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)

Ref, FP 0004; BMZ Project No: 2020,62,255

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

Lead author: Antonio Arenas Romero,
Senior Organisational Development
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

Table of Contents

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 licensed 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. <u>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.</u>

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

Very high	High	Medium	Low	Very low

Step 1. Infrastructure Hazard Assessment,

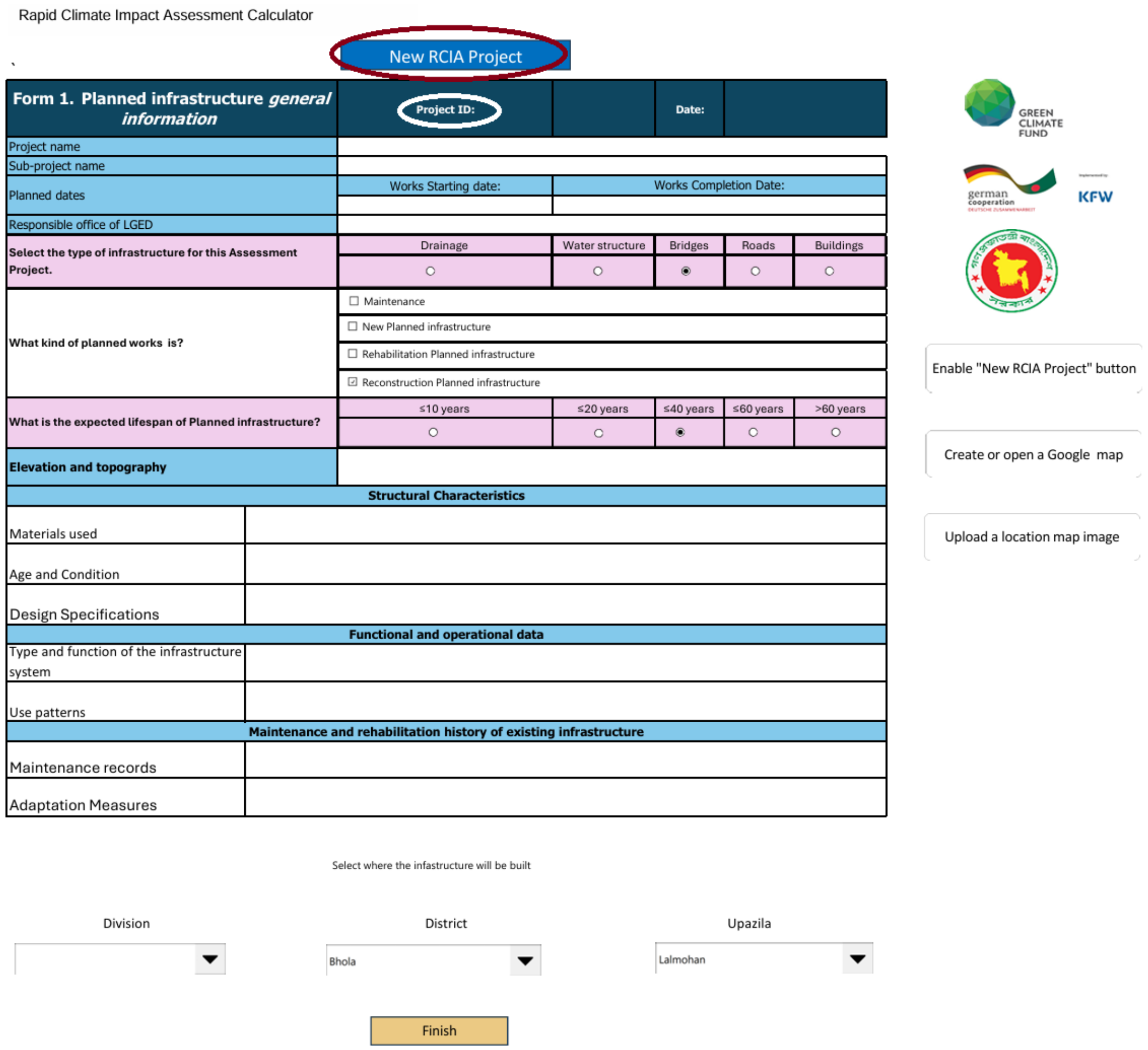
1.1 The first step is to describe the type of infrastructure to be subjected to the rapid assessment. Proceed as follows:

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.



Rapid Climate Impact Assessment Calculator

New RCIA Project

Form 1. Planned infrastructure *general information*	Project ID:		Date:		
Project name					
Sub-project name					
Planned dates	Works Starting date:	Works Completion Date:			
Responsible office of 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					
Structural Characteristics					
Materials used					
Age and Condition					
Design Specifications					
Functional and operational data					
Type and function of the infrastructure system					
Use patterns					
Maintenance and rehabilitation history of existing infrastructure					
Maintenance records					
Adaptation Measures					

GREEN CLIMATE FUND

german cooperation

KFW

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: Bhola

Upazila: Lalmohan

Finish

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.**

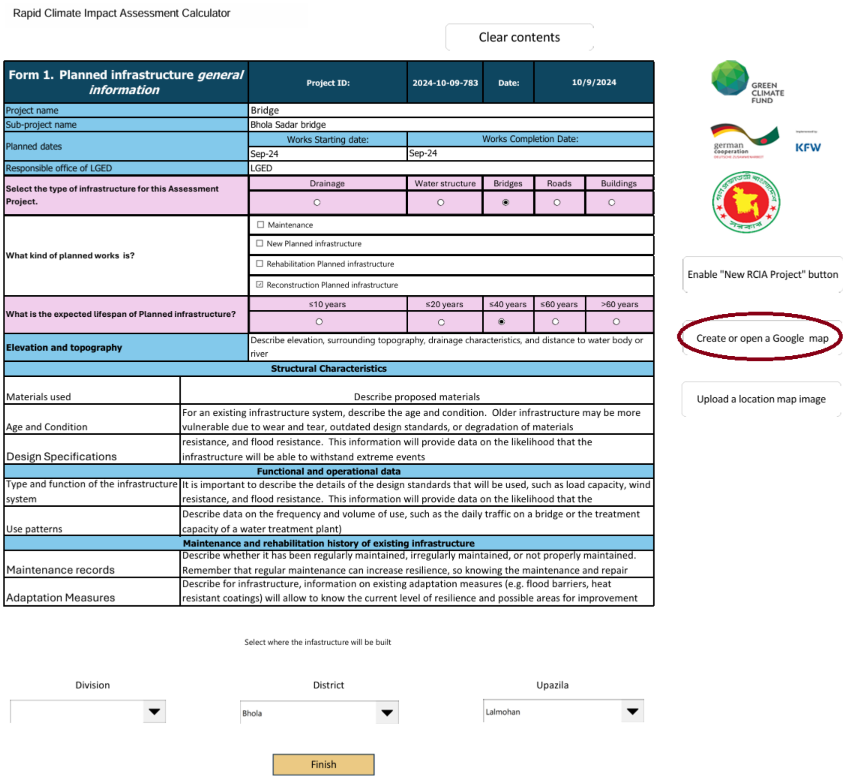
i. Maintenance records: Indicate whether it has been regularly maintained, irregularly maintained, or not properly maintained. Remember that regular maintenance can increase resilience, so knowing the maintenance and repair history will help in assessing vulnerability.
ii. Adaptation Measures: Provide 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 using the same RCIA project name you used in form 1.

→ Keep in mind that the infrastructure system you are assessing may cover one or more upazilas, so make sure 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,



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: Sep-24	Works Completion Date: 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			

GREEN CLIMATE FUND

german cooperation

KFW

Enable "New RCIA Project" button

Create or open a Google map

Upload a location map image

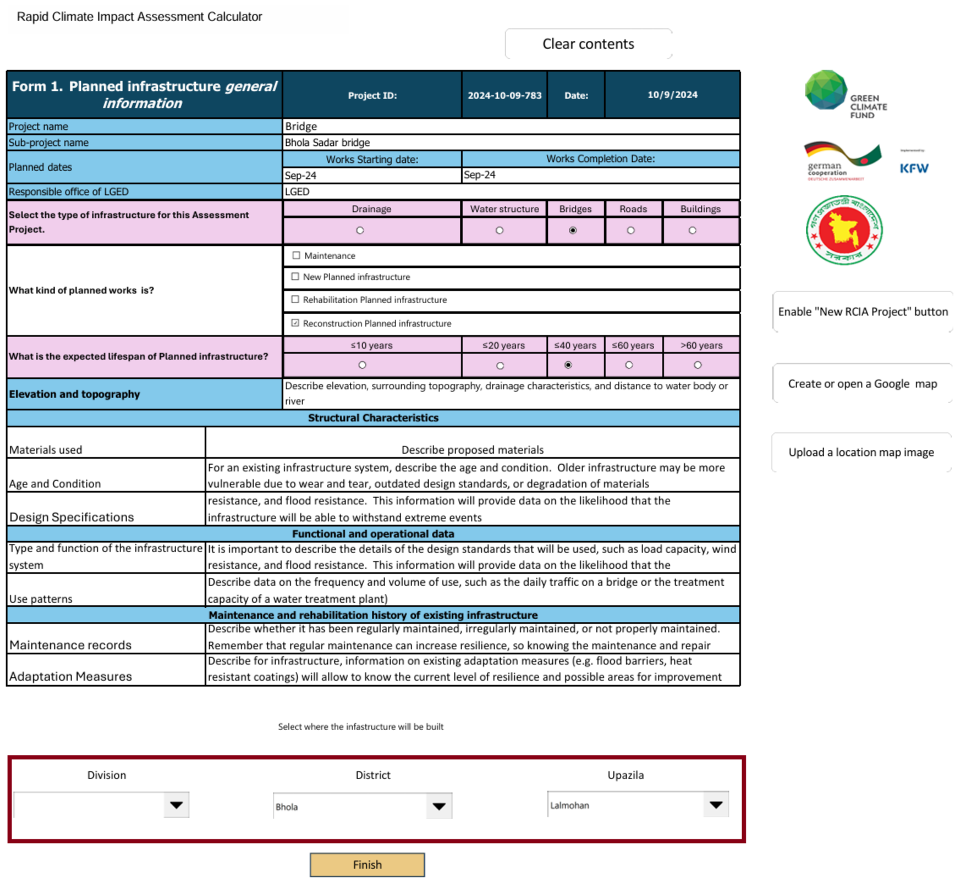
Select where the infastructure will be built

Division | District: Bhola | Upazila: 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: Sep-24	Works Completion Date: 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			

GREEN CLIMATE FUND

german cooperation

KFW

Enable "New RCIA Project" button

Create or open a Google map

Upload a location map image

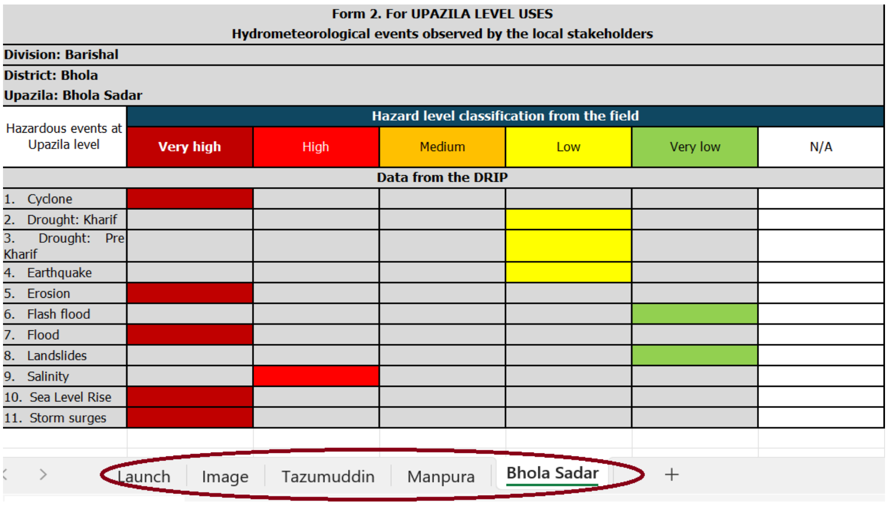
Select where the infastructure will be built

Division | District: Bhola | Upazila: 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).

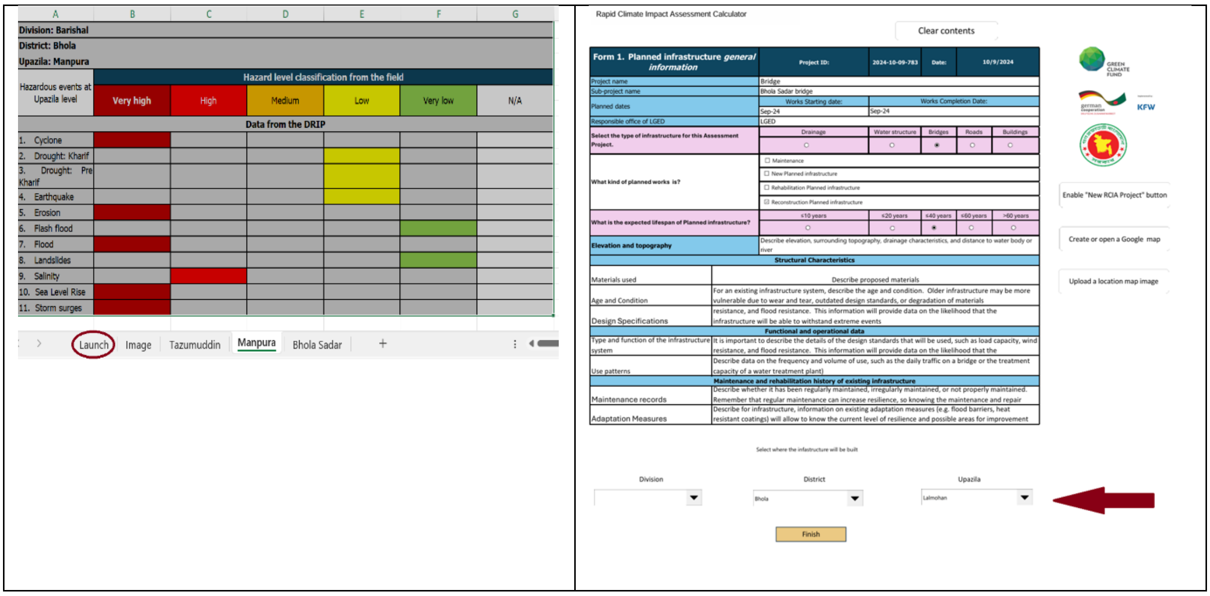
1.9 Click on the tab with the name of the upazila and check that Form 2 has been created and is properly completed, as showed in the following figure.



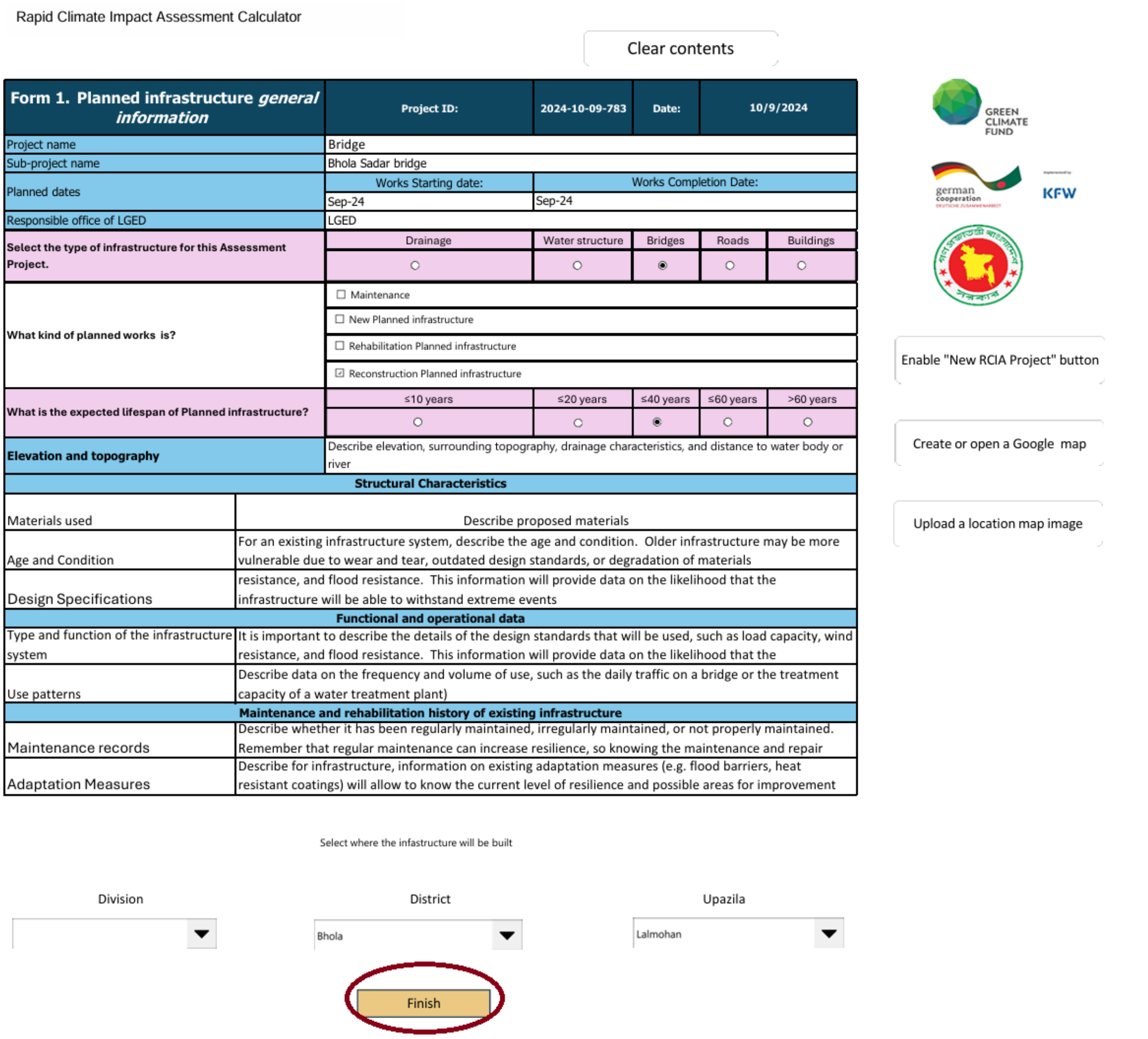
Form 2. For UPAZILA LEVEL USES Hydrometeorological events observed by the local stakeholders						
Division: Barishal						
District: Bhola						
Upazila: Bhola Sadar						
Hazardous events at Upazila level	**Hazard level classification from the field**					
	Very high	High	Medium	Low	Very low	N/A
Data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

1.10 To add more upazilas to your RCIA project, 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				
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				

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 **by one or more LGED engineers from the district office and/or upazila,**

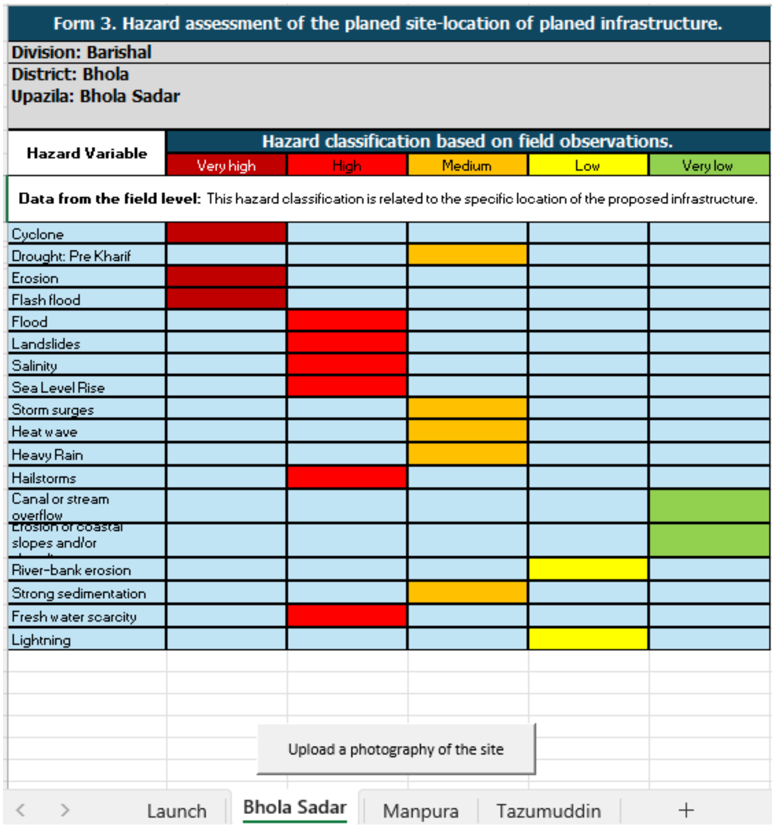
Form 3. Hazard assessment of the planed site-location of planed infrastructure.					
Division: Barishal District: Barguna Upazila: Amtali					
Hazard Variable	Hazard classification based on field observations.				
	Very high	High	Medium	Low	Very low
Data from the field level: This hazard classification 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.

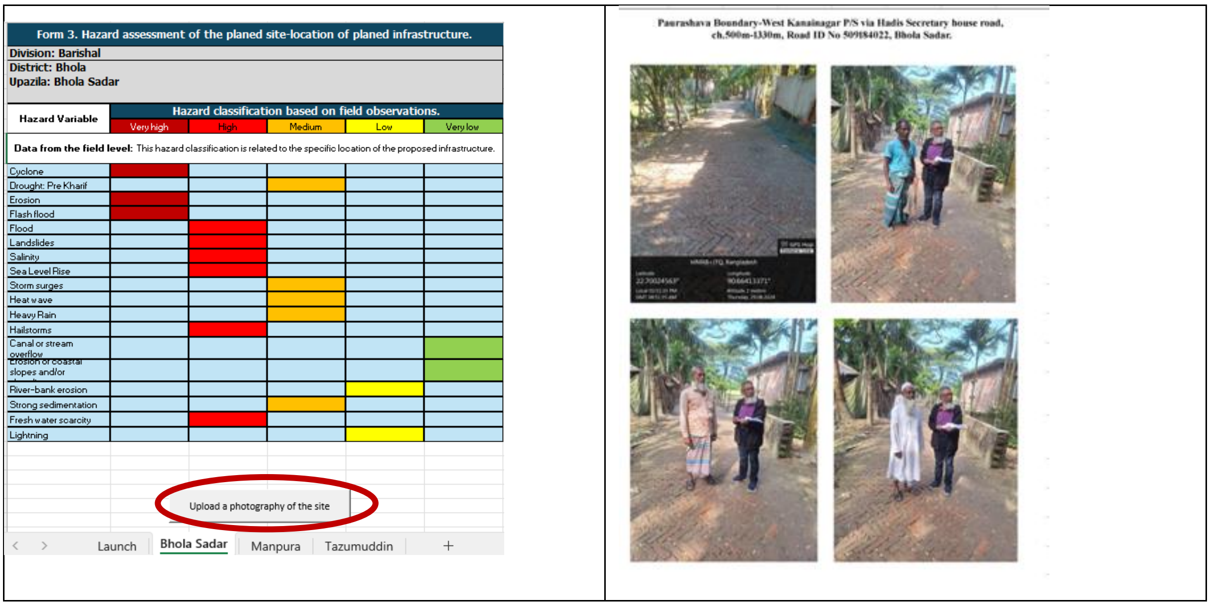
Division: Barishal
District: Bhola
Upazila: Bhola Sadar

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					

Upload a photography of the site

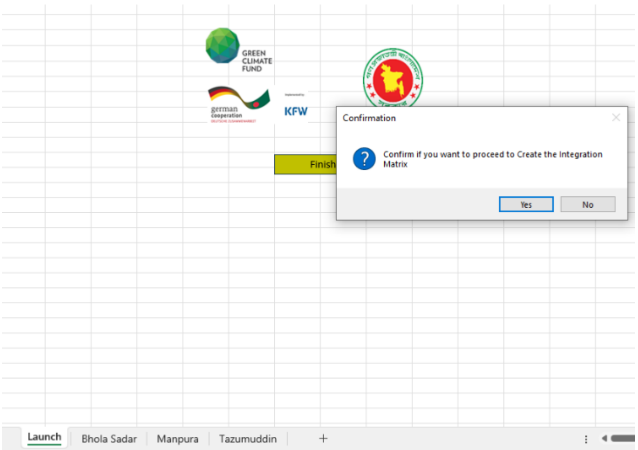
Launch | Bhola Sadar | Manpura | Tazumuddin | +

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 <u>will integrate Form 2 (DRIP data) and Form 3 (field data)</u> 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]				

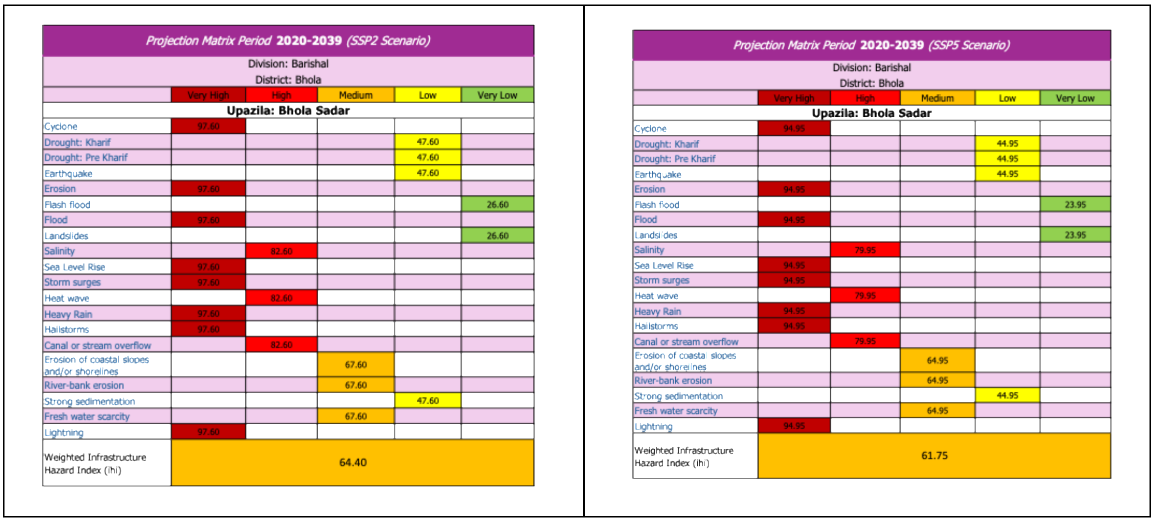
1.24 Review the Integration Matrix and then press 'Finish' on the 'Launch' **tab**. The CT will ask you to create a projection matrix.

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)*						*Projection Matrix Period* ***2040-2059*** *(SSP5 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge			Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low		Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar						**Upazila: Bhola Sadar**					
Cyclone	82,95					Cyclone	85,95				
Drought: Pre Kharif					2,95	Drought: Pre Kharif					5,95
Erosion			42,95			Erosion			45,95		
Flash flood			42,95			Flash flood			45,95		
Flood	82,95					Flood	85,95				
Landslides				22,95		Landslides				25,95	
Salinity				22,95		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	
Projected AHi	42,95					Projected 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. __**This is very important action when analysing the results and writing the final report.**__



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				

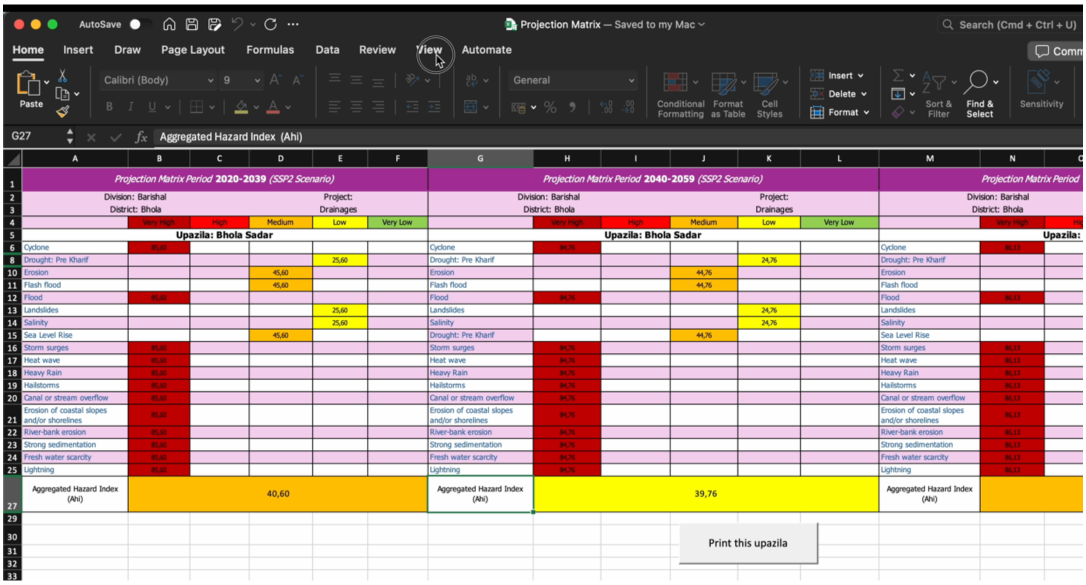
Projection Matrix Period **2020-2039** *(SSP2 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	85,60				
Drought: Pre Kharif					5,60
Erosion				25,60	
Flash flood			45,60		
Flood	85,60				
Landslides					5,60
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				

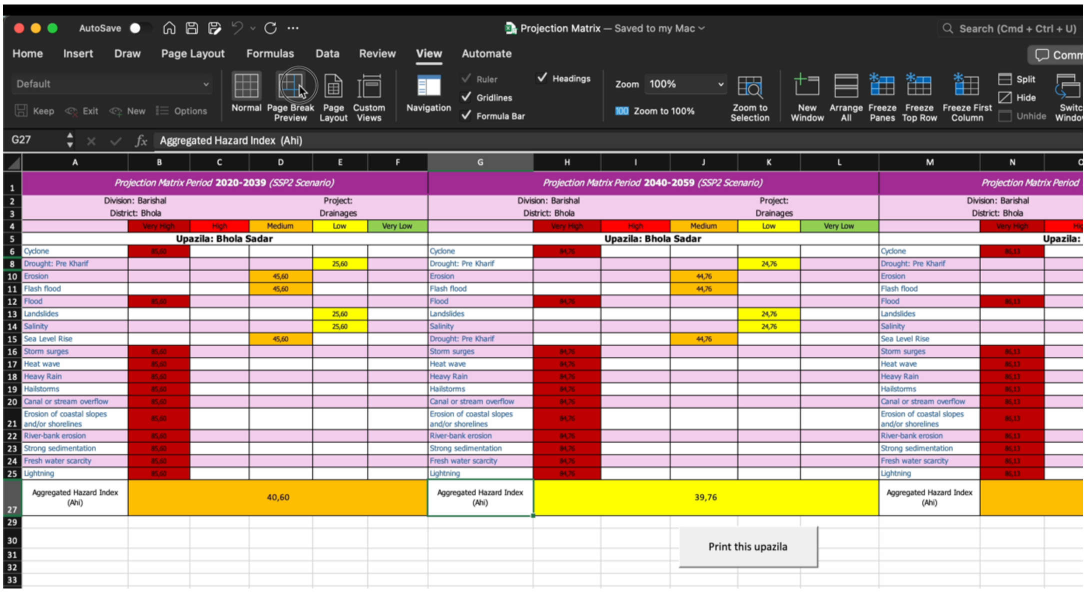
Projection Matrix Period **2040-2059** *(SSP2 Scenario)*					
Division: Barishal District: Bhola			Project: Bridge		
	Very High	High	Medium	Low	Very Low
Upazila: Bhola Sadar					
Cyclone	84,76				
Drought: Pre Kharif					4,76
Erosion				24,76	
Flash flood			44,76		
Flood	84,76				
Landslides					4,76
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).





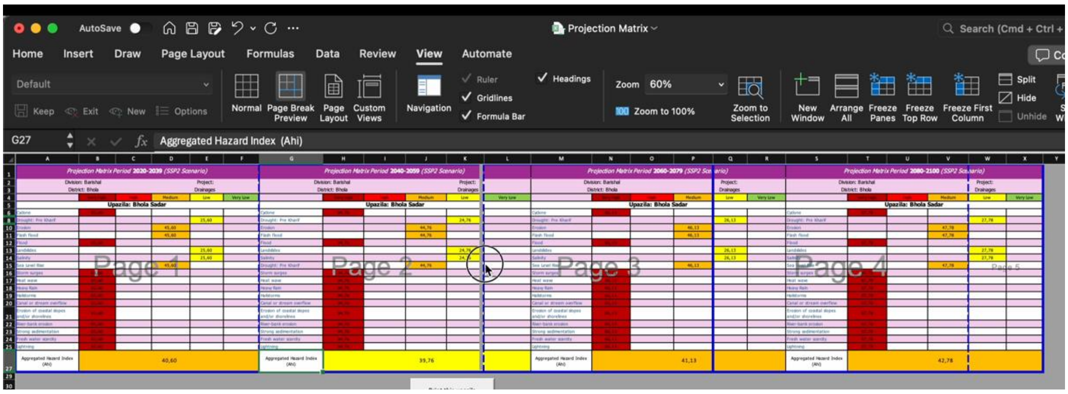
- Now, you'll see a preview of your worksheet with blue dashed and solid lines marking the page breaks.

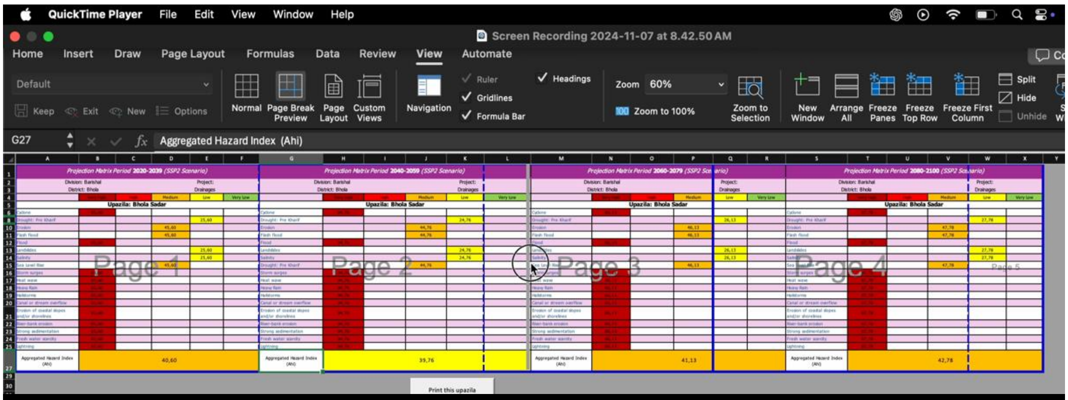
b) Understanding Page Breaks

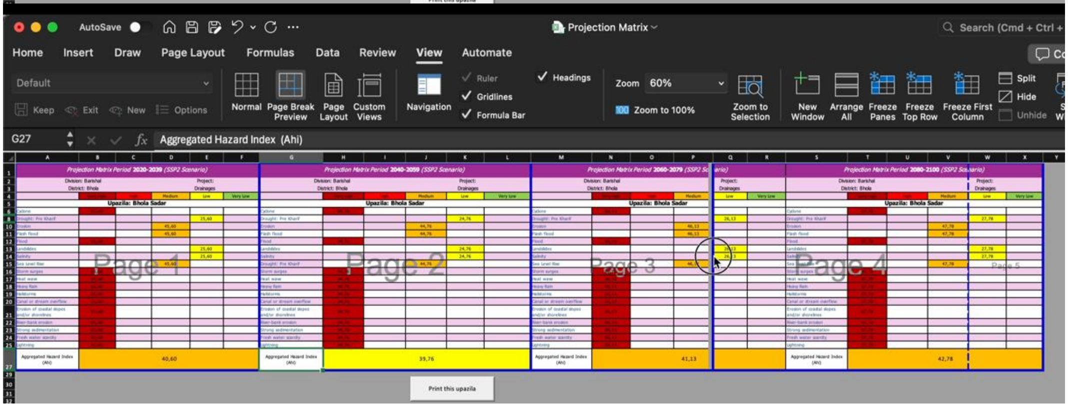
- Blue dashed lines indicate automatic page breaks set by Excel based on the page size and margins.
- Blue solid lines are manual page breaks you can add or adjust yourself.

c) Adjusting Page Breaks

- Move a page break Clicking and dragging 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.

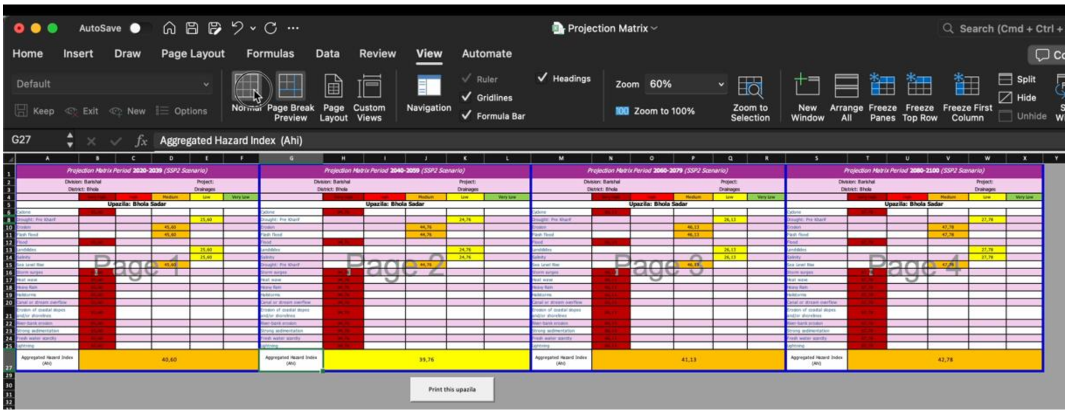


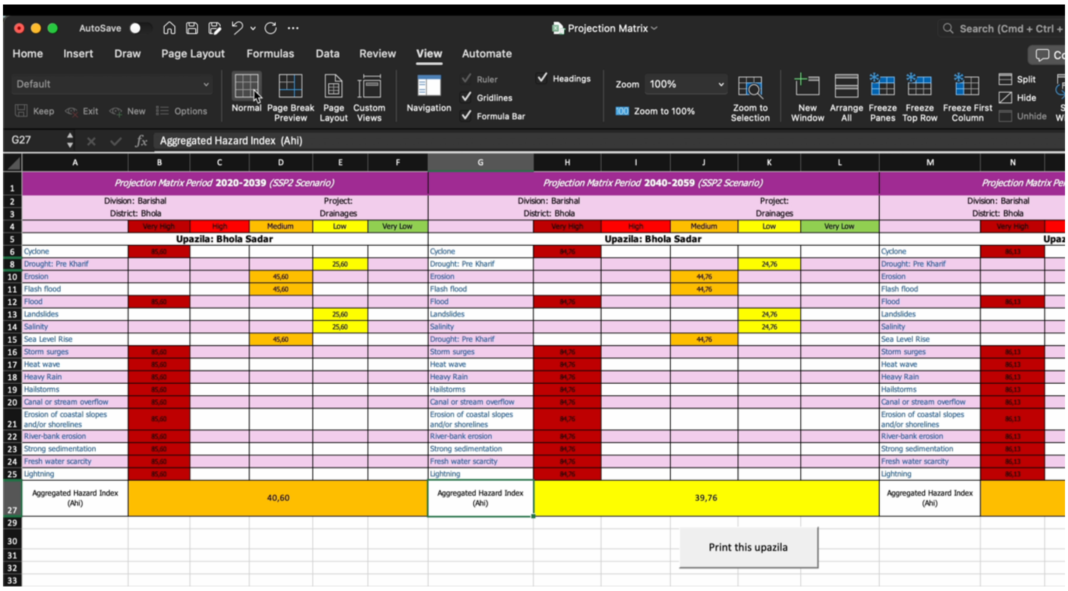




d) Returning to Normal View

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





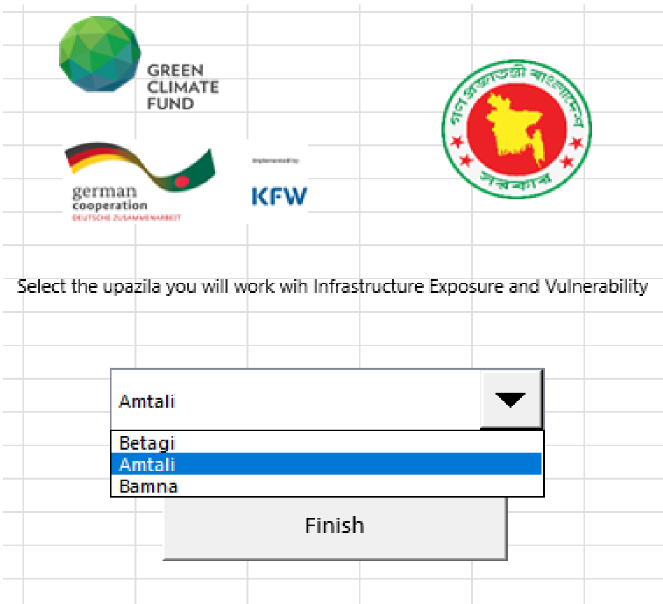
Step 2. Assessing Infrastructure Exposure and Vulnerability

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.

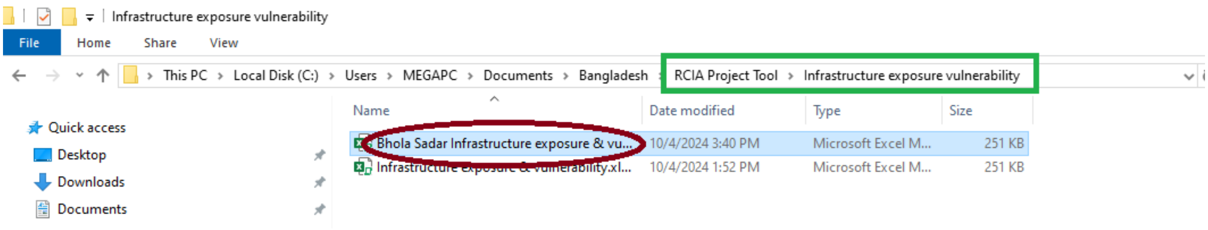
2.2 The following step is to select the upazila where the exposure and vulnerability of the proposed infrastructure will be assessed and estimated. To do this, go to the ***'Launch'*** tab in the ***'Projection matrix'*** and select one of the upazilas from the list in your RCIA project.



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.

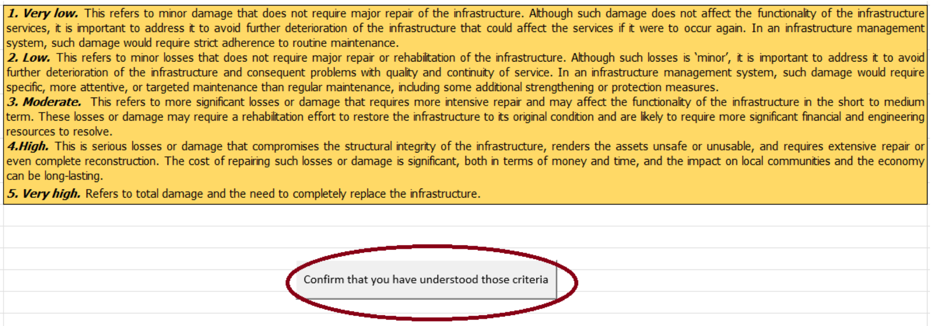
2.5 Go to the folder and open the created Exposure and Vulnerability Excel file with the name of the corresponding upazila.



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**:

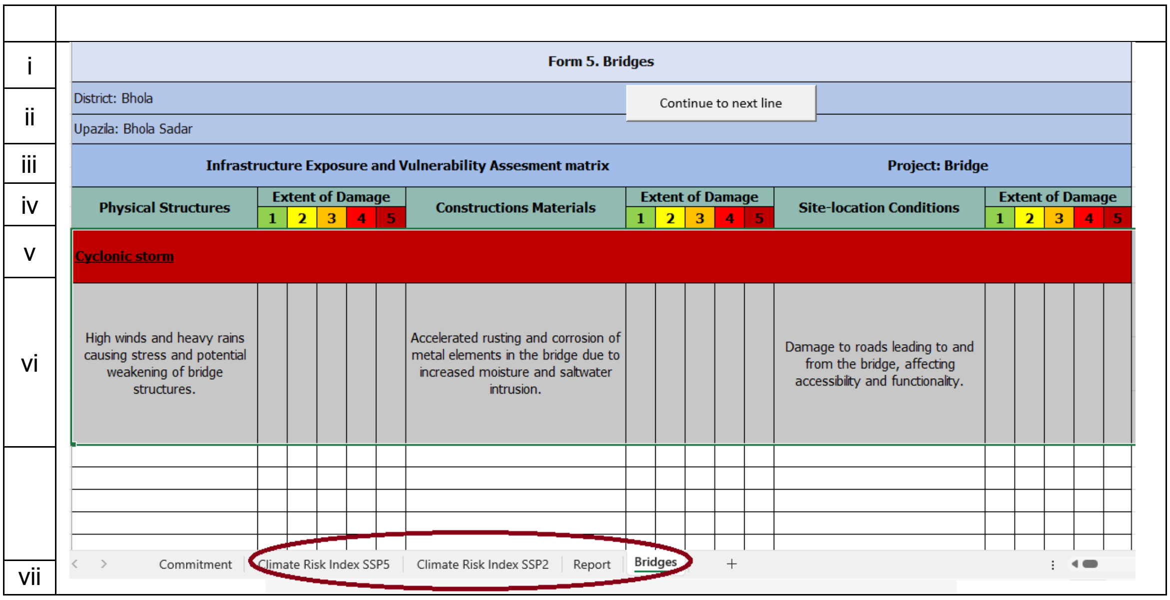
i. Type of infrastructure tab.

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.

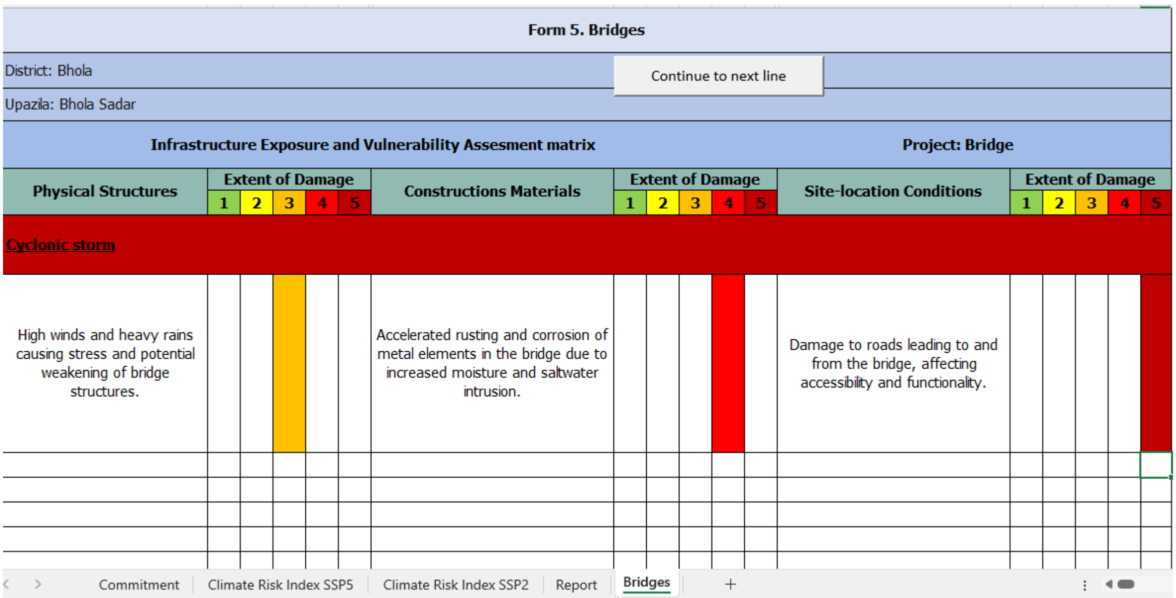
vi. The sixth row describes the likely damage that could occur if the described hydrometeorological event were to affect the infrastructure. In the boxes on the right, you can rate the level of damage that could occur according to the standard criteria described above.

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:

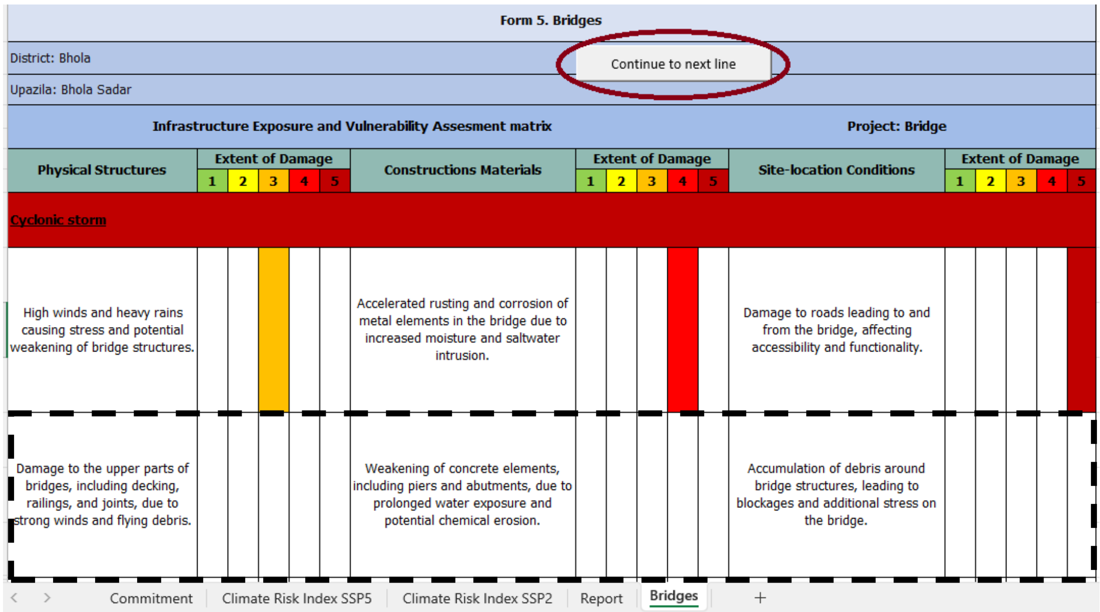
i. Start by looking at the type of hydrometeorological event and its magnitude.

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.

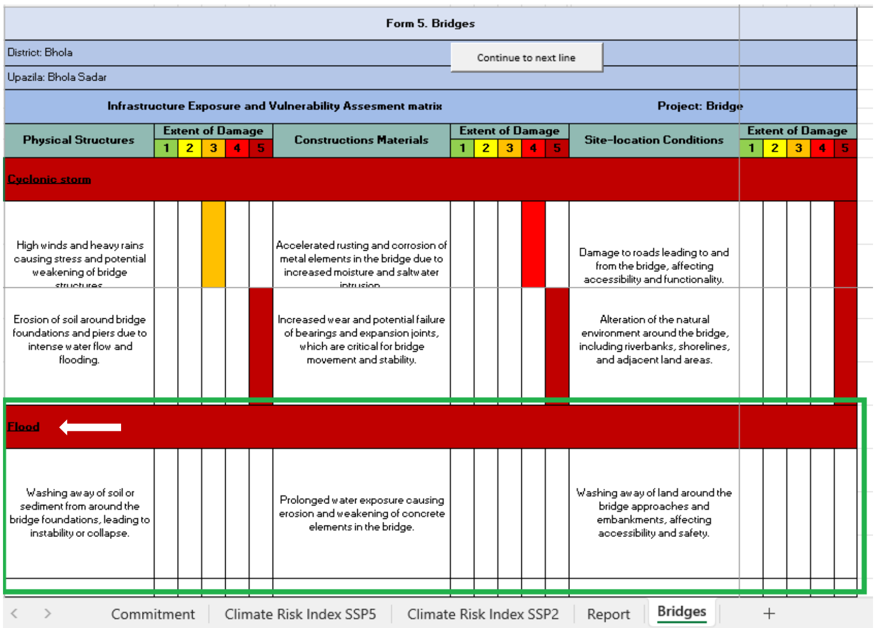


2.10 Once you have completed this initial analysis, you should continue the analysis by clicking on the ***'Continue to next line'*** button and a new line of analysis will be displayed.



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:

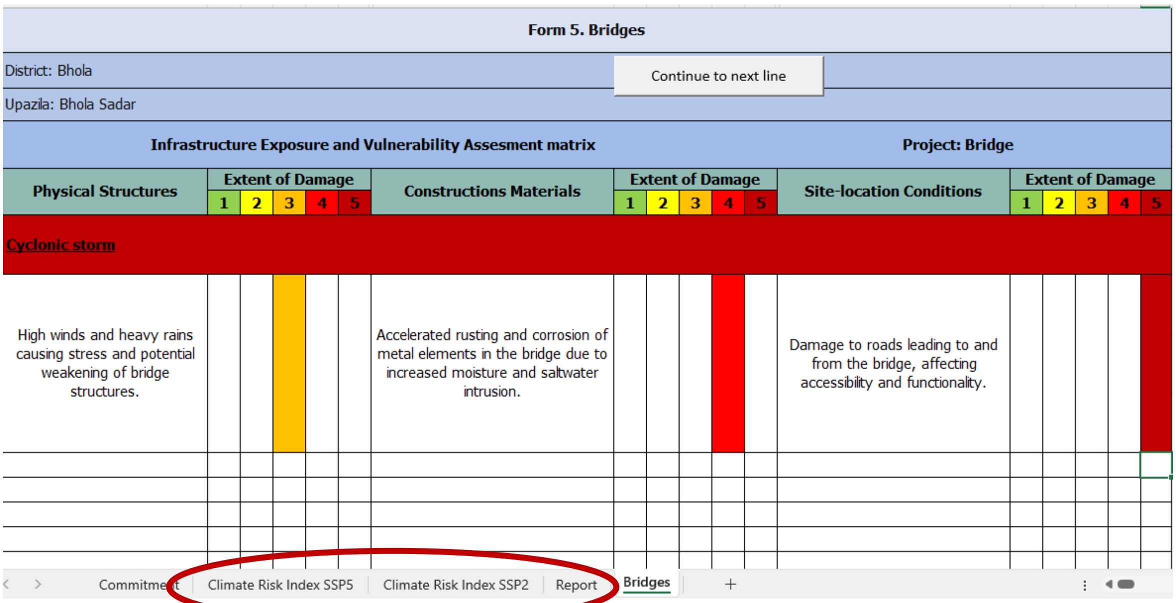
12) Revised Design and Cost Estimate for Climate Resilient Urban and Rural Upazila and Union Road (Type-5 and Type-8).
13) Designs Relevant to Infrastructure Measures, Part A: Revised Design and Cost Estimate for Climate Resilient LGED Bridges & Culvert, and Cyclone Shelter or Buildings.

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'***.

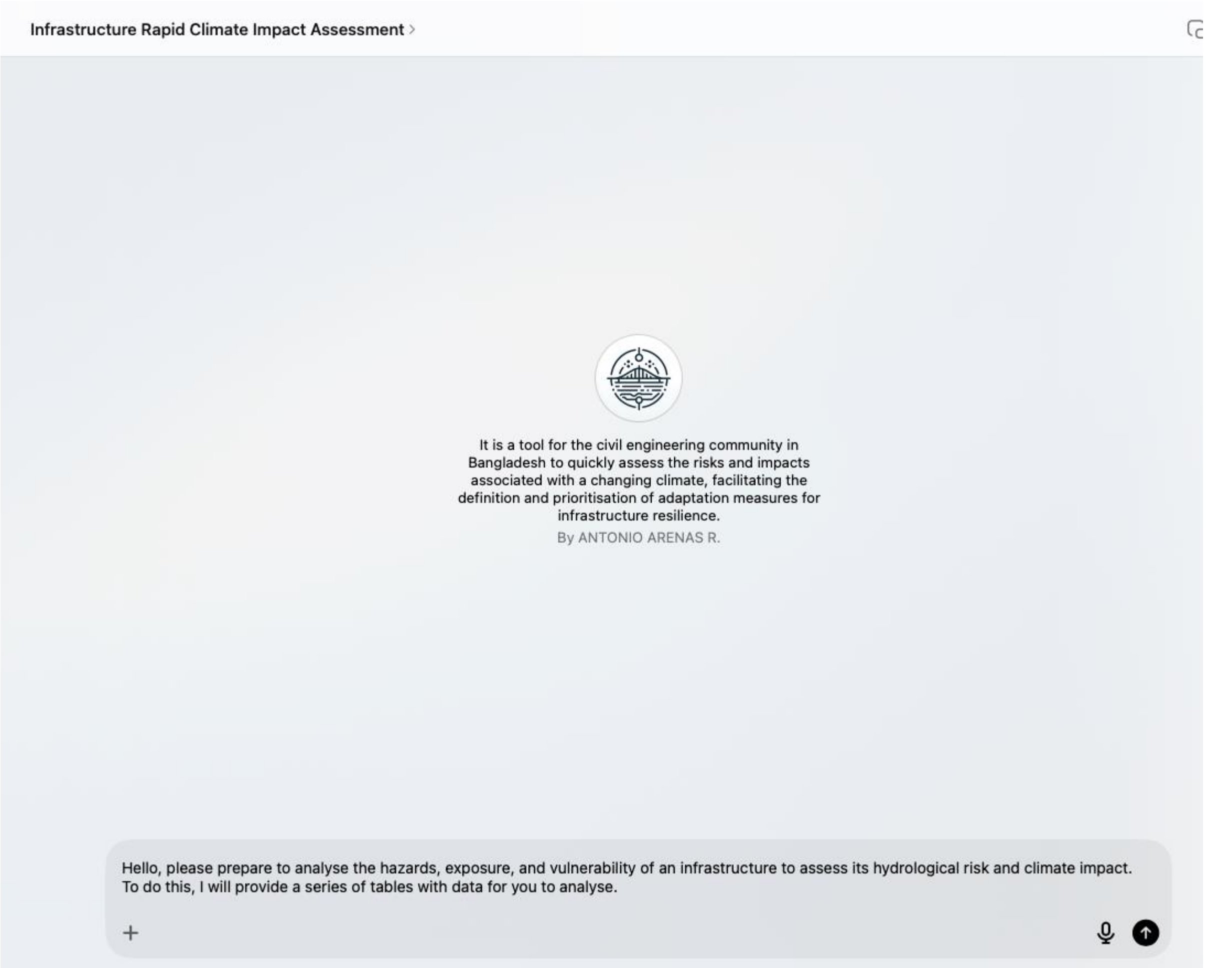


Form 5. Bridges															
District: Bhola															
Upazila: Bhola Sadar															
Infrastructure Exposure and Vulnerability Assesment matrix										Project: Bridge					
Physical Structures	Extent of Damage					Constructions Materials	Extent of Damage					Site-location Conditions	Extent 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.					

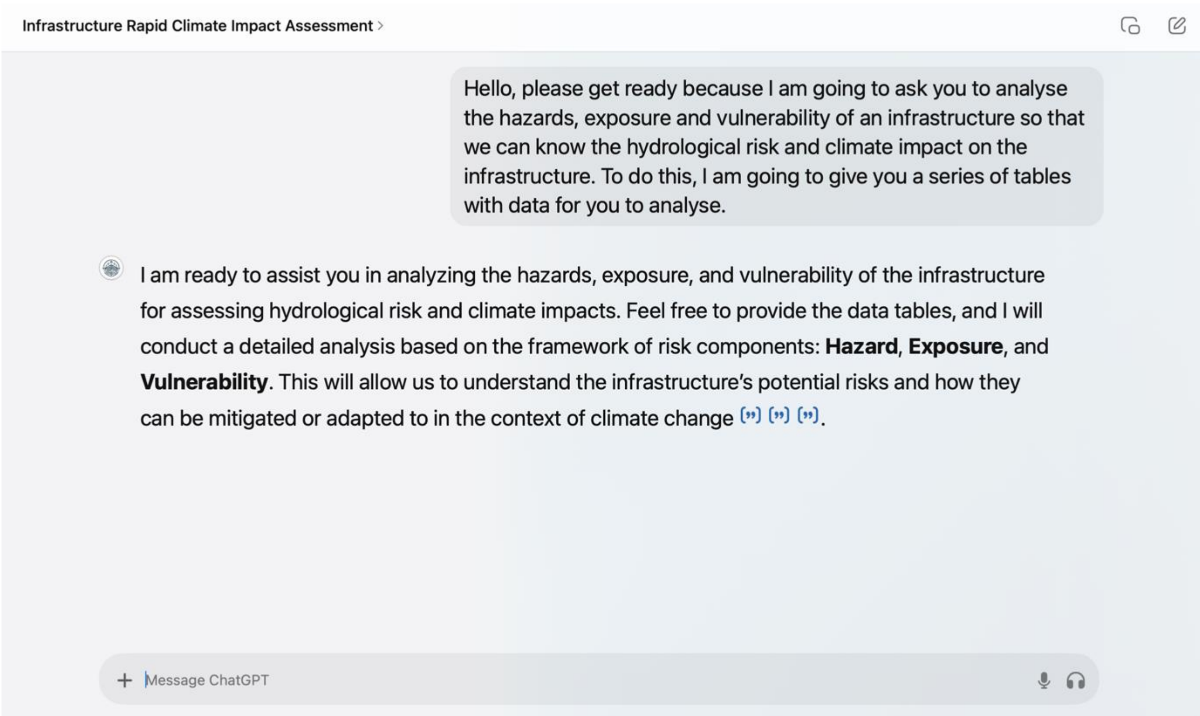
Step 4. General report supported by the RCIA/GPT

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:

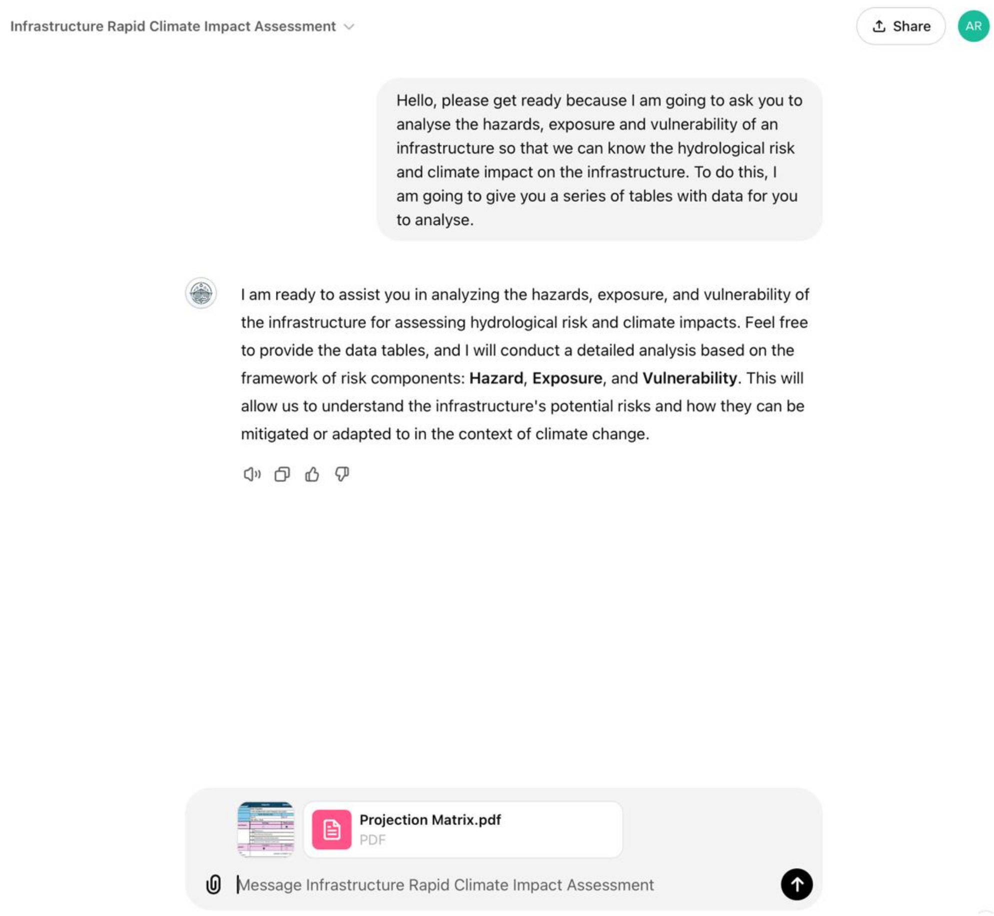
   Hello, please prepare to analyse the hazards, exposure, and vulnerability of an infrastructure to assess its hydrological risk and climate impact. To do this, I will provide a series of tables with data for you to analyse.



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:

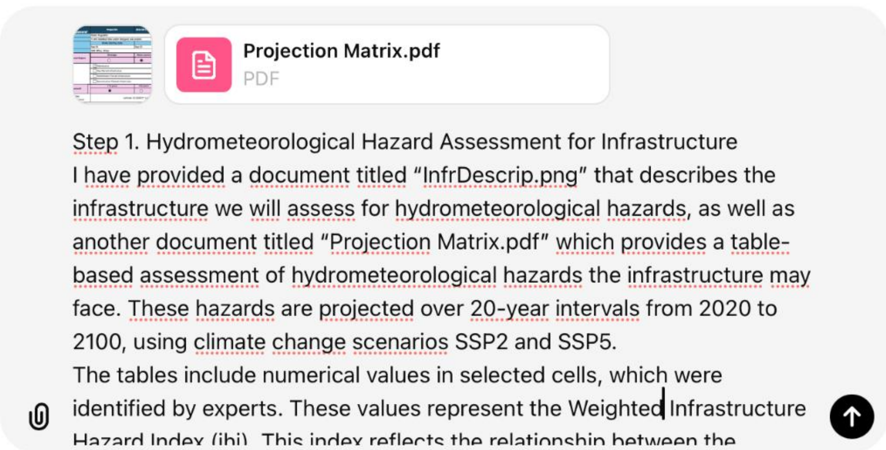
- **ihi** = Weighted Infrastructure Hazard Index

- **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

This annex outlines the calculation methodology and conceptual assumptions behind the RCIA–CT tool. It is intended to serve as a living document, evolving as knowledge and experience in the tool's application accumulate.

Methodological Purpose. The RCIA–CT is designed to provide a rapid, structured assessment of the likely impacts of hydrometeorological hazards on infrastructure, driven by climate change signals. Its main output is a climate risk index, indicating the potential magnitude of damages across different infrastructure assets.

Assessment Framework. The RCIA–CT follows an integrated approach to climate risk assessment, combining both quantitative and qualitative methods. This framework includes:

- Normalizing data to ensure comparability across variables.
- Weighting variables to reflect their importance in the risk context.
- Classifying results into standardized categories for interpretation and prioritization.

This mixed-methods strategy provides a more comprehensive and context-sensitive understanding of risk.

Conceptual Foundation. The approach builds on established practices in climate risk analysis:

- **Normalization**: Converts different variables to a common scale, using techniques like z-scores or rescaling (e.g., 0–100), to allow meaningful comparison.
- **Weighting**: Assigns relative importance to indicators. These weights may be equal or expert-informed, reflecting consensus among stakeholders or analytical judgment.
- **Classification**: Groups results into levels such as 'low', 'medium', and 'high' risk. This enhances the clarity of outputs and guides adaptation planning.

These principles are consistent with international best practices, including the GIZ *Climate Risk Sourcebook* (2023), the *Guide for Climate Risk Assessment* (2023), and the PIEVC Protocol (2024).

Integration with Climate Hazard Data. The RCIA–CT tool incorporates hazard information for each upazila, based on the Disaster Risk Information Plataform (DRIP). These data are stored in a centralized CT database and automatically populate each project file within the RCIA.

Ordinal Hazard Classification in DRIP. DRIP assigns hazards a score from 1 (very low) to 5 (very high). This ordinal scale is widely used in risk assessments for its simplicity and effectiveness.

Conversion to a Continuous Scale. To enable greater precision in analysis and integration with exposure and vulnerability dimensions, the RCIA–CT transforms this 1–5 scale into a continuous 0–100 scale. This facilitates more nuanced comparisons and scoring.

Rationale for the Continuous Scale. The 0–100 scale allows:

- Better resolution between intermediate levels of hazard.
- A midpoint that aids decision-making.
- Standardized integration across all components of risk (hazard, exposure, vulnerability).

Normalization Table for Hazard Magnitudes. The following table shows how DRIP hazard categories are translated into normalized values used in the RCIA–CT tool:

Table 1. Normalization

Normalization table			
DRIP		**RCIA/CT**	
Classification	Scale	Ranges of normalization	Normalized values of 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

Justification for Standardization

The standardization of values on a 0–100 scale ensures that the three core components of climate risk—hazard, exposure, and vulnerability—can be measured in a consistent and proportionate way. This enhances the precision and comparability of risk assessments across various infrastructure types, including roads, bridges, urban drainage systems, and water supply networks.

Moreover, normalization enables a more direct and meaningful comparison of infrastructure exposed to different hydrometeorological hazards. This is consistent with recommendations from international climate risk assessment frameworks, such as the PIEVC Protocol. By adopting this approach, engineers and planners can better prioritize mitigation and adaptation measures, thereby improving the efficiency and relevance of infrastructure-related climate risk management.

Weighting variables

Rationale for Weighting Hazards. Hydrometeorological hazards affect infrastructure systems differently. For example, bridges, roads, buildings, drainage networks, and water systems may suffer distinct types and levels of damage depending on the hazard involved. To account for this, the RCIA–CT assigns specific weights to each hazard based on their potential to cause infrastructure damage. This approach is supported by climate risk assessment literature and guidance documents.

Literature Basis. The *Guide for the Detailed Analysis of Climate Risk* (CAF, 2019) emphasizes how different types of climatic events—such as torrential rainfall, temperature extremes, or cyclones—exert varied impacts on infrastructure. These differences justify applying differentiated weights that reflect the hazard-specific risks to different infrastructure categories.

Design Implications. The Guide further highlights the importance of adapting infrastructure design and planning to the magnitude and characteristics of climate hazards. In practice, this means prioritizing hazards that pose the greatest threats to infrastructure integrity, safety, and service continuity.

Methodological Approach. To operationalize this idea, the RCIA–CT tool uses pre-defined weights for each hazard. These weights are based on their documented impact on roads, bridges, drainage systems, buildings, and water supply infrastructure. This helps stakeholders prioritize mitigation and adaptation investments.

Table 2. Weights Assigned to Hydrometeorological Hazards in the RCIA-CT

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

Weighting Process. Weights were assigned through a multi-step methodology tailored to Bangladesh's context. The process included:

- Review of historical records on hazard frequency and damage intensity.
- Infrastructure-specific vulnerability assessments.
- Expert consultations and technical analysis.

Considerations in Assigning Weights

i. Hazard Impact and Frequency

Data from Bangladesh show that floods and cyclones are both frequent and highly destructive. Thus, these hazards receive the highest weights (Flood: 100, Cyclone: 95).

ii. Severity of Infrastructure Damage

Certain hazards—like heavy rains and flash floods—especially compromise urban drainage and road networks, resulting in high weights (e.g., Heavy Rain: 90, Flash Flood: 80). Other hazards cause slower, cumulative impacts, such as sea level rise or erosion (moderate weights: 70–50).

iii. Context-Specific Adjustments

Some hazards, such as salinity intrusion, disproportionately affect coastal infrastructure. Their weight reflects their local relevance, particularly for water supply systems in southern Bangladesh.

iv. Balancing Direct and Indirect Impacts

Direct, immediate hazards (e.g., cyclones, flash floods) receive higher weights. Slower-onset or indirect hazards (e.g., drought, heat waves) are given moderate weights due to their longer-term, systemic effects on infrastructure functionality.

Automated Calculation in Form 2

The hazard scoring process begins with **Form 2**, which is automatically populated with hazard data from the DRIP system stored in the CT database. The steps executed by the RCIA–CT tool are as follows:

i. Normalization of DRIP Data

The tool first normalizes the raw hazard magnitude data from DRIP using the normalization table described above. This step ensures all hazard data are on a comparable scale (0–100). It is performed automatically in Form 2.

ii. Combining Weights and Normalized Values

Each normalized hazard value is then combined with the corresponding weight assigned to that hazard type. Form 2 contains formula cells that automatically calculate the product of these two values. This yields a new metric: a **normalized and weighted hazard value**, which quantifies the adjusted impact of each hydrometeorological hazard on infrastructure.

iii. Formula Used

The calculation follows a simple but effective formula: **Weighted Hazard Score=** $\frac{MHv\ x\ HMv}{100}$

Where:

- **WHv** = Weight assigned to the specific hydrometeorological hazard
- **HMv** = Normalized magnitude of the hazard based on DRIP
- **100** = Normalization constant to maintain the scale within 0–100

iv. Execution

When Form 2 is activated within the RCIA–CT tool, the system automatically detects which cells contain DRIP hazard data and applies the formula accordingly. The result is a set of weighted hazard scores that reflect both the severity and the relevance of each hazard for the assessed infrastructure.

Visual Representation. Form 2 thus acts as a dynamic interface where hazard values are normalized, weighted, and integrated into the broader risk calculation process. These computed scores are key inputs for subsequent steps involving exposure and vulnerability assessment.

Table 3. **Computation Matrix of Weighted and Normalized Hazard Scores (Weighted Hazard Score)**

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

Field-Based Hazard Assessment: Form 3

Limitations of DRIP Data. It is important to highlight that DRIP hazard data are generalized and not specifically tailored for individual infrastructure systems. Furthermore, the resolution of these data is relatively low compared to the level of detail required for site-specific hazard assessment. To address this gap, the RCIA–CT methodology includes **Form 3**, which replicates the hydrometeorological hazard variables found in DRIP but enables their re-evaluation through field observation.

Purpose and Use of Form 3 (table 4). Form 3 is designed for completion after conducting a detailed on-site inspection of the infrastructure system. In addition to the DRIP-aligned variables, it includes additional relevant hydrometeorological indicators that may influence the local hazard profile. During the field survey, the responsible engineer performs a **technical inspection** of the site and fills in Form 3 by marking an "X" in the cell that corresponds to the observed magnitude of the hazard affecting the infrastructure.

Calculation Procedure. Once the appropriate cell is marked with an "X", the RCIA–CT tool applies the same normalization and weighting process used in Form 2. This ensures that the field-observed hazard data are incorporated into the risk assessment in a consistent and standardized manner.

Dynamic Scoring in Form 3. The tool identifies the cell activated with the "X" and executes the formula to calculate a **weighted hazard score**, integrating both the normalized field observation and the pre-assigned hazard weight. This dynamic scoring process supports the generation of a more accurate, context-sensitive hazard profile for each infrastructure asset assessed.

Table 4. Field-Based Hazard Assessment: Form 3.

Form 3. Hazard assessment of the planed site-location of planed infrastructure						
Division: Barishal District: Barguna Upazila: Amtali						
Hazard Variable	**Weighted hazard value (WHv)**	**Normalised value of the hazard magnitude (HMv) based on field observations,**				
		Very high **Value: 90**	**High** **Value: 70**	**Moderate** **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
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

Integration Matrix and Aggregated Hazard Index (AHi)

Once **Forms 2 and 3** are completed for a given *upazila*, the RCIA–CT tool generates an **Integration Matrix**. This matrix integrates the hazard data derived from both the DRIP system and field observations to estimate the overall **Aggregated Hazard Index (AHi)** for the assessed infrastructure.

Reconciling Field and Secondary Data. The CT checks for differences in the hazard magnitude values between DRIP-based data (Form 2) and field-assessed data (Form 3):

- If both sources provide values for the same hazard variable and they differ, the tool calculates the **average** of the two values.
- If only one source provides a value, that value is used directly.
- Only **active cells** (i.e., those with data from DRIP, the field, or both) are considered in subsequent calculations.

Step 1: Calculate the Weighted Hazard Index (WHi)

For each active hydrometeorological variable in the Integration Matrix, the CT calculates a **Weighted Hazard Index (WHi)** using the following formula:

$$AHi \ = \frac{MHv \ x \ HMv}{100}$$

Where:

- **WHi** = Weighted Hazard Index (per hazard variable)
- **WHv** = Weight assigned to the hazard type
- **HMv** = Normalized hazard magnitude
- **100** = Normalization factor (to maintain a 0–100 scale)

The WHi reflects the **relative contribution of each hazard** to the overall risk profile, accounting for both the magnitude of the hazard and its relevance (hazardous) to the specific infrastructure.

Step 2: Compute the Aggregated Hazard Index (AHi)

The **AHi** represents the **composite hazard score** for the infrastructure system and is computed as the **average of all WHi values** corresponding to active cells in the matrix: AHi= Average of all active Whi values

This final index summarizes the cumulative impact of multiple hydrometeorological hazards and serves as a core input for the next phases of the risk assessment process (exposure and vulnerability analysis).

Table 5. Integration matrix of form 2 and form 3 and aggregated hazards index.

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)						

Temporal Validity of WHi and AHi

The **Weighted Hazard Index (WHi)** and the resulting **Aggregated Hazard Index (AHi)** are considered valid for the current planning horizon, extending up to the year **2039**. This assumption is based on the observed and projected rates of change in the **Extreme Climate Indices (ECIs)**.

According to climate data analysis, variations in ECIs during this period are generally modest:

- In most cases, the change rates remain **below 5%**.
- In exceptional cases, the variation may reach **up to 10%**, but rarely exceeds this threshold.

Given this relatively low rate of change, the hazard-related indicators used in the RCIA–CT tool are deemed sufficiently **stable** for near- to mid-term infrastructure risk assessments. However, periodic reviews are recommended to validate assumptions and integrate updated climate projections when available.

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

1. Tool Capability. The RCIA–CT tool is equipped to project the **rate of change in hydrometeorological hazards** based on variations in key climate variables. This functionality is supported by a built-in climate database, specifically developed to align with the tool's analytical requirements.

2. Assumption of Linear Relationship. The methodology estimates changes in hazard levels by assuming a **linear relationship** between:

- The rate of change in climate variables (e.g., temperature, precipitation), and
- The corresponding magnitude of hydrometeorological hazards (e.g., floods, droughts).

This linearity implies that a proportional increase in a climate driver results in an equivalent increase in hazard intensity.

3. Justification and Limitations of the Linear Assumption. While the linear assumption allows for **rapid, simplified estimation**, it does not fully capture the complexity of interactions between the climate system and socio-environmental dynamics. The key limitations are:

a. Non-linearity in natural and human systems

Many systems exhibit **threshold behaviors** or **non-linear responses**, due to:

- Cumulative effects like soil saturation influencing flood risk.
- Land-use dynamics and urbanization patterns affecting runoff.
- Variations in topography and vegetation altering hydrological responses.

b. Disproportional escalation of extreme events

Increases in mean climate variables (e.g., global temperature) can trigger **non-linear surges** in extreme events. For instance, a 1°C rise may lead to a disproportionately high increase in heatwave frequency and severity.

4. Validity of the Assumption in Context. Despite its limitations, the linear assumption remains a valid approximation for the purpose of **preliminary, rapid climate risk screening**. It serves to inform whether further, more comprehensive analysis is warranted for infrastructure risk and adaptation planning. It should be interpreted strictly within this **referential and operational context**.

5. Projection Matrix for SSP2 and SSP5 Scenarios. The RCIA–CT includes a projection matrix for **SSP2 (moderate scenario)** and **SSP5 (high-emission scenario)**. In this matrix, the **Rate of Climate Change (RCC)** is expressed as a normalized percentage, enabling comparative analysis across hazards and infrastructure systems.

Fig. 4. Example of the Projection Spreadsheet					
Division District Upazila					
Hazard Variable (VH)	HAZARD LEVEL				
	Very high	High	Medium	Low	Very low
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

Temporal Scope of Hazard Projections

Validity of Present-Day Hazard Values through 2039. The **Integration Matrix**—which combines hazard data from Forms 2 and 3—generates values that represent current hazard conditions. Given that the **rate of change in climate variables relevant to infrastructure** (e.g., temperature, precipitation extremes) generally does not exceed **5%–10%** in most regions, these hazard values are considered valid for **projection up to the year 2039** for all *upazilas* in Bangladesh.

Transition Period: 2040 and Beyond. Starting from **2040**, the projected **rate of change in engineering-relevant climate variables** exceeds the 5%–10% threshold in many *upazilas*, making the shifts in hazard intensity more **pronounced and significant**. These higher rates indicate that the projected hazard conditions diverge meaningfully from current ones, warranting updated assessments.

Table 5. Projection matrix example.

Projection Matrix Period **2020-2039** *(SSP2 Scenario)*						*Projection Matrix Period* **2040-2059** *(SSP2 Scenario)*					
Division: Barishal District: Barguna			Project: a			Division: Barishal District: Barguna			Project: a		
	Very High	High	Medium	Low	Very Low		Very High	High	Medium	Low	Very Low
Upazila: Amtali						**Upazila: Amtali**					
Cyclone	91,10					Cyclone	90,26				
Drought: Pre Kharif				33,60		Drought: Pre Kharif				32,76	
Erosion			59,60			Erosion			58,76		
Flash flood			45,60			Flash flood			44,76		
Flood		65,60				Flood		64,76			
Landslides				30,60		Landslides				29,76	
Salinity			50,60			Salinity			49,76		
Sea Level Rise		61,60				Drought: Pre Kharif		60,76			
Storm surges	81,60					Storm surges	80,76				
Heat wave			50,60			Heat wave			49,76		
Heavy Rain	86,60					Heavy Rain	85,76				
Hailstorms				23,60		Hailstorms				22,76	
Canal or stream overflow		77,60				Canal or stream overflow		76,76			
Erosion of coastal slopes and/or shorelines			59,60			Erosion of coastal slopes and/or shorelines			58,76		
River-bank erosion			50,60			River-bank erosion			49,76		
Strong sedimentation			41,60			Strong sedimentation			40,76		
Fresh water scarcity			59,60			Fresh water scarcity			58,76		
Lightning				32,60		Lightning				31,76	
Projected AHi	59,26					Projected AHi	58,41				

Projected Aggregated Hazard Index (AHi): Methodological Explanation

As part of its forward-looking analysis capabilities, the RCIA–CT tool allows for the projection of the Aggregated Hazard Index (AHi) under different climate change scenarios (e.g., SSP2 and SSP5). This projection is achieved through the following steps:

Projection of Hazard Magnitude (HMv). Using the Projection Matrix, the tool estimates future values of hazard magnitude for each hydrometeorological variable. These values are derived from the Rate of Climate Change (RCC) associated with key climate drivers (e.g., temperature, precipitation) stored in the CT's climate database.

Recalculation of Weighted Hazard Index (WHi). The projected hazard magnitudes (HMv) are then combined with the corresponding hazard weights (WHv), which reflect the relative importance of each hazard type for infrastructure. This combination yields new, projected WHi values, calculated using the same formula applied in the present-time assessment:

$$Projected\ Whi\ = \frac{WHv\ x\ Projected\ HMv}{100}$$

Calculation of Projected Aggregated Hazard Index (AHi). The tool computes the **Projected AHi** by averaging the projected WHi values across all active hazards for each infrastructure asset or location:

Projected AHi= Average of all Projected Whi values
This projected AHi provides a forward-looking indicator of how hazard-related risks may evolve under climate change conditions for a given *upazila* or infrastructure system.

4. Application. The comparison between the **current AHi** and the **projected AHi** allows decision-makers and engineers to:

- Identify infrastructure that will face significantly higher hazard pressures.
- Prioritize locations or systems for adaptation investment.
- Decide whether more detailed dynamic risk modeling is warranted.

This capability transforms the RCIA–CT from a static diagnostic tool into a dynamic planning support system, facilitating anticipatory action in the face of climate uncertainty.

BOX. 1. 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:

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

- 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.

In the RCIA–CT methodology, **exposure** and **vulnerability** are key components for understanding the potential impact of hydrometeorological hazards on infrastructure systems.

- **Exposure** refers to the **degree of potential damage or loss** that an infrastructure asset may experience **if a hazardous hydrometeorological event affects its location**.
- **Vulnerability** refers to the **intrinsic susceptibility** of infrastructure to damage, determined by engineering-related factors such as design standards, materials used, structural condition, and adaptive capacity. It captures how likely the infrastructure is to suffer harm, assuming it is exposed to a hazard.

1. Exposure Assessment Method. The RCIA–CT tool evaluates exposure by first identifying **hazards classified as 'High' or 'Very High'** in the Integration Matrix for the current time period. Hazard types with 'Moderate', 'Low', or 'Very Low' classifications are excluded from the exposure analysis, as their likelihood or potential impact is considered insufficient to trigger significant loss or damage.

2. Exposure Scenarios. For each high or very high hazard type identified, the tool generates an **exposure scenario**. These scenarios describe plausible **damage or loss patterns** affecting the physical integrity, materials, or functioning of the infrastructure asset in question—whether it is a building, road, bridge, drainage system, or water supply facility.

3. Relationship with Vulnerability. In this methodology, **vulnerability is assumed to be comparable across similar damage/loss scenarios**—a simplification referred to as *overt exposure*. This assumption is based on the understanding that the **severity of impact is closely related to two key vulnerability factors**:

- **Sensitivity**: the degree to which the infrastructure is likely to be affected by the hazard.
- **Adaptive Capacity**: the infrastructure's built-in ability to absorb, resist, or recover from impacts.

These factors are indirectly captured in existing features such as **design parameters, material choices, and site-specific conditions**.

This simplified treatment of vulnerability is consistent with international best practices for **screening-level climate risk assessments**. Sources such as the *CAF Guide to Detailed Climate Risk Analysis (2019)*, the *PIEVC Protocol*, and the *GIZ Climate Risk Sourcebook* acknowledge that when conducting **initial scoping or prioritization exercises**, it is both reasonable and methodologically sound to treat vulnerability in an aggregated or semi-quantitative manner. This approach helps to balance **analytical efficiency with decision-making relevance**, especially in contexts where data availability is limited or rapid guidance is needed.

Nevertheless, this assumption should be explicitly recognized as a **practical simplification**. For any subsequent detailed or site-specific assessment, a more granular analysis of vulnerability should be conducted, considering the specific structural, environmental, and social characteristics of the infrastructure system.

4. Classification Scale for Exposure and Vulnerability

Table 6. Exposure severity classification scale

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

Integrating Vulnerability Through Exposure Scenarios

In the RCIA–CT methodology, **vulnerability is not estimated as a separate dimension**, but rather **inferred through the severity of exposure scenarios**. This approach, known as **overt exposure**, assumes that vulnerability is embedded in the nature and extent of the anticipated damage or loss associated with each hazard.

This simplification is based on the premise that two core components of vulnerability:

- **Sensitivity** (the propensity of the infrastructure to be adversely affected), and

- **Resilience** (its built-in adaptive capacity),are inherently reflected in the observed or expected outcomes—i.e., how the infrastructure performs when exposed to a hazard.

Therefore, when the severity of damage or loss is assessed (e.g., to the structure, materials, or site), the RCIA–CT interprets this as an expression of **both exposure and vulnerability combined**. This combined perspective:

- Allows for operational efficiency in rapid risk screening.
- Aligns with international guidance for early-stage assessments.
- Facilitates integration with the overall climate risk index.

Automated Scoring Matrix. Each cell in the **Exposure and Vulnerability Assessment Matrix** of the RCIA–CT tool contains a **predefined value** that represents the **combined severity of exposure and vulnerability** for a given scenario of expected loss or damage. These values are designed to reflect the integrated probability of losses or damanges posed by different hydrometeorological hazards to key components of infrastructure systems.

When an evaluator marks an "X" in a matrix cell—selecting a scenario of probable damage—the RCIA–CT tool **activates the corresponding value**. This value is computed using a **weighted formula** that accounts for the relative importance of three critical infrastructure components:

- **Physical structure** (40%)
- **Construction materials** (30%)
- **Site conditions/location characteristics** (30%)

Each component is assessed according to the **severity level of potential loss or damage**, based on the following standardized classification:

Table 7. Severity level of Exposure and Vulnerability

Severity Level	Assigned Value
Very High	90%
High	70%
Medium	50%
Low	30%
Very Low	10%

The RCIA–CT calculates the final **combined exposure–vulnerability score** using the following formula:

$$Combined\ Score = \frac{[(PxV) + (MxV) + (LxV)]}{100}$$

Where:

- P, M, and L represent the predefined weight percentages for **Physical** (40), **Material** (30), and **Location** (30) components, respectively.
- V is the assigned **severity value** (e.g., 70% for "High").

Alternatively, this formula can be broken down into:

$$Combined\ Score = \frac{[(40xVp) + (30xVm) + (30xVl)]}{100}$$

Where: Vp, Vm, and Vl are the evaluator-assigned severity values for each component.

This automated classification ensures that the scoring reflects not only the level of hazard exposure but also the **engineering and locational characteristics** that define vulnerability, providing a consistent and replicable method for rapid climate risk screening.

Application of Exposure–Vulnerability Scores in Index Calculation

Although the **RCIA–CT tool evaluates all potential exposure–vulnerability combinations** through the comprehensive **Assessment Matrix**, it is methodologically designed to proceed with **only those scenarios classified as "High" or "Very High"** when calculating the **Integrated Index of Infrastructure Exposure and Vulnerability**. This selective focus serves two key purposes:

1. **Prioritization of Critical Scenarios.** Scenarios categorized as "High" or "Very High" represent conditions under which infrastructure systems face **severe or potentially catastrophic damage**. By concentrating on these cases, the RCIA–CT ensures that the analysis focuses on **the most urgent and impactful situations**, aligning with standard risk management principles that emphasize prioritizing high-consequence events.
2. **Screening Efficiency and Decision-Making Utility.** In the context of screening-level assessments, it is neither necessary nor efficient to include lower-severity scenarios in the final index. Doing so may dilute the sensitivity of the index and obscure priority risks. The tool, therefore, uses a **threshold approach** that filters out moderate to low risk combinations, enabling decision-makers to **rapidly identify infrastructure assets that require deeper analysis, adaptation planning, or immediate intervention**.

This approach is consistent with methodologies used in tools such as the **PIEVC Protocol**, the **CAF Climate Risk Assessment Guide**, and the **GIZ Climate Risk Sourcebook**, all of which endorse **threshold-based filtering** as a valid practice in rapid climate risk diagnostics.

The **Integrated Index of Infrastructure Exposure and Vulnerability** is thus derived by aggregating only the **activated values** in the matrix that fall into the "High" or "Very High" severity categories (table 8). This index feeds directly into the broader risk calculation framework of the RCIA–CT.

Table 8. Exposure and Vulnerability Assessment Matrix

Description	**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 of exposure & vulnerability by severity level.	$\mathbf{IeC = S\frac{\bar{x}ci}{Nci}}$	$\mathbf{IeC = S\frac{\bar{x}ci}{Nci}}$	$IeC = S\frac{\bar{x}ci}{Nci}$	$IeC = S\frac{\bar{x}ci}{Nci}$	$IeC = S\frac{\bar{x}ci}{Nci}$
Integrated Index of Infrastructure	$\mathbf{IeUp = S\frac{IeC}{2}}$		Excluded		

Exposure and Vulnerability (IeUp)		

Calculation of the Integrated Index of Infrastructure Exposure and Vulnerability by Upazila (IeUp)

Once the evaluator identifies the scenarios of **"High" or "Very High" severity** in the Exposure and Vulnerability Assessment Matrix, the RCIA–CT tool computes the **Weighted Index of Exposure and Vulnerability (IeC)** for each activated cell. This is done using the component-based formula discussed previously, which integrates:

- 40% of the physical structure score,
- 30% of the materials score,
- 30% of the site/location score.

Each score is multiplied by the assigned severity value (e.g., 90 for "Very High"), and divided by 100.

Step 1: Compute Weighted Index for Each Activated Cell (IeC)

$$IeC = \frac{\sum \bar{x}ci}{Nci}$$

Where:

$\sum \bar{x}_{ci}$ = sum of all weighted values from the activated cells in the matrix

N_{ci} = number of activated cells (cells marked "High" or "Very High").

This provides an average weighted score representing the level of exposure and vulnerability for each activated scenario.

Step 2: Compute the Integrated Index per Upazila (IeUp)

To obtain a single, integrated index that reflects the exposure and vulnerability status of a given upazila, the tool calculates the average of all the IeC values computed for that upazila:

$$IeUp = \frac{\sum IeC_i}{N_{IeC}}$$

$\sum IeC_i$ = sum of the exposure–vulnerability indices (IeC) for each infrastructure component or hazard type

N_{IeC} = total number of IeC values computed in the upazila.

This **Integrated Index (IeUp)** allows direct comparison of risk levels between different upazilas and infrastructure types, helping prioritize where adaptation measures are most urgently needed.

The Climate Change Risk Index Calculation.

To estimate the **baseline Climate Risk Index** for infrastructure systems by *upazila*, the RCIA–CT tool generates a dedicated **visualization tab** within the Climate Risk Index report.

This tab consolidates the results of the hazard, exposure, and vulnerability assessments into a single integrated indicator of climate risk.

The Climate Risk Index is calculated using the following components:

1. Integrated Index of Infrastructure Exposure and Vulnerability (IeUp)

$$IeUp = \frac{\sum IeC_i}{N_{IeC}}$$

Where:

IeC_i = Weighted Exposure–Vulnerability Index for each activated scenario.

N_{IeC} = Number of activated exposure–vulnerability combinations.

This index reflects the overall susceptibility of the infrastructure system in the upazila, based on structural, material, and locational factors.

2. Aggregated Hazard Index (AHi)

$$AHi = \frac{\sum \bar{x}H}{NH}$$

Where:

$\bar{x}_H$ = weighted and normalized hazard value for each hydrometeorological event,

N_H = number of activated hazard types (typically 5 major hazard types are assessed).

This index represents the **average magnitude and relevance of the hazards** affecting infrastructure in each upazila, based on current and projected climate data.

3. Infrastructure Risk Index (IRi)

$$IRi = \frac{IeUp + AHi}{2}$$

This final index provides a **quantitative estimation of climate-related disaster risk** for infrastructure systems in each upazila. It combines:

- the internal system characteristics (exposure and vulnerability), and
- the external forcing factors (hazards),

to offer a balanced and scalable metric for risk-informed planning and prioritization.

Clarifications:

- The use of average functions in both IeUp and AHi ensures internal consistency and comparability across regions and infrastructure types.
- All formulas are aligned with **screening-level risk assessment standards**, such as PIEVC and CAF frameworks, and allow the RCIA–CT to serve as a robust decision-support tool.

Application and Database

The application is a system developed in C#. The source code is in GitHub, the repository name is "crelic". Inside the repository "crelic", in the folder "RCIA Project" is the user final application. It is a ".zip" file. And the source code of the C# application is in crelic/crelic folder.

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 weighted hazard level for each upazila and the type of hazard. The CT is built from this data.

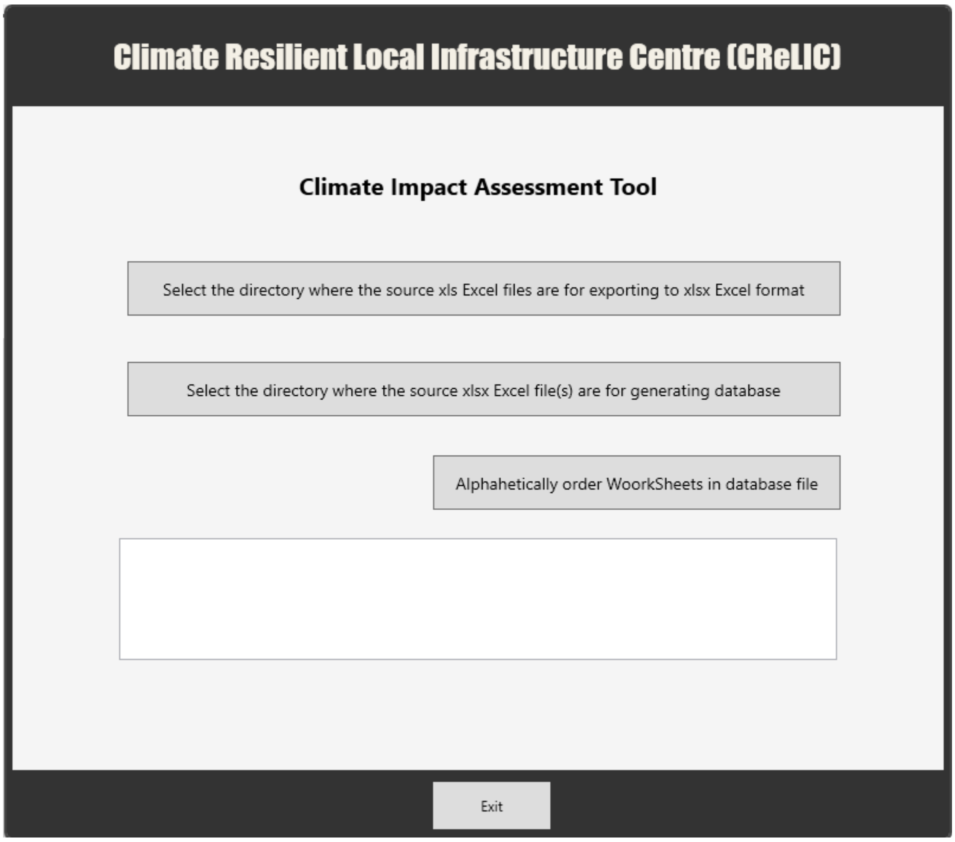
The steps explained below were executed to obtain from the DRIP the hazard data (type and hazard level) corresponding to all upazila (567 in total[5]),

The steps are as follows:

1. Obtain the DRIP data for the required upazila and hazard. There are two ways to do this:
   i. **The first way is to go hazard by hazard for each upazila:**
      a. The DRIP web url is MapView - DRIP (plancomm.gov.bd).
      b. The output is a xls file that contains the hazard level for that upazila.

   ii. **The second way is searching all hazards for each upazila:**
      a. 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 for the selected upazila.
      b. The outputs are the reports for each hazard for the selected upazila. These reports must be downloaded one by one.
      c. The outputs are 'xls' Excel files that contain the hazards level for that upazila for all the hazards.

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



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 into the "download" directory inside de "RCIA Project Tool/Database/Application" directory (recommended),
    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/Database/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 OR UPDATE THE DATABASE WITH THE xlsx FILE GOT IN PREVIOUS STEP

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

,,/Project/Database/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/Database/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":

	Very high	High	Medium	Low	Very low
cyclone	85,5	66,5	47,5	28,5	9,5
drought: pre kharif	36	28	20	12	4
erosion	54	42	30	18	6
flash flood	72	56	40	24	8
flood	90	70	50	30	10
landslide	45	35	25	15	5
salinity	45	35	25	15	5
sea level rise	63	49	35	21	7
storm surge	85,5	66,5	47,5	28,5	9,5

Very high	High	Medium	Low	Very low
95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
95x90/100	95x70/100	95x50/100	95x30/100	95x10/100

- 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":

	Very high	High	Medium	Low	Very low
cyclone	85,5	66,5	47,5	28,5	9,5
drought: pre kharif	36	28	20	12	4
erosion	54	42	30	18	6
flash flood	72	56	40	24	8
flood	90	70	50	30	10
landslide	45	35	25	15	5
salinity	45	35	25	15	5
sea level rise	63	49	35	21	7
storm surge	85,5	66,5	47,5	28,5	9,5

Very high	High	Medium	Low	Very low
95x90/100	95x70/100	95x50/100	95x30/100	95x10/100
40x90/100	40x70/100	40x50/100	40x30/100	40x10/100
60x90/100	60x70/100	60x50/100	60x30/100	60x10/100
80x90/100	80x70/100	80x50/100	80x30/100	80x10/100
100x90/100	100x70/100	100x50/100	100x30/100	100x10/100
50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
50x90/100	50x70/100	50x50/100	50x30/100	50x10/100
70x90/100	70x70/100	70x50/100	70x30/100	70x10/100
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