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স্থানীয় সরকার প্রকৌশল অধিদপ্তর
আগারগাঁও, শেরেবাংলা নগর
ঢাকা- ১২০৭।
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শেখ হাসিনার মূলনীতি
গ্রাম শহরের উন্নতি

স্মারক নং- ৪৬.০২.০০০০.৩১২.৯৯.০১৩.২৩-৯৬৩

তারিখ: ০২/০৭/১৪৩০ বাং।
১৮/১০/২০২৩ খ্রিঃ।

প্রতি,

১। প্রকল্প পরিচালক
------------------------------- প্রকল্প।
এলজিইডি, সদর দপ্তর, ঢাকা- ১২০৭।

২। নির্বাহী প্রকৌশলী/উপ- প্রকল্প পরিচালক
------------------------------- প্রকল্প।
এলজিইডি, সদর দপ্তর/জেলাঃ ----------------- ।

বিষয়: উন্নয়ন প্রকল্পে স্কীম প্রনয়নের সময় Climate Resilient Local Infrastructure Centre (CReLIC) কর্তৃক প্রণীত Climate Resilient tool (CRT) ব্যবহার প্রসঙ্গে।

উপরোক্ত বিষয়ের প্রেক্ষিতে জানানো যাচ্ছে যে, সরকারি খাতে উন্নয়ন প্রকল্প প্রণয়ন, প্রক্রিয়াকরণ, অনুমোদন ও সংশোধন নির্দেশিকা (জুন ২০২২ পরিপত্র) অনুযায়ী প্রকল্প প্রণয়নের ক্ষেত্রে জলবায়ু পরিবর্তনের প্রভাব বিশ্লেষণ ও গৃহীত ব্যবস্থাদির বিষয়টি বাধ্যতামূলক করা হয়েছে। এছাড়াও উন্নয়নে সহযোগী সংস্থার সাথে Policy Based Lending (PBL) এর ক্ষেত্রে এটি একটি অত্যাবশ্যকীয় পূর্বশর্ত। সেই প্রেক্ষিতে CReLIC কর্তৃক Climate Impact Assesment (CIA) শিরোনামে একটি Climate Resilient Tool (CRT) প্রস্তুত করা হয়েছে।

এমতাবস্থায়, উন্নয়ন প্রকল্প প্রণয়নের সময় অবকাঠামোর ওপর জলবায়ু পরিবর্তনের প্রচার বিশ্লেষণ ও গৃহীত ব্যবস্থাদি এবং প্রাক্কলিত ব্যয় নির্ধারণের ক্ষেত্রে Climate Impact Assesment (CIA) গাইডলাইন আবশ্যকভাবে ব্যাবহারের জন্য অনুরোধ করা হলো।

সংযুক্তি: CIA গাইডলাইন।

(মো: আলি আখতার হোসেন)
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অনুলিপিঃ
১। অতিরিক্ত প্রধান প্রকৌশলী (সকল/সকল বিভাগ/পরিচালক- CReLIC), এলজিইডি।
২। তত্ত্বাবধায়ক প্রকৌশলী (সকল/সকল অঞ্চল), এলজিইডি।
৩। প্রকল্প পরিচালক --- ।
৪। নির্বাহী প্রকৌশলী/উপ- প্রকল্প পরিচালক -------------------------------- ।

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Implemented by:

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Ministry of Local Government, Rural Development and Cooperatives
Local Government Engineering Department (LGED)
LGED Bhaban, Agargaon, Dhaka-1207
Bangladesh

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

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A Guiding Document to Conduct Rapid Climate Impact Assessment

Milestone 8b (Part)

(Final Version 1.1)

July 2023

A Joint Venture of AMBERO – COMO Consult – TTT

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Table of contents

List of acronyms

8FYP	Eight Five Year Development Plan 2020-2025
ACCNLDP	Adaptation to Climate Change into the National and Local Development Planning
ADB	Asian Development Bank
ADKAR	Awareness, Design, Knowledge, Ability and Reinforcement
AIIB	Asian Infrastructure and Investment Bank
AOP	Annual Operational Plan
BMD	Bangladesh Meteorological Department
BDP 2100	Bangladesh Delta Plan 2100
BPC	Bangladesh Planning Commission
CAG	Consultative Advisory Group of CReLIC
CCA	Climate Change Adaptation
CCIA	Comprehensive Climate Impact Assessment
CEGIS	Centre for Environment and Geographic Information Services
CIA	Climate Impact Assessment
CReLIC	Climate Resilient Local Infrastructure Centre
CRIM	Climate Resilient Infrastructure Mainstreaming Project
GCF	Green Climate Fund
GCM	Global Circulation Models/ Global Climate Models
GIS	Geographic Information System
GIZ	Gesellschaft fur Internationale Zusammenarbeit
GoB	Government of Bangladesh
IADB/IDB	Inter-American Development Bank
ICCCAD	International Climate Change Centre on Adaptation and Development
IsDB	Islamic Development Bank
IKI	International Climate Initiative
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature

KfW	German Development Bank/ Kreditanstalt fur Wiederaufbau
KMS	Knowledge Management System
LGED	Local Government Engineering Department
MoEF&CC	Ministry of Environment, Forestry and Climate Change
NAP	National Adaptation Plan of Bangladesh 2023-2050
NCVA	Nationwide Climate Vulnerability Assessment
NDC	Nationally Determined Contribution
NGO	Non-Government Organization (incl. Civil Society Organization)
OECD	Organization for Economic Cooperation and Development
PIK	Potsdam Institute for Climate Impact Research
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PBR	Proportional Baseline Ratio
RCIA	Rapid Climate Impact Assessment
SDG	Sustainable Development Goals
SLE	Center for Rural Development (Seminar fur Landliche Entwicklung-Berlin University).
UNDRR	United Nations Disaster Risk Reduction
UNOPS	United Nations Office for Project Services
USAID	United States Assistance for International Development
WB	World Bank

Key terminology

Adaptation. In human systems, climate change adaptation is the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities (IPCC Special Report 1.5C).

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description of the climate system.

Climate Change Impacts. The effects of climate change on natural and human systems. Depending on the state of adaptation, one can distinguish between potential impacts and residual impacts:

- Potential impacts. All impacts that may occur given a projected change in climate, without considering adaptation.
- Residual impacts. The impacts of climate change that would occur after adaptation has taken place.

Climate Impact Assessment (CIA). The practice of identifying and evaluating, in monetary and/or in non-monetary terms, the effects of climate change on natural and human systems. In general the assessment comprises the following steps (World Bank): (i) Hazard exposure of the project location and proposed interventions or project components, (ii) Potential impact that identifies the sensitivity of project location and proposed interventions to identified climate exposure and ability to cope, (iii) Adaptive capacity, how resilient are the resources of the project location; is resilient built into the proposed project interventions/components, and (iv) Project risk, taken together, what are the project location and proposed interventions vulnerable to, and to what extend?

Climate Model. A numerical representation of the climate system that is based on the physical, chemical, and biological properties (IPCC AR5, 2013). A qualitative or quantitative representation of the climate system based on the physical, chemical and biological properties of its components, their interaction and feedback processes and accounting for some of its known properties.

Climate Projection. The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases, often based on simulations by climate models. Climate projections critically depend on the emissions scenarios used and therefore on highly uncertain assumptions of future socioeconomic and technological development.

Climate Resilience can be generally defined as the capacity for a socio-ecological system to: (i) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (ii) adapt, recognise, and evolve into more desirable configurations that improve the sustainability of the (infrastructure) system, leaving it better prepared for future climate change impacts.

Climate Scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observed current climate.

Climate System. The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryo-sphere, the lithosphere, and the biosphere, and the interactions among them. The climate system evolves in time under the influence of its own internal dynamics and because of external forces such as volcanic eruptions, solar variations, and anthropogenic forces such as the changing composition of the atmosphere and land use change.

Decision Scaling: A decision-making process that informs planning processes and users a decision analytical framework to reveal the full range of climate information that is needed to best inform the decision at hand.

Downscaling is a method that derives local-to-regional-scale (10 to 100 kilometers) information from larger scale models or data analyses. There are two main methods: dynamical downscaling and empirical or statistical downscaling. The dynamical method uses the output of regional climate models, global models with variable spatial resolution, or high-resolution global models. The empirical or statistical methods develop statistical relationships that link large-scale atmospheric variables with local and regional climate variables.

Extreme Weather Event: Event that is rare at a particular place and time of the year. Definitions or 'rare' vary, but an extreme weather event would normally be as rare or rarer than the 10th or 90th percentile of the observed probability density function.

Impacts (Consequences, Outcomes). Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change.

Mitigation to Climate Change: A human intervention to reduce the sources or enhance the sinks of greenhouse gases and/or the lessening of the potential adverse impacts of physical hazards (including those that are human induced) through actions that reduce hazard, exposure, and vulnerability.

Representative Concentration Pathways (RCPs): RCPs are scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use / land cover. RCPs were used to develop climate projections in CMIP5. See also Shared Socioeconomic pathways (SSP). SSP is consistent with a range of RCPs.

Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or re-organizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014).

Shared Socio-Economic Pathways (SSP): SSPs are part of a framework established by the climate change research community to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. The SSP examine how global society, demographics and economics might change over the next century. The SSPs are based on five narratives describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fuelled development, and middle-of-the-road development. Each SSP is consistent with a range of RCPs

Introduction

"It is better to have a moderately useful tool than a perfectly useless one".

The Rapid Climate Impact Assessment tool (RCIA) forms part of a toolbox that in all form part of the Climate Resilience Handbook. The RCIA is a rapid method to understanding the magnitude of hazards associated with a changing climate that could impact an infrastructure project, and thus identify the challenges for climate resilient engineering. As such the RCIA supports answering the questions 25.3 and 32 of the Development Project Proposal (DPP).

RCIA is a set of analytical forms and matrices that facilitate the rapid tracking, collection, and processing of secondary and empirical data and information to support the decision making process during the project feasibility phase. In this sense, RCIA answers the question: What potential climate-related hazards does the project need to consider when planning and designing the infrastructure? To answer this question, RCIA aims to:

I. Estimate the level of hazard associated with climate signals and the aggregate impacts to which the project may be exposed now and over its lifetime.
II. Gather local knowledge of climate-related hazards and assess conditions at the project site.
III. Identify adaptation challenges for the project, considering commonly used standard designs and materials, and the selected location.
IV. Report findings and recommendations for improving the feasibility study process, while defining technical adaptation specifications for design, materials, and possible site improvements.

The RCIA is designed to be carried out during the feasibility phase at the sub-project or scheme level in the sectors for which the LGED is responsible (rural, urban, water), regardless of the size or type of infrastructure. It is also an important tool to contribute to the formulation and feasibility analysis of urban master plans or water development plans.

In certain situations, given the size of the investment, the complexity, the lifespan of the infrastructure and the hazard level of the area where the project will be located, the RCIA is used to determine the scope of the technical specifications leading to the full climate impact assessment using the Comprehensive Climate Impact Assessment (CCIA) tool.

The RCIA tool provides a step-by-step guide (fig. 1) to the process of collecting, analysing and making a preliminary assessment of secondary information extracted from the various documents available in the CReLIC knowledge management platform, such as Bangladesh National Adaptation Plan 2023-2050, Delta Plan 2100, Perspective Plan, and Climate Projections from renowned institutes. Together with the updated guidelines with climate indicators and adaptation options, the engineer can summarise conclusions and provide technical recommendations to adapt the project and proceed to final design and planning or, if necessary, provide a set of technical specifications to define the scope of the CCIA and proceed with it. The report will answer the following key questions:

- What climate hazards do the project face and how will they change in the future?
- What is the potential exposure of the project and how will it change in the future?
- What are the potential impacts on the project and how will they change in the future?

- What are the current challenges and how will they change in the future?

- What measures will need to be taken in terms of design, materials and/or siting between now and the next 10 years if CCIA is not required/need?

- What are the technical specifications that should be defined and their scope to proceed to CCIA if necessary?

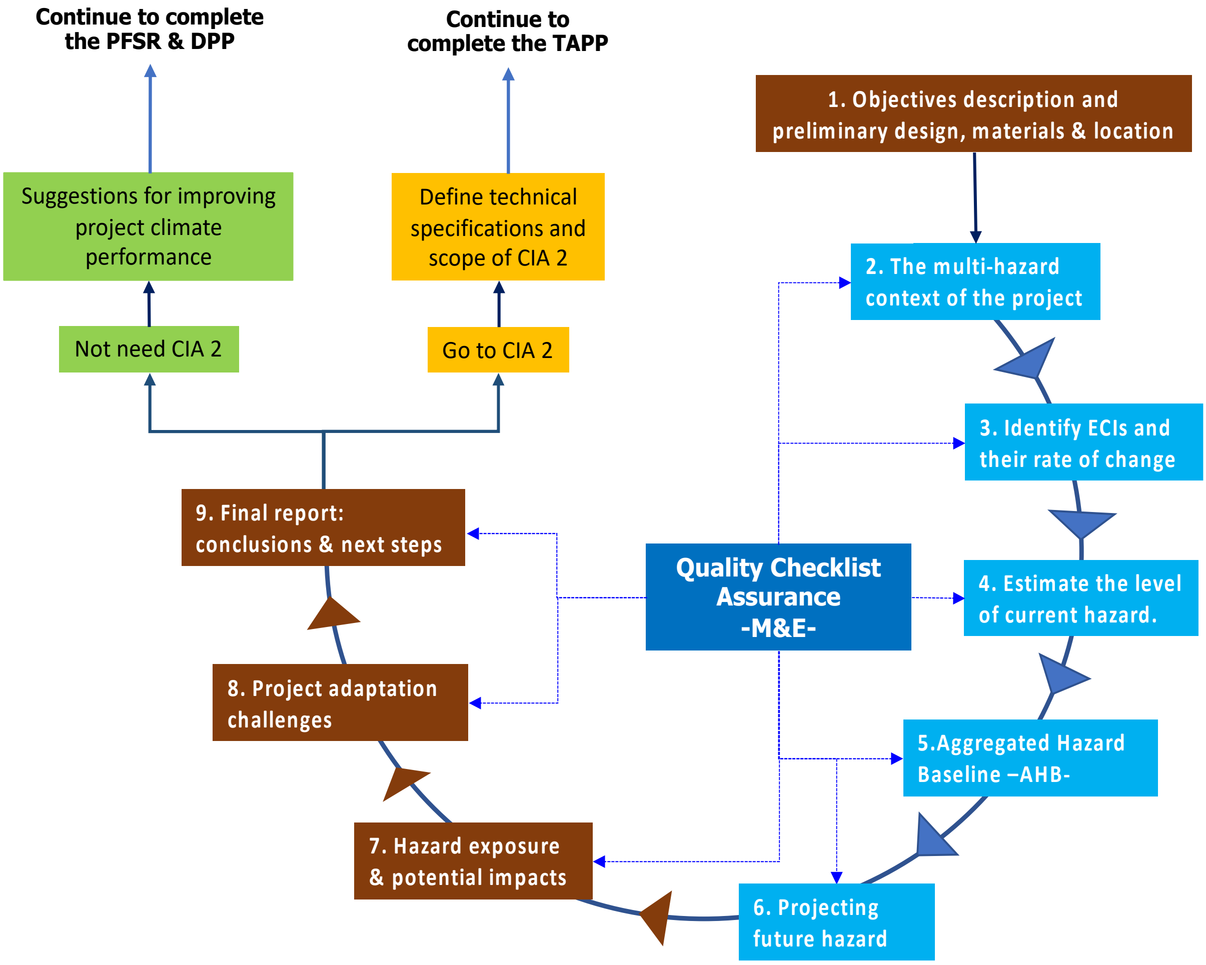


Fig.1. Components of RCIA in the feasibility project framework

The first step is to ensure that climate resilience is integrated in all levels of development planning and the decision-making process. This included a detailed description of the subproject profile and its likely locations and/or layout is requested, as well as a description of the initial design idea and materials to be used. Obtaining a site map (through IT Unit, Google Earth, ARCGIS) of the project location.

The second step is to identify if the project site is in a hotspot area or Climate Stress zones. The climate stress area projected in the NAP include a multi-hazard map of Bangladesh shows the spatial distribution of eleven climate stress zones *"prominent of climatic hazards"*, followed by a form where the list of climatic hazards and the affected districts are related, to contextualise the sub-project within a general framework of hazardous situations.

The third step leads to the identification of Extreme Climate Indices (ECIs) and their rate of change; for this purpose, the technical guidelines are given for the collection of data on the "climate extremes of extremes" (90-95 and/or 10-05 percentiles) for the reference period, the historical period and the projections for the next decades, in order to calculate the rate of change of the Extreme Climate Indices (ECIs) of interest for civil engineering, in 20-year periods and considering the emission scenarios SSP2-4.5 and SSP5-8.5. Climate data can be obtained from or through CReLIC.

The fourth step is to analyse the different types of hazards that exist in the area where the sub-project is to be developed, and to calculate the aggregate level of hazards that characterise the area for the current period. To do this, the engineering team will need to (1) coordinate with the LGED office at the Upazila level to lead the site-level assessment and community stakeholder consultations to collect valuable information from the field; in parallel, (2) the engineering team in charge will need to review in detail the national and international platforms that display this type of information (such as the DRIP); and finally, but very importantly, (3) they will need to consult in detail the documents and database available in the KMS (RCIA folder/library).

In the fifth step the *Hazard baseline Aggregated (HbA)* is calculated, that allows us to project into the future the aggregate set of climate-related hazards identified in Form 5, according to the expected rate of change in the ECIs calculated in Form 3.

The sixth step, hazard levels are projected into the future, considering the climate change scenarios SSP2-4.5 and SSP5-8.5, for the same 20-year periods used to calculate the ECIs. This projection is made under the following assumptions: (i) there is a proportional relationship between the magnitude of the ECIs and their percentage change per decade, with the hydrometeorological responses and the proportion by which these could change in the future; (ii) land use trends, which also modify the hydrometeorological responses, will continue without significant change.

In the seventh step, the exposure and potential impact (probability of loss and expected damage) corresponding to a specific type of infrastructure is analysed; this is the moment when the knowledge and experience of the engineering team in charge of the sub-project comes into play. Considering the climatic signals and hydro-meteorological hazards, the impact chains to which the infrastructure could be exposed are defined, pondering the preliminary design, the materials to be used and the planned location of the infrastructure, i.e., the level of exposure to the hazards. The objective is to enhance the resilience of infrastructure and ensure that development projects are designed to withstand the impacts of climate change. Use or reference to the updated guidelines and climate indicators for each sub-sector (available in KMS folder/library Guidelines and CIA).

Step eighth is to specify/describe in detail the adaptation challenges faced by the sub-project, given the expected impacts of climate change during its lifetime. This process involves typical teamwork, drawing on the depth of the reference framework and the knowledge of the technical team in charge of the sub-project. In this step it is advisable to engage with local community and stakeholders as recommended in the National Adaptation Plan 2023-2050.

Step ninth is summarising the findings of the RCIA in a final report. This report explains the analytical steps carried out, the results of each step, the conclusions, and the next steps to be taken. If the next step is to proceed to CCIA, the technical team will need to propose the technical specifications for the scope of the CCIA and meet the requirements to apply for the Technical Assistance Project Proposal - TAPP.

If the sub-project meets the criteria to exclude the step to CCIA, the technical team must provide a set of technical guidelines to increase the climate resilience of the sub-project's design, materials, and location. For this purpose, RCIA provides a sample menu of adaptation measures for civil works, as well as a very important document entitled *"Recommendations and Adjustments of Standard Measures, Part A: Revised Design and Cost Estimate for Climate Resilient LGED Bridges & Culvert, and Cyclone Shelter or Buildings"*.

If the sub-project does not need to proceed to CCIA because it meets the exclusion criteria, the engineering team must prepare the required items from the Project Feasibility Study Report and Development Project Proposal -DPP- as recommended in this Step 9 of the RCIA.

Scope of application

RCIA is a tool for analysing and assessing the hazard and exposure potential of the area where the proposed infrastructure is to be developed. The analysis can cover territorial scales ranging from an Upazila (two or more union councils) to a district (two or more Upazilas), or it can even be used to analyse hazard and exposure potential at a divisional scale (two or more districts). However, the choice of the territorial scale of the hazard and exposure analysis must be consistent with the location and/or likely layout of the subproject to be assessed.

On the other hand, RCIA provides the tool to make a preliminary analysis of the likely impact (probability of loss or damage) that could occur to a specific type of infrastructure, considering the preliminary design, materials and proposed location or likely layout.

For some types of infrastructure, such as a road or utility system whose route may pass through several union councils or Upazilas, or even several districts, the engineering team must first identify the areas of greatest risk (hotspots) and focus the impact analysis on the specific infrastructure, considering these hotspots.

Pre-requirements to use the RCIA.

Before engineers start with the RCIA process for the first time we recommend that engineers follow two online courses. Following the online course improves understanding of the process, terminology, IPCC and UNFCCC specific tools and terminology commonly used in climate impact assessments. Participation requires registration (email and password). Successful completion of the course delivers an internationally recognised certificate. We advise engineers to submit a copy of this certificate to CReLIC and LGED Human Resource Unit.

- https://wbg.edcast.com
- https://unccelearn.org/course/view.php?id=7&page=overview

Hazard and Exposure rapid assessment

STEP 1: Objectives description and preliminary design, materials & location.

Objective. To understand the project characteristics such as project type, location, duration, design & material considerations, and others key aspects.

Process:

1.1 Fill the following Form 1 providing a basic project description and likely location.

<table>
<tr><th colspan="5">Form 1. Project general information at feasibility stage</th></tr>
<tr><td>Project name</td><td colspan="4"></td></tr>
<tr><td>(a) Sponsoring Ministry/Division
(b) Implementing Agency</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Project brief description</td><td colspan="2">Problems to be solved:</td><td colspan="2">Project Objectives:</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Sector & Subsector</td><td colspan="4"></td></tr>
<tr><td>Project Category (Based on Environment Conservation Rules 2023)</td><td colspan="4"></td></tr>
<tr><td rowspan="4">Sub-project</td><td colspan="2">Sub-project
Major components</td><td>Areas</td><td>Length</td></tr>
<tr><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2"></td><td></td><td></td></tr>
<tr><td rowspan="2">What is the expected lifespan of sub-project?</td><td>>10y</td><td>>30y</td><td>>50y</td><td>>70y</td></tr>
<tr><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td rowspan="3">What kind of sub-project is?</td><td colspan="4">☐ New sub-project</td></tr>
<tr><td colspan="4">☐ Rehabilitation sub-project</td></tr>
<tr><td colspan="4">☐ Reconstruction sub-project</td></tr>
<tr><td rowspan="2">Sub-Project Geographic Location</td><td>Divis</td><td>Distr</td><td>Upazi</td><td>Others (Corporati Pourashv</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Add the expected sub-project site-location map, indicating the exact project site and/or trace.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Specify how the sub-project will be implemented: i.e., what is the standard design to be applied, the materials to be used and how many schemes are foreseen to implement the sub-project:</td></tr>
</table>

Add an image of standard design to be used and/or outline of the initial sub-project schematic idea and erase this yellow-coloured text.

STEP 2: The multi-hazard context of the project

Objective: To understand the general contexts of hazards to which the project may be exposed during its lifespan.

Process:

2.1 Considering the following multi-hazard risk map for Bangladesh prepared by CEGIS 2022 (which divides the country into 11 climate stress zones), identify in which climate stress zone the project is planned to be located (Figure 2).

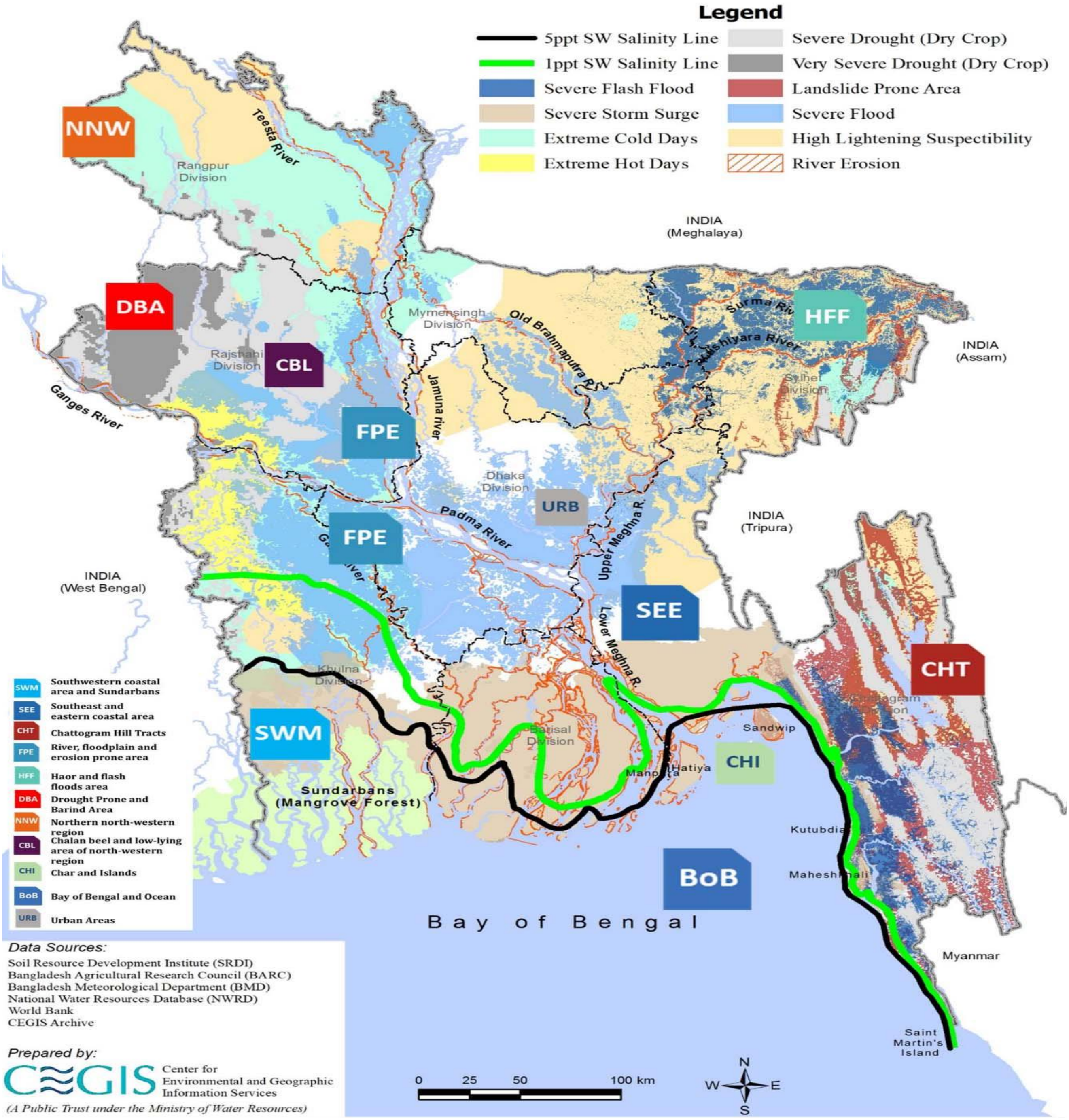


Figure 2. Climate Stress Areas of Bangladesh. Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh in National Adaptation Plan of Bangladesh (2023-2050)

2.2 Next, proceed to review the following Form 2 and according to the district where the project will be located, tick the appropriate box, and carefully read the corresponding *prominence climate hazards*.

Form 2: Climate stress area and related hazards

Climate Stress zone	Districts	Prominence of Climate Hazards	Mark the project location
Southwestern coastal area and Sundarbans (SWM)	Satkhira, Khulna, Bagherhat, Pirojpur, Barguna, Barisal, Patuakhali, Jhalokhathi, Bhola, Shariatpur, Gopalganj, Jashore, Sundarbans	Rainfall variability, river flood, sea level rise, salinity, cyclonic storm surge, drought, extreme heat wave, extreme cold, riverbank erosion and lightning.	☐
Southeast and eastern coastal area (SEE)	Noakhali, Feni, Lakshmipur, Chattogram, Cox's Bazar, Chandpur	Rainfall variability, river flood, sea level rise, salinity, cyclonic storm surge, drought, extreme heat wave, extreme cold, riverbank erosion, lightning, and landslide.	☐
Chattogram Hill Tracts (CHT)	Rangamati, Khagrachari, Bandarban	Rainfall variability, flash flood, cyclonic storm surge, drought, extreme heat wave, extreme cold, lightning and landslide.	☐
River, floodplain and erosion prone area (FPE)	Nilphamari, Kurigram, Lalmonirhat, Gaibandha, Rangpur, Bogura, Sirajganj, Pabna, Rajshahi, Jamalpur, Tangail, Manikganj, Dhaka, Munshiganj, Mymensingh, Sunamganj, Netrokona, Habiganj, Kishorganj, Sylhet, Brahmanbaria, Narsingdi, Narayanganj, Rajbari, Faridpur, Madaripur, Gopalganj, Narail, Sariatpur, Barisal, Patuakhali, Bhola, Jhalokathi, Khulna, Chandpur, Cumilla, Noakhali, Lakshmipur, Cox's Bazar	Rainfall variability, river flood, cyclonic storm surge, extreme heat wave, extreme cold, riverbank erosion and lightning.	☐
Haor and flash floods area (HFF)	Sunamganj, Netrokona, Habiganj, Kishorganj, Sylhet, Maulvibazar, Brahmanbaria	Rainfall variability, flash flood, cyclonic storm surge, extreme heat wave, extreme cold, riverbank erosion, lightning, and landslide.	☐
Drought Prone and Barind Area (DBA)	Naogaon, Chapainawabganj, Rajshahi, Bogura, Joypurhat, Rangpur, Dinajpur, Meherpur, Chudanga, Kushtia, Jashore, Magura, Jhenaidah	Rainfall variability, cyclonic storm surge, drought, extreme heat wave, extreme cold and lightning.	☐
Northern north-western region (NNW)	Panchagarh, Thakurgaon, Nilphamari, Lalmonirhat, Rangpur, Kurigram, Dinajpur	Rainfall variability, river flood, flash flood, cyclonic storm surge, drought, extreme heat wave, extreme cold, riverbank erosion, lightning, and landslide.	☐
Chalan beel and low-lying area of north-western region (CBL)	Pabna, Natore, Sirajganj, Rajshahi, Naogaon	Rainfall variability, river flood, cyclonic storm surge, extreme heat wave, extreme cold, riverbank erosion and lightning.	☐
Char and Islands (CHI)	Nilphamari, Lalmonirhat, Kurigram, Gaibandha, Sirajganj, Jamalpur, Mymensingh, Manikganj, Munshiganj, Shariatpur, Chandpur, Bhola, Patuakhali, Feni, Noakhali, Lakshmipur, Chattogram, Cox's Bazar	Rainfall variability, river flood, sea level rise, salinity, cyclonic storm surge, extreme heat wave, extreme cold, riverbank erosion, lightning, and sea surface temperature and ocean acidification	☐
Bay of Bengal and Ocean (BoB)	Bay of Bengal (Maritime boundary)	Rainfall variability, sea level rise, salinity, cyclonic storm surge, extreme heat wave, lightning and sea surface temperature and ocean acidification	☐
Urban Areas (URB)	43 cities	Rainfall variability, urban flood, sea level rise, salinity, cyclonic storm surge, drought, extreme heat wave, extreme cold and lightning.	☐

2.3 Having identified the main hydrometeorological hazards that occur in the district where the project is intended to be located, we will now proceed to identify the main climatic drivers of these hazards.

STEP 3: Identify extreme climate indices -ECIs- and their rate of change.

Objective: Identify the main climate drivers of hydrometeorological hazards, represented by Extreme Climate Indices (ECI) and the Rate of Change for the coming decades.

Please note that an explanation about the climate variables and indices that have been selected to work in RCIA can be found in the Community of Practice´s document repository:

→ https://drive.google.com/open?id=11zyaI4MZlBYonQdlUrNnT-RQnSBCf3CW&authuser=antarenas%40gmail.com&usp=drive_fs

Process: This process consists of answering the questions, what are the current values of ECIs in the region of interest? What changes might they exhibit in the future decades?

3.1 To answer these questions, it is necessary to complete Form 3, which is designed to calculate the percentage change of the main ECIs by decade and to analyse them comparatively to obtain an aggregate indicator of climate change.

3.2 Until the KMS is implemented in CReLIC, we recommend the use of the Climate Change Knowledge Portal (CCKP), a tool for development practitioners and policy makers, which can be found at the following link:

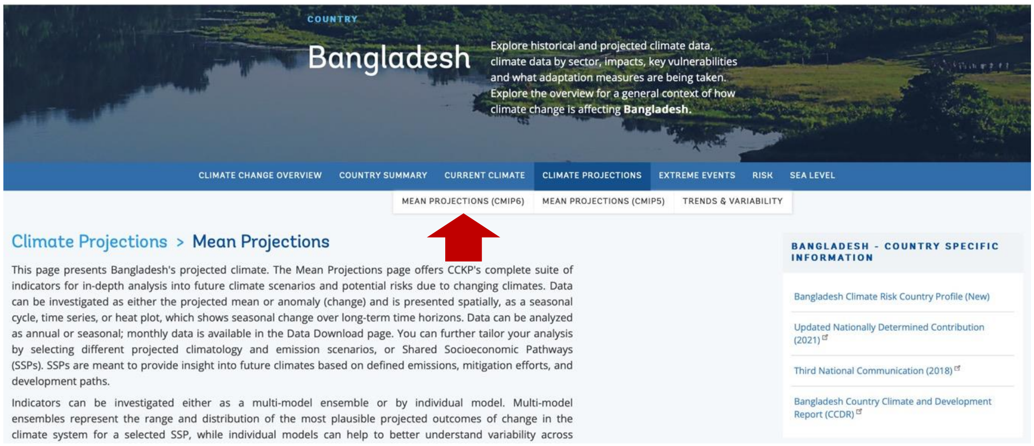
https://climateknowledgeportal.worldbank.org/country/bangladesh

3.2.1 This link 1 will take you to the page summarising the overall status of climate change in Bangladesh. It is important to review this to get a general idea of climate change in the country.

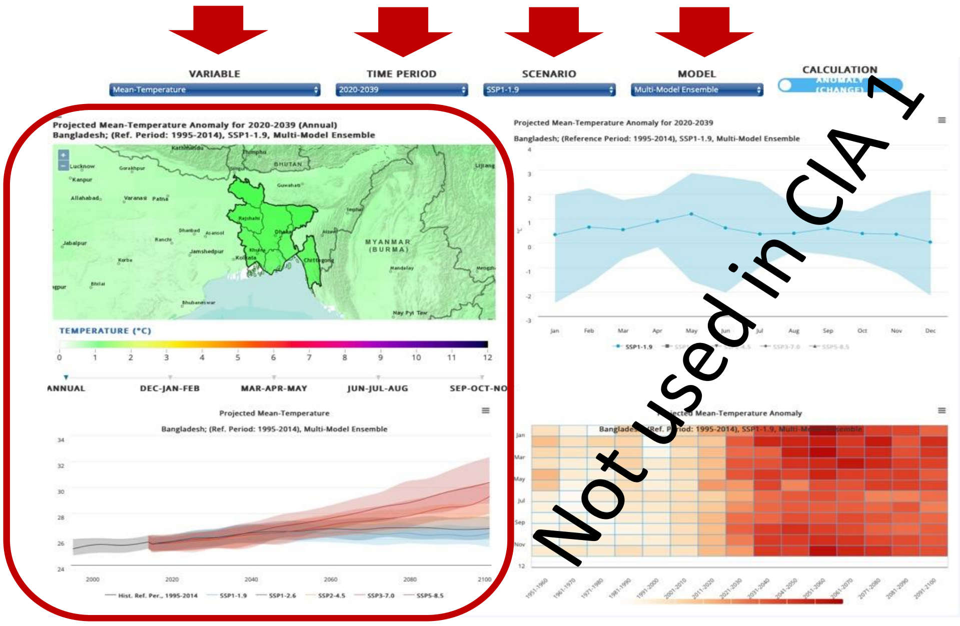
3.2.2 This second link will take you directly to the Bangladesh climatology data viewer page where you can extract the data that is needed to complete the Form 3. Please read the introduction carefully.

https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-projections.

3.2.3 Once you are in the page, please click on *"climate projections"* and then on "mean projections (CMIP6)", as showing tin the following figure:



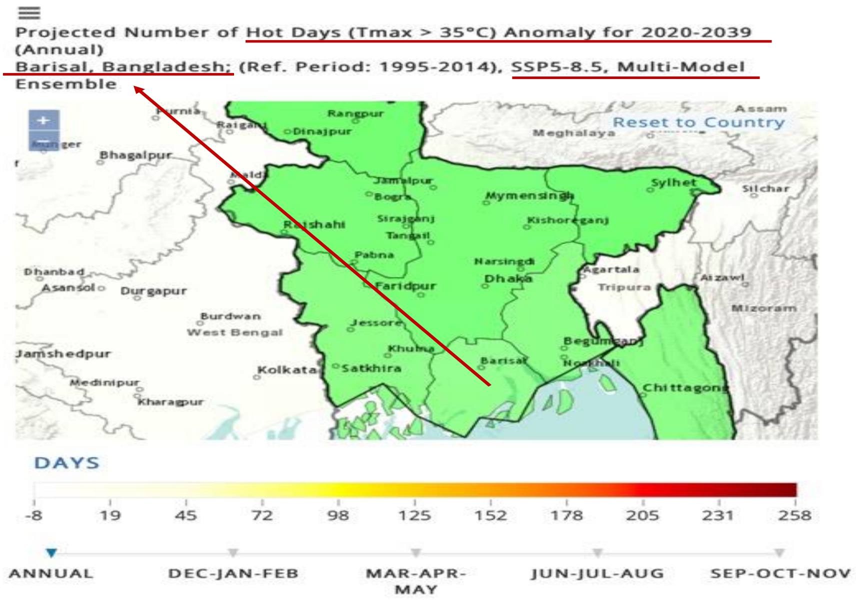
3.2.4 Below the introduction are 4 images, but please look only at the images on the left of the screen where you will see a map of Bangladesh and below that a projection graph (fig…).



3.2.5 In this area, the circle in red, we will work on extracting the data for the full Form 3. To do this, we need to select the options in the top panel as required in Form 3, so select the variable, the period, and the scenario, and please check that the multi-model ensemble is selected (red arrow). The other buttons can be left as they are.

3.2.6 Please, select the division where the project will be siting, by clicking on the map and assure that the description on the top of the map describe the name of the division selected (fig…).

3.2.7 Next, select the variable, the period, and the scenario, as Form 3 request. Please check that the "multi-model ensemble" is selected. See figure ….

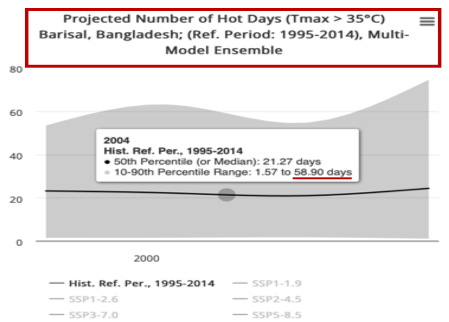


3.2.1 The next task is to extract the data required by Form 3. **Note that the data to be extracted must always be in the 90-95 percentile (see figure …),** no matter if precipitation or temperature.

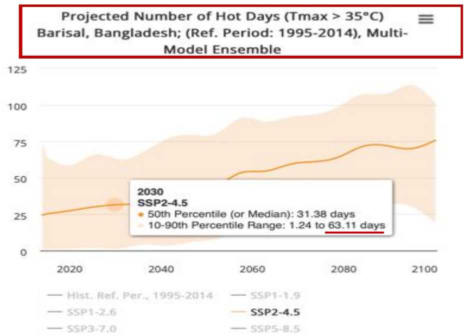
3.2.2 First select the period, then position the cursor on the graph and locate the representative year of the period (usually the year in the middle of the decade is used). For example:

- For the reference period, the reference year is 2004 because it is halfway between 1995 and 2014. For the projection 2020 to 2039, the reference year is 2030 because it is halfway between of the decade. For the projection 2040 to 2060, the reference year is 2050 because it is halfway between of the decade. And so on, so on as is figure …

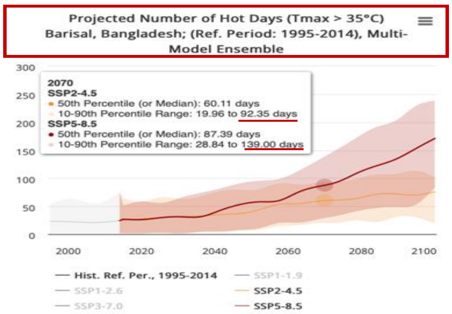
A



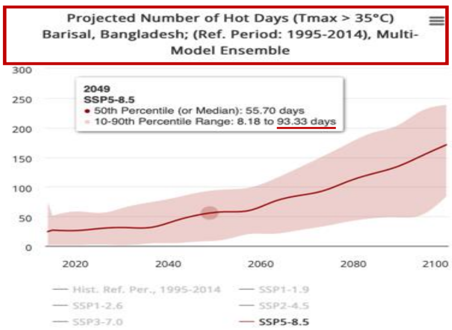
B



D



C



3.3 Now extract and complete all the data requested in Form 3.

- → The first column names the main ECIs.
- → The second column shows the unit of measure.
- → In the third, the extreme values calculated for the reference period.
- → The fourth column shows the projected short-term values overlapping with the recent or current years, and the estimated percentage change relative to the reference period.
- → The fifth, sixth and seventh columns project the ECIs in the longer term and therefore the respective percentage change can be observed for each projected period.
- → **This Form has been filled as an example, using climate multi-model ensemble values for Barisal division under the SSP 8.5)**

Form 3. Annual Extreme Climate Indices -ECIs- and percentage of change projection for selected emission scenario, multi-model ensemble

Extreme Climate Index	Unit	Period 1995-2014	Projection 2020-2039		Projection 2040-2059		Projection 2060-2079		Projection 2080-2100	
		Value 2004	Value 2030	% change	Value 2050	% change	Value 2070	% change	Value 2090	% change
Days with TX above 35ºC (TX35)	Days	*58.90*	*63.80*	*1.34*	*94.19*	*9.66*	*139*	*21.94*	*205.72*	*40.22*
Days with TX above 40ºC (TX40)		*0*	*0*	*0*	*0*	*0*	*16.40*	*4.49*	*29.15*	*7.98*
Days with TX above 42ºC (TX42)		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Days with TX above 45ºC (TX45)		*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Largest Monthly Cumulative Precipitation	mm	*717.40*	*822.30*	*14.62*	*897.41*	*25.09*	*991.35*	*38.18*	*986.82*	*37.55*
Maximum 1-day precipitation (RX1day)		*140.20*	*151.18*	*7.83*	*177.65*	*26.70*	*190.95*	*36.19*	*207.91*	*48.29*
Maximum 5-day precipitation (RX5day)		*354.70*	*385.75*	*8.75*	*448.19*	*26.35*	*453.44*	*27.83*	*536.22*	*51.17*
Max Number of Consecutive Dry Days	Day	*103.01*	*117.69*	*4.02*	*110.08*	*1.93*	*114.63*	*3.18*	*122.01*	*5.20*
Sea level rise (SLR)	M	0	0.22	22	0.47	47	0.78	78	1.2	120
Average rate of change			**9.44%**		**21.15%**		**32.11%**		**48.82%**	

3.4 To calculate the percentage of change, the following process has been carried out:

a. For each time-period, a reference year is taken which corresponds to the year that is right in the middle of the period; that reference year will represent the whole time series; for example, considering the period 1995 - 2014 the reference year will be 2004 for the whole period.

b. For the period 2020 - 2039, the year in the middle of the time series is 2030 and therefore this year will represent the whole period. And so on for the other future periods.

c. The data of interest taken for the calculation correspond to the 90th percentile in all cases.

d. To calculate the percentage of the temperature variable. Temperature ECIs (Tx) are calculated based on the number of days in the year when an extreme temperature occurs, i.e., out of 365 days in a year. The percentage change is then calculated by a simple rule of three:

″Υὼ ő ὼ ἡ ὼ ὶ ᶻρ π π / σ φ υ
TxC = Percentage of change Vp = Projected period Value Vr = Reference period value 365= number of days of a year

e. Since the precipitation ECIs are calculated in millimetres, then the percentage change is calculated as follows:

ʽΥὼ ő ʽΥ ἡ ʽΥ ὶ ᶻρ π π / ʽΥ ὶ
RxC = Percentage of change Rp= Projected period value Rr= Reference period value

f. To calculate the *average rate of change*, the value of the data is summed and divided by the number of data considered, but zero is excluded.

g. Note that natural variability and/or change in a climate variable for 10 years or more, whose range is around 5%, is not significant for engineering purposes. As an example, see *Max Number of Consecutive Dry Days* in Form 3.

3.5 Advanced expert users may complete this form by using the above-mentioned platforms or other higher resolution platforms[1], and making the analysis by using a different SSP scenarios.

Recommendations on using digital platforms and maps:

→ It is very important that engineers look very carefully at the resolution or scale of the map(s) they have collected for analysis. Table 1 below provides a benchmark of the recommended scale and/or resolution of data that should be considered at different stages of the planning and construction cycle of a climate-resilient project.

Table 1. Map scale and raster resolution conversion table.

Map scale	Detectable size (In meters)	Raster resolution (In meters)	Minimum expected uses
1:1,000	1	0.5	Construction
1:5,000	5	2.5	Detailed design

[1] CReLIC is working to produce these ECIs at a larger scale, using resolutions at approximately 25 kms to be used with greater confidence at the Upazila level, which will be available on the KMS

1:10,000	10	5	Feasibility review
1:25,000	25	12,5	
1:50,000	50	25	Referential use at district level.
1:100,000	100	50	Just for referential uses at national level.
1:250,000	**250**	**125**	

→ Resolution of the images to detect their features: Several satellite images and climate change projection available in several online platforms provide pixel resolution data instead of using classical map scales. So, while working with that data from online platforms we will convert the data into our known map scale. E.g.:

- To find out the mapping scale from a known image resolution, perform the following operation: Raster resolution (in meters) * 2 * 1000 = Map scale.
- To get the detectable size of an object in meters from the map or to draw an object in the same scale of the map, the rule is, divide the denominator of the map scale by 1000. The resolution is half this amount: (Scale / 1000) / 2 = raster resolution (in meters).

Step 4. Estimate the level of current hazard.

On the one hand, the destructive, damaging, or disruptive potential of hazards is directly related to the IDF of extreme events driven by the climate signals represented by the ECIs. On the other hand, these hazard potentials are also directly related to the vulnerability of the existing or planned infrastructure. For now, however, we will focus only on the hazard factors for a project, through stakeholder consultations and field surveys at the proposed project site, complemented by document review and available data in online platforms.

Objective: To identify extreme hydro-meteorological events and the level of risk they may pose to the project.

Process: This process will help us to answer the question: What is the current magnitude of hydrometeorological events, in terms of Intensity, Duration and Frequency (IDF) occurring in the district of interest and what level of hazard do they represent?

4.1 Set up a virtual meeting with the LGED office of the Upazila(s) of interest and explain the analysis process to be undertaken. Review each of the following steps with the Upazila(s) engineers to ensure that the task is fully understood and that the required information will be collected correctly:

a) Review Form 4 carefully with the Upazila Engineers and ensure that they have understood the terms and concepts used. This can be done through a virtual call or in person.

b) Explain the need to complete this form with the beneficiary community leaders to ensure that their perceptions and experiences of climate hazards are well reflected in the form.

c) Emphasise that the form should be completed during a meeting with the beneficiary leadership during a visit to the site or different hazard hotspots where the project will be located.

d) Form 4 asks for a ranking of the severity of the hazard in relation to the severity of the damage caused. Three criteria are used to define what constitutes minor, moderate, and major damage:

- **Minor damage:** This refers to minor damage that does not require extensive repair or complete reconstruction of the infrastructure. This damage may be of a more superficial, aesthetic, or functional nature and does not significantly affect the structural safety or functionality of the asset concerned. Examples of such damage may include minor cracks in roads, loss of surface coating on structures, damage to signage, minor damage to street furniture, etc. Although this damage is "minor", it is important to address it to prevent further deterioration of the infrastructure. In an infrastructure management system, such damage would require routine maintenance rather than major reconstruction or rehabilitation.
- **Moderate damage:** This is more significant damage that requires more intensive repair and may affect the functionality of the infrastructure in the short to medium term. This damage may include major cracks or deformations in roads or bridges, damage to water or electricity systems that disrupts services for days or weeks, or damage to buildings that requires major repairs but does not threaten the overall structural integrity of the building. These losses may require a rehabilitation effort to restore the infrastructure to its original condition and are likely to require more significant engineering and financial resources to resolve.
- **Major damage:** This is severe damage that compromises the structural integrity of the infrastructure, renders facilities unsafe or unusable, and requires extensive repair or even complete reconstruction. Such damage may include the collapse of bridges or buildings, severe damage to water or energy treatment facilities that disrupts services for an extended period, or damage to roads or bridges that renders them completely impassable. Such damage requires an immediate emergency response, detailed assessment by engineers and experts, and a significant reconstruction effort. The cost of repairing such damage is significant, both in terms of money and time, and the impact on local communities and the economy can be long-lasting.

e) Explain the importance of making a list of the people attending the meeting, distinguishing between men and women.

f) Emphasise the importance of taking photographs of the surroundings and location of the proposed project to illustrate the information provided in Form 4.

g) Once Form 4 is completed, the Upazila officials should send it along with the list of participants and the photographs, by e-mail.

Form 4. For UPAZILA LEVEL USES Hydrometeorological events observed by the local stakeholders in last 20 years					
Hydrometeorological events at Upazila level	Highly damaging	Moderate damage	Little damaging	*Unknow	N/A

1. Heat wave					
2. Heavy Rain					
3. Cyclones					
4. Droughts					
5. Hailstorms					
6. Floods / coastal floods					
7. River floods					
8. River-bank erosion					
9. Strong sedimentation					
10. Water scarcity					
11. lightning					
12. Storm surges					
13. Sea level rise					
14. Salinity intrusion					
15. Coastal erosion					

4.2 While the Upazila level officials carry out the task described above, the HQ engineering team will carry out the following tasks:

a. Identify hydrometeorological events whose destructive or damaging potential has been observed in the district where the project is intended to be located, by reviewing the documentation in the Community of Practice document repository[2].

b. There you will find a set of technical and scientific reports that you should review in detail to extract the data and process information needed to complete form 5.

c. Once you have reviewed the documents, extracted the data and above all, once you have understood the processes of setting up hydrometeorological hazards, you can complement the information obtained by reviewing the following digital platforms:

→ Disaster and climate Risk Information Platform (DRIP) http://drip.plancomm.gov.bd/
→ Think Hazard https://thinkhazard.org/en/report/23-bangladesh

4.3 Welcome to once you have checked and extracted the data to fill in column 2 with the maximum IDF values found, proceed to rate the hazard level in the following columns (a, b, c, d) according to the values found in the checked documents and recommended platforms, and considering the information in Form 4 and the photographs sent by the Upazila officials.

[2] https://drive.google.com/open?id=1-G3mTzAWQE2x_gIN6gqnxCpfTKeuOafe&authuser=antarenas%40gmail.com&usp=drive_fs)

4.4 To achieve this, it is important to consider a thoughtful 'normalisation' to complete Form 4 as recommended in Box 1:

Box 1.
Normalization.

In the case of climate change risk and impact analysis, where different sources of information with quantitative and qualitative data produced under different conceptual frameworks, methodologies and models must be used, it is necessary to resort to statistical normalisation to standardise data and make them comparable for multi-criteria analysis purposes.

Normalisation also makes it possible to place data or information of a non-directly numerical and rather qualitative nature, which are necessary to establish a correspondence between textual elements and numerical values, on a comparable common scale.

Form 4 facilitates the normalisation of different values or levels of hydrometeorological hazard even if the data come from different sources of information and have been elaborated based on various conceptual and methodological models. The result is to place all these hazard values or levels in a normalised form in three ranges of percentage values according to a level of intensity, duration and frequency assessed from the reviewed documentation:

High ≤ 95%	Moderate ≤ 65%	Low ≤ 35%

For the definition of the percentage ranges, the usual practice of hazard classification used in the field of disaster risk management has been followed.

4.5 Note that column 'd' refers to information gaps or insufficient clarity or understanding. Often, this gap in knowledge is an institutional weakness that can result in the design and construction of a project that is also vulnerable or insufficiently resilient to climate change, creating favourable conditions for avoidable and foreseeable loss and damage to occur.

4.6 In this context, the scores in column "d" are considered low to moderate hazard for our project and are accounted for as such.

(The following Form 5, has been filled just as an example using information of Barisal and classification by using expert-judgment criteria)

Form 5. Climate related hazards that have occurred on District during reference period, rated by its IDF						
Hydrometeorological events observed around last 10 years	**Max value found (IDF)**	**Current hazard rating classification and its percentage of weights**				**N/A**
		High ≤ 95%	**Moderate ≤ 65%**	**Low ≤ 35%**	***Unknow Weight 40%**	
1. **Hw. Heat wave**	38^{o}	X				
2. **Hr. Heavy Rain**	56mm/24h		X			
3. **Cy. Cyclones**	High	X				
4. **Dg. Droughts**	----				X	
5. **Hs. Hailstorms**	------					X
6. **Fl. Floods / coastal floods**	Very High	X				
7. **Fr. River floods**	--------					X
8. **Re. River-bank erosion**	Very High	X				
9. **Sd. Strong sedimentation**	Moderate		X			

10. **Wc. Water scarcity**			X			
11. **Lt. lightning**	No significant			X		
12. **Ss. Storm surges**	No extremes			X		
13. **SLR. Sea level rise**	No significant			X		
14. **Si. Salinity intrusion**	Important process		X			
15. **Ce. Coastal erosion**	Seems important		X			
Aggregated hazard index for the reference period		4	5	3	1	
		[illegible]				

4.7 The aggregate hazard index formula used in Form 4 are as follows:

Formula to calculate the aggregated hazard index

[illegible]

Hi= Aggregated Hazard Index
Nh= number of hazards considered by column a, b, or c.
H= high weigh (95%)
M= moderate weigh (65%)
L= low weigh (35%)
Σa= sum column a
Σb= sum column b + column d
Σc= sum column c

4.8 Make sure that the information you are reviewing and extracting from the documents <u>is not older than 10 years.</u>

4.9 Please note that the outliers' values of hydrometeorological events that you have found in the document's reviews, could be expressed in numbers, percentages, weigh classifications or in a qualitative manner.

4.10 It is highly recommended to Check the availability of recent LGED projects in the area and or review existing Environmental Impact Assessment studies covering the project area. (Connect with CReLIC).

Step 5. Aggregate Hazard Baseline (AhB)

5.1 Review Step 3 in detail, where you have defined the baseline aggregated extreme weather indices for the reference period, making sure you have done everything well.

5.2 Review Step 4 where you have calculated the aggregated hydrometeorological hazard index for approximately the same period, making sure that all is well done.

5.3 Since ECIs are the independent variable and hydrometeorological events are the dependent variable, knowing the percentage change in ECIs for future decades allows us to estimate the corresponding proportional change in hydrometeorological hazards for those same future decades.

5.4 This dependent proportionality relationship for the reference period is called the aggregate hazard baseline (AhB). This AhB should be estimated for each district of interest using the following form 6:

→ In the "ECIs" column place the climate variables names and next, the corresponding values. Then, place the aggregated hazard index for the reference period calculated in Form 4.

→ *Following the example of Form 3 and Form 4 for Barisal, Form 6 below has estimated the AhB, which is interpreted as follows: "Given the observed ECI values for the reference period 1995-2014, the estimated proportional hydrometeorological IDF response for Barisal district shows a moderate aggregated Hazard Index of* ***63,57%****."*.

Form 6. Aggregated and Disaggregated Hazard Baselines		
ECIs	**Values**	**AhB**
– Days with extreme temperatures observed over the entire period.	*58.9*	***65.38%***
– Millimetres of precipitation in the wettest month of the entire period.	*717.40*	
– Millimetres of precipitation accumulated in the wettest day of the entire period.	*140.2*	
– Millimetres of precipitation accumulated in the 5 consecutive rainy days in the whole period.	*354.7*	
– Consecutive days with no precipitation observed over the entire period.	*103.01*	
– Millimetres of sea elevation for the entire period.	*0*	

5.5 Once you have synthetized AhB, you are enabled to continue the process and project hazards linked to future climate change scenarios.

Step 6. Projecting future hazard levels given the percentage change in climate.

Objective: Calculate the hydrometeorological hazard index for the coming decades.

→ The projections will be estimated for the following time periods: 2020-2039, 2040-2059, 2060-2079 and 2080-2100.

Process:

6.1 This process consists of answering the question: what could be the new aggregate hazard index and what level of hazard will it represent, given the expected rate of climate change in the coming decades?

6.2 To answer this question, we will work with the following information:

a. The Aggregate Hazard Baseline -AHB- (Form 5) estimated for the District of interest and for referential period.
b. The ECIs average rate of change for projected decades (Form 3).

6.3 To estimate the aggregate hazard index for the coming decades, we will take the percentage change calculated for each time-period and add it to the AHI, i.e.: time period percentage change + AHB = Aggregate hazard index.

→ Following the example of the Barisal district:

- The AHB value is ***65.38%***
- The percentage change of the ECI for the period 2020-2039 is 9.44%.
- The calculation operation is: 9.44% + ***65.38%*** = 74.82%. So, the aggregated hazard index for 2020-2039 period is ***74.82%***

6.4 Once the hazard index has been calculated for the desired time-period, it is necessary to re-classify the level of hazard signified by this index. For this purpose, we will use table 3 for the reclassification of the hazard:

Table 3. Hazard reclassification table.
Extremely high ≥ 96%
High ≤ 95%
Moderate hazard ≤ 65%
Low hazard ≤ 35%

→ We continue with the example of the Barisal district. We now take this aggregate hazard index for the period 2020-2039, whose value is ***74.82%,*** and compare it with the weighting table 3 to rank the hazard level for this period. The result indicates that the index ***74.82%*** is in the **High hazard** level range.

6.5 As explained (and exemplified) in the previous points, proceed with the hazard index calculations for the next decades according to the expected lifespan of the project and reclassify the related hazard level by using the Table 3.

6.6 For both the hazard index and the hazard level projection we will use form 7.

(this table has been filled for example purpose, using Barisal District example).

Form 7. Projections of the aggregate hazard index and hazard level, based on ECIs projections.				
Proportional baseline ratio -PBR- 1995-2014	**Hazard index 2020-2039**	**Hazard index 2040-2059**	**Hazard index 2060-2079**	**Hazard index 2080-2100**
65.38%	*74.82%*	86.53 %	**97.94 %**	**114.20%**

Box 2.

The assumption on Aggregate hazard index for future time-period, based on ECIs projections

→ The resulting Form 6 analysis assumes that the intensity, duration, and frequency (IDF) of each of the hydrometeorological events analysed and classified in Form 4 will change proportionally to the intensification of the climate extremes represented by the ECIs calculated in Form 3.

6.7 Once the projections in Form 7 have been made, the changes in ***the magnitude of the hazard***, represented by the corresponding hazard index and hazard level for each time-period, can be clearly seen.

→ Let us continue with the example of the Barisal district which is described in Form 7:

- There is no change in the magnitude of the threat between the 1995-2014 reference period and the 2020-2039 period.
- Between 2020-2039 and 2040-2059 there is a change in the magnitude of the hazard (from moderate to high) and between 2040-2059 and 2060-2079 there is a further jump in the magnitude of the hazard from high to extremely high.
- Between the periods 2060 - 2079 and 2080-2100, no change in hazard magnitude is observed.

6.8 We now have a general idea of the magnitude of the hazard to which the project would be exposed, both now and in the future. We will now carry out the analysis procedures to detail the level of exposure of the project to specific hydrometeorological hazards.

Step 7. Hazard exposure levels and potential impacts.

Objective: Determine the level of exposure of the project to the impact of future hydrometeorological hazards.

→ For this analysis, you should use the impact chain analysis technique as explained in Chapter 1.

Process:

7.1 During this process we will make projections for those hydrometeorological hazards that are most significant for the project. For this, we are going to work with the following Form 8 that relates the time periods with each hydrometeorological event, and we will do it in the following way:

a. In the row corresponding to the reference period 1995-2014, copy the hazard level classification corresponding to each hydrometeorological event, as classified in Form 5.

b. Next, check in Form 7 if there is a jump in the hazard magnitude, i.e., if there is a change in the colour classification.

c. If we observe that there is a change in the colour classification between time periods in Form 7 (i.e., if there is any change from low to moderate, or from moderate to high, or from high to extremely high) then we will modify the hazard classification for all hydrometeorological phenomena, raising their classification corresponding to the change in hazard magnitude.

d. If, on the other hand, we observe no change in the colour classification between time periods in Form 8, then we will maintain the colour classification for all hydrometeorological events.

→ Following the example of Barisal. Form 7 shows that there is no significant change in the hazard levels between the reference period 1995-2014 and the period 2020-2039. In other words, the hazard level is classified as "moderate". This means that the classification of all hydrometeorological phenomena remains unchanged for the period 2020-2039, but for the other periods they must be reclassified in proportion to the jump in the magnitude of the hazard for those decades. e.g:
   - Events classified as low hazard (green) in the baseline period will have to be reclassified as moderate hazard (yellow) in the period 2020-2039.
   - Events classified as moderate hazard (yellow) in the baseline period will have to be reclassified as high hazard (red) in the period 2020-2039.
   - Events classified as high hazard (red) reference period will have to be reclassified as extremely high hazard (strong red) in the period 2020-2039.
   - And so on for next decades.

(This form has been filled in following the example of the Barisal and under the hypothetical assumption of a project lifespan not exceeding 40 years.)

Period	Hw	Hr	Cy	Dg	Hs	Fl	Fr	Re	Sd	Wc	Lt	Ss	SLR	Si	Ce
1995 2014															
2020 2039															
2040 2059															
2060 2079															
2080 2100															

7.2 Once Form 8 has been completed for all periods, corresponding to the lifespan of the project, we will have a general idea of the potential magnitude of each hydrometeorological hazard and its future evolution, and can then proceed to the impact analysis.

7.3 This is where the engineering knowledge and experience that the engineering team has of LGED projects and the expert judgement developed during the previous five steps comes into play.

7.4 Gather the team of engineers responsible for the project and facilitate a working session in which they bring into play the information learned during the review of the documents and information platforms to build the impact chain (Figure 3) based on:

a. Weather signals identified as ECIs.
b. The impacts of these climate signals on the physic-natural elements present in the project region.
c. The hydrometeorological responses to the magnitude of these impacts, in the form of hydrometeorological hazards.
d. Next, we proceed to analyse the aggregate impacts that could be expected in the form of likely losses and damage and disruptions to the physical structure of the project and the services it will provide.
e. To this end, it continues with the development of the chain of aggregate impacts for both the physical structure of the project and the services to be provided.

Project team making a brainstorming related to impact chain

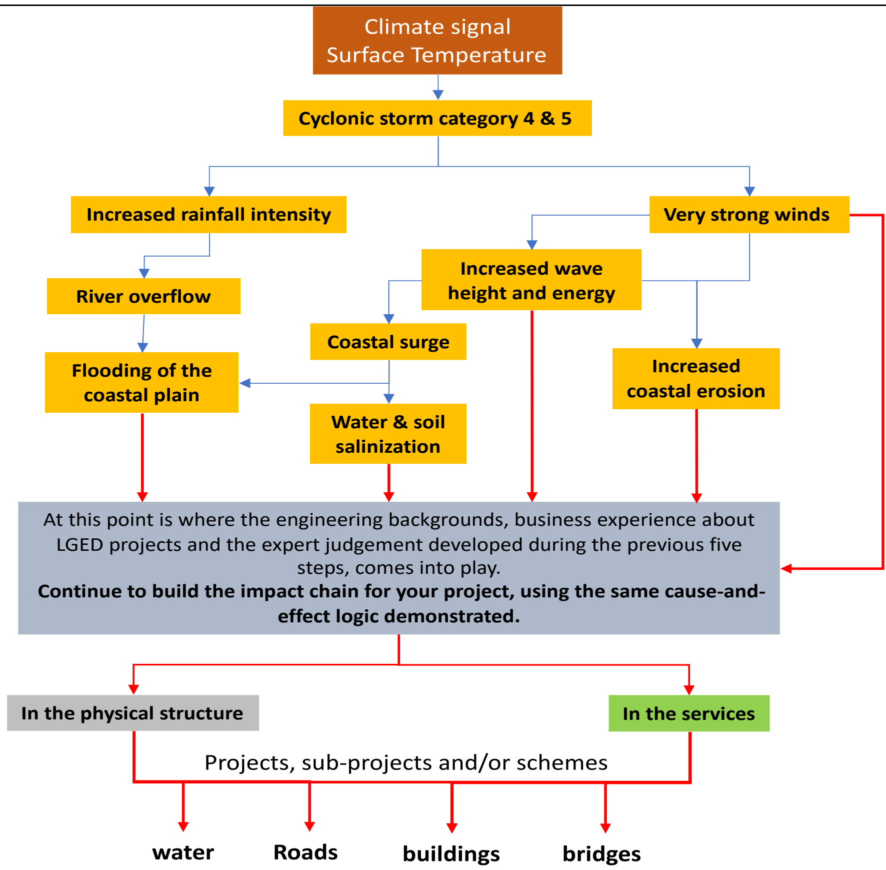


Figure 3. Example of a chain of impact, extending from a climatic signal (surface temperature in this case) through the occurrence of extreme tropical cyclones whose winds and precipitation, will generate strong waves and tidal waves, overflowing rivers, coastal flooding, etc., to impact on project with probable losses and damage to the different systems that make up the infrastructure: standard design, materials, and site location.

Finally, **note that this analysis should be done at the District level, whether it is a project, a sub-project, or a scheme.** In other words, in each District where the project or a part of it is to be implemented, this analysis must be carried out.

7.5 To carry out this impact chain analysis, work with cards, markers, pushpins, and a board on which you can arrange the cards according to the logical cause-effect sequence.

7.6 Please note that you will need to construct an impact chain for each hydrometeorological hazard **that reaches a high and/or extremely high hazard level during the lifespan of the project (form 7) and for each time series**.

7.7 Once you have completed all the impact chains, proceed to photograph them and to answer the following questions[3] by using next form 8.

[3] Note that these questions must be answered collectively by the team of project responsible engineers.

Q1. What physical elements of the project could suffer loss or damage? In your answer, please describe the losses and damages that could occur, given the standard design, materials, and site project location.

Q2. What services could be interrupted or altered? In what way?

7.8 When writing your answers, be rigorous describing <u>(i) the process that explains how the impact could occurs, (ii) the specific likely losses, damage that could occur, and (iii) the consequences of these (destructive, damaging and/or disruptive)</u>.

Form 9. Impact analysis	
Current scenario	Q1: Q2:
2021-2040	Q1: Q2:
2041-2060	Q1: Q2:
Another scenario	Q1: Q2:

Step 8. Project adaptation challenges.

In this step it is quite advisable to engage with local community and stakeholders as recommended in the National Adaptation Plan 2023-2050, pp 33.

Objective: To define the challenges that the project may face given the level of exposure to hazards and potential impacts that may affect the project.

Process:

8.1 Based on the results of the impact chain analysis carried out in step 7 above and form 9, identify and formulate the central problematic situation related to -> <u>the (1) standard design, (2) standard materials and/or (3) selected project site</u>.

> This mean that the problematic situation that we need to analyse here, is not the hazardous situation but what part of project **—> <u>design and/or materials and/or site</u> <—** will present losses and damage given the previous analysis made on step 7 impact chain. This is <u>the real problematic situation that we need analyse in this step 8.</u>

8.2 These central problematic situation on —> design and/or materials and/or site <—, correctly formulated constitute the main adaptation challenges that the project need to address to move towards a climate-resilient design.

8.3 Considering the likely losses and damages identified in step 7 (impact chain and form 9), now proceed to fill in form 10, by identifying central problematic situations related to the (1) standard design, (2) standard materials and/or (3) selected project site.

Form 10. Adaptation challenges for the project		
Answer the questions based on the observed findings: Which of the following aspects of the project: the standard design, the materials used and/or the location chosen could fail and cause damage or loss given the impact of the hazards?		
Standard design problematics situation*	**Standard materials problematics situation****	**Project site problematics situation*****

** It refers to the probability of loss and damage attributable to the weakness in the standard design.*

*** It refers to the probability of loss and damage attributable to the weakness or inadequacy of materials.*
**** It refers to the probability of loss and damage attributable to the characteristics of the site conditions.*

8.4 To conduct the analysis of adaptation challenges for our project, it is necessary for the engineering team to conduct a working session using the same methodology as the impact chains.

8.5 To obtain a correct formulation of "problematic situation" as adaptation challenges, some rules must be enforced such as:

Box 3.

"It is much more important to formulate problems correctly than to solve them..." (A.E.)

a. Like any other problem analysis technique, this exercise requires a collaborative effort from the entire project team.
b. Be aware that a problem is a negative situation in relation to a desired situation. But in any way, the situation can be verified objectively as a problematic situation or not.
c. In this regard, a problem formulation should be evidenced as negative situation (in relationship with a desirable situation) that can be verified because it exists. There is never a lack of something; a lack of something means not existing. When something is lacking, it can´t be observed objectively and so, it is not a problem, e.g., the problem will never be drafted as: lack of finance... or absence of knowledge... or deficits of technics, etc. In this regard, never use the word "lack" or any synonymous of it or other word that give the idea of not existence of something.
d. The problem formulation should never condition the solution, e.g., "the lack of finance resources...". Drafted like this, you act under the assumption that if you put the money, then the problem will be solved, and we have many evidence showing that this is not real, and you may increase the problematic situation.
e. On the other hand, it´s necessary to differentiate the causes of the problems and the consequences of it. Together, both the problem, its causes, and consequences, configuring a challenge situation for adaptation.

Step 9. Final report.

9.1 The objectives:

The report has two main objectives: firstly, **to present the conclusions of the study, highlighting the following points:**

1) the extreme climatic and hydro-meteorological hazards to which the project is exposed,

2) analyse the likely chain of impacts on the project

3) identify adaptation challenges, and

4) provide a technical recommendation based on the process and results of RCIA.

Secondly, **meet some of the requirements of the 'Project Feasibility Study Report' and certainly answer some of the key questions of the 'Development Project Proposal (DPP)'**:

Project Feasibility Study Report	***Development project proposal -DPP-.***
Section 3: Market/Demand Analysis	Question 14.1 Background with Problem Statement
Section 4: Technical/Technological & Engineering analysis	Question 15.2 Outcomes.
Section 5: Environmental Sustainability, Climate Resilience and Disaster Risk Analysis.	Question 15.3 Outputs
Section 10: Alternative/Options Analysis.	Question 17 Whether any pre-appraisal/feasibility study/pre-investment study was done before formulation of this project? If so, attach summary of findings & recommendations. (If not, mention the causes)
Section 11: Recommendations and Conclusion.	Question 25.3 Disaster management, climate change
Section 12: Annexes.	Question 27 Specific linkage with (i) Bangladesh Delta Plan 2100, (ii) Perspective Plan 2021-2041, (iii) Five Year Plan, (iv) SDG targets and (v) Ministry/Sector Priority (Mention the pages with clauses of respective document/ attach the relevant pages of those document).

9.2 Use the following proposed *table of contents* as a **guide** not as a recipe, for writing the technical report. *It is very important that you use your judgement as a professional engineer in your reporting and include all relevant aspects to support your conclusions and recommendations*.

9.3 Please organize your explanation considering the following criteria: An 'explanation' is a description or clarification provided to help understand how or why a particular phenomenon or event occurs. The following is a general structure that may be useful:

→ An introduction to the phenomenon or event: This is where you introduce what you want to explain. It is important to provide enough context for the reader of the report to understand the significance of the issue and why it is important to understand it.

→ Statement of the fact or phenomenon to be explained: In this section, give a clear and concise description of the phenomenon or event.

→ Explanation or interpretation: This is the central part of the explanation, where you give a detailed description of how or why the phenomenon or event occurs. Sufficient detail should be provided, and clear language should be used to assist the reader of the report.

→ Supporting evidence or examples: This is where you support your explanation with evidence, data, or examples. These are mainly the graphs, tables or forms produced, as well as quotes from studies or reports consulted, statistics from the platforms consulted, real-life examples or information from the field, quotes from experts, etc. This is an essential part of any explanation, as it lends credibility and allows the reader of the report to verify the information for themselves.

→ Conclusion and recommendations: The conclusion summarises the explanation and emphasises the importance of understanding the phenomenon or event. Recommendations are clear and concise and state the next steps to be taken and/or decisions to be made.

→ It is important to remember that a good explanation should be clear, precise, and based on the facts or evidence analysed throughout the RCIA process.

1. **Chapter I: Project Description and Hazardous Context.**

   a. Copy and paste Form 1: General Project Information at Feasibility Stage.
   b. Add any comments relating to the project that are relevant to the background.
   c. From the Form 2, extract the list of prominent hazards affecting the district of interest and ***explain*** how the hazard occurs in the project area.

2. **Chapter II**: **Hazard Exposure Context & Impact Chain Analysis.**

   a. Copy and paste form 3, **explaining** what extreme climate indices are, what the average rate of change means, and the results obtained.
   b. Copy and paste form 5 and explain why the hazard level has been assigned to the hydrometeorological events. Throughout the explanation, refer to the intensity, duration and frequency of the events observed during the reference period.
   c. Then copy and paste forms 6 and 7 and ***explain*** the process used to project hazards into the future and the results obtained.
   d. Finally, copy and paste form 8 and ***explain*** which hydro-meteorological hazards are the most significant (in terms of their IDF) for the project and for each forecast period calculated.

e. Take each of the cause-effect chains constructed in step 7 and ***explain*** the cause-effect relationship of climatic and hydrometeorological events and how they would affect the different elements of the project (design, materials, and services) in terms of loss and damage. For the latter, use the answers given in Form 9.

3. **Chapter III: Project adaptation challenges for the project**.

a. Each of the 'problems' identified in Form 10 represents an adaptation challenge to make a project more resilient.
b. From Form 10, extract and fully explain the most significant problems (related to standard design, materials, and location): **The causes that drive or shape the problem and the consequences if nothing is done about it**.
c. In your analysis, consider issues of technology, knowledge, and information, as well as issues of material and resource availability.

4. Chapter IV. Closing the information and data gap

a. Forms 4 and 5 have a column marked **"*Unknown"**, which means that no information has been found or that these aspects are not sufficiently known.
b. Please take all aspects that remain as **"*Unknown"** and fill in this form 11 with them.
c. Organise the information or data gaps from most important to least important.

Form 11. Summary of information that have not been found or there´re insufficient understanding of such aspects	
Items not found or not sufficiently understood and marked '*Unknown' in forms 4 and 5	**Comments and clarifications**

6. Chapter V. Conclusions and recommendations.

Write a summary of the previous chapters in the form of conclusions:

6.1 Main hazards

6.2 Main expected impacts

6.3 Key adaptation challenge

6.4 Key overarching conclusions that integrate the previous points.

6.5 Key recommendations for increasing the resilience of the project, considering:

6.5.1 The criteria and indicators for deciding whether or not to conduct a Comprehensive Climate Impact Assessment (CCIA) for a project are described below.

→ **If one of these criteria applies to the project, it would be advisable to conduct a CCIA.**

→ **If at least two of these criteria apply to the project, a CCIA is strongly recommended.**

→ **If at least three of these criteria apply to the project, a CCIA is mandatory.**

Table … criteria to proceed or not toward comprehensive climate impact assessment.

Criteria	Indicators to proceed toward the CCIA	Indicators to not proceed toward CCIA
1. Conformity with Environment Conservation Act (ECA) and Environment Conservation Rules (ECR) of Bangladesh: ECR established a classification system for development projects based on the location, the size and the severity of potential pollution. There are four categories of projects: (i) Green, (ii) Yellow, (iii) Orange and (iv) Red with respectively no, minor, medium and severe environmental impacts. Environment Clearance Certificate is mandatory for carrying out Yellow, Orange and/or Red Category Project.	→ Orange and Red category projects → Road construction/ renovation of minimum 5km → Bridge construction of minimum 100m → Residential & commercial building (min. 5,000 sq.m built-up area)	The level of impact is 'no' or 'minor'.
2. **Level of hazard:** This criterion considers the frequency and intensity of hydro-meteorological and climatic events that could affect the infrastructure. A high-hazard level would mean that the area is regularly affected by severe events such as floods, storms, hurricanes, etc. In this case, it would be essential to carry out a comprehensive climate impact assessment study.	→ The hazard level is hight HIGH at any stage of infrastructure lifespan	→ The level of hazard is moderate of low.
3. **Useful life of the infrastructure:** This criterion refers to the period during which the infrastructure is expected to be in operation. If the infrastructure has a long lifespan, it is more likely to experience extreme weather events during its lifetime and therefore it is more critical to conduct a comprehensive climate impact assessment.	→ The lifespan is >10 years	→ The lifespan is ≤10 years;
4. **Information gaps:** This criterion assesses whether sufficient information on climate risks and their impact on infrastructure is already available. If there are significant gaps in this information, a comprehensive climate impact assessment study could be critical to provide a complete picture of the risks. **A significant information gap is when one third or more of the hazard variables are unknown**.	→ **There are 4 or more** variables marked "*unknown" in form 5.	→ **There are 3 or less variables** marked "*unknown" in form 5.
5. Critical infrastructures: Is infrastructure critical to society and the economy? Critical infrastructure refers to physical systems and assets that are essential to the functioning of a society and its economy. The likely damage to or destruction of these systems or assets can have a	→ The project is directly linked to **energy, health, water, transport,**	→ The project is linked to **energy, health, water, transport, communication**

debilitating impact on security, the economy, public health, or national security. Infrastructure associated to **energy, health, water, transport, communication, and food security,** are critical to the functioning of a society and should therefore be given high priority in any risk assessment.	**communication or and food security sectors.**	**or and food security sectors.**
6.Vulnerability of the surrounding population: If the infrastructure is in an Upazila or crosses several Upazilas classified as high or very high vulnerability, it is particularly important to conduct a comprehensive climate impact assessment.	→ Vulnerability of nearby populations **is high or very high.**	→ Vulnerability of nearby populations **is moderate or low**.

6.5.2 Then the project **<u>no need to go on CCIA procedures</u>**. In this case, some adjustments in design, materials and/or location may be required. <u>In this case, please refer to:</u>

→ Recommendations and Adjustments of **Standard Measures, Part A: Revised Design and Cost Estimate for Climate Resilient LGED Bridges & Culvert, and Cyclone Shelter or Buildings.** <u>You can find this document in the CReLIC - KMS.</u>

→ Annex 1, **list of proposed measures and actions to improve the climate resilience for a project** that do not require a CCIA.

→ If the project doesn't require a Comprehensive Climate Impact Assessment - CCIA - then proceed to extract the information needed to complete the following sections of the **Project Feasibility Study Report and Development Project Proposal -DPP-** from the RCIA report that has been carried out (see Annex 1).

Chapter VI. Bibliography.

a. Provide a list of documents and digital platforms reviewed that support the overall analytical process, conclusions, and recommendations of RCIA.
b. <u>Include photographs of field and Upazila/district level consultations</u>.
c. Any other documents that support the analysis, conclusions, and recommendations.

Annex 1. Inputs from RCIA to the Project Feasibility Study & to the Development Project Proposal (DPP)

If the project does not require a Comprehensive Climate Impact Assessment - CCIA, you will need to provide information for the Project Feasibility Study and Development Project Proposal - DPP. The information for both documents should be taken from the RCIA report you have completed.

If the project is to undertake CCIA, then these sections of the Project Feasibility Study and Development Project Proposal documents will need to be answered once CCIA has been completed.

- **Section 3: Market/Demand Analysis**
    - (a) Problem Statement
    - (b) Relevance of the Project Idea
    - (c) Proposed Project Interventions
    - (d) Stakeholders
    - (e) Demand Analysis
    - (f) SWOT analysis, focus on weakness and threats to the project.
- **Section 4: Technical/Technological & Engineering analysis**
    - (a) Location
    - (b) Technical design
    - (c) Output Plan
    - (d) Cost estimates
    - (e) Implementation timeline
- **Section 5: Environmental Sustainability, Climate Resilience and Disaster Risk Analysis.**
    - (a) What are the likely environmental, disaster and climate change impacts or risks from the project (any impact of project to increase the existing disaster and climate change related risks and/or contribute to create new risks)?
    - (b) What counter measures should be taken to reduce these impacts?
    - (c) What is the cost for reducing/mitigating[4] the negative impacts?
    - (d) N/A
    - (e) N/A
    - (f) Is there any resettlements issue to be addressed? If yes, provide resettlement modality in details.
- **Section 10 Alternative/Options Analysis.** Option Analysis with recommendations & justifications. Technology and strategy recommended to achieve the goals and objectives of the proposed project should be described along with

[4] This term is not used to refer to the reduction of greenhouse gases (GHG), but rather to the reduction of loss and damage that could be caused by a disaster risk situation.

advantages and disadvantages considering various technologies and strategies applicable.

- **Section 11: Recommendations and Conclusion.** Illustrate the solutions specifically to overcome the critical issues that may hinder the project implementation and that would be supported by different sections of analysis.
- **Section 12: Annexes.** Include the RCIA report, along with technical and engineering designs, plant prototypes designs etc, and the Financial & Economic models and any supporting documents.

Then extract from the RCIA report that has been carried out the information needed to complete/feed the following sections of the ***Development project proposal -DPP-.***

- **Section 14.1: Project Background with Problem Statement** → In this respect, the RCIA report contains an important problem statement regarding the level of hazard and project exposure to climate change impacts, which needs to be mentioned at this point in relation to the problem statement.
- **Section 15.2: Outcomes** → It is very important that the project outcome can clearly express how the project will increase the resilience of the infrastructure to climate change. In this respect, the RCIA report is an important input to the definition of project outcomes.
- **Section 15.3: Outputs** → As mentioned above, it is very important that at least one project output can clearly express how the project will increase the resilience of the infrastructure to climate change. In this respect, the RCIA report is an important input to the definition of project outputs.
- **Section 17: Whether any pre-appraisal/feasibility study/pre-investment study was done before formulation of this project? If so, attach summary of findings & recommendations. (If not, mention the causes)** → Answer this question by stating that a climate change impact assessment has been carried out as part of the pre-appraisal/feasibility/pre-investment study, and attach the RCIA report.
- **Section 25.3: Disaster management, climate change** → Answer this question by extracting from RCIA report, the main conclusions, and recommendations.
- **Section 27: Specific linkage with (i) Bangladesh Delta Plan 2100, (ii) Perspective Plan 2021-2041, (iii) Five Year Plan, (iv) SDG targets and (v) Ministry/Sector Priority (Mention the pages with clauses of respective document/ attach the relevant pages of those document)** → In this respect, the RCIA report provides important information on elements that respond to the above-mentioned guidelines, in particular the Delta Plan 2100, the NAP and the sectoral measures described therein, and SDG 13.

ANNEX 2: List of proposed measures and actions to improve the climate resilience of the project that do not require a CCIA

Indicative list of climate change adaptation measures in civil engineering practice.

1 Coastal protection measures.

Climate change has led to increased storm surges, sea level rise and erosion. To address these issues, civil engineers may design and implement measures such as:

1.1 Coastal protection: Constructing seawalls, breakwaters, groins, and revetments to protect coastlines from erosion, storm surges and sea level rise.

1.2 Beach nourishment: This involves adding sand to beaches that have eroded due to rising sea levels and storm surges.

1.3 Wetland restoration: Wetlands can act as natural buffers against storm surges and sea level rise. Restore degraded wetlands or create new ones to provide coastal protection.

1.4 Dune restoration: Dunes are natural barriers against erosion and storm surges. can restore or build dunes to protect coastal areas.

1.5 Living shorelines: These are natural or nature-based solutions that use plants, sand, and other natural materials to protect coastal areas from erosion and storm surges.

1.6 Flood protection measures: These include the construction of flood walls, levees, and storm surge barriers to protect coastal communities from flooding.

1.7 Relocation of infrastructure: this may involve moving critical infrastructure such as power stations, hospitals, and transport systems away from vulnerable coastal areas.

1.8 Coastal zoning and land-use planning: can work with planners and policy makers to develop coastal zoning and land-use plans that discourage development in vulnerable areas and promote resilient design.

1.9 Building codes and standards: can develop building codes and standards that require structures in coastal areas to be resilient to the impacts of climate change.

1.10 Monitoring and early warning systems: can install sensors and monitoring systems to detect changes in sea level, wave height and coastal erosion, and provide early warning of approaching storms.

2 Flood protection measures

With more intense rainfall and more frequent floods, can implement flood protection measures such as:

2.1 Stormwater management systems: This includes the construction of retention ponds, swales and other stormwater management infrastructure to prevent flooding.

2.2 Green infrastructure: Incorporates natural features such as wetlands, rain gardens and green roofs into stormwater management systems to absorb and filter stormwater.

2.3 Flood control structures: These include levees, dams and floodwalls to control the flow of water and prevent flooding.

2.4 Land use planning: can work with planners and policy makers to develop zoning and land use plans that discourage development in flood-prone areas and promote resilient design.

2.5 Building codes and standards: can develop building codes and standards that require structures to be resilient to the effects of flooding, including elevating buildings and installing flood-resistant materials.

2.6 Early warning systems: can install sensors and monitoring systems to detect changes in water levels and provide early warning of approaching floods.

2.7 Floodplain mapping: can use geographic information systems (GIS) to map flood-prone areas and identify vulnerable infrastructure.

2.8 Infrastructure relocation: can relocate critical infrastructure such as power stations, hospitals, and transport systems away from flood-prone areas.

2.9 Urban drainage systems: can design and implement urban drainage systems, including storm drains and gutters, to manage and divert storm water away from infrastructure.

2.10 Retrofitting: can retrofit existing infrastructure to make it more resilient to flooding, including elevating buildings and installing flood-resistant materials.

3 Heat Island reduction measures

With increased temperatures and more heat waves, design and implement heat island reduction measures such as:

3.1 Urban green spaces: This involves increasing the amount of green space in urban areas, such as parks, green roofs, and green walls, to provide shade and reduce temperatures.

3.2 Cool roofs and pavements: Cool roofs and pavements can be installed to reflect sunlight and reduce heat absorption.

3.3 Vegetative barriers: This involves planting trees and other vegetation along roads and pavements to create a barrier against heat.

3.4 Urban forestry: can increase the number of trees in urban areas to provide shade and reduce temperatures.

3.5 Building design: can design buildings with heat resistant materials and technologies, such as high-performance insulation and ventilation systems.

3.6 Water features: Can add water features such as fountains and ponds to provide evaporative cooling.

3.7 Sustainable transport: can promote sustainable transport such as walking, cycling and public transport to reduce the number of cars on the road and reduce heat emissions.

3.8 Urban Heat Island Monitoring: can install sensors and monitoring systems to measure temperature and provide data for urban planning.

3.9 Cool Communities Programme: This programme works with communities to implement urban cooling strategies and raise awareness of the heat island effect.

3.10 Urban Forestry and Green Space Management: can manage and maintain urban forestry and green spaces to optimise their cooling benefits.

4 Water management measures

Climate change has resulted in more intense and frequent precipitation, which can lead to flash flooding and erosion. can design and implement water management measures such as:

4.1 Rainwater harvesting: This involves the collection and storage of rainwater for later use, such as irrigation and toilet flushing.

4.2 Greywater reuse: can design and implement systems to collect and treat greywater from sinks, showers and washing machines for non-potable uses.

4.3 Low impact development: This involves designing and managing urban landscapes to mimic natural hydrological processes, such as reducing impervious surfaces, preserving natural features, and promoting infiltration.

4.4 Green infrastructure: can include green infrastructure such as bioswales, rain gardens and green roofs to manage stormwater and improve water quality.

4.5 Wastewater treatment: can design and implement wastewater treatment systems to remove pollutants and protect public health and the environment.

4.6 Desalination: Can use technology to remove salt and other minerals from seawater or brackish water to provide a new source of fresh water.

4.7 Water conservation: can work with communities to promote water conservation practices, such as fixing leaks, reducing water use in landscaping, and installing water-efficient fixtures.

4.8 Water reuse: can design and implement systems to treat and reuse wastewater for non-potable uses, such as irrigation and industrial processes.

4.9 Smart water management: Can use sensors and data analysis to optimise water use and identify leaks and other inefficiencies.

4.10Public education and outreach: Can develop educational materials and outreach programmes to promote water conservation and sustainable water management practices.

5 Infrastructure resilience measures

Climate change events can cause significant damage to infrastructure. To ensure resilience, design and implement infrastructure resilience measures such as:

5.1 Retrofitting: This involves upgrading existing infrastructure such as buildings, bridges and roads to withstand extreme weather events such as floods, hurricanes and heat waves.

5.2 Diversifying energy sources: can design and implement systems to diversify energy sources, such as renewable energy technologies, to reduce the vulnerability of infrastructure to power outages and other disruptions.

5.3 Adapted building codes: can develop and implement building codes that incorporate climate resilience measures, such as higher design standards for wind, flooding, and heat.

5.4 Early warning systems: This includes installing and implementing systems to provide early warning of extreme weather events, such as flood gauges, weather monitoring stations and emergency alert systems.

5.5 Resilient infrastructure planning: can work with communities and policy makers to develop resilient infrastructure plans that consider the impacts of climate change and incorporate adaptation measures.

5.6 Nature-based solutions: Can integrate nature-

5.9 Infrastructure hardening: This involves retrofitting existing infrastructure with stronger materials and reinforcements to withstand extreme weather events.

5.10Natural infrastructure: can incorporate natural infrastructure such as wetlands, reefs and dunes to provide additional protection from storms and sea level rise.

5.11Green infrastructure: May include green infrastructure such as green roofs and bioswales to manage stormwater and reduce the urban heat island effect.

5.12Adaptive maintenance and management: Can implement adaptive maintenance and management practices to monitor and maintain infrastructure resilience over time.

5.13Infrastructure redundancy: This involves building redundancy into critical infrastructure systems, such as power and water supplies, to ensure continuity of service during extreme weather events.

5.14Risk financing and insurance: can work with policy makers and insurance providers to develop risk financing and insurance options for

based solutions such as green infrastructure, coastal restoration and forest management into infrastructure design and planning. 5.7 Climate risk assessment: can conduct climate risk assessments to identify and prioritise infrastructure projects that are most vulnerable to climate change impacts. 5.8 Infrastructure maintenance and repair: can prioritise regular maintenance and repair of infrastructure to reduce the risk of failure during extreme weather events.	infrastructure owners and operators. 5.15 Emergency planning and response: can work with emergency responders and local authorities to develop and test emergency plans for extreme weather events. 5.16 Critical infrastructure protection: can work with stakeholders to identify critical infrastructure and develop protection plans to minimise the impact of extreme weather events. 5.17 Public education and outreach: can develop educational materials and outreach programmes to inform the public about the importance of climate resilience and adaptation measures that can be taken to increase the resilience of infrastructure.

6 Sustainable construction materials and methods

The use of sustainable materials, such as those that require less energy to produce and have lower embodied carbon, can reduce the carbon footprint of buildings and infrastructure. can also design buildings to be more energy-efficient and to use renewable energy sources.

6.1 Climate-resilient building codes: can work with policy makers to update building codes to reflect climate risks such as higher temperatures, more intense storms and sea level rise. 6.2 Use climate-resilient materials: can specify and use materials that are resistant to climate risks such as extreme temperatures, humidity and saltwater corrosion. 6.3 Design and construct buildings and infrastructure that last longer, using materials and designs that are resistant to weathering, corrosion and other climate risks. 6.4 Passive climate control: can design and construct buildings that use passive cooling and heating techniques such as natural ventilation, shading and insulation. 6.5 High performance insulation: can specify and use high performance insulation materials to improve building energy efficiency and reduce climate impact. 6.6 Stormproof design: can design and construct buildings and infrastructure to withstand storms, floods and other extreme weather events. 6.7 Fire-resistant design - can design and build buildings and infrastructure that are resistant	6.11 Climate-responsive building design: can incorporate climate-responsive design features such as shading, insulation and natural ventilation to reduce the energy demand of buildings and increase their resilience to extreme temperatures and weather events. 6.12 Resilient building materials: can use durable and low-maintenance materials such as fibre cement, polymer composites and recycled materials to improve the durability and longevity of buildings. 6.13 Waterproofing and drainage systems: can design and install waterproofing and drainage systems, such as waterproofing membranes and drainage mats, to prevent moisture ingress and mitigate water damage. 6.14 Flood resistant construction techniques: This involves designing buildings to withstand the effects of flooding, such as elevating buildings above flood levels, using flood-resistant materials and installing flood barriers. 6.15 Wind-resistant construction techniques: may include the use of wind-resistant materials, such as reinforced concrete, to increase the wind resistance of buildings. 6.16 Earthquake-resistant construction techniques: may include the use of earthquake-resistant materials, such as reinforced concrete and steel frames, to increase the earthquake resistance of buildings. 6.17 Energy-efficient construction: This involves the use of energy-efficient construction methods, such as passive solar design, energy-efficient lighting

to wildfires and other fire hazards. 6.8 Resilient roofs - can specify and build roofs that can withstand high winds, heavy rain and other weather hazards. 6.9 Building standards and practices: can update building standards and practices to take account of climate risks, incorporating new materials, designs and construction methods. 6.10 Innovative materials: can research and develop new materials that are more resistant to climate risks such as extreme temperatures, flooding and wind.	and efficient HVAC systems, to reduce the energy consumption and carbon footprint of buildings. 6.18 Green building certification: can work with green building certification programmes such as LEED and Green Globes to improve the environmental performance and resilience of buildings. 6.19 Maintenance and retrofitting: can implement regular maintenance and retrofitting practices to improve the durability and resilience of buildings over time. 6.20 Public education and outreach: can develop educational materials and outreach programmes to raise awareness of climate risks and promote the use of resilient building materials and practices.

These are just a few examples of the many civil engineering adaptation measures that can be taken to address the impacts of extreme climate change events. By implementing these measures, help ensure that our communities are resilient and sustainable in the face of a changing climate.

7 Reducing the impact of heatwaves on the infrastructures

7.1 Cool roofs: This involves the use of reflective materials on roofs to reduce the amount of heat absorbed by buildings.

7.2 Green roofs: can design and implement green roofs covered with vegetation to reduce the amount of heat absorbed by buildings and improve air quality.

7.3 Heat resistant pavements: can use materials with higher solar reflectance and thermal emittance to reduce the temperature of pavements and prevent them from cracking or deteriorating.

7.4 Heat resistant building materials: This involves using heat resistant materials for buildings, such as insulation, windows and shading devices, to reduce the amount of heat that enters buildings.

7.5 Urban heat island mitigation: can design and implement strategies to reduce the urban heat island effect, such as increasing vegetation cover, improving ventilation and reducing the number of heat-absorbing surfaces.

7.6 Passive cooling techniques: can incorporate passive cooling techniques such as natural ventilation and shading into building design to reduce the amount of energy needed for air conditioning.

7.7 Heat resistant electrical infrastructure: Can use materials that are more resistant to high temperatures for electrical infrastructure, such as transformers and power lines, to reduce the risk of power outages during heat waves.

7.8 Cool pavements: can use materials with high solar reflectance to reduce the temperature of pavements and prevent them from cracking or deteriorating.

7.9 Water management: can design and implement systems to manage water resources, such as using rainwater for irrigation and promoting rainwater harvesting, to reduce the amount of heat absorbed by buildings and pavements.

7.10 Smart city technologies: This involves using sensors and data analysis to optimise energy use and reduce the urban heat island effect.

8 Heavy rain protection for infrastructure

8.1 Green infrastructure: This involves the use of natural systems such as rain gardens, bioswales and green roofs to absorb and manage stormwater runoff.

8.2 Rainwater harvesting: can design and implement systems to capture and store rainwater for later use, such as irrigation or non-potable water supply.

8.3 Permeable pavements: can use permeable paving materials, such as porous asphalt or concrete, to allow rainwater to infiltrate into the ground.

8.4 Stormwater management ponds: This involves the design and construction of ponds to capture and treat stormwater runoff, improving water quality and reducing the risk of flooding.

8.5 Flood walls and barriers: can design and construct flood walls and barriers to protect infrastructure in flood prone areas.

8.6 Elevated buildings: can design and construct buildings on elevated platforms to reduce the risk of flooding.

8.7 Drainage systems: Can design and construct drainage systems, such as storm drains and culverts, to move storm water away from infrastructure and into receiving waters.

8.8 Retention basins: may include the design and construction of retention basins to capture and temporarily store stormwater runoff to reduce the risk of downstream flooding.

8.9 Flood protection measures: May include the implementation of flood-proofing measures, such as waterproofing buildings and installing backflow prevention devices, to reduce the risk of damage from flooding.

8.10Improved urban planning: Can work with urban planners to develop sustainable urban drainage plans that consider the impacts of climate change and incorporate stormwater management measures.

9 Cyclone infrastructure protection

9.1 Wind-resistant buildings: can design and construct buildings that are wind-resistant, such as using reinforced concrete and steel structures to reduce the risk of damage from high winds.

9.2 Flood resistant buildings: can design and construct buildings that are resistant to flooding, such as elevating buildings above flood levels to reduce the risk of damage from storm surges.

9.3 Coastal defence structures: Can design and construct coastal defence structures such as sea walls, breakwaters and groynes to protect infrastructure from storm surges and erosion.

9.4 Emergency power supply: can design and install emergency power supplies, such as generators and battery storage systems, to ensure that critical infrastructure remains operational during power outages caused by cyclones.

9.5 Underground infrastructure: can design and build underground infrastructure, such as utility lines and water storage tanks, to reduce the risk of damage from high winds and storm surges.

9.6 Advanced warning systems: Can develop and implement advanced warning systems, such as early warning systems and storm tracking technologies, to provide timely information and enable effective evacuation and emergency response.

9.7 Resilient transport infrastructure: can design and build transport infrastructure such as bridges and highways to be more resilient to cyclones, for example by using robust materials and incorporating drainage systems.

9.8 Structural hardening: This involves retrofitting existing infrastructure, such as buildings and bridges, with wind-resistant features, such as bracing and strengthening systems, to improve their resilience to cyclones.

9.9 Disaster recovery planning: can work with local authorities and emergency management organisations to develop disaster recovery plans that prioritise critical infrastructure and ensure rapid restoration of essential services.

9.10 Building community resilience: This involves working with local communities to raise awareness of cyclone risks, promote preparedness and develop community resilience programmes.

10 Reduce the impact of drought on infrastructure

10.1 Rainwater harvesting: Can design and install rainwater harvesting systems, such as rooftop collection systems and underground storage tanks, to supplement or replace traditional water supplies.

10.2 Greywater recycling: can design and install greywater recycling systems that treat and reuse water from sinks, showers and washing machines for non-potable uses such as irrigation and toilet flushing.

10.3 Desalination: can design and build desalination plants that convert seawater or brackish water into potable water that can supplement or replace traditional water supplies.

10.4 Water-efficient infrastructure: can design and build water-efficient infrastructure, such as low-flow toilets and showerheads, and landscaping that uses less water.

10.5 Leak detection and repair: can design and install leak detection systems, such as smart meters and sensors, to identify and repair leaks in water supply systems.

10.6 Water reuse: can design and install water reuse systems that treat and reuse wastewater for non-potable uses such as irrigation and toilet flushing.

10.7 Groundwater recharge: Can design and construct systems to recharge depleted aquifers and improve groundwater supplies, such as using infiltration basins, artificial recharge wells and infiltration galleries.

10.8 Efficient irrigation systems: can design and install efficient irrigation systems, such as drip irrigation and subsurface irrigation, to reduce water loss and improve irrigation efficiency.

10.9 Drought-resistant infrastructure: can design and build infrastructure that is more resistant to drought, such as using materials that are less prone to cracking and erosion and incorporating drought-tolerant landscaping.

10.10 Public education and outreach: This involves working with the public to increase awareness of water conservation measures, such as public service announcements, education campaigns and outreach programmes.

11 Protecting infrastructure against landslides

11.1 Slope stabilization: can design and construct slope stabilization systems to prevent or control landslides, such as retaining walls, rock bolts, soil nails and gabion walls.

11.2 Drainage systems: can design and install drainage systems, such as surface and subsurface drainage, to reduce water saturation and improve slope stability.

11.3 Geosynthetics: can use geosynthetics such as geotextiles and geogrids to reinforce slopes and improve their stability.

11.4 Terracing: This involves building terraces into the slope to reduce the slope angle and increase stability.

11.5 Ground improvement: can use ground improvement techniques such as dynamic compaction, grouting and soil stabilisation to increase the strength and stability of the ground.

11.6 Vegetation: can plant vegetation on slopes to improve stability, as vegetation roots can help to bind soil and reduce erosion.

11.7 Monitoring systems: can design and install monitoring systems such as inclinometers, piezometers and seismometers to detect changes in slope stability and allow early warning and intervention.

11.8 Retention structures: can design and construct retention structures, such as catchment basins and sediment retention ponds, to collect and control sediment movement and reduce the impact of landslides on downstream infrastructure.

11.9 Emergency response systems: This involves establishing emergency response plans and systems, such as early warning systems and evacuation procedures, to reduce the impact of landslides on infrastructure and public safety.

12 Flash floods on the infrastructures

12.1 Flood control structures: can design and construct flood control structures such as levees, floodwalls, and detention basins to manage flood flows and protect infrastructure.

12.2 Stormwater management: can design and install stormwater management systems such as green roofs, rain gardens and permeable pavements to reduce runoff and mitigate flooding.

12.3 Channel stabilization: can stabilize channels and waterways to reduce erosion and prevent sediment build-up that can cause blockages and flooding.

12.4 Infrastructure elevation: can design and build infrastructure such as buildings and roads at higher elevations to reduce their vulnerability to flooding.

12.5 Infrastructure retrofitting: can retrofit existing infrastructure with flood-resistant materials and seals to protect against flood damage.

12.6 Land-use planning: can work with urban planners to develop land-use plans that avoid flood-prone areas and priorities the protection of critical infrastructure.

12.7 Early warning systems: can develop early warning systems that use sensors and real-time data to alert communities to potential flood events, allowing for timely evacuation and preparation.

12.8 Floodplain mapping: can map floodplains and assess their potential impact on infrastructure, enabling them to develop strategies to mitigate the effects of flooding.

12.9 Emergency response systems: can work with emergency response teams to develop plans and systems to respond to flash flood events and minimize damage to infrastructure and public safety.

13 To reduce the impact of river-bank erosion

13.1 Riparian zone management: can manage the riparian zone, the area between the river and the land, to help stabilize the riverbanks. This may include planting vegetation to anchor the soil and reduce erosion.

13.2 Bank protection structures: can design and construct bank protection structures such as gabions, riprap and retaining walls to prevent erosion and protect infrastructure such as bridges and buildings.

13.3 Slope stabilization: can stabilize riverbanks by grading the slope, installing retaining walls or terraces, or planting vegetation. This can help prevent soil erosion and stabilize the bank.

13.4 Floodplain management: can manage the floodplain to prevent the river from shifting and eroding the banks. This can include floodplain mapping, zoning, and land use planning.

13.5 Channel improvements: can improve the river channel by straightening, widening, or deepening the channel to prevent erosion and maintain a stable water flow.

13.6 Geotechnical investigations: can carry out geotechnical investigations to understand soil characteristics and determine the best methods of stabilization and protection.

13.7 Monitoring and maintenance: can monitor the riverbank for signs of erosion and maintain bank protection structures to ensure they remain effective.

14 Measures to reduce the impact of strong sedimentation

14.1 Sediment control structures: can design and construct sediment control structures such as sediment basins, sediment ponds and sediment traps to capture sediment before it reaches waterways and infrastructure.

14.2 Sediment removal: can remove sediment from waterways and infrastructure such as culverts, bridges, and intakes. This can be done by dredging or other sediment removal techniques.

14.3 Erosion control: can implement erosion control measures such as revegetation, mulching and soil stabilization techniques to reduce sediment run-off from construction sites and other disturbed areas.

14.4 Stormwater management: can design and implement stormwater management systems to capture and treat stormwater runoff, reducing the amount of sediment that reaches waterways and infrastructure.

14.5 Watercourse maintenance: can maintain watercourses by regularly removing accumulated sediment and debris, helping to prevent blockages and erosion.

14.6 Education and outreach: can work with communities to educate them on the importance of reducing sedimentation and implementing best management practices to prevent sediment runoff.

14.7 Geotechnical investigations: can conduct geotechnical investigations to understand soil characteristics and determine the best methods for sediment control and erosion prevention.

14.8 Monitoring and maintenance: can monitor sediment levels and the effectiveness of sediment control measures and maintain them to ensure they remain effective.

15 Measures against water scarcity

15.1 Water conservation: can design and implement water conservation measures such as rainwater harvesting, grey water reuse and water-efficient fixtures to reduce water demand and ensure water availability.

15.2 Water recycling and reuse: can design and implement systems to recycle and reuse wastewater to reduce the need for freshwater resources.

15.3 Desalination: can design and implement desalination plants to convert seawater or brackish water into fresh water, increasing water availability in coastal areas.

15.4 Water storage: can design and construct water storage facilities such as reservoirs, tanks and dams to capture and store water during wet periods for use during dry periods.

15.5 Water distribution systems: can design and maintain water distribution systems to minimize leakage and losses and ensure that water is delivered efficiently to users.

15.6 Water pricing and regulation: can work with policy makers to develop water pricing and regulation strategies that encourage water conservation and sustainable water use practices.

15.7 Education and outreach: can work with communities to educate them on the importance of water conservation and the implementation of water-saving practices.

15.8 Water-efficient landscaping: can design and implement water-efficient landscaping practices such as xeriscaping and the use of drought-tolerant plants to reduce the need for irrigation water.

16 To reduce the impact of lightning on the infrastructures

16.1 Lightning Protection Systems: can design and install lightning protection systems, such as lightning rods and earthing systems, to divert lightning strikes away from critical infrastructure and prevent damage.

16.2 Surge protection devices: can install surge protection devices, such as surge arresters and transient voltage suppressors, to protect electronic equipment from lightning-induced surges.

16.3 Insulation: can design and install electrical insulation systems to prevent lightning induced electrical discharges and damage to critical infrastructure.

16.4 Conductive pathways: can design and install conductive pathways, such as lightning arrestors and grounding wires, to provide a path of least resistance for lightning strikes and prevent damage to infrastructure.

16.5 Lightning Resistant Materials: can use lightning resistant materials, such as fiberglass reinforced plastic (FRP), to replace traditional materials that are susceptible to lightning damage.

16.6 Emergency Response Plans: can develop emergency response plans that include procedures for assessing and repairing lightning damage to critical infrastructure, as well as procedures for evacuating and protecting people during lightning storms.

16.7 Lightning detection systems: can install lightning detection systems to provide early warning of approaching thunderstorms and allow timely shutdown of critical infrastructure.

16.8 Risk assessment: can carry out risk assessments to identify vulnerable infrastructure and priorities lightning protection measures accordingly.

17 To protect infrastructure from the sea level rise and storm-surges

17.1 Coastal Protection - can design and build coastal defenses such as seawalls, breakwaters, and levees to protect coastal areas from storm surges.

17.2 Raising infrastructure - can design infrastructure such as buildings, bridges, and roads to be raised above expected storm surge levels.

17.3 Flood-proofing: can design and implement flood-proofing measures such as waterproofing, raising electrical sockets and appliances above flood levels, and sealing openings to prevent floodwater from entering buildings.

17.4 Drainage systems: can design and install drainage systems to manage storm water run-off and prevent flooding in low-lying areas.

17.5 Green infrastructure: can design and implement green infrastructure such as rain gardens and bioswales to manage stormwater and reduce the impact of storm surges on infrastructure.

17.6 Risk assessment and planning: can conduct risk assessments to identify vulnerable infrastructure and develop emergency response and evacuation plans to minimize the impact of storm surges.

17.7 Dune restoration and beach nourishment: can design and implement dune restoration and beach nourishment projects to protect coastlines from storm surges and minimize erosion.

17.8 Storm surge barriers: can design and construct storm surge barriers, such as tidal gates and storm surge barriers, to prevent storm surges from entering coastal areas.

17.9 Managed retreat: In some cases, recommend managed retreat, which involves relocating infrastructure and communities away from areas that are at risk of sea level rise.

18 To reduce the impact of salinity intrusion on the infrastructures

18.1 Well location and design: can design and locate wells to minimize the risk of saltwater intrusion by ensuring that they are in areas where freshwater aquifers are deeper than saltwater aquifers.

18.2 Artificial recharge: can design and implement artificial recharge projects to replenish groundwater levels and prevent saltwater intrusion.

18.3 Desalination: can design and build desalination plants to treat saline water and produce fresh drinking water for communities.

18.4 Managed aquifer recharge: can design and implement managed aquifer recharge projects to artificially recharge aquifers with fresh water to create a buffer against saltwater intrusion.

18.5 Land use planning: can work with local governments to develop land use plans that protect freshwater resources and reduce the impact of development on groundwater levels.

18.6 Barrier systems: can design and install barrier systems such as underground dams, sheet piling and grout curtains to prevent saltwater intrusion into freshwater aquifers.

18.7 Pump and treat systems: can design and implement pump and treat systems to remove saltwater from contaminated groundwater and discharge it to the sea or other saline water bodies.

18.8 Wastewater treatment: can design and build wastewater treatment facilities to treat and reuse wastewater, reducing demand on freshwater resources and helping to prevent saltwater intrusion.

18.9 Monitoring and modelling: can develop and implement monitoring and modelling systems to track the movement of saltwater intrusion and predict potential impacts on infrastructure.

19 Measures to reduce the impact of coastal erosion on the infrastructures

19.1 Beach nourishment: can replenish eroded beaches by adding sand or other sediments, which can help protect infrastructure and provide recreational opportunities for communities.

19.2 Dune restoration: can restore natural dunes or create artificial dunes to act as a natural barrier against coastal erosion, protecting infrastructure and providing habitat for wildlife.

19.3 Seawalls and revetments: can design and build seawalls and revetments to protect infrastructure from the effects of waves and erosion.

19.4 Offshore breakwaters: can design and construct offshore breakwaters to absorb wave energy and protect coastal areas from erosion.

19.5 Living shorelines: can design and implement living shorelines, which use natural materials such as oyster shells and marsh grasses to create a buffer against coastal erosion while providing habitat for wildlife.

19.6 Managed retreat: in some cases, managed retreat is recommended, where infrastructure and communities are moved away from eroding shorelines to protect them from the long-term effects of erosion.

19.7 Beach stabilization: can stabilize the beach by installing groins, which are long, narrow structures perpendicular to the shoreline, to trap sand and prevent it from moving offshore.

19.8 Vegetative stabilization: can stabilize the shoreline by planting vegetation to help trap sand and stabilize the shoreline.

19.9 Monitoring and modelling: can develop and implement monitoring and modelling systems to track the movement of coastal erosion and predict potential impacts on infrastructure.

ANNEX 3: Monitoring & Evaluation System Quality Assurance Checklist for the RCIA

Objective

The Quality Assurance Checklist (QAC) is a component of the monitoring and evaluation system established for the CRT-Handbook. The QAC checklist helps to ensure that the quality of the RCIA process is robust, transparent, and ambitious, considering the quality of the final report and the feasibility of its recommendations.

It is designed to enable RCIA users to:

1. Monitoring the quality of the analytical process.	→ to correct errors, capitalize on successes, address emerging difficulties, and seize opportunities to ensure a high level of confidence in the conclusions and recommendations produced in the final report
2. Evaluate the quality of the RCIA and the final report.	→ to ensure that the quality of the RCIA process is robust, transparent, and ambitious, considering the quality of the final report and the feasibility of its recommendations.

To this end, the QAC provides a set of questions that require your expert-judgement criteria to monitor and evaluate the quality of the procedures undertaken, the quality of the outputs, and the final report.

It is important to note that the QAC is an iterative monitoring and evaluation process that the engineering team must apply to each step of the RCIA. In this regard, it should be applied throughout the process of collecting, analyzing, and preparing the RCIA and not just at the end of the process.

In this way, errors will be corrected in time and the quality of the RCIA will be generated in the production process itself. Therefore, the QAC should be applied as many times as necessary to achieve optimum confidence and quality in the final report.

The monitoring process is carried out as the engineering team applies the QAC always checking the quality of progress in the preparation of the RCIA. It is recommended to carry out the evaluation at the end of each step to ensure the quality of progress. However, it is mandatory to carry out the evaluation at the end of the RCIA production process and its final report.

Monitoring and Evaluation matrix.

- → **If the issue is fully covered in RCIA, tick YES.**
- → **If the issue is not fully covered in RCIA, please tick NO, and comment an explanation.**
- → **If the issue is partially addressed, please tick NO, and comment an explanation.**

This section focuses on the scope of application and basic conditions to proceed with RCIA:

Issue	Yes	No	Notes
1. Is this infrastructure at a sub-project or scheme level, or at a geographical scale ranging from a District (two or more Upazilas) to one Upazila (two or more union councils)?	☐	☐	
2. Did the engineering team obtain, at least, the certificate for completing the training curse of Climate Change Knowledge Portal: https://wbg.edcast.com and/or the module 1 of: https://unccelearn.org/course/view.php?id=7&page=overview?	☐	☐	

This section helps to ensure that the nine steps that form part of the RCIA analysis process are carried out with a sufficiently robust, appropriate, and transparent level of quality and reliability.

STEP 1: Objectives description and preliminary design, materials & location.

The objective of this step is to understand the project characteristics such as project type, location, duration, design, and material considerations, as well as other key aspects, because of full fill the **Form 1 of RCIA**.

Issue	Yes	No	Notes
1. Has the **RCIA-Form 1**, been completed with the subproject information and included in the final report?	☐	☐	
2. Does the final report detail a description of the sub-project profile at the district level and its likely location, based in **RCIA-Form 1**?	☐	☐	
3. Does the final report included the site-location map and/or it trace, based in **RCIA-Form 1**?	☐	☐	
4. Does the final report detail how many schemes are foreseen to implement the sub-project and a description of the initial design idea and the materials that were used in each of them (standard design), based on **RCIA-Form 1**?	☐	☐	

STEP 2: Multi-hazard context of the project.

The objective of this step is to understand the general contexts of hazards to which the project may be exposed during its lifespan.

Issue	Yes	No	Notes
1. Has it been identified in which climatic stress zone the project is planned to be located, based in the multi-hazard risk map for Bangladesh prepared by CEGIS 2022[5]?	☐	☐	
2. Was **RCIA-Form 2** reviewed according to the district where the project will be located? Was the project location marked, and were the prominent weather hazards read and considered in the final report?	☐	☐	
3. Has the **RCIA-Form 2** been completed and included in the final report?	☐	☐	
4. Does the final report explain the general contexts of hazards to which may be exposed during its lifespan, considering the questions 1 to 3 listed in this QA Checklist for the Step 2?	☐	☐	

STEP 3: Identify extreme climate indices (ECIs) and their rate of change.

The objective of this step is to identify the main climate drivers of hydrometeorological hazards, represented by Extreme Climate Indices (ECI) and the Rate of Change for the coming decades.

Issue	Yes	No	Notes
1. Has the **RCIA-Form 3** been full filled through the main ECIs currently available on the CCKP[6], IPCC Interactive Atlas[7] or other higher resolutions[8] platforms?	☐	☐	
2. In the **RCIA-Form 3**, has the percent of change in a) temperature, b) precipitation and c) number of consecutive dry days, relative to the reference period, calculated following the instructions of Step 3.3 of the RCIA.	☐	☐	
3. Is it clear in the final report what are the current values of the ECIs in the region of interest? And what changes could they exhibit in the coming decades?	☐	☐	
4. Has the **RCIA-Form 3** been included in the final report?	☐	☐	
5. Are the main climate drivers of hydrometeorological hazards, represented by ECI and the Rate of Change for the coming decades identified and included in the final report?	☐	☐	

STEP 4: Estimate the level of hazard.

This step focus specifically on hazard's factors. The objective is to identify extreme hydrometeorological events and the level of hazard they may represent for the project.

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[5] Climate Stress Areas of Bangladesh. Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh in National Adaptation Plan of Bangladesh (2023-2050)

[6] The CCKP platform can be access in the link: https://climateknowledgeportal.worldbank.org/country/bangladesh

[7] The IPCC Interactive Atlas platform can be access in the link: https://interactive-atlas.ipcc.ch/

[8] For the period in which this Quality Assurance Checklist is designed, the CReLIC is working to produce these ECIs at a larger scale, using resolutions at approximately 25 kms to be used with greater confidence at the Upazila level, which will be available on the KMS.

Issue	Yes	No	Notes
1. Have you communicated with LGED office officials at the Upazila level to clarify the participatory analysis process required in Form 4?	☐	☐	
2. Have you been able to verify that LGED office officials at the Upazila level understand the terms and concepts in Form 4?	☐	☐	
3. Were the leaders of the project's beneficiary population convened to discuss the hazards to which the project might be exposed?	☐	☐	
4. Was a sex-disaggregated list of participants prepared?	☐	☐	
5. Was Form 4 completed at the project site?	☐	☐	
6. Was the location of the project site determined using the GPS on the mobile phone?	☐	☐	
7. Did the participants identify the critical hazard hotspots for the project?	☐	☐	
8. Were the critical points located using the GPS on the mobile phone?	☐	☐	
9. Were photographs taken of the project site and critical points?	☐	☐	
10. Were photographs taken of the meeting with community leaders?	☐	☐	
11. Has the documentation in the Community of Practice document repository been reviewed and use to process the information needed to complete **all this Step 4**? https://drive.google.com/open?id=1-G3mTzAWQE2x_gIN6gqnxCpfTKeuOafe&authuser=antarenas%40gmail.com&usp=drive_fs	☐	☐	
12. Is the information reviewed and extracted from documents **less than 10 years old**?	☐	☐	
13. Are hydrometeorological event outliers supported by document revisions expressed in numbers, percentages, weight ranks and/or in a qualitative way?	☐	☐	
14. Has information from recent LGED projects in the area been analysed and have existing Environmental Impact Assessment studies covering the project area been reviewed? Is this information connected with CReLIC?	☐	☐	
15. Does the data extracted during the document review explain the hydrometeorological hazard establishment processes clearly enough in the final report and these results are understood by the engineering team?	☐	☐	
16. Once the results of the previous question were understood, were the following digital platforms used to complete the information? - Disaster and Climate Risk Information Platform (DRIP): http://drip.plancomm.gov.bd/ - Think Hazard: https://thinkhazard.org/en/report/23-bangladesh	☐	☐	
17. Were the data from the different sources of information normalized, using the RCIA- Form 5, by using the three ranges of percentage values according to the Intensity, Duration and Frequency (IDF) level?	☐	☐	
18. Does the final report include, in an understandable and robust way, what is the current magnitude of the hydrometeorological events, in terms of Intensity, Duration and Frequency (IDF) that occur in the district of interest?	☐	☐	

STEP 5. Hazard Baseline Aggregate (HbA)

Issue	Yes	No	Notes
1. Have you calculated the baseline HbA?	☐	☐	
2. Was the Aggregate Hazard Baseline (AHB) estimated for each district of interest using the **RCIA-Form 6** and its instructions?	☐	☐	
3. Does the final report include what level of hazard do the hydrometeorological events, in terms of Intensity, Duration and Frequency (IDF) represent, using the example mentioned in the step 4 of the RCIA?	☐	☐	
4. Has the **RCIA-Form 6** been completed and included in the final report?	☐	☐	

STEP 6. Projecting future hazard levels given the percentage change in climate.

The objective of this step is to calculate the hydrometeorological hazard index for the coming decades, using the following time periods: 2020-2039, 2040-2059, 2060-2079 and 2080-2100.

Issue	Yes	No	Notes
1. Has the AHB summarized before proceeding with the project hazards linked to future climate change scenarios in this Step 6?	☐	☐	
2. Was the AHB estimated by adding the ECIs percentage change (for the periods listed in **RCIA-Form 3**) plus the estimated AHB for the District of interest in the reference period?	☐	☐	
3. Does the final report include the AHB result for all the upcoming decades, according to the expected lifespan of the project: 2020-2039, 2040-2059, 2060-2079 and 2080-2100?	☐	☐	
4. Does the final report include the re-classification of the level of hazard for all the upcoming decades, according to the expected lifespan of the project, using the **Table 3 of RCIA**?	☐	☐	
5. Has **RCIA-Form 7** been completed and incorporated into the final report, including both, the Hazard Index Projection for all the upcoming decades according to the expected lifespan of the project, and the AHB for the District of interest in the reference period?	☐	☐	
6. Does the engineering team understand that the resulting **RCIA-Form 7** analysis assumes that the IDF of each hydrometeorological events analysed and classified in **RCIA-Form 5** will change proportionally to the intensification of the climate extremes represented by the ECIs calculated in **RCIA-Form 3**?	☐	☐	
7. Does the report clearly explain what the actual and new added hazard index might be and what level of hazard it will represent, given the expected rate of climate change in the next decades? For more detail you can review the examples of step 6 of RCIA	☐	☐	

STEP 7: Hazard exposure levels and potential impacts.

The objective of this step is to determine the level of exposure of the project to the impact of future hydrometeorological hazards.

Issue	Yes	No	Notes
1. Does the **RCIA-Form 8** include the hazard level classification for all the hydrometeorological events observed in the last 10 years, as classified in **RCIA-Form 5**?	☐	☐	
2. In case of changes in the hazard magnitude in **RCIA-Form 7** * (i.e., from low to moderate, or from moderate to high, or from high to extremely high), has the hazard classification for all hydrometeorological phenomena been modify, raising their classification to the corresponding change in the hazard magnitude. You can review an example on step 6 of RCIA ** If this question does not apply, mark "No" and indicate it in the Notes*	☐	☐	
3. Has the final version of **RCIA-Form 8** been completed and included in the final report?	☐	☐	
4. Does the engineering team understand the potential magnitude of each hydrometeorological hazard and its future evolution, resulted for **RCIA-Form 8**? This is a requisite before to proceed with the impact analysis.	☐	☐	
5. Did the engineering team responsible for the project have a working session in which they bring and discuss the information learned during the review of the documents and information platforms to build the impact chain?	☐	☐	
6. In the work session, were the weather signals identified as ECIs considered, as well as the impacts of these climatic signals on the physical-natural elements present in the project region and the hydrometeorological responses to the magnitude of these impacts, in the form hydrometeorological hazards?	☐	☐	
7. During the work session, the aggregate impacts that could be expected in the form of losses, damages, and disturbances on the physical structure of the project and the services that it will provide for each District where the project or a part of it is developed were analysed? You can review an example on **Figure 3 of RCIA**	☐	☐	
8. Does each hydrometeorological hazard that reaches a high and/or extremely high hazard level, during the lifespan of the project, have its impact chains developed for each time series? Are all these impact chains included by photographs in the final report?	☐	☐	
9. Was the **RCIA-Form 9** answered collectively by the engineering team?	☐	☐	
10. Is this Form 9 included in the final report?	☐	☐	
11. In this **RCIA-Form 9**, is the description given of the losses and damages that may occur considering the standard design, materials, and location of the site project?	☐	☐	
12. In this **RCIA-Form 9**, are the answers rigorous describing: (i) the process of how the impact can occurs, (ii) the specific likely losses, damage that can occur, and (iii) the consequences of these destruction, damaging and/or disruption?	☐	☐	
13. Has the level of project exposure to the impact of future hydrometeorological hazards been determined and clearly included in the final report?	☐	☐	

STEP 8: Project adaptation challenges.

The objective of this step is to define the challenges that the project may face given its level of exposure to hazards and potential impacts.

Issue	Yes	No	Notes
1. What part of project — (1) design, (2) materials and/or (3) site — will present losses and damage given the previous analysis made on **Step 7 impact chain** and **RCIA Form 9**?	☐	☐	
2. Does the final report identify and explain the central problematic situation related to the (1) standard design, (2) standard materials and/or (3) selected project site?	☐	☐	
3. Did the engineering team responsible for the project have a working session to complete the **RCIA-Form 10**?	☐	☐	
4. In this working session, did the engineering team follow the rules of the **Box 3 of the RCIA**?	☐	☐	
5. Was the **RCIA-Form 10** completed taking into consideration the potential loss and damage identified **in Step 7**, its **chain of impact**, and its **RCIA-Form 9**? Is the full filled Form 9 included in the final report?	☐	☐	
6. Has the engineering team verified that the analysis in this **Step 8** does not use the word "lack" or any of its synonyms or another word that gives the idea of the *non-existence* of something when speaking about problems?	☐	☐	
7. Does the engineering team have cleared the difference between the causes of the problems detected and the consequences of it? Remember that both, its causes, and consequences, configuring a challenge situation for adaptation.	☐	☐	
8. Does the engineering team understand that the central problem situation — about (1) design, (2) materials, and/or (3) site —, correctly formulated, constitutes the main adaptation challenge that the project must address to move towards a weather -resistant design?	☐	☐	
9. Are the challenges that the project may face, given its level of exposure to hazards and potential impacts, defined, and clearly included in the final report?	☐	☐	

STEP 9: Final report to decision making.

Issue	Yes	No	Notes
1. Does the final report accomplish the document structure requested by the RCIA in its step 9?	☐	☐	
2. Does the final report describe the findings on the extreme climatic and hydro-meteorological hazards to which the project is exposed in a clearly way?	☐	☐	
3. Does the final report analyse the likely chain of impacts on the project in a robust way?	☐	☐	
4. Does the final report identify all the adaptation challenges related with the design, materials, and location of the site project?	☐	☐	
5. Does the final report provide a robust technical recommendation based on the process and results of RCIA?	☐	☐	
6. In the final report, Chapter I: Description of the project and hazardous context, are **Form 1 and 2** included, as well as any comments related to the project that are relevant to the background?	☐	☐	
7. Does the final report, Chapter I: Project Description and Hazardous Context, contain the list of prominent hazards affecting the district of interest, as well as explanations of how these hazards occur in the project area?	☐	☐	
8. In the final report, Chapter II: Hazard Exposure Context, is **Form 3** included, as well as an explanation of what are the extreme weather indices, what does the average rate of change mean and the results	☐	☐	

Issue	Yes	No	Notes
obtained?			
9. In the final report, Chapter II: Hazard Exposure Context, are **Form 4 and 5** included, as well as an explanation of why the hazard level has been assigned to hydrometeorological events?	☐	☐	
10. In the final report, Chapter III: Context of Exposure to Hazards, **Forms 6, 7 and 8** are included, as well as an explanation of the process of projecting hazards into the future and the results obtained?	☐	☐	
11. Does final report, Chapter III: Impact chain, explain how the cause-effect chain of climatic and hydrometeorological events on the project is produced for each of the impacts built in step 6, and how they can be observed in terms of losses and damage?	☐	☐	
12. In the final report, Chapter IV: Project adaptation challenges, is the **Form 9** included, as well as its explanation through an argumentation organized by design, materials, and location?	☐	☐	
13. In the final report, Chapter IV: Project adaptation challenges, are adaptation challenges ranked in terms of importance and priority considering the results of **Form 9**?	☐	☐	
14. Does the final report explain why the ranking was constructed in this way? (as explained in form 9)	☐	☐	
15. Is **Form 9** included in the final report?	☐	☐	
16. Does Chapter V: Closing the information and data gap. Does contain a summary of all aspects that remain partially addressed, not addressed, or insufficiently understood (marked as "Unknown" on Forms 4 and 5)	☐	☐	
17. Does Chapter V: Closing the information and data gap, contain a solid explanation of what the adaptation challenges are for the project, related to a) design, b) materials and c) site?	☐	☐	
18. Does Chapter VI: Conclusions and recommendations, contains a summary of the previous a) significant hazards, b) main expected impacts, c) the core adaptation challenge and d) the comprehensive conclusions that involve the previous points.	☐	☐	
19. Does Chapter VI: Conclusions and recommendations. Have you drawn conclusions about key hazards, expected impacts and adaptation challenges?	☐	☐	
20. If the project does not require a Comprehensive Climate Impact Assessment - CCIA - have you developed the necessary recommendations to increase the resilience of the project?			
21. Does the final report include a list of the documents and digital platforms reviewed that support the entire analytical process, conclusions, and recommendations of RCIA?	☐	☐	
22. Does the final report include photographs of the project site and Upazila/district level consultations?	☐	☐	
23. Was the final report of this RCIA reviewed by the engineering team leader?	☐	☐	

Evaluation matrix

How to use the scoring matrix:

→ From the total number of questions, remove those that do not apply to the type of project being considered.

→ Once this total is obtained, calculate the percentage of questions that have been answered positively.

→ Using the percentage obtained, mark the corresponding results on the colour scale with an 'X'.

% obtained	Interpretation	Result	Scale of colours
90% to 99%	The RCIA analysis and final report exceeds the expectations and/or is not deficient (meets the key criteria).	Very satisfactory (MS):	
76% to 90%	The RCIA analysis and final report meets most of the expectations and/or its deficiencies are minor.	Satisfactory (S):	
61% to 75%	The RCIA analysis and final report meets the expectations and/or has some significant deficiencies.	Reservedly Satisfactory (RS):	
46% to 60%	The RCIA analysis and final report is found somewhat below expectations and/or has significant deficiencies	Moderately Unsatisfactory (MI):	
31% to 45%	The RCIA analysis and final report is far below expectations and/or has significant deficiencies	Unsatisfactory (I):	
30% or less	The RCIA analysis and final report has serious deficiencies and does not meet the objective.	Highly unsatisfactory (AI):	

→ If the outcome of the evaluation is green, the RCIA report should be submitted with this monitoring and evaluation outcome attached.

→ If the assessment output is yellow or orange, errors or weaknesses in the process should be corrected to improve the quality of the RCIA. Use the form below to plan your response to improve the quality of the RCIA and its final report.

Then repeat this QAC to ensure that the final output is qualified.

→ If the result of the assessment is red, you should take a serious look at all aspects of the process and perhaps ask for help. Use the form below to plan your response to the poor quality of the RCIA and the final report.

Repeat this QAC as many times as necessary until the RCIA and its final output are qualified.

Note that this is an iterative assessment process, so correct errors and apply the assessment as necessary until an acceptable level of confidence and quality of the RCIA and final report is achieved Satisfactory (green rating).