accretion-erosion and changes in the GBM estuary during the last 240 years. Source: Rashid et al. 2008.





# Risk Map Bolodmara





Source: Urban Infrastructure Planning and Design, 2005



Source: Urban Infrastructure Planning and Design, 2005



Source: Urban Infrastructure Planning and Design, 2005



Source: Urban Infrastructure Planning and Design, 2005



Source: Urban Infrastructure Planning and Design, 2005



Source: Urban Infrastructure Planning and Design, 2005

# Data Relating to Loss and Damage happened due to Disaster Impacts

2005-2015, Total damage in '000 USD, EM-DAT		
2007	Flood	14000
2007	Flood	100000
2007	Storm	2300000
2009	Storm	270000
2013	Storm	20000
2014	Flood	160000
2015	Storm	4000
2015	Storm	40000
2015	Flood	40000
		<b>2948</b> million USD
		Total

Damage and loss caused by disasters (2009-2015), BBS 2015.		
Disasters	Million BDT	Million USD
Drought	10569	132
Flood	42807	535
Water logging	16062	200
Cyclone	28384	355
Tornado	4299	54
Storm/Tidal surge	12676	158
Thunderstorm	10940	136
River/Coastal erosion	36408	455
Landslides	249	3
Salinity	6072	76
Hailstorm	11471	143
Others	4306	54
Value of total loss and damage	184247	2301

# Policies

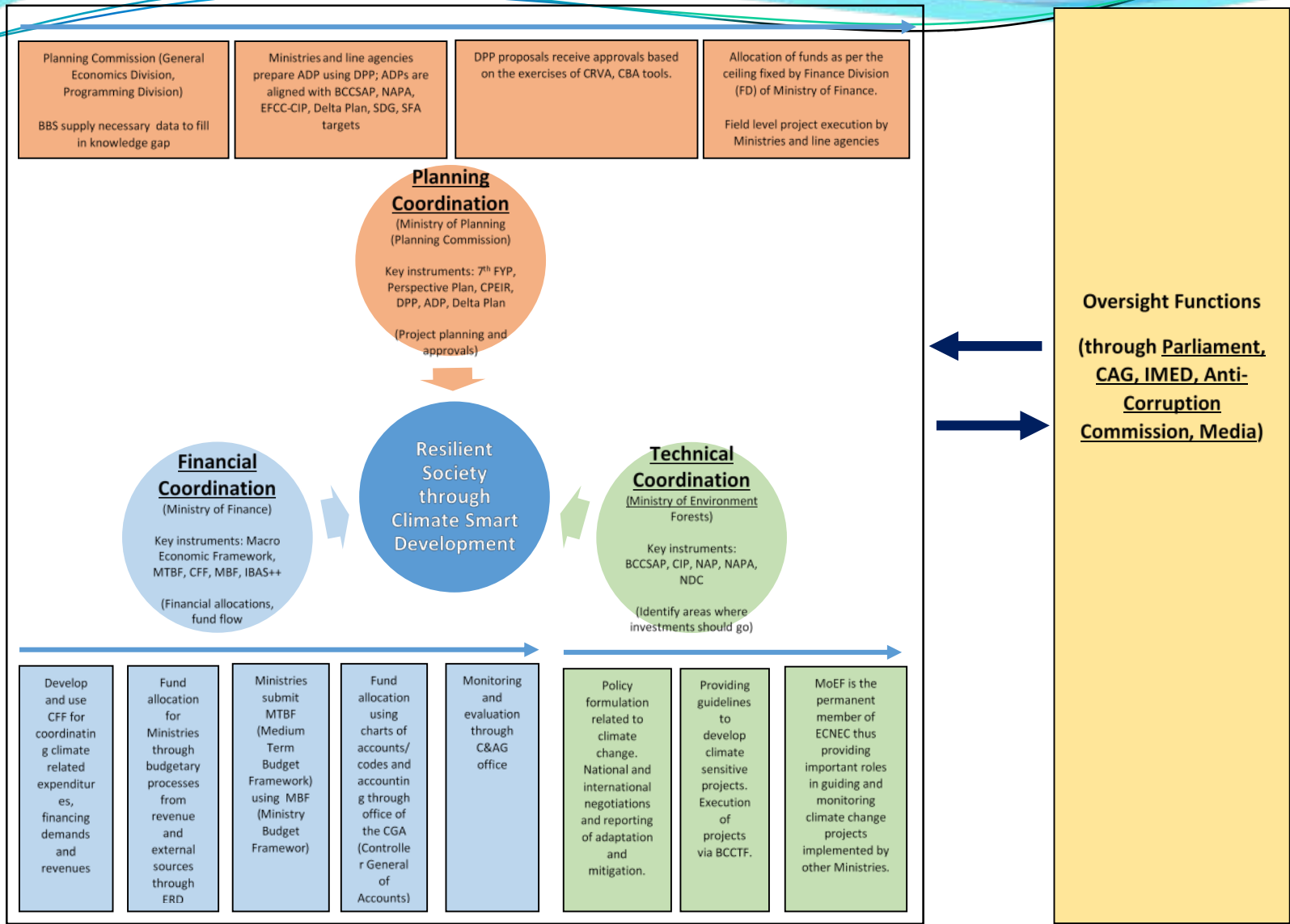
- NPDM (National Plan for Disaster Management)
- Disaster Management Act
- Standing Orders on Disasters
- National Adaptation Programme of Action
- BCCSAP (Bangladesh Climate Change Strategy and Action Plan)
- CIP (Climate Investment Plan)
- 7<sup>th</sup> Five Year Plan
- SDG attainment plan (BESF)

# Loss and damage information collected by the D Form of DDM

Information category	Description	Information category	Description
1	Name of Upazilla and district affected disasters	15	Damage of mobile phone towers
2	Number of wards/unions affected	16	Damage of structures of religious institutions
3	Affected area in square kilometres	17	Information on the damage of road networks of different categories
4	Affected people (man, women, children)	18	Number of bridge and culvert damage
5	Physically challenged persons (man, women, children)	19	Damage of embankments in kilometres
6	Affected households (partial, total)	20	Affected forest areas in hectares
7	Number of affected house (concrete, semi-concrete, thatch made)	21	Number of affected educational institutions
8	Affected disaster shelters (partial, total)	22	Affected industries (agriculture and non-agriculture)
9	Value of livestock lost (goats, lamb)	23	Number of affected tubewells
10	Value of livestock lost (cow, buffalo)	24	Affected toilets/latrines
11	Value of birds/poultry lost (chicken, duck)	25	Affected water reservoirs in numbers
12	Affected crops and seedbeds in hectares	26	Affected health centers (hospitals, clinic, community health centers)
13	Damage of other farms (e.g. shrimp hatchery etc.)	27	Loss of fishing boats and gears (boats, trawlers, fishing nets)
14	Damage of power lines (partial, total)		

Provided assistance to MoDMR in using high spatial resolution drone image in disaster impacts recovery process in Banshkhali (Chittagong).





Coordination Mechanisms of Climate Change Investments in Bangladesh.

# ATM Architecture

Category	Primary key in the user interface software	Variables	Statistical treatment	Category of divisions
1. Vulnerability	<b>Meteorological data</b>	Temperature	<ul style="list-style-type: none"> <li>- Characteristics</li> <li>- Average/Pattern</li> <li>- Threshold (monthly, seasonal and yearly)</li> <li>- Anomalies</li> <li>- Projected scenario/prediction (statistical down scaling: GCM simulation)</li> <li>- Interpolation</li> </ul>	<ul style="list-style-type: none"> <li>By year</li> <li>By area/station</li> <li>By Agro-ecological zones</li> <li>By hazard types</li> </ul>
		Rainfall		
	<b>Hazard and disaster impacts</b>	Floods (seasonal)	<ul style="list-style-type: none"> <li>- Hazard maps</li> <li>- Change in the river bank line</li> <li>- Scenario prediction mapping</li> </ul>	<ul style="list-style-type: none"> <li>By year</li> <li>By administrative boundary</li> <li>By Agro-ecological zones</li> </ul>
		Floods (flash type)		
		River bank erosion		
Waterlogging				
Cyclone				
Drought				
Salinity				
<b>Infrastructure</b>	Roads	-	By administrative boundary	
	Rails			
	Embankments			
	Social institutions			
<b>Land use pattern including land elevation</b>	Application of drone technologies	- Reference flood level for local level planning	<ul style="list-style-type: none"> <li>By year</li> <li>By administrative boundary</li> <li>By Agro-ecological zones</li> </ul>	
	Application of low resolution DEM (SRTM or Sentinel data of ESA)			
2. Adaptation interventions	<b>Vulnerability and interventions</b>	Household (HH)	<ul style="list-style-type: none"> <li>- Locational information of the household, photograph and mobile phone number</li> <li>- Database (vulnerability, sensitivity and exposure) against HH ID</li> </ul>	<ul style="list-style-type: none"> <li>Baseline Interventions</li> <li>Impacts</li> </ul>
		Community (CBO, Local Government)	<ul style="list-style-type: none"> <li>- Locational information, information about the representation and mobile phone number</li> <li>- Database (vulnerability, sensitivity and exposure) against HH ID</li> </ul>	<ul style="list-style-type: none"> <li>Baseline Interventions</li> <li>Impacts</li> </ul>
	<b>Major project activities in the area</b>	At local level	Project attributes	<ul style="list-style-type: none"> <li>Pre project</li> <li>During project</li> <li>Post project scenario</li> </ul>
3. Tracking Measuring and Reporting	<b>Numeric reporting</b>	Allocation of funds	<ul style="list-style-type: none"> <li>- Distributions of HH with specific financial allocations (may be range of value is used)</li> <li>- Allocations of funds to different social/local institutions</li> </ul>	<ul style="list-style-type: none"> <li>By adaptation intervention category</li> <li>By locations, hazard types</li> </ul>
		Vulnerability, sensitivity and exposure of the HH and local institutions		
	<b>Qualitative reporting</b>	CRA/RRAP for the union		
ModMR reporting (based on D form)				
<b>Spatial analysis (converting to kml)</b>	Case stories			
	Spatial analysis (converting to kml)	Production of maps based on user needs and queries		



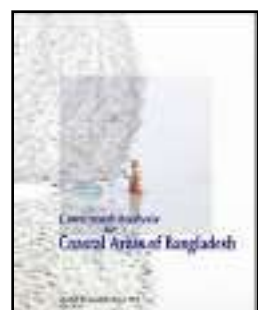
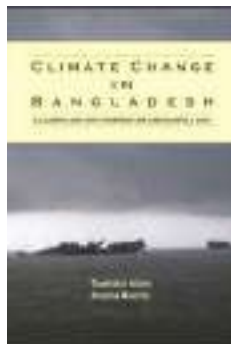
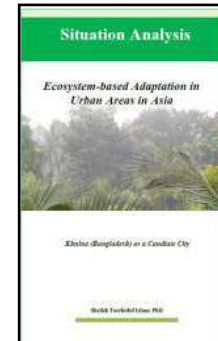
## ATM (Data and Methods)

- Climate Change Risks (**variability and change in the climatic variables**)
- Erratic rainfall; shifting precipitation pattern (**Statistical assessment and reporting; using R**)
- Heat spells over threshold level (**Statistics using R, modelling, thermal band of RS**)
- More floods, untimely floods (**use of series of satellite images, DEM/drone and reporting, OSM**)
- Increased river bank erosion (**use of series of satellite images and reporting**)

## ATM (Data and Methods)

- Increased, prolonged drainage congestion (**GIS/spatial analysis and RS**)
- Salinity intrusion into surface water, ground water and soil (**GIS, RS, Secondary data analysis**)
- More cyclone, storm surges with higher intensities (**RS, DEM/drone**)
- Reduced water availability for households and agricultural crops (**RS, GIS**)
- **Also information about land topography, settlements/village, physical information, institutions, commonplaces, land use, disaster prone/affected areas**





# Components of FDES

1. Environmental Conditions and Quality
2. Environmental Resources and Their Use
3. Residuals
4. Extreme Events and Disasters
5. Human settlements and Environmental Health
6. Environmental Protection, Management and Engagement

**Table 3.1: FDES uses a multi-level approach**

Component 1	Sub-component 2
<b>Component 1:</b> Environmental Conditions and Quality	Sub-component 1.1: Physical Conditions Sub-component 1.2: Land Cover, Ecosystems and Biodiversity Sub-component 1.3: Environmental Quality
<b>Component 2:</b> Environmental Resources and their Use	Sub-component 2.1: Mineral Resources Sub-component 2.2: Energy Resources Sub-component 2.3: Land Sub-component 2.4: Soil Resources Sub-component 2.5: Biological Resources Sub-component 2.6: Water Resources
<b>Component 3:</b> Residuals	Sub-component 3.1: Emissions to Air Sub-component 3.2: Generation and Management of Wastewater Sub-component 3.3: Generation and Management of Waste Sub-component 3.4: Release of Chemical Substances
<b>Component 4:</b> Extreme Events and Disasters	Sub-component 4.1: Natural Extreme Events and Disasters Sub-component 4.2: Technological Disasters
<b>Component 5:</b> Human Settlements and Environmental Health	Sub-component 5.1: Human Settlements Sub-component 5.2: Environmental Health
<b>Component 6:</b> Environmental Protection, Management and Engagement	Sub-component 6.1: Environmental Protection and Resource Management Expenditure Sub-component 6.2: Environmental Governance and Regulation Sub-component 6.3: Extreme Event Preparedness and Disaster Management Sub-component 6.4: Environmental Information and Awareness

**Table 3.2: FDES Components, Sub-components with Statistics**

1 digit	2 digits	3 digits	4 or 5 digits
Component	Sub-component	Statistical Topic	Statistics

# **Objectives of BESF 2016-2030**

- (i) identifying main quantifiable aspects of the environment,**
- (ii) identifying components, sub-components and topics that are relevant and statistically feasible according to defined national needs and priorities,**
- (iii) facilitating the development of a national programme of environmental statistics,**
- (iv) contributing to the assessment of data requirements, sources, availability and gaps,**
- (v) guiding the development of databases that can be used for multiple purposes and**
- (vi) assisting the co-ordination and organization of environmental statistics given the inter-institutional nature of the domain.**

## Reports to be developed proposed in the BESF (2016-2030)

1.	Compendium of Environmental Statistics
2.	Compilation of Resource Accounts following SEEA (on land/soil, water, forests, natural gas, energy, fish)
3.	Climate Change and Natural Disaster-related Statistics
4.	Compilation of Social Accounting Matrix
5.	Poverty Environment Accounts (PEA) in light with SEEA
6.	Experimental Ecosystem Accounts (EEA) in light with SEEACF
7.	Household Survey of Health and Sanitation in Disaster Prone Areas of Bangladesh
8.	Urban/Rural Waste Generation Recycling and Management survey
9.	Environmental Protection and Resource Management Expenditure Accounts
10.	Disaster Risk Reduction Expenditure Accounts
11.	Climate Change and Natural Disaster Impacts Vulnerability Index
12.	Pre-crisis Data Gathering Tools as Baseline Information
13.	Climate and Natural Disaster Induces Survey
14.	Urban/Rural Water generation Use and Management survey
15.	Developing a Web Based Data Sharing Reporting and Ensuring Access to Stakeholders

# Temperature analysis of 40 years

## Changes in Urban Heat Islands of Bangladesh by Institute of Remote Sensing, IUT

### Introduction

Bangladesh is experiencing a remarkable rate of urban growth. As people are increasingly migrating to the urban areas for livelihood, education or as a result of natural causes, urban areas are growing. As cities and other urban areas are spreading, changes occurring in their landscape (open land and vegetation replaced by residential buildings, roads and other infrastructures). These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape known as Urban Heat Island (UHI). The adverse effects of UHI include deterioration of living environment, increase in energy consumption, ground-level ozone formation and even air pollution in nearby area. UHI can provide negative impacts to urban flora and fauna.

In order to understand the changes in UHI in Bangladesh, Land Surface Temperature (LST) are analyzed using MODIS images of Terra's Advanced Very High Resolution Radiometer (AVHRR). Land Surface Temperature (LST) is the brightness temperature of the land surface, which has strong relationship with air temperature. Thus, LST is an indicator for UHI.

### Objective

- To analyze the trend of land surface temperature in Bangladesh in time line period: 2000-2005, 2006-2010 and 2011-2016.
- To show the spatial distribution of land surface temperature in Bangladesh in time line series.

### Methodology

The flowchart of the adopted method of the work is shown in Figure 1.



### Data and Software Used

- MODIS LST 250 Land Surface Temperature data
- Earthview 9.0 Geo Global View Imaging
- Spatial Boundary of Bangladesh
- Google Earth Engine

### Result and Discussion



Figure 10: Mean LST at Night in 2011-2016



Figure 11: Mean LST at Day in 2011-2016

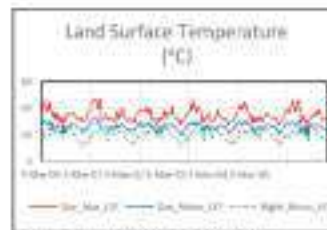


Figure 11: Trends of Temperature in 2011-2016

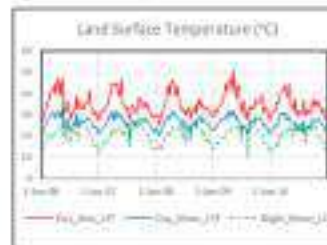


Figure 12: Trends of Temperature in 2006-2010

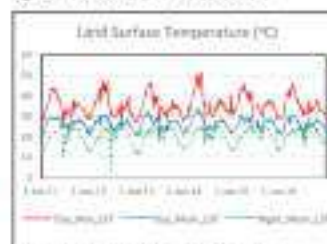


Figure 13: Trends of Temperature in 2000-2005

LINK: <http://www.earthview.com/earthview/Default.aspx?tabid=100000>



Figure 5: Mean LST at Night in 2000-2005

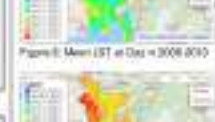


Figure 6: Mean LST at Day in 2000-2005



Figure 7: Mean LST at Night in 2006-2010



Figure 8: Mean LST at Day in 2006-2010

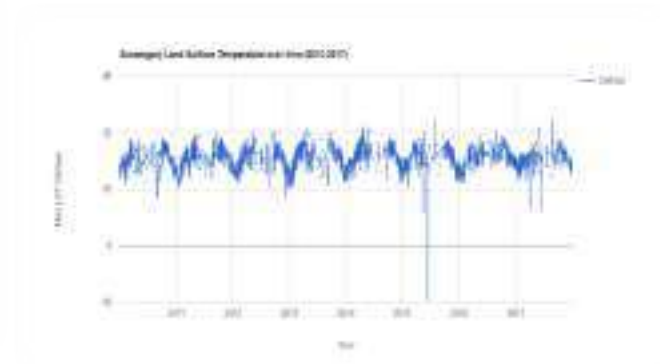
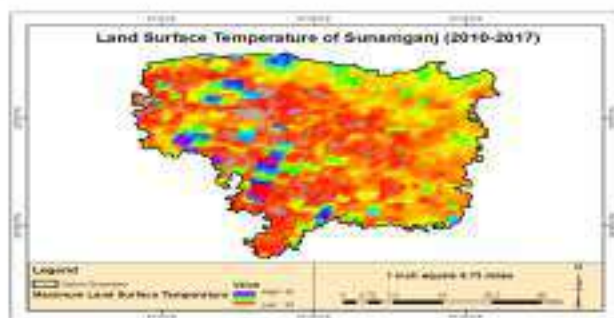
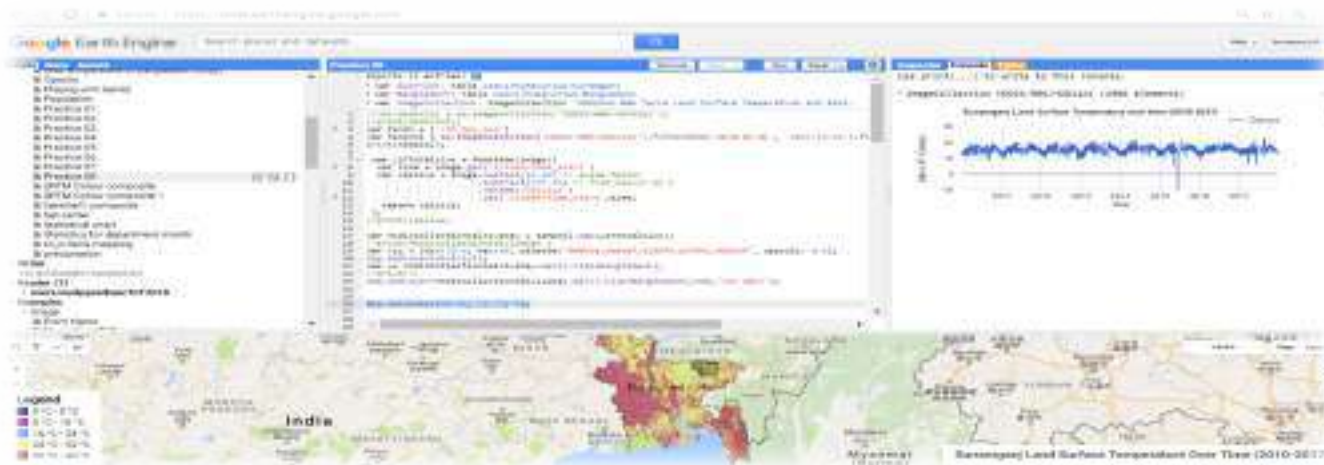


Figure 9: Max LST at Day in 2000-2005

The result shows that major cities and towns are in the effect of Urban Heat Island. Other urban areas particularly along the river in the west central and north-west part of the country are not affected. Some reductions have also been found in some areas. The changes in UHI are evident from the result.



## Rainfall and Temperature Dynamics

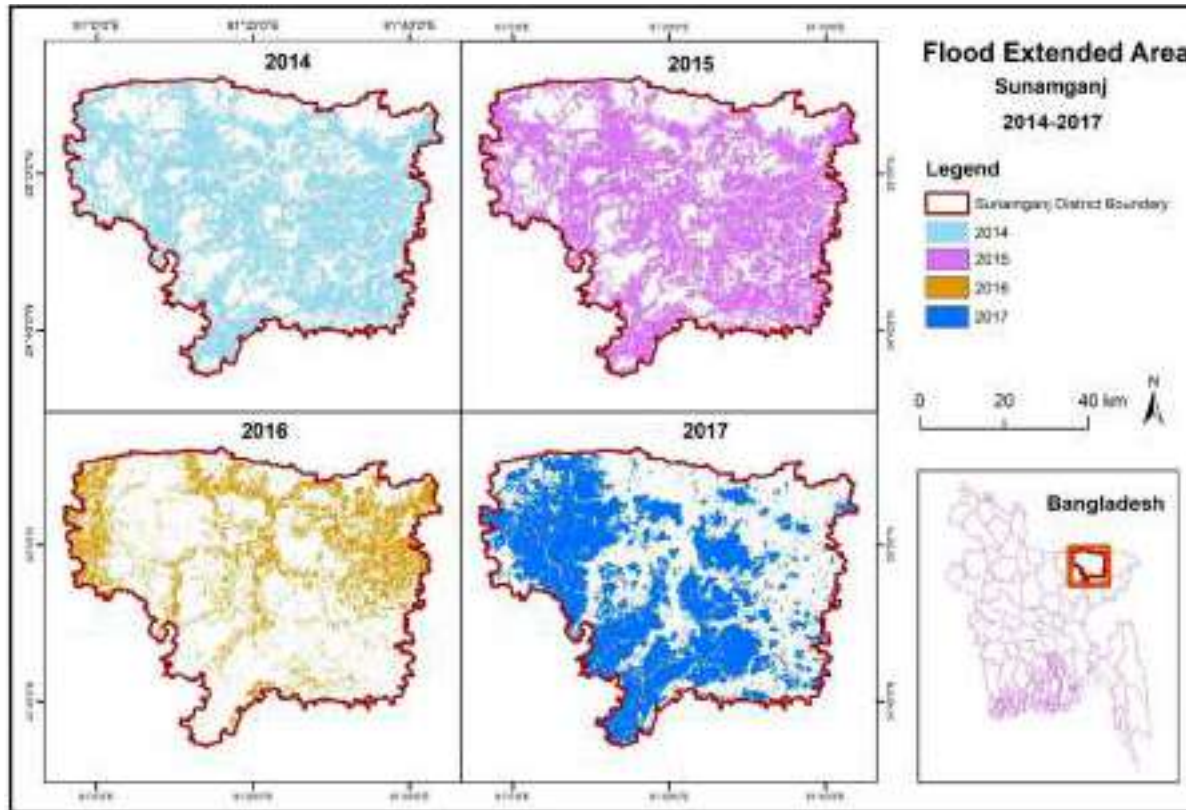




ICIMOD



## Flood Monitoring in Bangladesh



# Chart NDVI Over Time

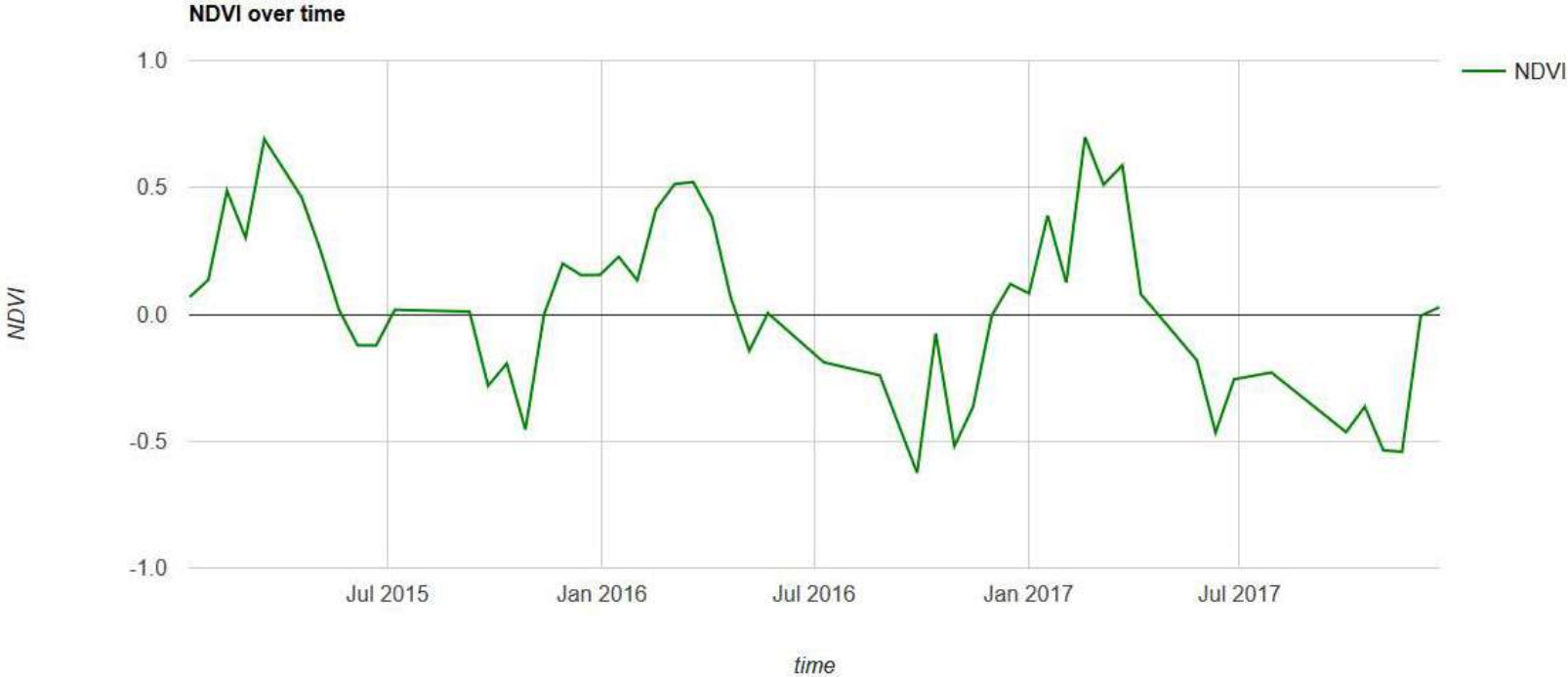
The screenshot displays the Google Earth Engine web interface. At the top, the Google Earth Engine logo and a search bar are visible. The main workspace is divided into several panels:

- Scripts Panel:** Shows a project structure with folders for 'users/krishnaju38/Japan\_EE2016', 'users/krishnaju38/ToT', and 'users/krishnaju38/UNSPIDER'. The '13 - Chart NDVI Over Time' script is selected.
- Code Editor:** Contains the following JavaScript code:

```
1 // Define a function that will add an NDVI band to a Landsat 8 image.  
2 var addNDVI = function(image) {  
3   var ndvi = image.normalizedDifference(['B5', 'B4']).rename('NDVI');  
4   return image.addBands(ndvi);  
5 };  
6
```
- Inspector/Console Panel:** Shows the console output with the instruction "Use print(...) to write to this console." Below it is a line chart titled "NDVI over time". The y-axis is labeled "NDVI" and ranges from 0.0 to 1.0. The x-axis represents time. A green line represents the NDVI values, showing seasonal fluctuations with peaks around 0.7 and troughs around 0.1.
- Map Panel:** Displays a satellite view of a forested area with a green location pin. The map includes navigation controls (pan, zoom, full screen) and a "Geometry Imports" button.

# Chart NDVI Over Time

[Download CSV](#) [Download SVG](#) [Download PNG](#)



# Compute NDVI

The screenshot displays the Google Earth Engine web interface. At the top, the Google Earth Engine logo is on the left, and a search bar with the text "Search places and datasets..." is in the center. On the right, there are "Help" and "krishna.ju38" dropdown menus.

The main interface is divided into several panels:

- Scripts Panel (Left):** Shows a list of scripts under the "Owner (5)" section. The script "Compute NDVI" is selected and highlighted.
- Script Editor (Center):** Displays the code for the "Compute NDVI" script. The code is as follows:

```
1 // Make a cloud-free composite and display it.
2 var l8raw: ImageCollection "USGS Landsat 8 Collection 1 Tier 1 Raw Scen...
3 collection: l8raw.filterDate('2017-01-01', '2017-12-31'),
4   asFloat: true
5 });
6 var trueColorVis = {min: 0, max: 0.3, bands: ['B4', 'B3', 'B2']};
7 Map.addLayer(composite, trueColorVis, 'composite');
8 // Compute NDVI.
9 var ndvi = composite.normalizedDifference(['B5', 'B4']).rename('NDVI');
10
11 // Display NDVI.
12 Map.addLayer(ndvi, {min: 0, max: 1, palette: ['white', 'green']}, 'ndvi');
```
- Inspector Panel (Right):** Shows the "Console" tab with the instruction: "Use print(...) to write to this console."

The bottom half of the interface shows a satellite map of a region with a river and surrounding greenery. The map includes navigation controls (hand, pan, zoom in/out, full screen) and a "Layers" panel on the right. The Google logo and "Map data ©2018 Google" are visible at the bottom left, and a scale bar and "Terms of Use" link are at the bottom right.

# Terrain Modeling

The screenshot displays the Google Earth Engine web interface. At the top, the Google Earth Engine logo is on the left, and a search bar with the text "Search places and datasets..." is in the center. On the right, there are "Help" and "krishna.ju38" dropdown menus.

The interface is divided into several panels:

- Scripts Panel (Left):** Shows a tree view of user folders: "users/krishnaju38/EE101", "users/krishnaju38/Japan\_EE2018", "users/krishnaju38/ToT", "users/krishnaju38/UNSPIDER" (containing "09 - Compute NDVI", "13 - Chart NDVI Over Time", and "Terrain\_Modeling.js"), and "Writer".
- Code Editor (Center):** The file "Terrain\_Modeling.js" is open. It contains the following code:

```
Imports (1 entry)
  var alos: Image "ALOS DSM: Global 30m" (6 bands)

1 // Import the ALOS DEM
2 var elev = alos.select(0);
3 // Add the elevation to the map. Play with the visualization tools
4 // to get a better visualization.
5 Map.addLayer(elev, {}, 'elev', false);
6
7 // Use the terrain algorithms to compute a hillshade with 8-bit values.
8
```
- Inspector Panel (Right):** Shows a layer named "DEM\_styled\_Mount\_Fuji" with a "RUN" button.

The main map area shows a 3D terrain visualization of the region around Japan and the Korean Peninsula. The terrain is color-coded by elevation, with green representing lower elevations and yellow/orange representing higher elevations. The map includes navigation controls (hand, pan, zoom in/out) on the left and "Layers", "Map", and "Satellite" buttons on the right. The Google logo is visible in the bottom left corner.

# Terrain Modeling

The screenshot displays the Google Earth Engine interface. At the top, the Google Earth Engine logo and a search bar are visible. The user's name, 'krishna.ju38', is shown in the top right corner. The interface is divided into several panels:

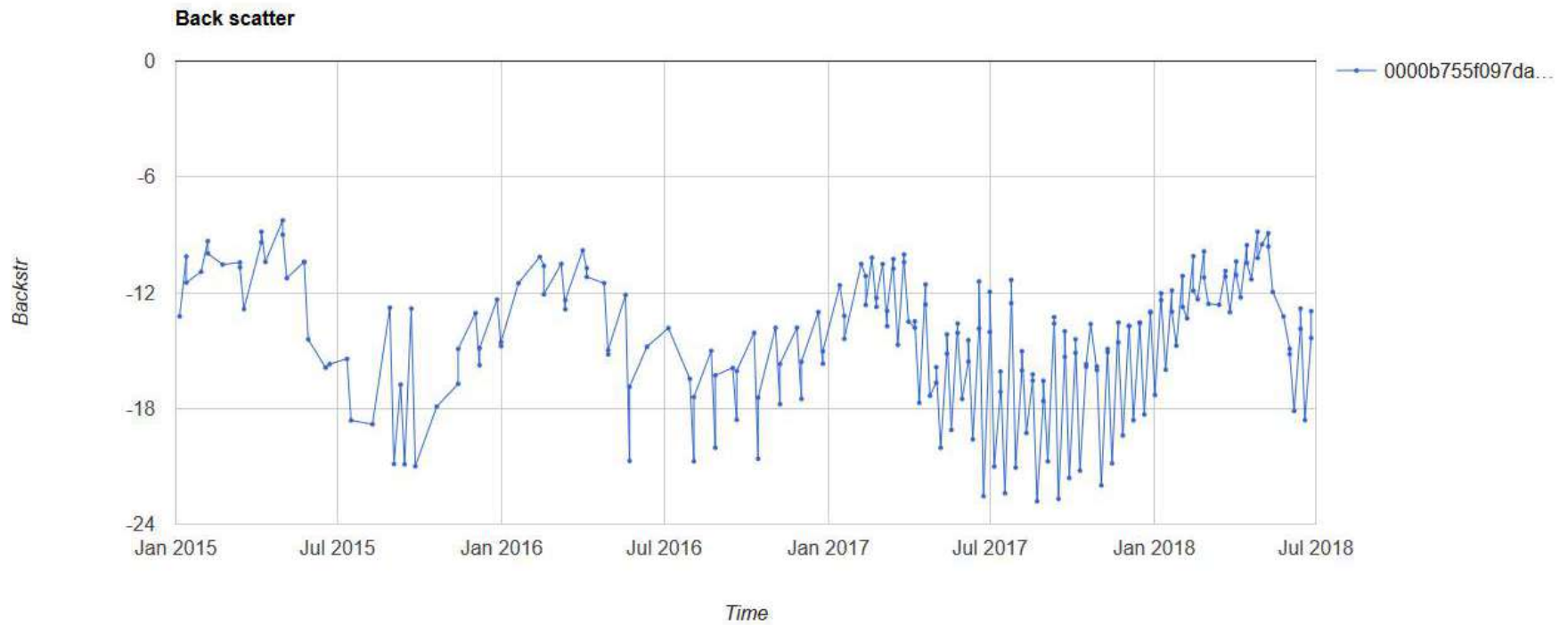
- Scripts Panel:** Shows a list of scripts under the 'Owner' section, including '09 - Compute NDVI', '13 - Chart NDVI Over Time', and 'NDVI using flood detection after edit'. The 'Terrain\_Modeling.js' script is selected.
- Code Editor:** Contains the following JavaScript code:

```
Imports (2 entries)
  var sentinel: ImageCollection "Sentinel-1 SA"
  var fc: Table users/krishnaju38/Sunamganj

1
2 //var fc = ee.FeatureCollection('ft:1620sdCLYY
3
4 //Map.setCenter(79.997660, 27.637736, 16);
5 Map.addLayer(fc, {'color': 'F00000'});
6
7 var select= sentinel.filterBounds(fc)
8   .filter(ee.Filter.listContains('transmitter
9   .select('W')
10  .filterDate('2015-1-1', '2018-6-30');
11
12 select = select.map(function(image) {
13
14
```
- Inspector Panel:** Shows the 'Back scatter' chart with the ID '0000b755f097da04f3b2'. The chart plots 'Backstr' (y-axis, ranging from -24 to 0) against 'Time' (x-axis, showing months from July to July). The data is represented by a blue line with markers, showing significant fluctuations.
- Map Panel:** Displays a map of the region around Sunamganj, Bangladesh. A large red-shaded area highlights the region of interest, which includes Sunamganj, Derai, and surrounding areas. The map shows roads, rivers, and various landmarks.

# Terrain Modeling

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# Flood Monitoring

The screenshot displays the Google Earth Engine web interface. At the top, the search bar contains the text "Search places and datasets...". The "Scripts" panel on the left shows a script named "Flood\*" with the following code:

```
Imports (1 entry)
var Sunameani: Table users/krishnaiu38/Sunameani
```

The "Inspector" panel on the right shows the message: "Use print(...) to write to this console." A red error box in the center of the map reads: "Authorization failed. Try refreshing the app." The map itself shows a large, irregularly shaped blue-shaded area covering a significant portion of the Sylhet region in Bangladesh. The map includes various geographical labels such as "Sylhet", "Kazir Gaon", "Mirpur", and "Mymensingh". The bottom right corner of the map area contains the text "Map data ©2018 Google 10 km".