Government of the People's Republic of Bangladesh

Ministry of Local Government, Rural Development and Cooperatives

Local Government Engineering Department (LGED)

LGED Bhaban, Agargaon, Dhaka-1207

Bangladesh

Project: Climate Resilient Infrastructure Mainstreaming Project (CRIMP)

Consulting Services regarding the Establishment of a

Climate Resilient Local Infrastructure Centre (CReLIC)

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Project No: 36206; Procurement No,: 502414

[Contract Package No: LGED/CRIM/IDC-1]

Rapid Climate Impact Assessment (RCIA)

Milestone 8

Version w/Calculator Tool

May 2024

A Joint Venture of AMBERO – COMO Consult – TTT

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Disaster Risk Management & Climate Change, AMBERO-IDC, With the technical support of IT expert Mrs, Valeria León Bravomalo in the development of the calculator tool for RCIA, In drafting this document, I am grateful for the contributions of my AMBERO-IDC colleagues, especially my colleague Dr Daan Boom, team leader, and the Action Team members Mr, J, Uddin, Mr, A, Khaleque, Mr, A, Taweed

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Introduction

The Rapid Climate Impact Assessment (RCIA) was originally developed in 2022 as a tool to assist engineers in the climate risks assessment of to be developed civil engineering infrastructures, The tool is a key component within the suite of resources of the Climate Resilience Tool Handbook.

Designed to simplify the assessment of climate risks associated with infrastructures planned in the designated pilot districts. During its testing of the tool in workshops, participant feedback led to adjustments. Recently, the RCIA was converted into a digital, Excel-based tool. The RCIA enables efficient analysis of current and future hydrometeorological hazards, using the IPCC SSP5 climate change scenario.

This revised and updated tool is suitable for infrastructure engineering projects, as it facilitates the evaluation of infrastructure exposure and vulnerability to imminent and long-term hydrometeorological events. The process concludes in the automatic generation of a specific climate risk index by Upazila, offering valuable insights for decision-making regarding climate risks in infrastructures planning.

To provide operational support, the RCIA methodology is complemented by the Calculator Tool, a computer-based resource built on Excel and enhanced with customized applications. This tool let users enter data manually or automatically, it then creates reports that summarize the evaluation results in a clear and comprehensive output, useful to be applied to complete the Bangladesh Development Project Proposal (DPP) question 25,3 (2022) and question 25,3(a), updated in February 2023.

From a methodological perspective, the RCIA aligns with the principles and analytical frameworks of the risk and impact model proposed by the Intergovernmental Panel on Climate Change (IPCC), This congruence ensures that the assessments conducted are robust, reliable, and in line with international guidelines on climate change and resilience.

Pre-requirements to apply the RCIA

Before engineers begin using the RCIA for the first time, it is necessary that they first complete the following courses to better understand the concepts, methodology and procedures used in the RCIA/CT. These courses are free and certified by the United Nations Institute for Training and Research (UNITAR):

→ Introductory e-Course on Climate Change:

https://unccelearn,org/course/view,php?id=7&page=overview

→ Climate Responsive Budgeting

https://unccelearn,org/course/view,php?id=14&page=overview

→ Cities and Climate Change

https://unccelearn,org/course/view,php?id=21&page=overview

→ Open Online Course on Gender and Environment

https://unccelearn,org/course/view,php?id=39&page=overview

→ Making the Right Choices - Prioritizing Adaptation Options

https://unccelearn,org/course/view,php?id=72&page=overview

Finally, it is further recommended that users review the Report on Standard Criteria for Gap analysis and the adjusted/updated guidelines for roads, bridges, culverts and water and the chapter VI of the CRT-Handbook.

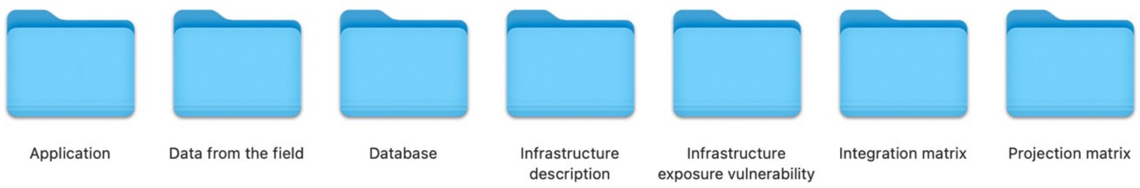
Very important

1. The CT is designed to run under the licence version of Microsoft Excel. **If you do not use a licensed version, the system will run with errors that will not allow a reliable assessment**.
2. The CT is designed to carry out the RCIA of infrastructure by type of infrastructure (buildings, roads, bridges, urban drainage and water systems). Therefore, an IARR project will always correspond to only one type of infrastructure.
3. In case the RCIA/CT must be carried out in a significant number of upazilas (e.g. more than 20), it is recommended to select a subset of upazilas representing the set of upazilas where the infrastructure is located.

Set up RCIA Calculator Tool

A. You will receive the Rapid Climate Impact Assessment Calculation Tool (CT) or you will need to download it from the Knowledge Management System (KMS). The CT is a compressed (zip or rar) file that needs to be unzipped to a directory on your device.

B. Once unzipped, the contents of the CT will be visible with the following directory structure:



C. Each of these folders contains Excel files that you will need to work with. Below is a description of each file:

→ **Application,** this directory contains an application that imports DRIP data into the CT database, which is an Excel file.

→ **Data from the Field,** this file contains the Excel file to record the field data of the site where the infrastructure is to be constructed.

→ **Database,** this file stores the data generated by the application and serves as the starting data for the CT.

→ **Infrastructure description,** this file contains the Excel file describing the infrastructure to be built.

→ **Infrastructure vulnerability and exposure,** this file contains the Excel file used to assess the exposure and vulnerability of the infrastructure.

→ **Integration matrix,** this file contains the Excel file that integrates the data from the CT database and the data collected in the field.

→ **Projection Matrix,** this file projects vulnerabilities up to the year 2100 using SSP2 and SSP5 data.

D. Create a folder called 'save to report'. In this folder you should save all the PDF reports and pictures that you will create during your RCIA project.

Note: The classification scale used in the RCIA/CT is as follows:

Very high	High	Medium	Low	Very low

Step 1. Infrastructure Hazard Assessment,

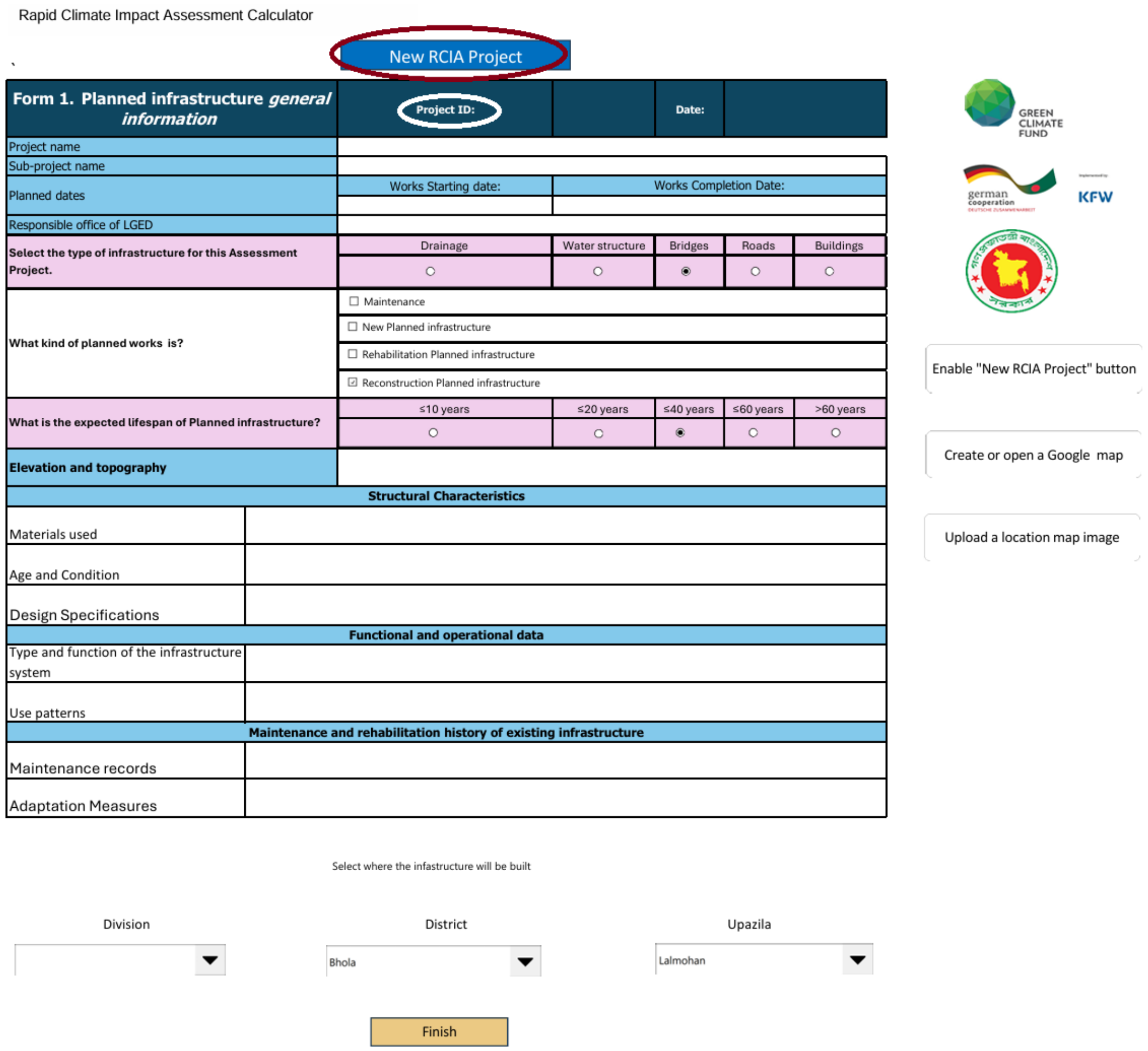
1.1 The first step is to describe the type of infrastructure to be subjected to the rapid assessment. Proceed as follows:

i. Open the file ***'Infrastructure Description.xlsm'*** in the folder ***'Infrastructure Description'***.

ii. Create a Rapid Climate Impact Assessment (RCIA) project, clicking on the button ***'New RCIA project'***.

iii. Once created, the CT will automatically assign an ID to your assessment project.

iv. There is a button ***'Clear contents'*** to delete the content and start again.



1.2 Once form 1 has been displayed, enter the basic information requested in Form 1 ***'Planned infrastructure general information'***.

1.3 Please, make sure that all the information and descriptions requested are entered. Here are some suggestions to enter the information:

→ **Elevation and topography:** Describe elevation, surrounding topography, drainage characteristics, and distance to nearby water bodies or river.

→ **Structural Characteristics:**

i. Materials Used: Describe the proposed materials to be used in the infrastructure.
ii. Age and Condition: For an existing infrastructure system, describe the age and condition. Older infrastructure may be more vulnerable due to wear and tear, outdated design standards, or degradation of materials.
iii. Design Specifications: It is important to describe the details of the design standards that will be used, such as load capacity, wind resistance, and flood resistance. This data helps assess the infrastructure's ability to withstand extreme events.

→ **Functional and operational data.**

i. Type and function of the infrastructure system: Briefly describe the type of infrastructure and the function or service it provides to the population.
ii. Use patterns: Describe data on the frequency and volume of use, such as the daily traffic on a bridge or the treatment capacity of a water treatment plant.

→ **Maintenance and rehabilitation history of existing infrastructure.**

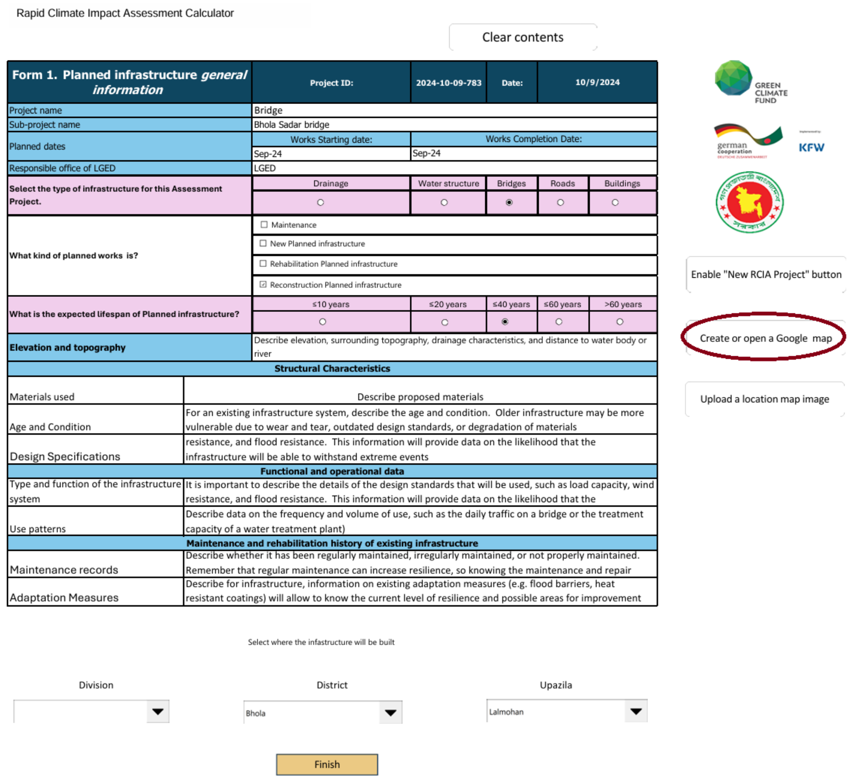
i. Maintenance records: Indicate whether it has been regularly maintained, irregularly maintained, or not properly maintained. Remember that regular maintenance can increase resilience, so knowing the maintenance and repair history will help in assessing vulnerability.
ii. Adaptation Measures: Provide information on existing adaptation measures (e.g. flood barriers, heat resistant coatings. This will help assess the infrastructure's current resilience and identify areas for improvement.

1.4 Once you have entered the information and descriptions requested in form 1, then click on the ***'Create or open a google map'*** button and follow the instructions provided by Google to create the map with the location and/or layout of the infrastructure system that is part of your assessment project. This button will open Google maps in your default browser.

1.5 Note, please ensure the following:

→ Create the map <u>using the same RCIA project name you used in form 1</u>.

→ Keep in mind that the infrastructure system you are assessing <u>may cover one or more upazilas</u>, so make sure <u>you have marked all relevant location and/or layout points during mapping of your infrastructure system, covering all the upazilas that are part of your rapid climate impact assessment project</u>,



Rapid Climate Impact Assessment Calculator

Clear contents

Form 1. Planned infrastructure *general information*	Project ID:	2024-10-09-783	Date:	10/9/2024	
Project name	Bridge				
Sub-project name	Bhola Sadar bridge				
Planned dates	Works Starting date:		Works Completion Date:		
	Sep-24	Sep-24			
Responsible office of LGED	LGED				
Select the type of infrastructure for this Assessment Project.	Drainage	Water structure	Bridges	Roads	Buildings
	○	○	◉	○	○
What kind of planned works is?	☐ Maintenance				
	☐ New Planned infrastructure				
	☐ Rehabilitation Planned infrastructure				
	☑ Reconstruction Planned infrastructure				
What is the expected lifespan of Planned infrastructure?	≤10 years	≤20 years	≤40 years	≤60 years	>60 years
	○	○	◉	○	○
Elevation and topography	Describe elevation, surrounding topography, drainage characteristics, and distance to water body or river				
Structural Characteristics					
Materials used	Describe proposed materials				
Age and Condition	For an existing infrastructure system, describe the age and condition. Older infrastructure may be more vulnerable due to wear and tear, outdated design standards, or degradation of materials				
Design Specifications	resistance, and flood resistance. This information will provide data on the likelihood that the infrastructure will be able to withstand extreme events				
Functional and operational data					
Type and function of the infrastructure system	It is important to describe the details of the design standards that will be used, such as load capacity, wind resistance, and flood resistance. This information will provide data on the likelihood that the				
Use patterns	Describe data on the frequency and volume of use, such as the daily traffic on a bridge or the treatment capacity of a water treatment plant)				
Maintenance and rehabilitation history of existing infrastructure					
Maintenance records	Describe whether it has been regularly maintained, irregularly maintained, or not properly maintained. Remember that regular maintenance can increase resilience, so knowing the maintenance and repair				
Adaptation Measures	Describe for infrastructure, information on existing adaptation measures (e.g. flood barriers, heat resistant coatings) will allow to know the current level of resilience and possible areas for improvement				

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Enable "New RCIA Project" button

Create or open a Google map

Upload a location map image

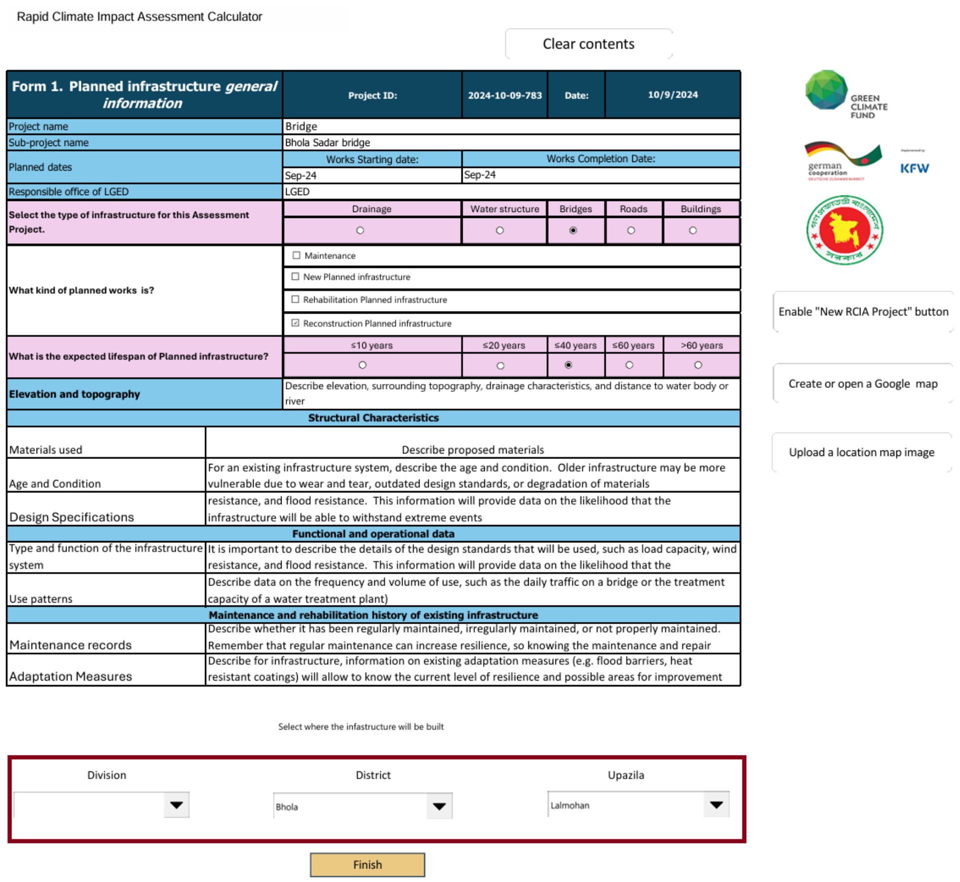
Select where the infastructure will be built

Division	District	Upazila
	Bhola	Lalmohan

Finish

1.6 Once you have created the map, press the bottom "upload a location map image".

1.7 Next, select the division, district and specific upazila where the infrastructure is or will be located.



Rapid Climate Impact Assessment Calculator

Clear contents

Form 1. Planned infrastructure *general information*	Project ID:	2024-10-09-783	Date:	10/9/2024	
Project name	Bridge				
Sub-project name	Bhola Sadar bridge				
Planned dates	Works Starting date:		Works Completion Date:		
	Sep-24	Sep-24			
Responsible office of LGED	LGED				
Select the type of infrastructure for this Assessment Project.	Drainage	Water structure	Bridges	Roads	Buildings
	○	○	◉	○	○
What kind of planned works is?	☐ Maintenance				
	☐ New Planned infrastructure				
	☐ Rehabilitation Planned infrastructure				
	☑ Reconstruction Planned infrastructure				
What is the expected lifespan of Planned infrastructure?	≤10 years	≤20 years	≤40 years	≤60 years	>60 years
	○	○	◉	○	○
Elevation and topography	Describe elevation, surrounding topography, drainage characteristics, and distance to water body or river				
Structural Characteristics					
Materials used	Describe proposed materials				
Age and Condition	For an existing infrastructure system, describe the age and condition. Older infrastructure may be more vulnerable due to wear and tear, outdated design standards, or degradation of materials				
Design Specifications	resistance, and flood resistance. This information will provide data on the likelihood that the infrastructure will be able to withstand extreme events				
Functional and operational data					
Type and function of the infrastructure system	It is important to describe the details of the design standards that will be used, such as load capacity, wind resistance, and flood resistance. This information will provide data on the likelihood that the				
Use patterns	Describe data on the frequency and volume of use, such as the daily traffic on a bridge or the treatment capacity of a water treatment plant)				
Maintenance and rehabilitation history of existing infrastructure					
Maintenance records	Describe whether it has been regularly maintained, irregularly maintained, or not properly maintained. Remember that regular maintenance can increase resilience, so knowing the maintenance and repair				
Adaptation Measures	Describe for infrastructure, information on existing adaptation measures (e.g. flood barriers, heat resistant coatings) will allow to know the current level of resilience and possible areas for improvement				

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Enable "New RCIA Project" button

Create or open a Google map

Upload a location map image

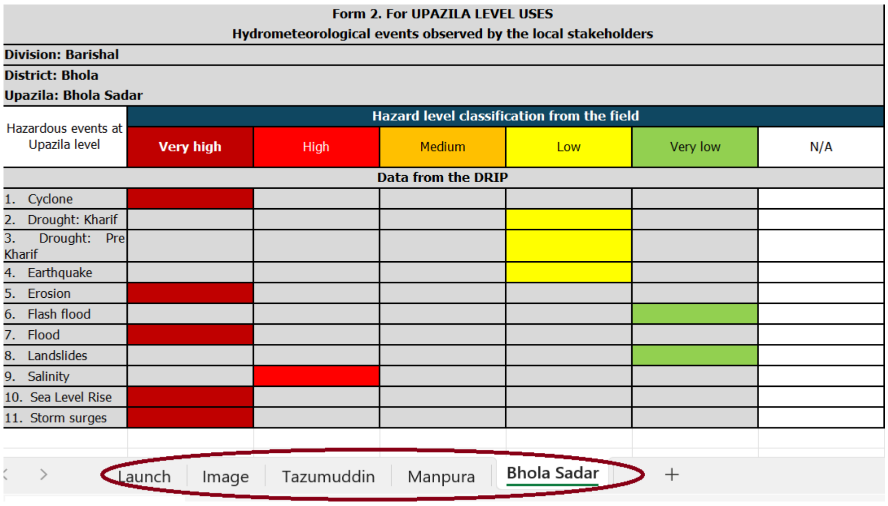
Select where the infastructure will be built

Division	District	Upazila
	Bhola	Lalmohan

Finish

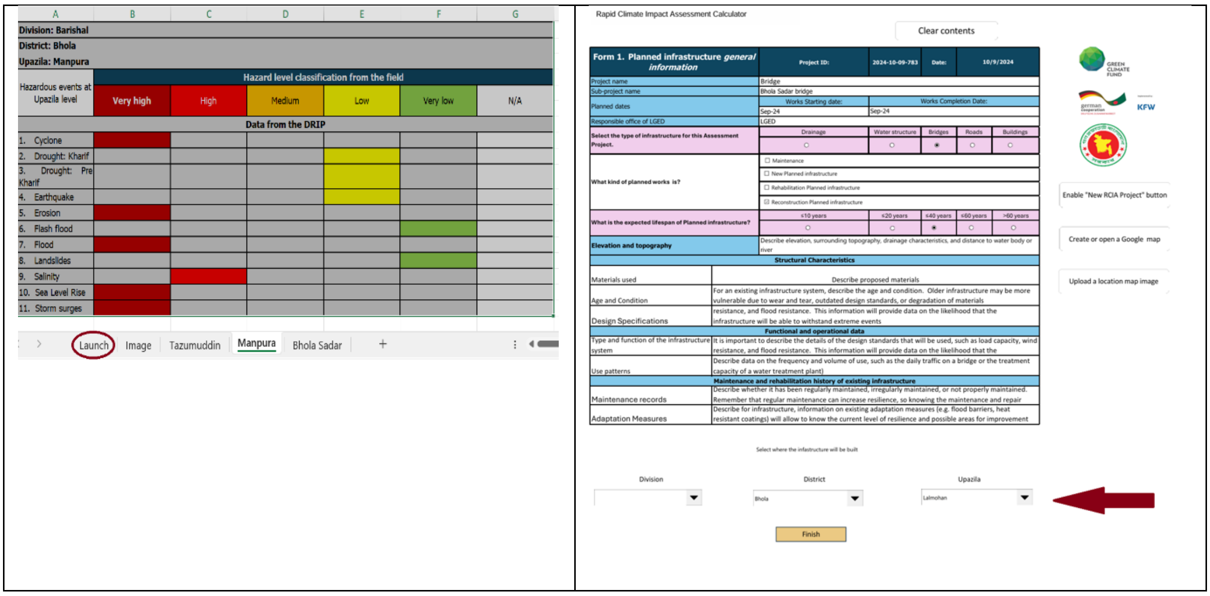
1.8 Once the upazila is selected, the CT will create a tab named after the selected upazila, and a completed Form 2 will be generated with data on the magnitude of hydro-meteorological hazards (very high, high, medium, low or very low) extracted from the Disaster Risk Information Platform (DRIP).

1.9 Click on the tab with the name of the upazila and check that Form 2 has been created and is properly completed, as showed in the following figure.

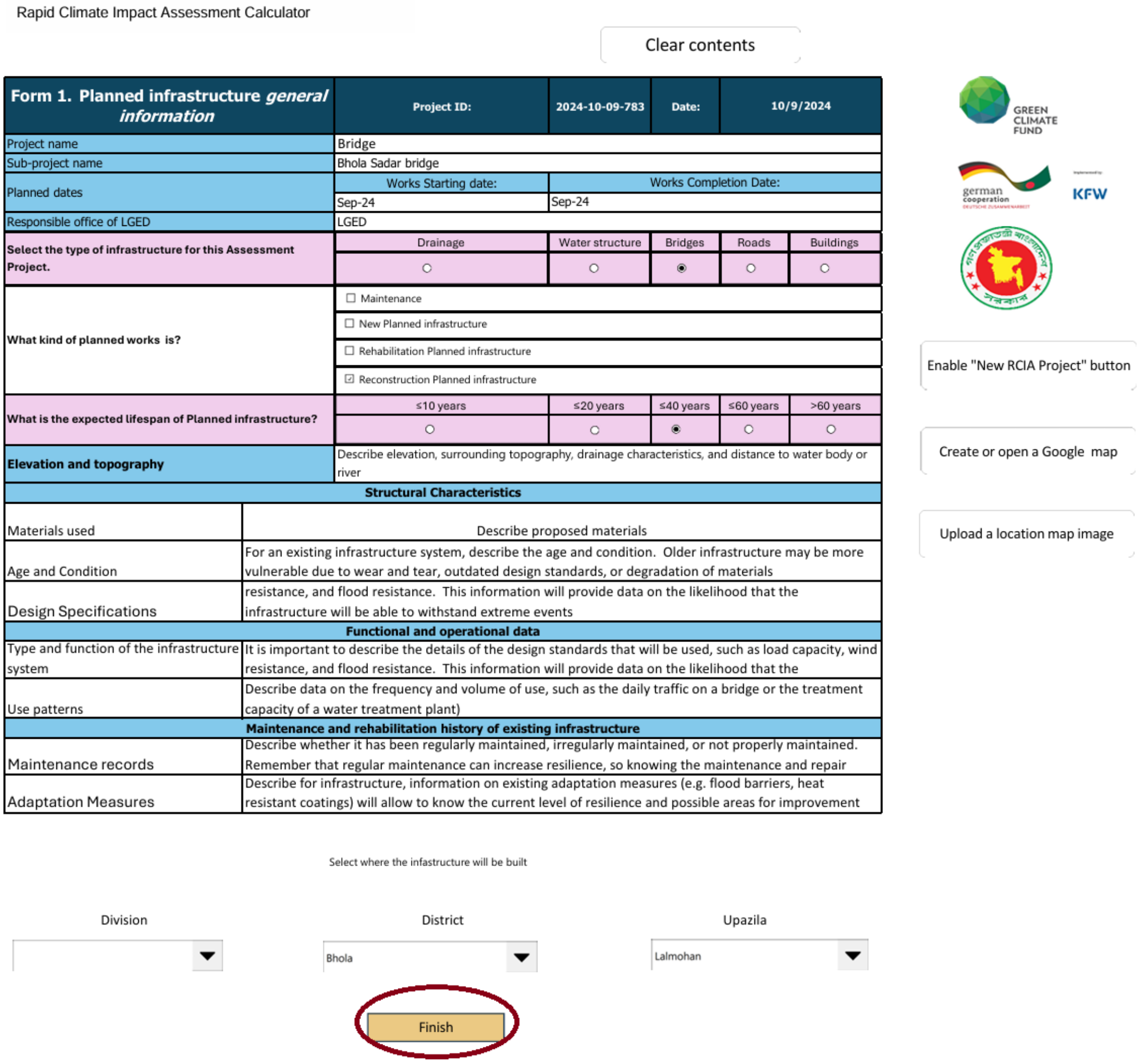


1.10 <u>To add more upazilas to your RCIA project</u>, click on the **'Launch'** tab, the form 1 will be displayed again and then, select the new upazila that you want to add to the RCIA project.

1.11 Repeat this process as many times as you need to add upazilas to your RCIA project.



1.12 Once you have selected all the upazilas that make up your RCIA project, go back to the 'Launch' tab, form 1 will appear again and click on the 'Finish' button,



Rapid Climate Impact Assessment Calculator

Clear contents

Form 1. Planned infrastructure *general information*	Project ID:	2024-10-09-783	Date:	10/9/2024	
Project name	Bridge				
Sub-project name	Bhola Sadar bridge				
Planned dates	Works Starting date:	Works Completion Date:			
	Sep-24	Sep-24			
Responsible office of LGED	LGED				
Select the type of infrastructure for this Assessment Project.	Drainage	Water structure	Bridges	Roads	Buildings
	○	○	◉	○	○
What kind of planned works is?	☐ Maintenance				
	☐ New Planned infrastructure				
	☐ Rehabilitation Planned infrastructure				
	☑ Reconstruction Planned infrastructure				
What is the expected lifespan of Planned infrastructure?	≤10 years	≤20 years	≤40 years	≤60 years	>60 years
	○	○	◉	○	○
Elevation and topography	Describe elevation, surrounding topography, drainage characteristics, and distance to water body or river				
Structural Characteristics					
Materials used	Describe proposed materials				
Age and Condition	For an existing infrastructure system, describe the age and condition. Older infrastructure may be more vulnerable due to wear and tear, outdated design standards, or degradation of materials				
Design Specifications	resistance, and flood resistance. This information will provide data on the likelihood that the infrastructure will be able to withstand extreme events				
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Type and function of the infrastructure system	It is important to describe the details of the design standards that will be used, such as load capacity, wind resistance, and flood resistance. This information will provide data on the likelihood that the				
Use patterns	Describe data on the frequency and volume of use, such as the daily traffic on a bridge or the treatment capacity of a water treatment plant)				
Maintenance and rehabilitation history of existing infrastructure					
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Adaptation Measures	Describe for infrastructure, information on existing adaptation measures (e.g. flood barriers, heat resistant coatings) will allow to know the current level of resilience and possible areas for improvement				

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Enable "New RCIA Project" button

Create or open a Google map

Upload a location map image

Select where the infastructure will be built

Division	District	Upazila
	Bhola	Lalmohan

Finish

1.13 The CT will check the data that you entered and, if everything is correct, the CT will ask you to create a form 3 named *'data from the field'.*

1.14 Click 'Ok' and then form 3 will be displayed.

1.15 It is then recommended that you make a video call to the relevant Upazila and/or District Office to request a technical inspection. They should complete Form 3[1], ticking the appropriate boxes during the visit to the proposed site of the infrastructure.

[1] Form 3 work requires a technical field inspection **<u>by one or more LGED engineers from the district office and/or upazila,</u>**

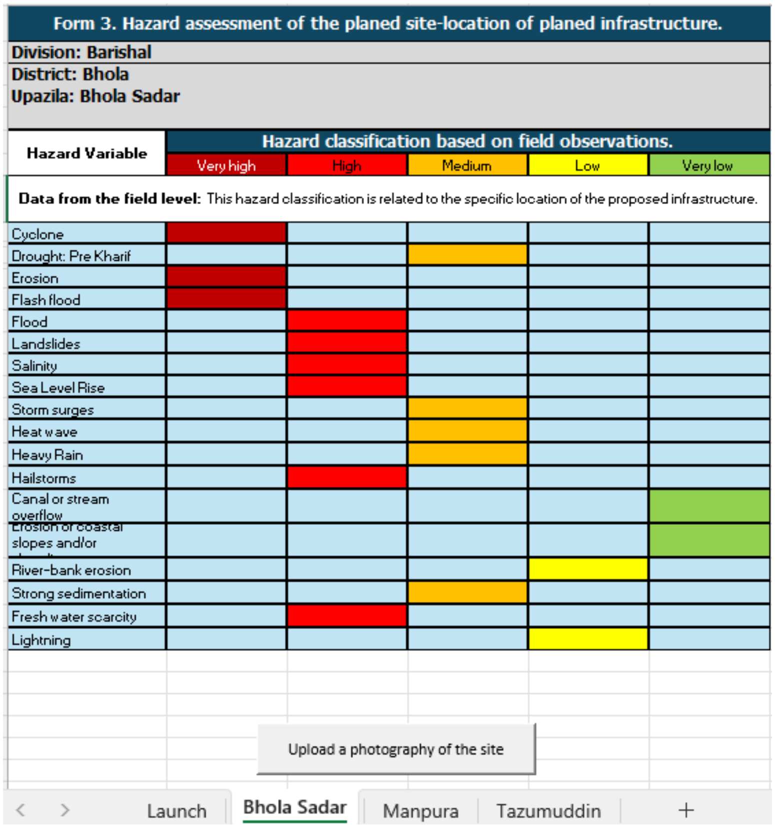
Form 3. Hazard assessment of the planed site-location of planed infrastructure.					
Division: Barishal District: Barguna Upazila: Amtali					
Hazard Variable	Hazard classification based on field observations.				
	Very high	High	Medium	Low	Very low
Data from the field level: This hazard classification is related to the specific location of the proposed infrastructure.					
Cyclone					
Drought: Pre Kharif					
Erosion					
Flash flood					
Flood					
Landslides					
Salinity					
Sea Level Rise					
Storm surges					
Heat wave					
Heavy Rain					
Hailstorms					
Canal or stream overflow					
Erosion of coastal slopes and/or shorelines					
River-bank erosion					
Strong sedimentation					
Fresh water scarcity					
Lightning					

1.16 Form 3 will help you to assess in more detail the hazards considered in the DRIP and to assess other hydrometeorological hazards that need to be considered in the field.

1.17 Field observation may **identify critical signs** to be classified in Form 3, interviewing local people about hydro-meteorological hazards at the site can provide insights into hazards that should be considered during the design phase of the infrastructure (citizen science)

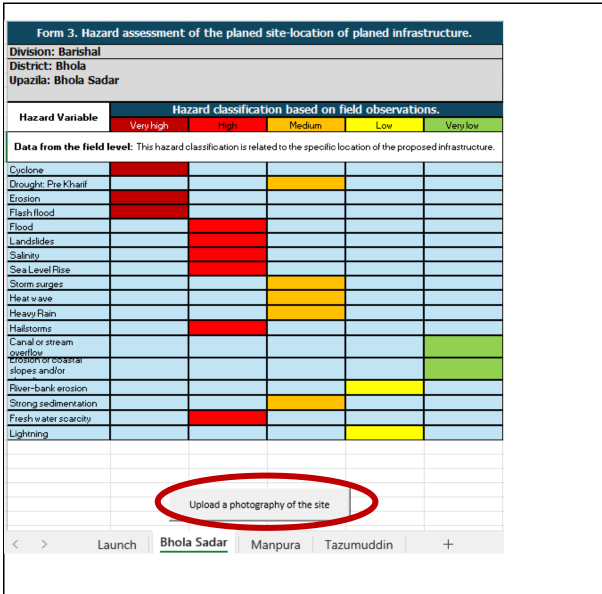
1.18 Information collected to complete Form 3 may include videos and photographs of the site where the infrastructure system will be located and the surrounding area.

1.19 When you have received Forms 3 from the LGED office(s), forward them to the CT by putting an 'X' in the appropriate cell. Each time you mark an 'X' in the cell of CT, it is activated and marked with the colour that classifies the magnitude of the hazard.



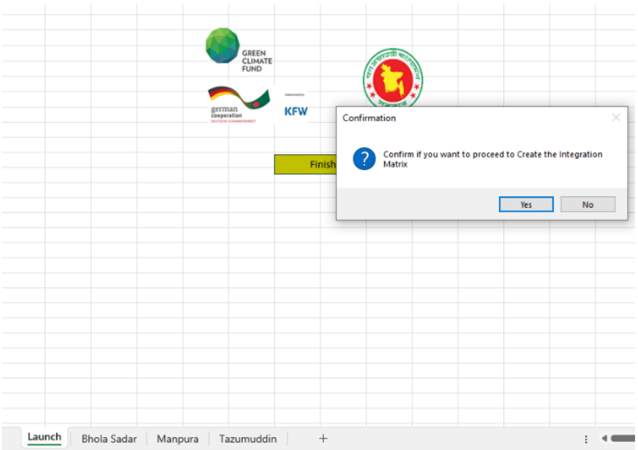
Form 3. Hazard assessment of the planed site-location of planed infrastructure.					
Division: Barishal					
District: Bhola					
Upazila: Bhola Sadar					
Hazard Variable	Hazard classification based on field observations.				
	Very high	High	Medium	Low	Very low
Data from the field level: This hazard classification is related to the specific location of the proposed infrastructure.					
Cyclone					
Drought: Pre Kharif					
Erosion					
Flash flood					
Flood					
Landslides					
Salinity					
Sea Level Rise					
Storm surges					
Heat wave					
Heavy Rain					
Hailstorms					
Canal or stream overflow					
Erosion of coastal slopes and/or					
River-bank erosion					
Strong sedimentation					
Fresh water scarcity					
Lightning					

1.20 To upload an image or photograph of the site where the infrastructure system is located or will be located, please use the button ***'Upload a photograph of the site'*** and select the file where the image is, select it and the CT will upload it and place the image in the same tab of the upazila´s form 3.



1.21 When you have finished entering the Form 3s with the data received from the field into the CT, click on the 'Launch' tab and then on the 'Finish' button.

1.22 The CT will ask you to confirm that you want to create the integration matrix, If you are sure you want to proceed, click on the 'OK' button,



1.23 The CT will integrate Form 2 (DRIP data) and Form 3 (field data) into the integration matrix and calculate the Weighted Hazard index (WHi) for the infrastructure to be site in the corresponding upazila.

INTEGRATION MATRIX					
Division: Barishal					
District: Bhola					
Upazila: Bhola Sadar					
Hazard Variable (VH)	**Hazard Level (HL)**				
	Very high	High	Medium	Low	Very low
Cyclone					
Drought: Pre Kharif					

Erosion					
Flash flood					
Flood					
Landslides					
Salinity					
Sea Level Rise					
Storm surges					
Heat wave					
Heavy Rain					
Hailstorms					
Canal or stream overflow					
Erosion of coastal slopes and/or shorelines					
River-bank erosion					
Strong sedimentation					
Fresh water scarcity					
Lightning					
Aggregated Hazard Index (Ahi)	AHi for Upazila Bhola Sadar [38,125500275294]				

1.24 Review the Integration Matrix and then press 'Finish' on the 'Launch' **tab**. The CT will ask you to create a projection matrix.

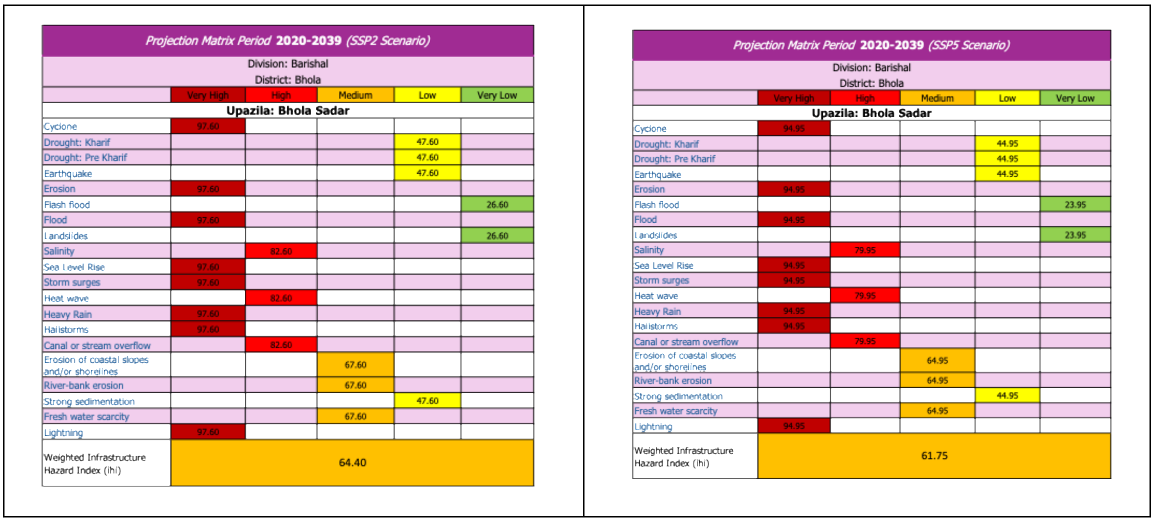
1.25 Press Ok and the CT will produce a probabilistic estimate of future hazards for each upazila. Each projection will cover both the current period and the future period up to 2100, using the SPP5 and SPP2 climate change scenarios. In addition to calculating the projection of future hazards, the CT will also calculate the projected AHi.

Projection Matrix Period ***2020-2039*** *(SSP5 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	82,95				
Drought: Pre Kharif					2,95
Erosion			42,95		
Flash flood			42,95		
Flood	82,95				
Landslides				22,95	
Salinity				22,95	

Projection Matrix Period ***2040-2059*** *(SSP5 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	85,95				
Drought: Pre Kharif					5,95
Erosion			45,95		
Flash flood			45,95		
Flood	85,95				
Landslides				25,95	
Salinity				25,95	

Sea Level Rise			42,95			Drought: Pre Kharif			45,95		
Storm surges		62,95				Storm surges		65,95			
Heat wave			42,95			Heat wave			45,95		
Heavy Rain			42,95			Heavy Rain			45,95		
Hailstorms		62,95				Hailstorms		65,95			
Canal or stream overflow					2,95	Canal or stream overflow					5,95
Erosion of coastal slopes and/or shorelines					2,95	Erosion of coastal slopes and/or shorelines					5,95
River-bank erosion				22,95		River-bank erosion				25,95	
Strong sedimentation			42,95			Strong sedimentation			45,95		
Fresh water scarcity		62,95				Fresh water scarcity		65,95			
Lightning				22,95		Lightning				25,95	
Aggregated Hazard Index (Ahi)	42,95					Aggregated Hazard Index (Ahi)	45,95				

1.26 Check that the CT has produced the projections and save a copy of the projected hazard matrices in PDF format in the 'Save for report' folder (this folder should have been created when the CT was set up). To produce the PDF, set up Excel correctly so that each table fits on each page of the PDF, as shown in the figure below. **<u>This is very important action when analysing the results and writing the final report.</u>**



Projection Matrix Period **2020-2039** *(SSP2 Scenario)*					
Division: Barishal District: Bhola					
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	97.60				
Drought: Kharif				47.60	
Drought: Pre Kharif				47.60	
Earthquake				47.60	
Erosion	97.60				
Flash flood					26.60
Flood	97.60				
Landslides					26.60
Salinity		82.60			
Sea Level Rise	97.60				
Storm surges	97.60				
Heat wave		82.60			
Heavy Rain	97.60				
Hailstorms	97.60				
Canal or stream overflow		82.60			
Erosion of coastal slopes and/or shorelines			67.60		
River-bank erosion			67.60		
Strong sedimentation				47.60	
Fresh water scarcity			67.60		
Lightning	97.60				
Weighted Infrastructure Hazard Index (ihi)	64.40				

Projection Matrix Period **2020-2039** *(SSP5 Scenario)*					
Division: Barishal District: Bhola					
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	94.95				
Drought: Kharif				44.95	
Drought: Pre Kharif				44.95	
Earthquake				44.95	
Erosion	94.95				
Flash flood					23.95
Flood	94.95				
Landslides					23.95
Salinity		79.95			
Sea Level Rise	94.95				
Storm surges	94.95				
Heat wave		79.95			
Heavy Rain	94.95				
Hailstorms	94.95				
Canal or stream overflow		79.95			
Erosion of coastal slopes and/or shorelines			64.95		
River-bank erosion			64.95		
Strong sedimentation				44.95	
Fresh water scarcity			64.95		
Lightning	94.95				
Weighted Infrastructure Hazard Index (ihi)	61.75				

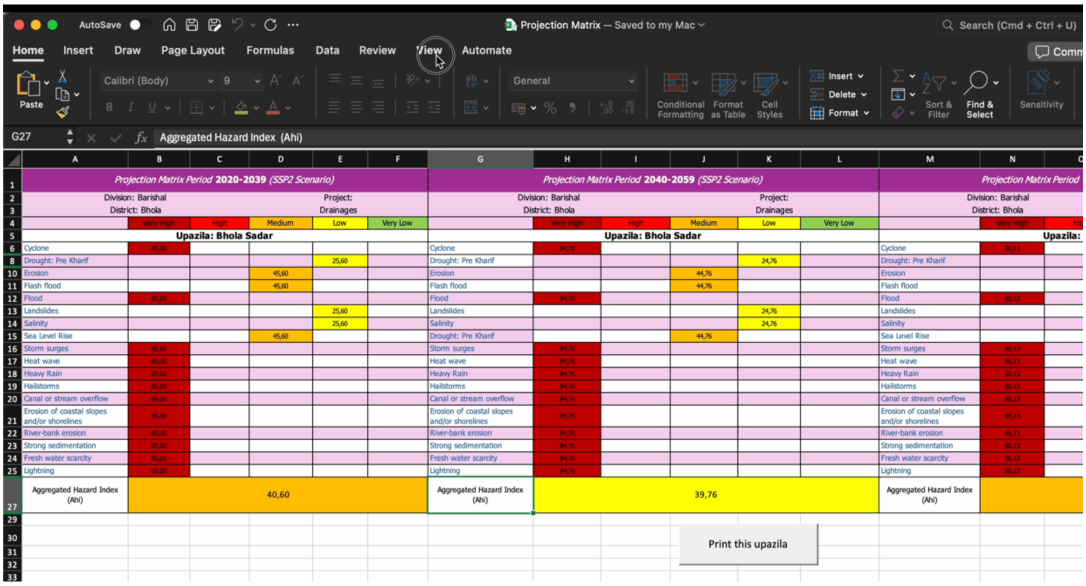
Projection Matrix Period **2020-2039** *(SSP2 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	85,60				
Drought: Pre Kharif					5,60
Erosion				25,60	
Flash flood			45,60		
Flood	85,60				
Landslides					5,60
Salinity					5,60
Sea Level Rise				25,60	
Storm surges		65,60			
Heat wave	85,60				
Heavy Rain	85,60				
Hailstorms		65,60			
Canal or stream overflow			45,60		
Erosion of coastal slopes and/or shorelines				25,60	
River-bank erosion				25,60	
Strong sedimentation				25,60	
Fresh water scarcity					5,60
Lightning			45,60		
Aggregated Hazard Index (Ahi)	45,60				

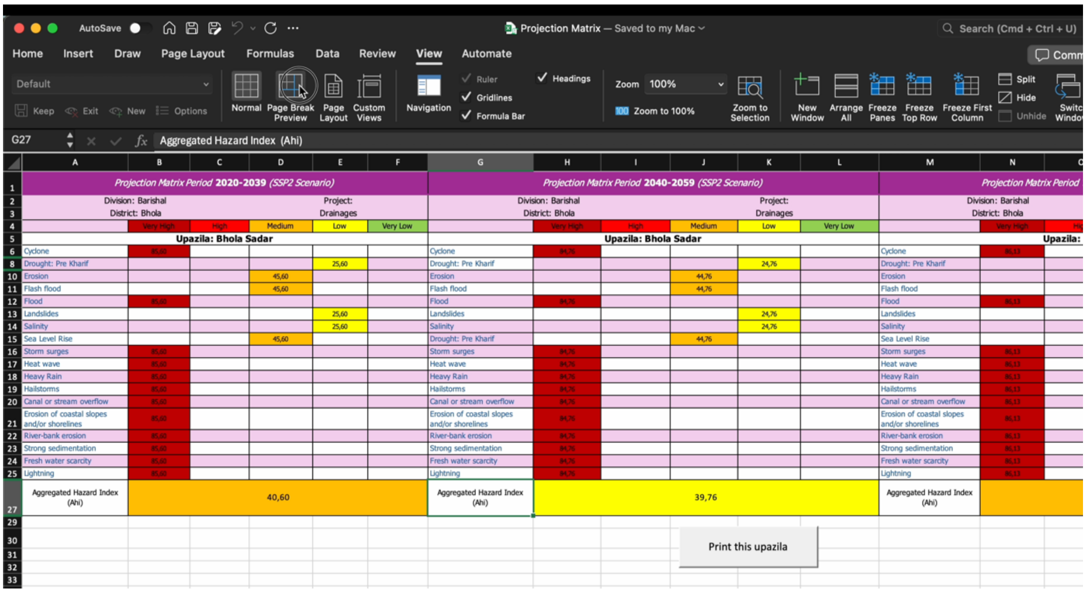
Projection Matrix Period **2040-2059** *(SSP2 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	84,76				
Drought: Pre Kharif					4,76
Erosion				24,76	
Flash flood			44,76		
Flood	84,76				
Landslides					4,76
Salinity					4,76
Drought: Pre Kharif				24,76	
Storm surges		64,76			
Heat wave	84,76				
Heavy Rain	84,76				
Hailstorms		64,76			
Canal or stream overflow			44,76		
Erosion of coastal slopes and/or shorelines				24,76	
River-bank erosion				24,76	
Strong sedimentation				24,76	
Fresh water scarcity					4,76
Lightning			44,76		
Aggregated Hazard Index (Ahi)	44,76				

1.27 To configure the Excel correctly, here is the suggestion to set-up:

a) Open Page Break Preview

- On your Excel file.
- Go to the View tab on the top menu.
- Click on Page Break Preview (usually found in the middle of the toolbar).





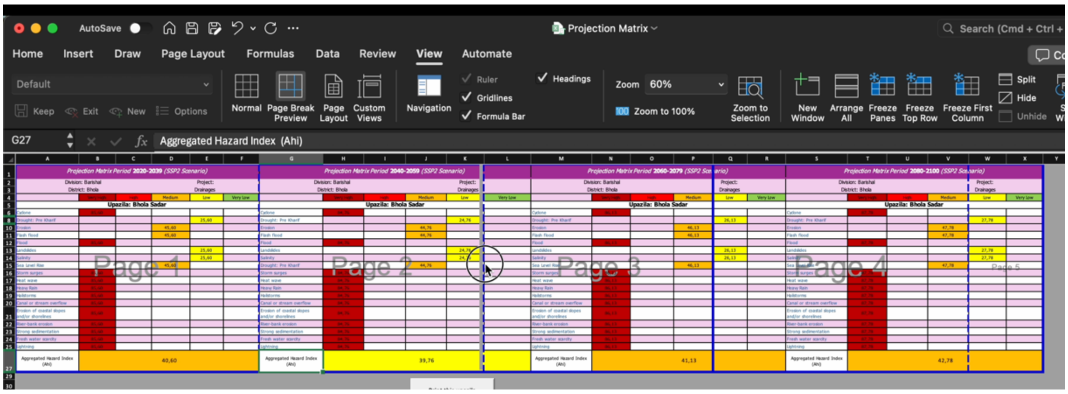
- Now, you'll see a preview of your worksheet with blue dashed and solid lines marking the page breaks.

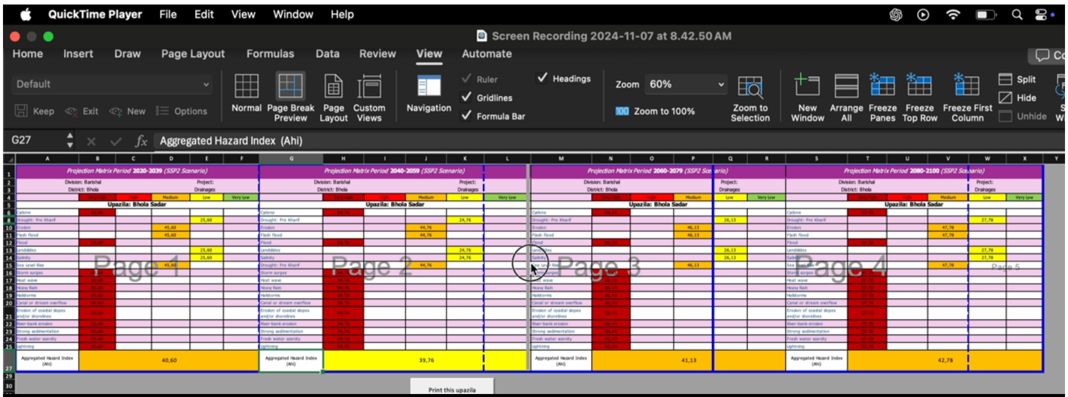
b) Understanding Page Breaks

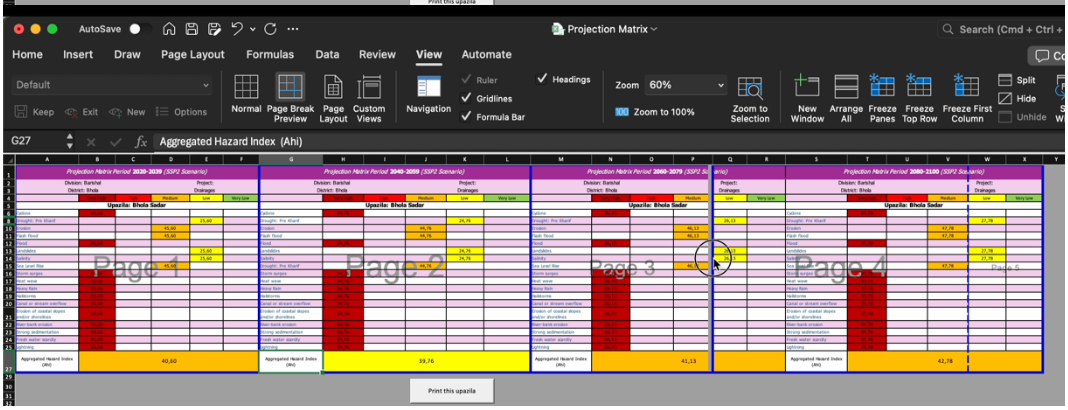
- Blue dashed lines indicate automatic page breaks set by Excel based on the page size and margins.
- Blue solid lines are manual page breaks you can add or adjust yourself.

c) Adjusting Page Breaks

- Move a page break Cclicking and draging any of the blue lines to move a page break. For example, if a column is spilling over to the next page, you can drag the blue vertical line to include it on the same page.

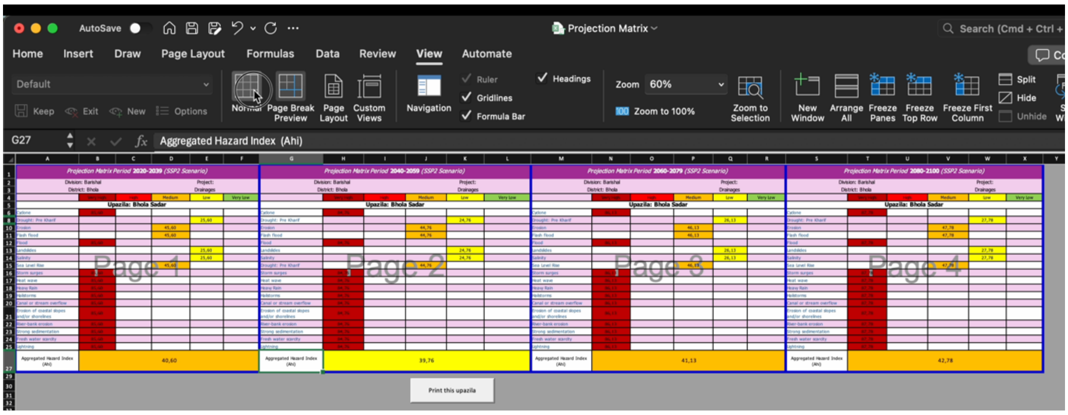


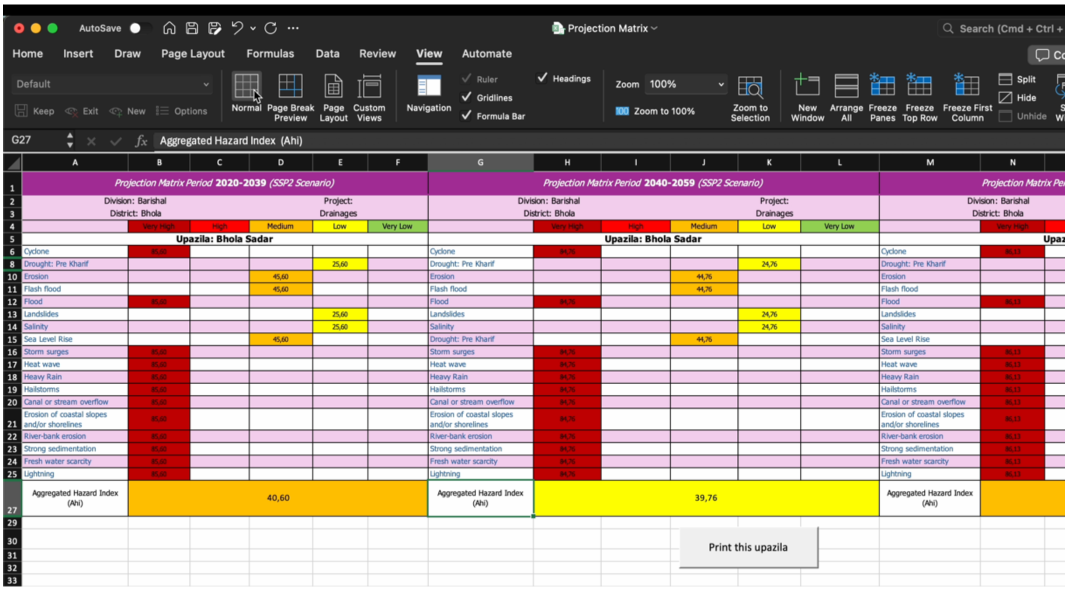




d) Returning to Normal View

- When you're done adjusting, go back to the View tab.
- Select Normal to return to the regular worksheet view.





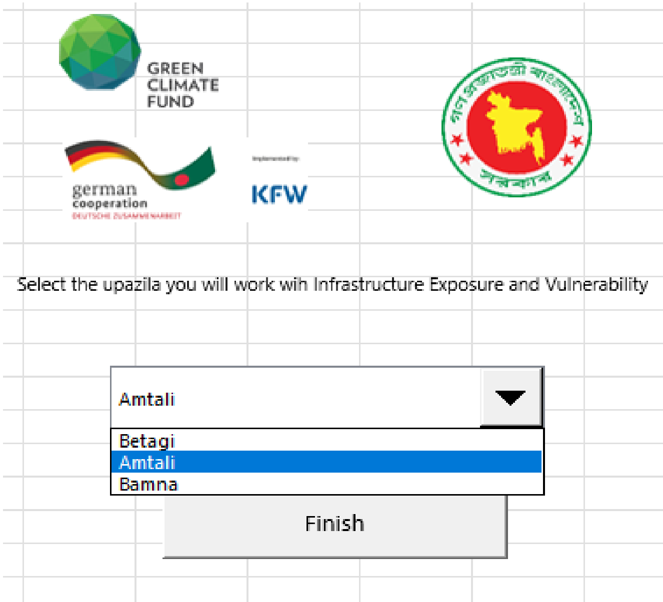
Step 2. Assessing Infrastructure Exposure and Vulnerability

2.1 This step has two objectives:

→ First, to assess the probabilistic exposure of the infrastructure, through the potential damage or loss that an infrastructure could experience if exposed to a hydrometeorological hazard at its location.

→ Second, to estimate the vulnerability of the infrastructure by identifying technical failures and/or omissions that could lead to likely damage and loss to the infrastructure when exposed to severe hazard hydrometeorological event.

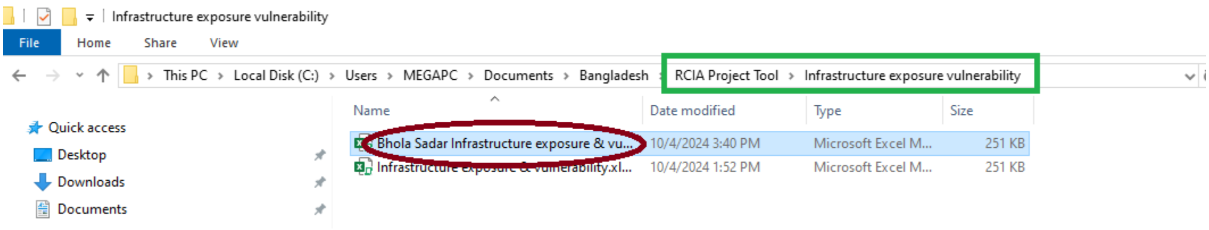
2.2 The following step is to select the upazila where the exposure and vulnerability of the proposed infrastructure will be assessed and estimated. To do this, go to the ***'Launch'*** tab in the ***'Projection matrix'*** and select one of the upazilas from the list in your RCIA project.



2.3 Note that the exposure and vulnerability assessment and estimation process needs to be carried out separately for each upazila. This is because each upazila has different hazard characteristics and therefore a different AHi, which will affect the exposure and vulnerability analysis.

2.4 Once you have selected the upazila, click on the 'Finish' button and the CT will create an Excel file with the name of the upazila you have selected into the 'Infrastructure Exposure and Vulnerability' folder.

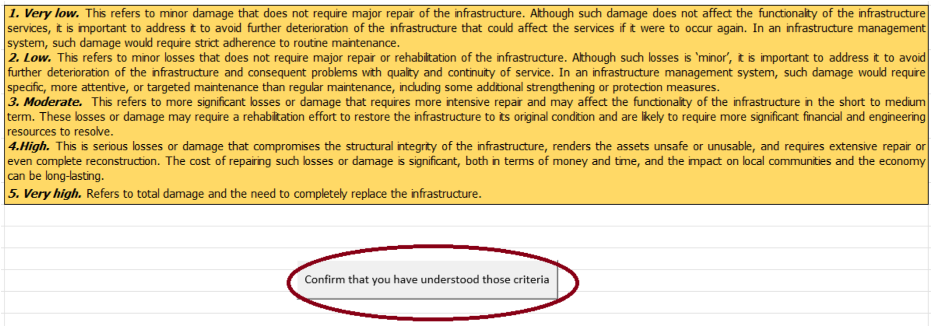
2.5 Go to the folder and open the created Exposure and Vulnerability Excel file with the name of the corresponding upazila.



2.6 When you open the file, you will be presented with a text with standard criteria to consider when classifying the level of exposure and vulnerability. These criteria are:

1. ***Very low.*** This refers to minor damage that does not require major repair of the infrastructure. Although such damage does not affect the functionality of the infrastructure services, it is important to address it to prevent further deterioration of the infrastructure that could affect the services if it happens again. In an infrastructure management system, such damage would require strict routine maintenance.
2. ***Low.*** This refers to minor losses that does not require major repair or rehabilitation of the infrastructure. Although these losses are 'minor', it is important to address them to avoid further deterioration of the infrastructure and consequent problems with quality and continuity of service. In an infrastructure management system, such damage would require specific, more attentive, or targeted maintenance than regular maintenance, including some additional strengthening or protection measures.
3. ***Moderate.*** This refers to more significant losses or damage that requires more intensive repair and may affect the functionality of the infrastructure in the short to medium term. These losses or damage may require a rehabilitation effort to restore the infrastructure to its original condition requiring more substantial financial and engineering resources.
4. ***High.*** This refers to serious losses or damage that compromises the structural integrity of the infrastructure, making it unsafe or unusable, and requires extensive repair or even complete reconstruction. The cost of repairing such losses or damage is significant, both in terms of money and time, and the impact on local communities and the economy can be long-lasting.
5. ***Very high.*** Refers to total damage and the need to completely replace the infrastructure.

2.7 Once you have carefully reviewed these criteria and are sure that you understand them, click on the '**Confirm**' button.



2.8 In the main space of the screen, the CT will display the Excel matrix Infrastructure Exposure & Vulnerability Assessment and **five tabs**:

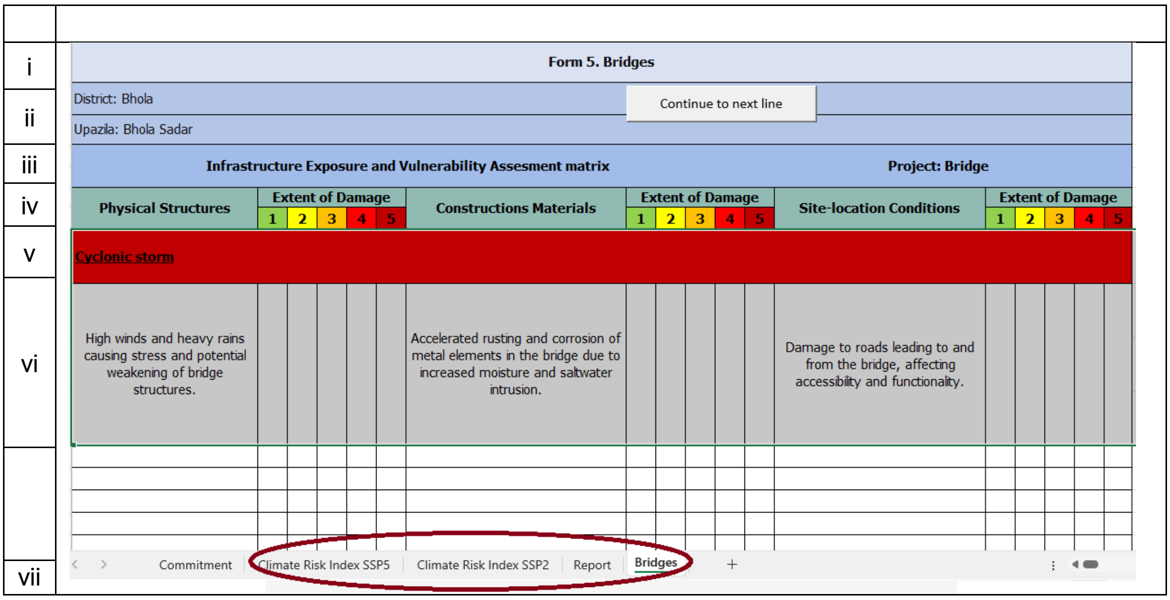
i. Type of infrastructure tab.

ii. Commitment tab

iii. Report tab

iv. Climate Risk Index for SSP5 tab

v. Climate Risk Index for SSP2 tab.



i. The first row describes the type of infrastructure being assessed.

ii. The second row describes the district and upazila where the infrastructure exposure and vulnerability assessment is being conducted.

iii. The third row describes the exposure and vulnerability being assessed and as well as the type of infrastructure system.

iv. The fourth row describes the infrastructure component being assessed: physical structure, construction materials and site conditions. There are also 5 levels of damage severity.

v. The fifth row shows the type of hydrometeorological event and indicates the magnitude of the event by colour. More hazardous events are displayed below as you progress through your analysis.

vi. The sixth row describes the likely damage that could occur if the described hydrometeorological event were to affect the infrastructure. In the boxes on the right, you can rate the level of damage that could occur according to the standard criteria described above.

2.9 Once you have reviewed the matrix and are confident that you understand its structure, proceed with the analysis by following the procedure below:

i. Start by looking at the type of hydrometeorological event and its magnitude.

ii. Then, working from left to right (physical structure, building materials and then site conditions), carefully read the damage scenario presented.

iii. Using your engineering knowledge and experience, rate the level of damage that could occur by placing an 'X' in the appropriate box according to the level of damage. When entering an "X", the cell will automatically change to the corresponding colour.

Form 5. Bridges

District: Bhola | Continue to next line

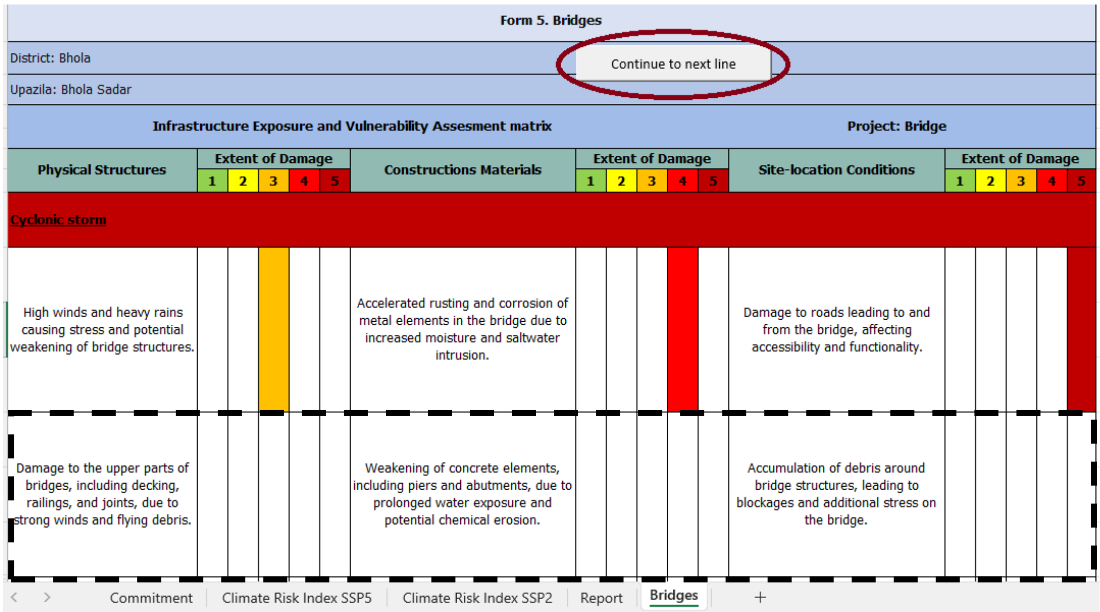
Upazila: Bhola Sadar

Infrastructure Exposure and Vulnerability Assesment matrix | **Project: Bridge**

Physical Structures	**Extent of Damage**					**Constructions Materials**	**Extent of Damage**					**Site-location Conditions**	**Extent of Damage**				
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Cyclonic storm																	
High winds and heavy rains causing stress and potential weakening of bridge structures.						Accelerated rusting and corrosion of metal elements in the bridge due to increased moisture and saltwater intrusion.						Damage to roads leading to and from the bridge, affecting accessibility and functionality.					

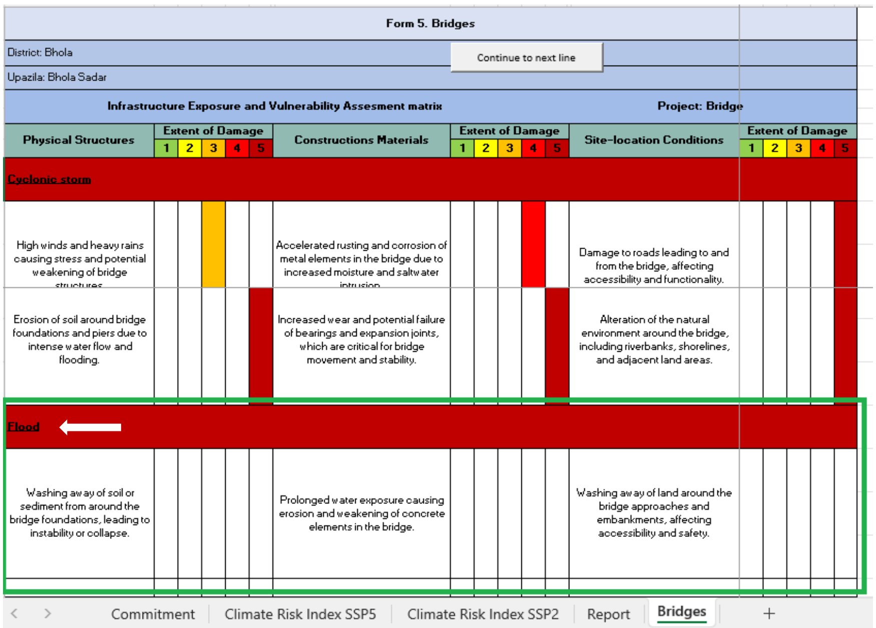
Commitment | Climate Risk Index SSP5 | Climate Risk Index SSP2 | Report | Bridges | +

2.10 Once you have completed this initial analysis, you should continue the analysis by clicking on the ***'Continue to next line'*** button and a new line of analysis will be displayed.



2.11 Continue analyzing and classifying the damages by hydrometeorological event. When the exposure and vulnerability analysis for a particular hazard type has been completed, the system will inform you that ***you have reached the last row for that hazard***. Proceed to the next hazard by clicking on the ***'Next Hazard'*** button

2.12 Clicking the 'Next Hazard' button will execute the first line of the next hazard.



2.13 Continue with 'Next line' and 'Next hazard' until the assessment is complete.

2.14 When you have completed the E&V assessment for the selected upazila, you should continue with the E&V assessment for the next upazila, repeating the above steps as many times as there are upazilas included in your RCIA project.

2.15 You can generate an E&V assessment report for each upazila. This option is available in the 'Report' tab. In this report you will find a unit estimate of the exposure and vulnerability index of the infrastructure system, given the magnitude of the hydro-meteorological hazard in the upazila where the existing infrastructure system is located or where the new infrastructure system is expected to be located.

Step 3. Probabilistic Infrastructure Risk Index.

3.1 This step measures the probability of experiencing a certain level of infrastructure damage or loss due to hydrometeorological events.

3.2 The risk index is obtained by averaging the hazard index and the combined exposure & vulnerability index of the infrastructure.

3.3 For upazilas with a low or very low risk index, the CCIA is not mandatory.

3.4 For upazilas with moderated risk index, it is recommended that a CCIA is carried out, or at least incorporate adaptation measures. After these measures are applied, the RCIA should be repeated to ensure that the risk index has been reduced.

3.5 For upazilas with a high or very high-risk index, it is mandatory to continue with the CCIA.

Go directly to CCIA		Is recommendable to conduct a CCIA or adaptation measures,	No need to go to CCIA	
Very high	High	Moderated	Low	Very low

3.6 For the design of adaptation measures it is recommended to consult the 11 adjusted LGED Guidelines with their proposed technical solutions for climate change:

1) Climate Resilient Rural Roads handbook
2) Guidelines for the implementation of the rural roads and culverts maintenance program
3) Guidelines for Bridge Design
4) Technical Specifications for Bridges and Upazila and Union Roads
5) Technical Specifications for Buildings
6) Building Design Guidelines for LGED
7) Operation and Maintenance Handbook
8) Guideline for operation and maintenance CSP
9) Municipal Infrastructure Design Handbook
10) Detailed design of SP structures for SSWRD
11) Operations and maintenance for SSWRD

In addition, two separate manuals are updated with climate recommendations and drawings:

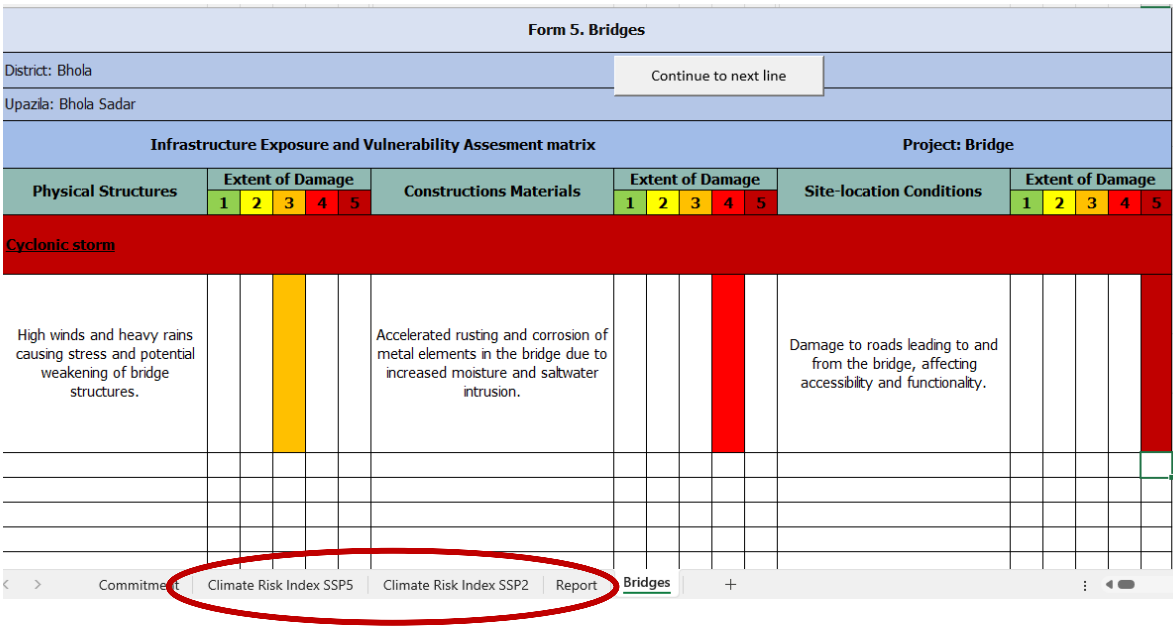
12) Revised Design and Cost Estimate for Climate Resilient Urban and Rural Upazila and Union Road (Type-5 and Type-8).
13) Designs Relevant to Infrastructure Measures, Part A: Revised Design and Cost Estimate for Climate Resilient LGED Bridges & Culvert, and Cyclone Shelter or Buildings.

To generate the risk index report

3.7 Go to the Climate Risk Index SSP5 or Climate Risk Index SSP2 tab of the calculation tool. These tabs display the 'Climate Risk Index', which is calculated dynamically and in real time as the assessment is carried out.

3.8 Select the 'Report' tab, The calculator will display the results for the selected upazila.

3.9 You can save the report in a folder called ***'save to report'***.

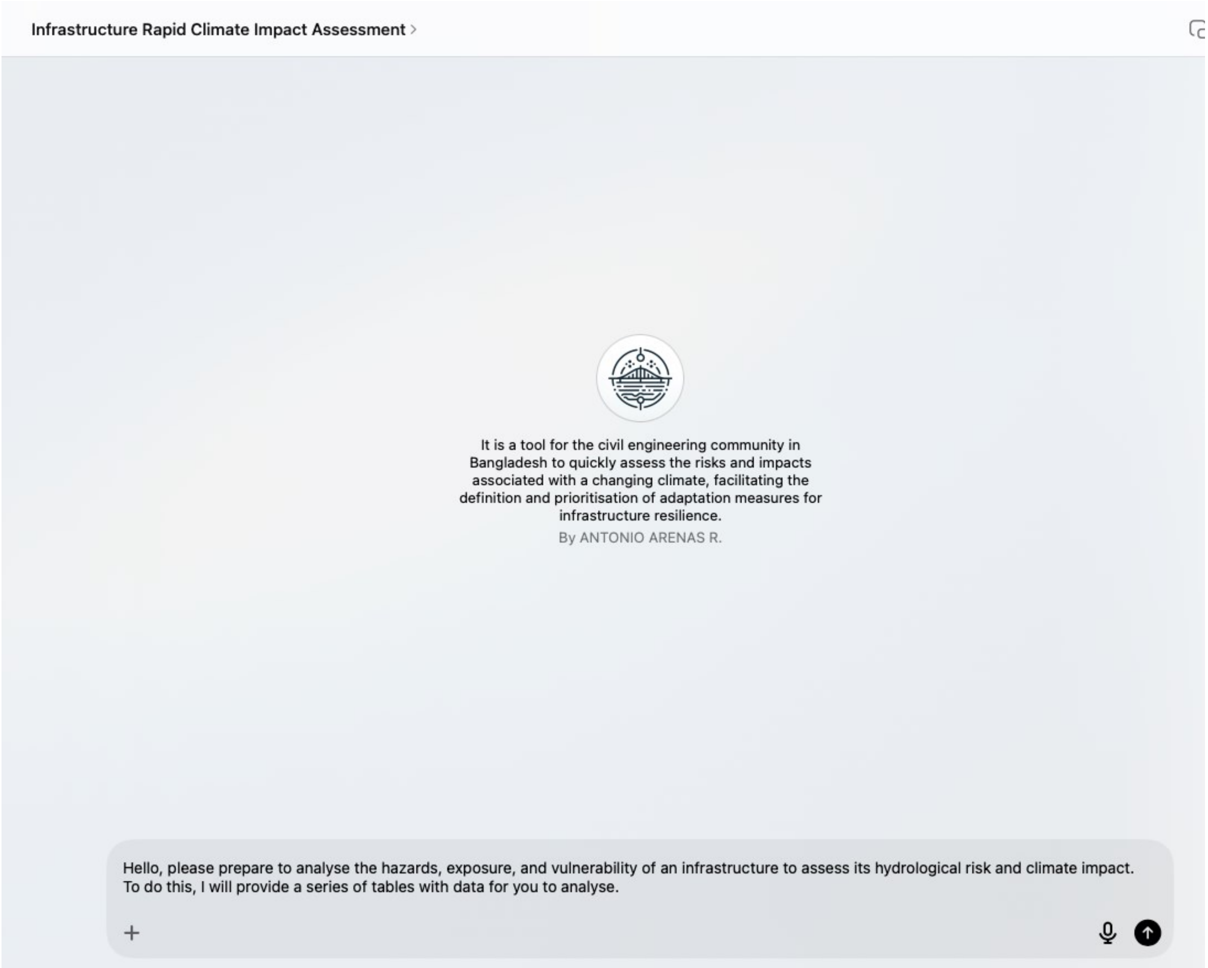


Form 5. Bridges																	
District: Bhola																	
Upazila: Bhola Sadar																	
Infrastructure Exposure and Vulnerability Assesment matrix												Project: Bridge					
Physical Structures	Extent of Damage					Constructions Materials	Extent of Damage					Site-location Conditions	Extent of Damage				
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Cyclonic storm																	
High winds and heavy rains causing stress and potential weakening of bridge structures.						Accelerated rusting and corrosion of metal elements in the bridge due to increased moisture and saltwater intrusion.						Damage to roads leading to and from the bridge, affecting accessibility and functionality.					

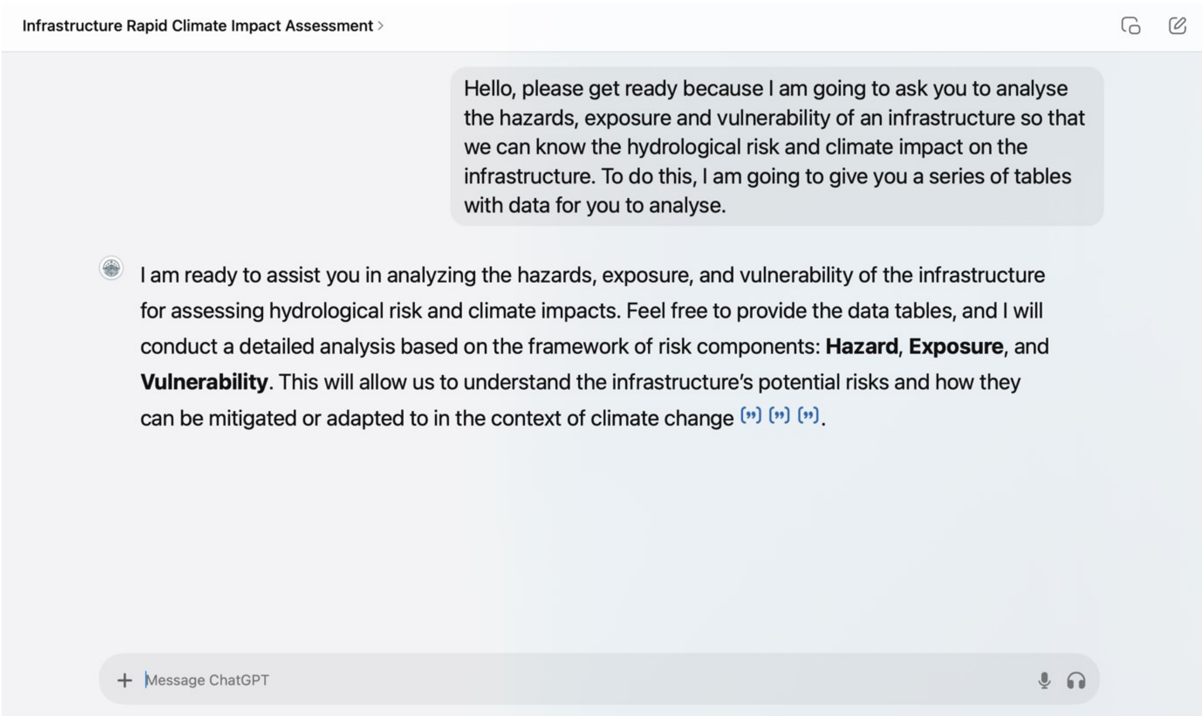
Step 4. General report supported by the RCIA/GPT

1. Open your web browser and paste the following address: https://chatgpt.com/g/g-T0B7rBGfc-infrastructure-rapid-climate-impact-assessment
2. The RCIA/GPT Wizard will open. Copy and paste the following preparation instructions:

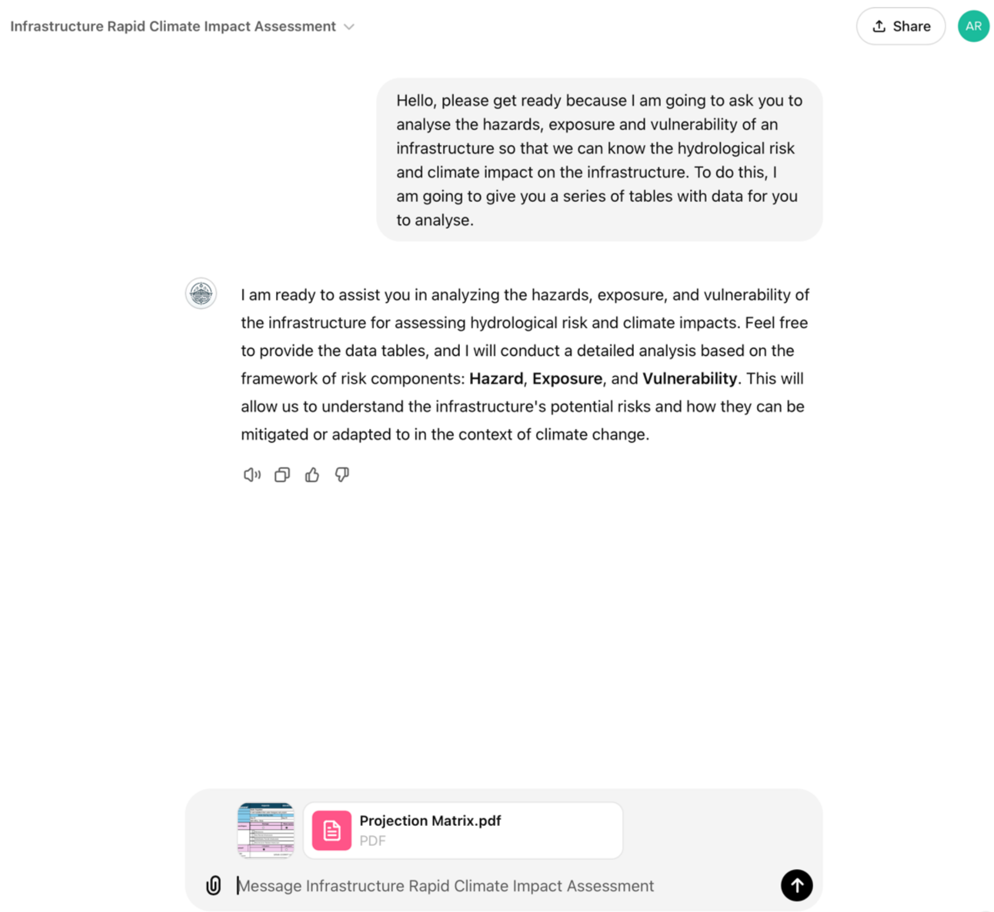
   Hello, please prepare to analyse the hazards, exposure, and vulnerability of an infrastructure to assess its hydrological risk and climate impact. To do this, I will provide a series of tables with data for you to analyse.



3. Then, click on the arrow (highlighted by the red circle in the image) and the RCIA/GPT will start the chat.



4. Next, locate Form 1 (Infrastructure Description) and the Projection Matrix (with all SSP2 and SSP5 tables in one pdf file), to start the Hazard Assessment Analysis.
5. Select the file and drag it into the GPT. Do this for each file and be sure that the file has been accepted by the GPT.



6. After uploading both files (infrastructure description and projection matrix), copy and paste the following text into the GPT dialogue box. Make sure that the yellow box is filled in with the correct text.:

Step 1. Hydrometeorological Hazard Assessment Analysis for Infrastructure
I have provided a document titled "(insert file name and extension e.g., "Hazard Projection.pdf")" that describes the infrastructure to be assessed for hydrometeorological hazards, and another document titled "(insert file name and extension,)" which provides a table-based assessment of hydrometeorological hazards the infrastructure may face. These hazards are projected in 20-year intervals from 2020 to 2100, using climate change scenarios SSP2 and SSP5.

The tables contain numerical values in certain cells, which were identified by experts. These values represent the **Weighted Infrastructure Hazard Index (ihi)**. This index shows the relationship between the severity of hydrometeorological events (classified as very high, high, medium, low, and very low) and their importance for the infrastructure being evaluated. This relationship is represented by:

ihi=(s)×(i)100ihi=100(s)×(i)

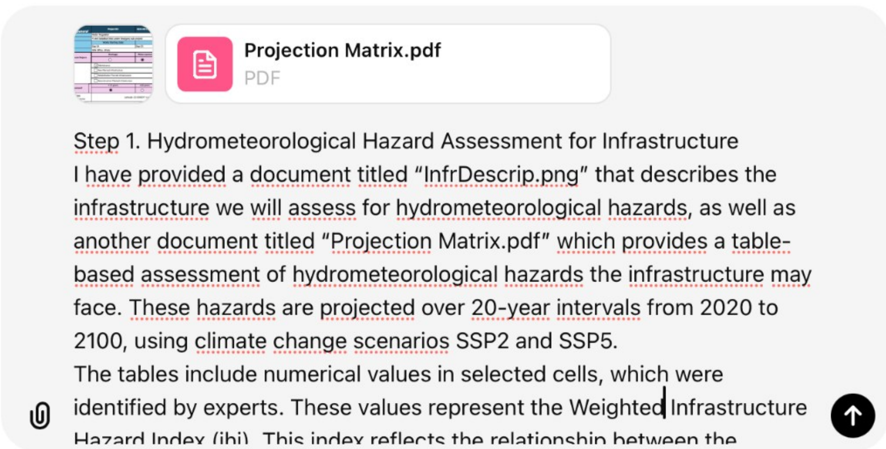
Where:

- **ihi** = Weighted Infrastructure Hazard Index
- **s** = severity of the hydrometeorological event
- **i** = importance for the infrastructure
- **100** = conversion factor to percentage

Please complete the following actions:

1. Based on your knowledge, analyze the data in each of the tables.
2. Compare the SSP2 and SSP5 scenarios presented in the tables.
3. Examine each hazard marked as medium, high, or very high.
4. Proceed to describe the analysis in a way that is **precise**, **relevant**, **significant**, and **coherent**:
    - **Precise**: Provide specific, clear, and accurate details, avoiding ambiguities to ensure the information accurately reflects the reality or object being described. Precision focuses on conveying concrete data that allows for a complete and accurate understanding of the matter at hand.
    - **Relevant**: Ensure that the description is appropriate and fitting for the specific situation or context being addressed.
    - **Significant**: Show the importance of an element in terms of its relationship to the specific context or objective in question.
    - **Coherent**: Reference the internal logic and consistency of an idea, plan, or argument. Coherence means the parts are aligned and work harmoniously together, forming a logical whole.
5. Draw preliminary conclusions focused solely on hydrometeorological hazards in relation to the infrastructure's characteristics.
6. Do not mention Vulnerability, Exposure, Risks, Impact, and Resilience. Also, do not include any recommendations or suggested action

7. Then click on the arrow to start the analysis.



8. The RCIA GPT will search in its knowledge base and generate a preliminary report. Please copy and paste this report into your document.
9. Now proceed with the Exposure and Vulnerability Assessment Analysis. Please locate the Exposure and Vulnerability Matrix file, select it, and drag and drop it into the RCIA/GPT. Then, copy and paste the instructions below. Make sure to enter the correct text in the coloured yellow text before sending the prompt.

Step 2. Exposure and Vulnerability Assessment Analysis.

Now, I've provided a document titled "(insert file name and extension, e.g., vulnerability and exposure.pdf)" containing tables evaluating the exposure and vulnerability of the infrastructure to hazards. The tables highlight different hydrometeorological hazards, with rows coulor-code to show intensity as follow:

- **Dark Red**: very high
- **Light Red**: high
- **Dark Yellow**: medium

For each hazard intensity level, the tables describe the infrastructure's **Exposure**, measured by potential damage levels: very low, low, moderate, high, and very high. This damage analysis is based on the **design of the physical structure, materials, and site conditions**.

Although the tables do not directly describe vulnerability as probable causes of technical or engineering failure that explain the potential damage, estimate this vulnerability or technical cause by extending the exposure analysis tto consider technical causes related to the physical structure, materials and site location conditions based on the knowledge we have provided. Please, refers this analysis as Vulnerability.

With these in mind, proceed with the following actions:

1. Review the structure and logic of all tables and describe your understanding of them.
2. Using your knowledge, analyse the data and explain how each hydrometeorological event in the tables results in a specific damage level and how this level relates directly to technical causes of damage or failure, with attention to their significance.
3. Describe your analysis with precision, relevance, significance, and coherence, making reference to the physical structure, materials, and site conditions.
4. In the analysis, explain how damage reflects **Exposure** and how the technical causes of damage reflects **Vulnerability**.
5. Draw preliminary conclusions focused solely on the infrastructure's exposure and vulnerability.
6. Present your conclusions as probabilistic Exposure and Vulnerability scenarios.
7. Avoid references to Risks, Impact, and Resilience in both analysis and conclusions.
8. Avoid recommendations on actions to take and disregard adaptation options.

10. Then, click on the GPT arrow to launch the prompt, and the RCIA/GPT will search its knowledge base to analyse the request and generate the analysis output. Please copy and paste this report in your document.

11. Let´s continue with the Risk Assessment Analysis. Please locate the Risk Assessment file, select it, and drag and drop it into the RCIA/GPT. Then copy and paste the instructions below. Make sure to enter the correct text in the yellow box before sending the prompt.

Step 3. Risk Assessment Analysis.

1. Analyze the structure of the tables for the SSP2 and SSP5 scenarios contained in the document titled "(insert file name and extension, e.g., "Risk.pdf")" and describe your analysis as an introduction.
2. From the SSP2 and SSP5 tables, analyze the items:
   - **Aggregated Hazard Index by Upazila (AhiU)**
   - **Weighted Index of Infrastructure Exposure by Upazila**

- **Weighted Index of Infrastructure Vulnerability by Upazila**
- **Infrastructure Risk Climate Index**

3. Describe each item with precision, relevance, significance, and coherence, emphasizing implications for the infrastructure under evaluation.
4. In your analysis, consider only the period that encompasses the infrastructure's lifespan.
5. To enrich the findings and conclusions from the risk analysis, combine the findings from **Step 1**(Hydrometeorological Hazard Assessment for Infrastructure) and **Step 2** (Exposure and Vulnerability).
6. In this combined analysis, rigorously and coherently apply the **IPCC Risk and Impact Model** for each scenario, SSP2 and SSP5.
7. Describe this combined analysis and its conclusions, emphasizing the **IPCC Risk and Impact Model**, framing it as a probabilistic risk and impact scenario.
8. Avoid references to Resilience.
9. Avoid recommendations on actions to take.
10. Do not consider adaptation options.
11. Avoid references to resilience, risk reduction, or adaptation measures.

12. Click on the GPT arrow to la lunch the prompt, and the RCIA/GPT will search in its knowledge base to analyse the request and generate the analysis output. Please copy and paste this report in your document.
13. Finally, to request technical adaptation options from RCIA GPT for your consideration and decision, copy and paste the following prompt.

Step 4. Proposal of Adaptation Measures

Based on your knowledge and the conclusions from **Step 1** (Hydrometeorological Hazard Assessment for Infrastructure), **Step 2** (Exposure and Vulnerability), and **Step 3** (Risk Analysis), proceed with the following actions:

1. Review your knowledge and analyze the adaptation options described there while also considering your understanding.
2. Describe the adaptation options analysis and prioritize measures as **unavoided**, **recommended**, and **desirable** to increase the infrastructure's climate resilience during its lifespan.
3. Note that some mandatory, recommended, and desirable measures may be implemented at different points during the infrastructure's lifespan, given the increasing hazards, exposure, and/or vulnerability over time.
4. In your proposal, consider a combination of **nature-based solutions**, **green, blue, and grey engineering**, as well as measures based on **early warning systems** and the **disaster management cycle** (preparation and response, emergency rehabilitation, and reconstruction).

14. Then click on the GPT arrow to launch the prompt. The RCIA/GPT will search in its knowledge base to analyse the requestand generate the analysis output. Please copy and paste this report in your document.

This is the end of the process. Congratulation!

ANNEX 1: the RCIA – CT methodology explained

The calculation methodology and the conceptual assumptions on which the tool is based are presented below, with the aim of incorporating modifications as appropriate as knowledge and experience in the application of the RCIA progresses,

1. Methodologically, the RCIA is designed to provide an overview of the likely effects of hydrometeorological events on infrastructure, driven by climate signals, and based on this to estimate the magnitude of likely damage and a climate risk index for infrastructure,
2. This climate risk assessment is in turn based on a hazard, exposure and vulnerability assessment, integrating both quantitative and qualitative analysis, This mixed approach provides a more complete and accurate understanding of the risks, The process involves normalising data to ensure comparability between different variables, weighting each variable according to its relevance in the risk context, and classifying results into standardised classes that facilitate interpretation and prioritisation of adaptation actions,
3. The idea of normalisation, weighting and ranking in climate risk assessment is supported by several reviewed documents in the literature:
    i. Data normalisation (or standardization). In the risk assessment process, it is common to transform variables to make them comparable, This is achieved through normalisation, For example, the Guide to Detailed Climate Risk Analysis describes how variables can be normalised through techniques such as the use of z-scores to standardise variables and ensure they are comparable on the same scale,
    ii. Weighting variables. Assigning weights to different indicators is an important step in aggregating results, It is mentioned that these weights can be equal or differentiated according to the relevance of each indicator, allowing for a more accurate assessment of sensitivity and adaptive capacity, The Guidance on Assessing Risks Associated with Climate Change also stresses the importance of consensus weighting among stakeholders to adequately reflect risks and prioritise actions,
    iii. Classification of results. After normalisation and weighting, classification of results into standardised classes facilitates interpretation and prioritisation, Categories such as 'low', 'medium' and 'high' are used to describe the level of risk, allowing for a complementary qualitative assessment of climate risk,
4. The CT collects information on the type and magnitude level of hazards for each upazila as defined in the DRIP. This information is stored in a CT database and is automatically displayed in the RCIA assessment project.

Normalization and classification,

5. The Disaster Risk Information Protocol (DRIP) classifies the magnitude of a hazard into 5 categories on a scale of 1 to 5, where 1 represents a very low level of hazard and 5 represents a very high level of hazard. This ordinal classification is widely used in risk assessment systems as it provides a clear and simple way of categorising levels of hazard,
6. However, the RCIA/CT has adapted this classification into a more detailed scale from 0 to 100, which allows greater precision in the measurement and comparison of risks and facilitates the integration of hazard, exposure and vulnerability into a standardised, comparable scoring system,
7. In addition, this approach establishes a midpoint that helps to distinguish between intermediate levels of hazard and is the value to be considered in the calculation process.

This distinction is critical for prioritising which infrastructure needs the most attention in terms of disaster risk reduction and climate change adaptation,

8. The following table shows the normalization and the new normalized values of the hazards magnitudes to be used in the RCIA/CT.

Normalization table			
DRIP		**RCIA/CT**	
Classification	Scale	Ranges of normalization	Normalized hazard magnitudes used in the RCIA/CT
Very low	1	0 to 19	10
Low	2	20 to 39	30
Moderate	3	40 to 59	50
High	4	60 to 79	70
Very high	5	80 to 100	90

RCIA/CT Hazard Magnitude Normalized Values				
Very high Value: 90	High Value: 70	Medium Value: 50	Low Value: 30	Very low value: 10

9. The purpose of standardising the 0-100 scale is to ensure that the three main components of climate risk analysis - hazard, exposure and vulnerability - can be measured in a proportional and consistent manner. This improves the accuracy and applicability of risk calculations and classifications across different types of infrastructure, such as roads, bridges, urban drainage systems and water supply networks,

10. This normalisation also allows a more direct comparison between different infrastructure exposed to different hydrometeorological hazards, as recommended by climate risk assessment guidelines and international protocols such as PIEVC. This approach helps engineers to prioritise mitigation and adaptation strategies, thereby optimising decision-making in the face of climate risks,

Weighting variables,

11. Since hydrometeorological events have different effects on a community, a crop or infrastructure (such as bridges, roads, buildings, urban drainage and water systems), the CT assigned weights to the different hydrometeorological hazards according to their importance to the infrastructure. This idea is supported by the documentation reviewed and described in the literature.

12. In particular, the Guide for the Detailed Analysis of Climate Risk (CAF 2019) mentions the different impacts that climatic events such as torrential rain, extreme temperatures, eCT, can have on infrastructure. These hazards are analyzed and weighted according to their specific impact on different types of infrastructure, such as bridges, roads, drainage systems, eCT.

13. It also emphasises the need to adapt infrastructure design and planning measures to the magnitude of the hydro-meteorological hazards, i,e, to give priority to those which pose the greatest risk to the continuity and safety of the infrastructure.
14. As hydrometeorological events affect infrastructure differently, it is important to assign a specific weight to each type of hazard according to the level of hazard it represents, To facilitate this assessment, we have estimated weights for each hydrometeorological hazard based on its effects on key infrastructure such as roads, bridges, buildings, urban drainage systems and small water systems, These weights help us to prioritise protection and adaptation measures more effectively.

Hydrometeorological Hazard	Weight	Justification
Cyclone	95	Cyclones cause widespread damage, particularly in coastal areas, affecting infrastructure like roads, bridges, and buildings
Drought	40	Droughts have a moderate impact, especially on water systems and agriculture, but less on physical infrastructure
Erosion	60	Erosion, especially riverbank and coastal, affects roads, bridges, and buildings near water bodies
Flash Flood	80	Flash floods cause significant damage to urban areas and transportation infrastructure like roads and drainage systems
Flood	100	Flooding is the most frequent and destructive hazard, severely impacting all types of infrastructure
Landslides	50	Landslides, though localized, can be devastating to mountainous roads and bridges
Salinity	50	Salinity affects water systems and agricultural infrastructure in coastal areas, especially due to sea level rise
Sea Level Rise	70	Rising sea levels exacerbate coastal erosion and flooding, threatening coastal infrastructure and urban drainage systems
Storm Surges	95	Storm surges, often associated with cyclones, cause severe coastal flooding and infrastructure damage
Heat Wave	50	Heat waves stress water supply systems and urban infrastructure but have less impact on physical structures
Heavy Rain	90	Heavy rainfall frequently leads to urban flooding, overwhelming drainage systems and causing road damage
Hailstorms	20	Hailstorms are rare and cause limited localized damage to buildings and agriculture, not major infrastructure

Canal or Stream Overflow	80	Frequent overflow of streams and canals causes damage to roads and urban drainage systems
Erosion of Coastal Slopes	60	Coastal erosion is accelerated by rising sea levels, threatening coastal infrastructure
River-bank Erosion	50	Riverbank erosion affects roads and bridges along rivers, causing long-term infrastructure degradation
Strong Sedimentation	40	Sedimentation impacts water bodies and canals, reducing their capacity and leading to overflow
Fresh Water Scarcity	60	Water scarcity stresses urban water systems and agricultural infrastructure, especially during droughts
Lightning	30	Lightning causes localized damage, mainly affecting electrical and communication infrastructure

15. The weights for hydrometeorological hazards were determined using a multi-step process that considered the specific characteristics and impacts of each hazard on critical infrastructure in Bangladesh. This approach ensures that the weights accurately represent the relative importance of each hazard in terms of potential damage to roads, bridges, buildings, urban drainage systems, and water supply networks.
16. The process involved a combination of historical data analysis, evaluation of the frequency and intensity of events, assessment of the vulnerabilities specific to Bangladesh's infrastructure, and expert judgment. These weights are crucial for engineers to prioritize effective mitigation and adaptation strategies.
17. Here's how the weights were assigned:

i. Understanding Hazard Impact and Frequency

- First, we reviewed historical data on climate-induced damage to infrastructure in Bangladesh, including reports on floods, cyclones, and other events, For example, flooding is known to be the most frequent and destructive hazard, causing major damage to roads, drainage systems, and buildings (SpringerOpen, ArcGIS StoryMaps),
- Some hazards, such as cyclones and floods, occur frequently and with high intensity, leading to severe damage, Therefore, they were assigned higher weights, e,g,, Flood: 100, Cyclone: 95,

ii. Severity of Infrastructure Damage

- Different types of infrastructure (e,g,, roads, bridges, drainage systems) react differently to specific hazards, For instance, flash floods and heavy rain can quickly overwhelm urban drainage systems, leading to severe urban flooding, hence these hazards received high weights, e,g, Heavy Rain: 90, Flash Flood: 80, (ArcGIS StoryMaps),
- Hazards like riverbank erosion and sea level rise may cause slower, but still significant, damage to coastal and riverine infrastructure, This leads to moderate but important weights, e,g,, Riverbank Erosion: 50, Sea Level Rise: 70 (SpringerOpen),

iii. Context-Specific Adjustments

- The weights were further adjusted by considering local vulnerabilities, For example, salinity intrusion is a serious issue in coastal regions of Bangladesh, particularly affecting water supply systems, Thus, salinity was given a higher weight (Salinity: 50) than in regions where this issue is less critical (ICCCAD[2]),

- Bangladesh experiences certain hazards more intensively, like storm surges and coastal erosion, which have devastating effects on coastal infrastructure, These factors were incorporated into the weighting system based on their relevance to the region (SpringerOpen and ICCCAD).

iv. Balancing Between Direct and Indirect Impacts

- Some hazards, like cyclones and flash floods, cause immediate and visible damage to infrastructure, such as the destruction of roads and bridges. These hazards were assigned higher weights.
- Others, like drought and heat waves, have less direct but still important impacts, particularly on water scarcity and longer-term degradation of infrastructure, Hence, their weights were moderate, e,g,, Drought: 40, Heat Wave: 50, (ICCCAD).

Calculation process

18. The calculation process starts with Form 2, which is filled in automatically using the hazard data from the DRIP system stored in the CT database, The process carried out by the CT is as follows:

i. The CT normalises the DRIP data according to the normalisation table explained in point 8, This process takes place in formulation 2.

ii. Form 2 contains simple formula cells which combine the weight assigned to each hydrometeorological hazard with the normalised value of the hazard magnitude obtained from the DRIP. The CT automatically applies the formula in the corresponding cell and calculates a new value, this time normalised and weighted, representing the hazard magnitude of the hydrometeorological event to the infrastructure.

iii. The normalisation and weighting formula used is: (WHv×HMv)/100.

iv. Where:

- WHv is the weighted hazard value.
- HMv is the normalised hazard value.
- 100 is the normalisation factor[3].

[2] ICCCAD is a three-way partnership between the Independent University, Bangladesh (IUB), Bangladesh Centre for Advanced Studies (BCAS) based in Dhaka and the International Institute for Environment and Development (IIED) in London, UK,

[3] The 'percentage normalization factor' refers to a calculation that adjusts the values of several variables with respect to a reference so that they can be compared on the same scale. For example, in climate data analysis, this factor can be applied to normalize intensity-duration-frequency (IDF) curves from current and projected climate data, adjusting these values to make future projections consistent with current conditions. Specifically, it is used in simulations to project climate change scenarios using an adjustment factor calculated from the differences between reference and projected periods. This procedure is essential for analyzing the differences between future scenarios and the current behavior of a system, thus facilitating the simulation and analysis of possible adaptation or risk management measures.

19. Form 2 below shows how the Weighted Hazard Value (WHv) is combined with the Normalised Hazard Value (HMv). The CT recognises the cell that has been activated with the DRIP data and executes the formula in the corresponding cell.

Hazard Variable	Weighted hazard value (WHv)	Form 2, Normalised value of the hazard magnitude (HMv)				
		Very high Value: 90	High Value: 70	Medium Value: 50	Low Value: 30	Very low Value: 10
Cyclone	95	95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
Drought	40	40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
Erosion	60	60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
Flash flood	80	80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
Flood	100	100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
Landslides	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Salinity	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Sea Level Rise	70	70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
Storm surges	95	95x90/100	95x70/100	95x50/100	95x30/100	95x10/100

20. It should be noted that the DRIP data are intended for general use and are not specific to the design of an infrastructure system. In addition, they are at a low level of detail compared to the level of detail required for the hazard assessment of an infrastructure system, For this reason, the RCIA includes a Form 3, which contains the same hydrometeorological variables as those assessed in the DRIP, which are to be re-assessed by direct observation in the field.
21. In addition, form 3 contains other hydrometeorological variables that are important for assessing the hydrometeorological hazard in the field. Therefore, this Form 3 should be completed after a detailed site survey of the infrastructure system location by conducting a technical inspection of the site, During the technical inspection, the engineer in charge should complete Form 3 by marking an 'X' in the appropriate cell to indicate the level or magnitude of the hazard to the infrastructure system.
22. Once the 'X' has been marked in the appropriate cell, the CT shall assign a value to that cell using the same weighted and normalised calculation procedure as explained for Form 2.
23. Form 3 below shows how the Weighted Hazard Value (WHv) is combined with the Normalised Hazard Value (HMv), The CT recognises the cell that has been activated with the "X" mark and executes the formula in the corresponding cell.

Form 3. Hazard assessment of the planed site-location of planed infrastructure						
Division: Barishal District: Barguna Upazila: Amtali						
Hazard Variable	Weighted hazard	Normalised value of the hazard magnitude (HMv) based on field observations,				
		Very high	High	Moderate	Low	Very low

	value (WHv)	Value: 90	Value: 70	Value: 50	Value: 30	Value: 10
Cyclone	95	95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
Drought	40	40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
Erosion	60	60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
Flash flood	80	80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
Flood	100	100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
Landslides	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Salinity	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Sea Level Rise	70	70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
Storm surges	95	95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
Heat wave	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Heavy Rain	90	90x90/100	90x70/100	90x50/100	90x30/100	90x10/100
Hailstorms	20	20x90/100	20x70/100	20x50/100	20x30/100	20x10/100
Canal or stream overflow	80	80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
Erosion of coastal slopes and/or shorelines	60	60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
River-bank erosion	50	50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
Strong sedimentation	40	40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
Fresh water scarcity	60	60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
Lightning	30	30x90/100	30x70/100	30x50/100	30x30/100	30x10/100

24. Integration Matrix. Once Forms 2 and 3 have been completed for each upazila, the CT generates a matrix that integrates these two forms to estimate the Aggregated Hazard Index (AHi) of the infrastructure system.
25. This process checks for differences in the common variables between the DRIP data and the data collected in the field. If there are differences, the CT calculates an average. If there are no differences, the CT proceeds to generate the integration matrix and calculates the weighted hazard index (WHi)[4] for each hydrometeorological variable according to the normalised magnitude, a value that will be implicit in each active cell in the matrix.
26. This WHi expresses the relationship between the magnitude of the hazard, the type of event and the importance of this hydrometeorological event for the infrastructure system.

[4] It is calculated as a normalized percentage.

This relationship is established using the following formula: WHi = WHv x HMv/100, where:

WHi = Weighting Hazar index

WHv = Weighting Hazar value

HMv = Hazard Magnitude value

100 = Is the percentual normalization factor

27. Finally, the CT calculates the aggregate hazard index (AHi). This index is obtained by averaging the values of WHi which is calculated considering only the cell that is activated in the Integration Matrix. An active cell is one that has been selected according to either the DRIP data and/or data from the field.

INTEGRATION MATRIX						
Division: Barishal District: Barguna Upazila: Amtali						
Hazard Variable and weights.		Normalised Magnitude of the hazards				
		Very high **Value: 90**	**High** **Value: 70**	**Medium** **Value: 50**	**Low** **Value: 30**	**Very low** **Value: 10**
Cyclone	95	WHi	WHi	WHi	WHi	WHi
Drought: Pre Kharif	40	WHi	WHi	WHi	WHi	WHi
Erosion	60	WHi	WHi	WHi	WHi	WHi
Flash flood	80	WHi	WHi	WHi	WHi	WHi
Flood	100	WHi	WHi	WHi	WHi	WHi
Landslides	50	WHi	WHi	WHi	WHi	WHi
Salinity	50	WHi	WHi	WHi	WHi	WHi
Sea Level Rise	70	WHi	WHi	WHi	WHi	WHi
Storm surges	95	WHi	WHi	WHi	WHi	WHi
Heat wave	50	WHi	WHi	WHi	WHi	WHi
Heavy Rain	90	WHi	WHi	WHi	WHi	WHi
Hailstorms	20	WHi	WHi	WHi	WHi	WHi
Canal or stream overflow	80	WHi	WHi	WHi	WHi	WHi
Erosion of coastal slopes and/or shorelines	60	WHi	WHi	WHi	WHi	WHi
River-bank erosion	50	WHi	WHi	WHi	WHi	WHi
Strong sedimentation	40	WHi	WHi	WHi	WHi	WHi
Fresh water scarcity	60	WHi	WHi	WHi	WHi	WHi

Lightning	30	WHi	WHi	WHi	WHi	WHi
Aggregated Hazard index (AHi)						

28. The WHi and the AHi are valid for the current period up to 2039, as the variations in the rate of climate change calculated for the Extreme Climate Indices rarely exceed 5%, and if they do, the rate of change does not exceed 10%,

Projected hydrometeorological hazard under the SSP5 and the SSP2 climate change scenario,

1. The CT is prepared to make projections of the rate of change of hydrometeorological hazards based on the rate of change of key climate variables that have been processed in the climate database contained in the CT, as it has been provided with a climate database prepared for this purpose.
2. The calculation of the projected rate of change of the hazard level in relation to the rate of change of the climate variables is an estimation made under the assumption that there is a linear relationship between the magnitude of the climate event and the proportional magnitude of a hydrological hazard event.
3. This linear relationship is considered in this methodology because of its simplicity and speed of calculation. However, it is well known that it does not necessarily fully reflect the complexity of the interactions of natural and human systems with the climate system. Its main limitations are:
    a. Natural and human systems often exhibit non-linear behaviour due to the interaction of multiple variables and feedback between them that are not necessarily linear. For example, the relationship between intense precipitation and flood probability may be influenced by factors such as previous soil saturation and/or land use (due to population dynamics and expansion of human settlements), topography and vegetation conditions.
    b. Extreme events may not scale linearly with changes in average variables. For example, a small increase in global temperature may lead to a disproportionate increase in the frequency and intensity of heat waves.
4. However, for a rapid analysis of climate impacts on infrastructure, and for deciding whether (or not) to undertake a more comprehensive analysis of the risk of loss and damage to infrastructure, the assumption and its limitations are correct if and only if, it is taken in this referential context.
5. The projection Matrix for SSP2 and SSP5 scenario (*RCC is the Rate of Climate Change, normalized as percentage*):

Fig. 4. Example of the Projection Spreadsheet

Division / District / Upazila					
Hazard Variable (VH)	HAZARD LEVEL				
	Very high Value: 90	**High Value: 70**	**Medium Value: 50**	**Low Value: 30**	**Very low Value: 10**
Cyclone	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Drought	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC

Erosion	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Flash flood	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Flood	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Landslides	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Salinity	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Sea Level Rise	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Storm surges	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Heat wave	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Heavy Rain	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Hailstorms	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Canal or stream overflow	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Erosion of coastal slopes and/or shorelines	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Slope displacement	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Sinking land or subsidence	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
River-bank erosion	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Strong sedimentation	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Fresh water scarcity	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC
Lightning	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC	WHi + RCC

6. The integration matrix made from Form 2 and 3 provides hazard values corresponding to the present time, and since the rate of climate change for the variables of infrastructure interest does not exceed 5%-10%, these hazard values can be projected up to 2039 for the upazilas of Bangladesh.
7. From 2040 onwards, the rate of change of climate variables of engineering interest tends to be higher than 5%-10% in most of the upazilas of the country and thus becomes significant. This is illustrated in the following example projection:

Projection matrix (Fig, 5, Example)											
Projection Matrix Period 2020-2039						**Projection Matrix Period 2040-2059**					
Division: Barishal						Division: Barishal					
District: Barguna						District: Barguna					
	Very high Value: 90	**High Value: 70**	**Medium Value: 50**	**Low Value: 30**	**Very low Value: 10**		**Very high Value: 90**	**High Value: 70**	**Medium Value: 50**	**Low Value: 30**	**Very low Value: 10**
Upazila: Amtali						Upazila: Amtali					
Cyclone	94,95					Cyclone	97,95				
Drought: Kharif				44,95		Drought: Kharif				47,95	

Drought: Pre Kharif			64,95			Drought: Pre Kharif			67,95		
Earthquake				44,95		Earthquake				47,95	
Erosion	94,95					Erosion	97,95				
Flash flood					23,95	Flash flood					26,95
Flood				44,95		Flood				47,95	
Landslides					23,95	Landslides					26,95
Salinity	94,95					Salinity	97,95				
Sea Level Rise		79,95				Sea Level Rise		82,95			
Storm surges		79,95				Storm surges		82,95			
Heat wave	94,95					Heat wave	97,95				
Heavy Rain		79,95				Heavy Rain		82,95			
Hailstorms		79,95				Hailstorms		82,95			
Canal or stream overflow			64,95			Canal or stream overflow			67,95		
Erosion of coastal slopes and/or shorelines					23,95	Erosion of coastal slopes and/or shorelines					26,95
River-bank erosion				44,95		River-bank erosion				47,95	
Strong sedimentation			64,95			Strong sedimentation			67,95		
Fresh water scarcity		79,95				Fresh water scarcity		82,95			
Lightning				44,95		Lightning				47,95	
Weighted Infrastructure Hazard Index (ihi)	29,71					55,89					

CT climate database from 1990 to 2100.

Through detailed analysis of various climate variables, the study highlights the significance of these findings for future planning and adaptation to climate changes, thus offering a crucial framework for evidence-based decision-making.

Step 1: Data Collection

Variable Selection. For the analysis, the following variables were selected based on the 90th percentile, due to their significance in understanding the climate impact on the region:

- Number of Hot Days (Tmax >35°C, >40°C, >45°C)
- Highest Precipitation in 1 Day (in mm)
- Highest Accumulated Precipitation in 5 Days (in mm)
- Number of Days with Precipitation >20mm
- Percent Change in Precipitation
- Sea Level Rise

This selection is based on their relevance in addressing the specific climate challenges of Bangladesh, providing a solid basis for predictive and strategic analysis,

Data Source. The 'Knowledge' portal of the World Bank was used as the primary source, specifically accessing the 'Climate Projection' section for Bangladesh. The 'Average Projections (CMIP6)' data in the SSP5 and SSP2 scenarios were collected by regions, covering a total of eight regions. This source was chosen for its rigor and the comparability of its data, ensuring the reliability of our analysis.

Historical Data and Projections. Historical data from 1990 to 2023 and future projections under the SSP5 and SSP2 scenario for the period 2024-2100 were analysed. **For historical reference for each variable, an average for the period 1990 - 2019 was established**, allowing for an accurate comparison with future projections and a deep understanding of climate trends and their future projection, thereby facilitating the development of informed adaptation strategies.

Step 2: Data Analysis

Creation of Database. A database was established in Excel, organized as follows:

- Tables by Region: A table was created for each of the eight regions, showing the annual average and the average annual change for each variable.
- Tables by Periods: On separate sheets, a table was created for each region where years were classified by decades, with the last group being a period of 11 years, repeating the process for the average change of each variable.
- Pivot Table for Rangpur: A pivot table was created as an example for the Rangpur region showing all variables by year, followed by the creation of graphs on a separate sheet to visually illustrate each variable.

Calculation of Averages

- The average for each decade was calculated by taking the median of the selected period.
- A twenty-year average was established for each variable to be used as a historical reference.
- The following formula was applied to calculate the average annual change:

$$\textit{Average rate of change} = \left(\frac{\textit{Annual Average of the Variable} - \textit{Historical Reference}}{\textit{Historical Reference}}\right) X\ 100$$

- The average change per year was obtained, followed by the calculation of the average by period.

Analysis of Sea Level Rise. Due to the lack of direct data for this variable, relevant studies such as those by Bijoy Mitra et al,, Md, Ashraful Islam et al,, Mohammed Abdul Baten et al,, and The Bangladesh Delta Plan 2100 were consulted, An annual increase of 0,063 mm with an uncertainty of ±0,120 mm/year was analysed, projecting an increase of 1 to 2 meters by the year 2100.

Calculation for Percentage of Climate Change

To calculate the percentage change, the following process was carried out:

i. For each period prior to 2020, the final year is compared to the initial year; for example, considering the period 1995 - 2014, the final year is subtracted from the initial year.
ii. The data of interest taken for the calculation corresponds to the 90th percentile in all cases.
iii. To calculate the percentage of the temperature variable. The Extreme Temperature Climate Indices (Tx) are calculated based on the number of days in the year when an extreme temperature occurs, i,e, from 365 days in a year. The percentage change is then calculated using a simple rule of three:

TxC = Percentage of change
V_i = Initial value
V_f = Final value
365 = Number of days in a year

$$TxC = \left(\frac{V_f - V_i}{365}\right) \times 100$$

Example: to calculate the percentage change for the period 1990 - 1999, Being 44,48 for 1990 and 45,20 for 1999, the calculation would be as follows:

$$TxC = \left(\frac{45.20 - 44.48}{365}\right) \times 100$$

iv. For each period after 2020, the average for the period is compared to the historical reference; for example, considering the period 2020 - 2029, the average will be 44,70, while the historical reference will be 35,84, thus:

$$TxC = \left(\frac{44.70 - 35.84}{365}\right) \times 100$$

v. Given that the Extreme Precipitation Climate Indices are calculated in millimeters, then the percentage change is calculated as follows:

RxC = Percentage of change
R_i = Initial value
R_f = Final value

$$RxC = \left(\frac{R_f - R_i}{V_i}\right) \times 100$$

vi. To calculate the average rate of change, the value of the data is added and divided by the number of data considered.
vii. If the sum of data equals 0, the **IF, ERROR** function will be used, making the result 0.

The infrastructure Exposure and Vulnerability assessment.

→ **Exposure.** This is expressed as the potential level of damage or loss that the infrastructure could suffer if a hazardous hydrometeorological event reached its location.

- → **Vulnerability.** The climatic vulnerability of infrastructure is estimated by factors inherent in civil engineering knowledge and practice that explain the damage and losses that infrastructure suffers when affected by a hazardous hydro-meteorological event.

8. To assess the exposure of a given infrastructure type, the CT selects the hazard event types classified as high and very high in the integration matrix for the current period. Other hazard types classified as Moderate (Medium), low and very low are not considered.
9. For each selected type and level of hydrometeorological hazard, the CT presents an exposure scenario that describes a type of loss or damage that could occur to the physical structure, materials, and condition of the intended location of the infrastructure (be it a building, road, bridge, small water system or drainage).
10. It is assumed that the level of vulnerability is very similar for each loss or damage scenario (overt exposure), as the severity of the loss or damage is directly related to the sensitivity and level of adaptive capacity (the two main factors of vulnerability) built into the design, choice of materials and location of the infrastructure to date.

11. The classification scale for Exposure & Vulnerability is:

Exposure severity classification scale				
Very high	High	Medium	Low	Very low
Value: 90	Value: 70	Value: 50	Value: 30	value: 10

12. Once the severity of the exposure (expressed in terms of loss or damage to the physical structure, the materials used and the site conditions) has been assessed, the vulnerability analysis is estimated using the following criteria:

    - → Any loss or damage to an infrastructure system associated with the occurrence of a hydrometeorological event affecting it will reflect two critical components of vulnerability → the sensitivity and resilience of the system.
    - → Sensitivity refers to the propensity of an infrastructure system to experience adverse effects when exposed to a particular hazard, such as an extreme climate/weather event or change in environmental conditions.
    - → Resilience is understood (in the CT context) as a manifestation of the adaptive capacity built into the infrastructure system, which ultimately determines the level of loss and/or damage in the face of minor or severe events.

13. By determining the significance of loss or damage, assuming that this is how exposure manifests itself, the CT estimate the sensitivity and resilience of the infrastructure system; that is, the CT estimate its vulnerability in the context of the physical structure, materials and site conditions.

14. When an 'X' is marked on the rating scale shown in the Exposure and Vulnerability Assessment Matrix (Step 2), the CT automatically assigns a value calculated using the following formula:

For Exposure and vulnerability estimation and classification:

Each cell has a value, so the calculation tool understands that this value is triggered by marking an 'X'. It then runs the weighted index by exposure level and the weighted index of infrastructure exposure to hazards by upazila.

	Very high Value: 90	**High Value: 70**	**Medium Value: 50**	**Low Value: 30**	**Very low Value: 10**
Physical structure weight 40	**(40x90)/100**	**(40x70)/100**	(40x50)/100	(40x30)/100	(40x10)/100
Materials weight 30	**(30x90)/100**	**(30x70)/100**	(30x50)/100	(30x30)/100	(30x10)/100
Site-location conditions 30	**(30x90)/100**	**(30x70)/100**	(30x50)/100	(30x30)/100	(30x10)/100
Weighted index by level of exposure & related vulnerability	$\mathrm{IeC} = S\frac{\bar{x}ci}{Nci}$	$\mathrm{IeC} = S\frac{\bar{x}ci}{Nci}$	$\mathrm{IeC} = S\frac{\bar{x}ci}{Nci}$	$\mathrm{IeC} = S\frac{\bar{x}ci}{Nci}$	$\mathrm{IeC} = S\frac{\bar{x}ci}{Nci}$
Weighted index of infrastructure exposure to hazards by upazila, and related vulnerability.	$\mathrm{IeUp} = S\frac{\mathrm{IeC}}{3}$		Excluded		

Where:
IeUp = Weighted index of infrastructure exposure and vulnerability to hazards by upazila
IeC = Weighted index by level of exposure and vulnerability estimation
S x̄c**i** = Sum of the averages of activated cell
Nc**i** = Number of actives cells

The Climate Change Risk Index.

To estimate the baseline Climate Risk Index for the infrastructure assessed by upazila, the CT generates a visualisation tab for the Climate Risk Index report based on the hazard, exposure and vulnerability data assessed in the RCIA-CT. The calculations performed by the CT for the Climate Risk Index are as follows,

Weighted index of infrastructure Exposure & Vulnerability to Hazard by Upazila,	$\mathrm{IeUp} = S\frac{\mathrm{IeC}}{3}$
Weighted Hazard Index (ihi)	$\mathrm{AhiH} = \frac{S(\bar{x}\%)\mathrm{HLA}}{5}$
Infrastructure Risk Index by Upazila (IRi)	$\mathrm{IRi} = (\mathrm{VgU} + \mathrm{IeUp} + \mathrm{AhiH})/3$

Where:

ViC = Weighted index by level of Vulnerability
IeC = Weighted index by level of Exposure,
HLA = Weighted index by level of Hazard,

Application and Database

The application is a system to populate the CT database with DRIP data. The system is an '.exe' file that must be run to populate the 'Database' file containing the hazard level for each upazila and the type of hazard. The CT is built from this data.
The steps explained below were executed to obtain from the DRIP the hazard data (type and hazard level) corresponding to all upazila (567 in total[5]),

The steps are as follows:

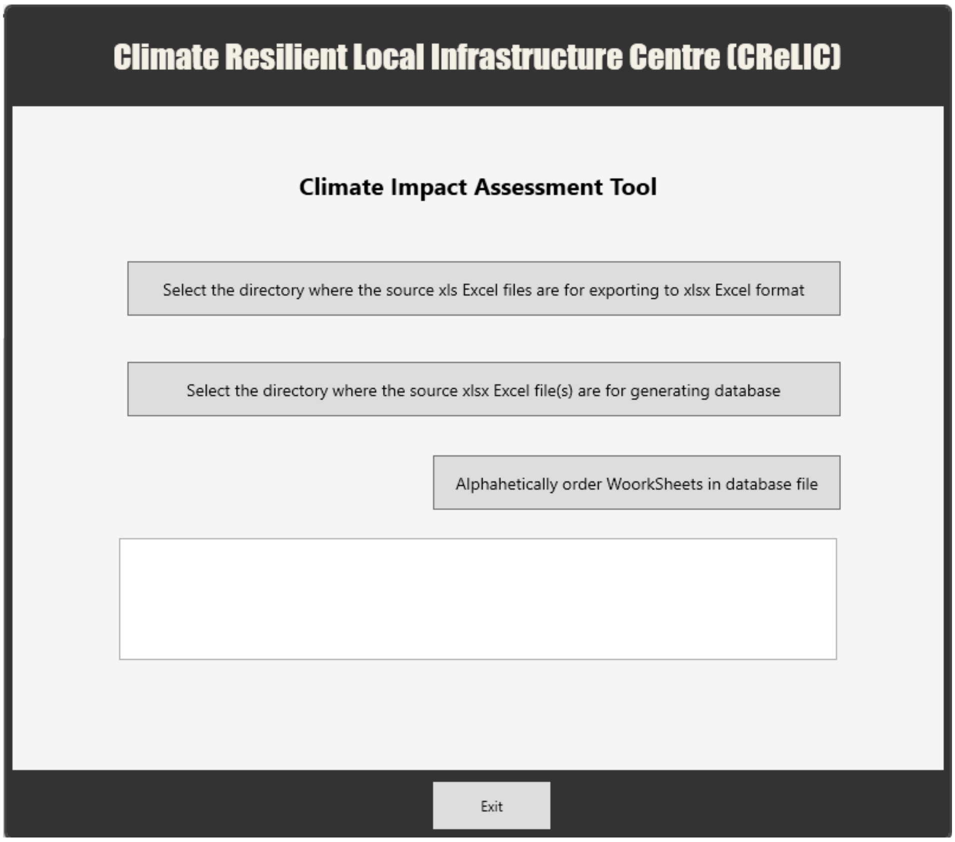
1. Obtain the DRIP data for the required upazila and hazard. There are two ways to do this:

   The first is to go hazard by hazard for each upazila:
   i. The DRIP web url is MapView - DRIP (plancomm.gov.bd)
   ii. The output is a xls file that contains the hazard level for that upazila.

The second is searching all hazards for each upazila:
   i. Within the DRIP web MapView - DRIP (plancomm.gov.bd), look for the 'Report' option, select division, district, upazila and select all the hazards and generate report.
   ii. The output is a 'xls' Excel file that contains the hazards level for that upazila for all the hazards.

2. Execute the application,
   i. Inside the folder 'Application', there is a file named 'crelic.exe' that must be executed,
   ii. When executed, a screen will be displayed:

[5] Number of upazilas according to DRIP database,



3. Click the first button: 'Select the directory where the source 'xls' Excel files are for exporting to xlsx Excel format',
    i. To have the Excel 'xls' files available, you must select the directory where the files were downloaded in previous step, this directory could be the "download" directory or another, for example you could move the files from the download directory of the system into the "download" directory inside de "RCIA Project Tool/Application" directory,
    ii. This step must be carried out because the files must be transformed to an Excel file with 'xlsx' extension,
4. The result of this action is that the 'xls' file(s) are converted to a 'xlsx' file and moved into the 'Origin' folder. The final path where the file(s) with data of the DRIP is/are:

,,/Project/Application/Origin

    i. You can check that the file(s) is/are into the folder, they have the same name of the file downloaded from the DRIP ('.xls') with the 'xlsx' extension.

STEPS TO FILL THE DATABASE WITH THE xlsx FILE GOT IN PREVIOUS STEP

5. Open the file 'upazila.xlsx' inside the 'Administration' folder, the path is:

,,/Project/Application/Administration

    i. On Worksheet 'Upazila' you must write the division, the district and the upazila name of the new(s) upazila on columns A, B and C respectively. For example, for the upazila 'Nachole' whose data was downloaded from the DRIP, the district is 'Ch. Nawaganj', and the division is 'Rajshahi'.
    ii. Alphabetically order the list by divisions, districts and upazilas.
6. In the application, select the second button 'Select the directory where the source xlsx Excel file(s) are for generating data base'
    i. Select the 'Origin' folder.

ii. The application will fill the database with the data of the files into the 'Origin' folder, creating or updating a worksheet for each upazila.
iii. Application will move the files to 'Backup' directory (../Project/Application/Backup).
iv. Press the button "Alphabetically order Worksheets in database file" to get a ordered database file.

7. The 'database' file will be uploaded to the CT according to the upazilas that are chosen as is explained in this document.
8. When two upazilas have the same name, the name of the district between brackets must be set for each upazila, for example:

- Companiganj (Noakhali)
- Companiganj (Sylhet)

i. In this case, before the '.xlsx' file be generated by the application, the name inside the '.xls' (file downloaded from the DRIP) file must be changed and must be equal to the name set in 'upazila.xlsx' file into "Upazila" worksheet.

WEIGHTED VALUES

To fill the data in the "database.xlsx" file, the application takes the value from the ".xls" file (downloaded from the DRIP) and calculate the value according to the weight it gets from the "upazila.xlsx" file, worksheet "Hazard". It is as follows:

For example:

- The ".xls" file downloaded from DRIP for "Aditmari" upazila, for cyclone hazard is:

Cyclone Graph (Aditmari Upazila)

Category	Series 1
Hazard Level	1,00
Exposure Level	2,00
Vulnerability Level	4,00
Risk Level	1,00

- The hazard level is "1,00". It means "Very Low" in the CT scale. So, it will be classified in the "Very Low" column of "database.xlsx" file:

Hazardous events at Upazila level	Hazard level classification from the field					
	Very high	High	Medium	Low	Very low	N/A
Data from the DRIP						

- The application will put the number in the "database.xlsx" file, worksheet "Aditmari", according to the value it gets into "upaila.xlsx" file, worksheet "Hazard", the left table, corresponding to "Cyclone", in this case is "9,5":

	A	B	C	D	E	F	G	H	I	J	K	L
1		Very high	High	Medium	Low	Very low		Very high	High	Medium	Low	Very low
2	cyclone	85,5	66,5	47,5	28,5	9,5		95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
3	drought: kharif	36	28	20	12	4		40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
4	drought: pre kharif	36	28	20	12	4		40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
5	earthquake	9,2	7,7	6,2	4,2	2,1		10x92/100	01x77/100	10x62/100	10x42/100	10x21/100
6	erosion	54	42	30	18	6		60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
7	flash flood	72	56	40	24	8		80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
8	flood	90	70	50	30	10		100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
9	landslide	45	35	25	15	5		50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
10	salinity	45	35	25	15	5		50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
11	sea level rise	63	49	35	21	7		70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
12	storm surge	85,5	66,5	47,5	28,5	9,5		95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
13												

- This value corresponds to the weight of a cyclone, as explained in this document.
- The formulas can be seen into the right table, in this case "95x10/100":

	A	B	C	D	E	F	G	H	I	J	K	L
1		Very high	High	Medium	Low	Very low		Very high	High	Medium	Low	Very low
2	cyclone	85,5	66,5	47,5	28,5	9,5		95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
3	drought: kharif	36	28	20	12	4		40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
4	drought: pre kharif	36	28	20	12	4		40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
5	earthquake	9,2	7,7	6,2	4,2	2,1		10x92/100	01x77/100	10x62/100	10x42/100	10x21/100
6	erosion	54	42	30	18	6		60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
7	flash flood	72	56	40	24	8		80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
8	flood	90	70	50	30	10		100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
9	landslide	45	35	25	15	5		50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
10	salinity	45	35	25	15	5		50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
11	sea level rise	63	49	35	21	7		70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
12	storm surge	85,5	66,5	47,5	28,5	9,5		95x90/100	95x70/100	95x50/100	95x30/100	95x10/100

- The CT builds the "Aditmari" worksheet into the 'database.xlsx" file as follows, filled with all the hazards downloaded from the DRIP, where each hazard corresponds to one ".xls' file and transformed to a ".xlsx" by the CT:

Form 2. For UPAZILA LEVEL USES Hydrometeorological events observed by the local stakeholders						
Division: Rangpur						
District: Lalmonirhat						
Upazila: Aditmari						
Hazardous events at Upazila level	**Hazard level classification from the field**					
	Very high	High	Medium	Low	Very low	N/A
Data from the DRIP						
1. Cyclone					**9,50**	
2. Drought: Kharif			**18,60**			
3. Drought: Pre Kharif				**12,00**		
4. Earthquake		**7,70**				
5. Erosion	**54,00**					
6. Flash flood					**8,00**	
7. Flood	**90,00**					
8. Landslides					**5,00**	
9. Salinity					**5,00**	
10. Sea Level Rise					**7,00**	
11. Storm surges					**9,50**	

Abhaynagar Adabor Adamdighi Aditmari Agailjhara