JICA Climate-FIT (Adaptation)

Climate Finance Impact Tool for Adaptation

Guidance on Climate Risk Assessment and Adaptation measures consideration

JICA Global Environmental Department

Office for Climate Change

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Introduction

The Paris Agreement was adopted in 2015 at the 21st Conference of the Parties to the UN Framework Convention on Climate Change (COP21 of the UNFCCC) as a new international framework for addressing climate change. The Paris Agreement calls for global efforts to limit the increase in global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C. It also aims to strengthen adaptive capacity and resilience and reduce vulnerability to the effects of climate change as a global goal for adaptation. Many developing countries require financial, technical and capacity development assistance to properly implement these efforts. In response to climate risks, as the international community shifts away from fossil-fuel-dependent socioeconomic structures and moving toward the realization of the Sustainable Development Goals (SDGs), not only the Japanese national but also local governments, as well as businesses, financial institutions and many other actors are taking strategic actions and prioritizing the shift toward decarbonized business models.

Meanwhile, in response to the needs of developing countries, JICA is called upon to promote even greater cooperation toward low-carbon, decarbonized, climate-resilient societies, taking into account various international climate-related frameworks (including the Paris Agreement, SDGs, Sendai Framework for Disaster Risk Reduction, etc.) and the Japanese government's own international commitments (including the Long-term Strategy under the Paris Agreement, carbon neutrality by 2050, etc.).

JICA has been promoting the mainstreaming of climate-related measures by having them integrated into development projects in all sectors. For development projects conducted by JICA, we published the "Adaptation" edition of the JICA Climate Finance Impact Tool (Climate-FIT) in 2011 (revised in 2019) as a tool to promote that mainstreaming, and with it have been promoting climate risk assessments and the consideration of adaptation measures for development projects.

The 2019 edition was revised to place an emphasis on review and implementation approaches for assessment of climate risk and consideration of adaptation to allow some flexibility in responding to location-specific and context-specific aspects of individual projects, all the while maintaining consistency with Intergovernmental on Climate Change (IPCC) concepts. That edition also clarified that through the use of this tool a project could be confirmed as contributing to climate adaptation and be counted as a part of JICA's climate finance, and also be reported as such more broadly, including to the UNFCCC Secretariat and the Development Assistance Committee of the Organization for Economic Cooperation and Development (OECD-DAC).[1]

This current document is a revision of the 2019 edition, revised and updated with the latest information to make it even more easy to use as a tool. For this edition of the Guidance document, the purpose and target audience have been clarified as follows:

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[1] Since January 2010, projects that contribute to adaption have been included in reporting as "adaptation markers" in the OECD-DAC Creditor Reporting System (CRS). Background on Rio Markers (DAC criteria for scoring of adaptation markers): https://www.oecd.org/dac/environment-development/Annex%2018.%20Rio%20markers.pdf

1. Objective

The purpose of this document is to provide guidance to ensure that climate risks are assessed and adaptation measures considered to the greatest extent possible at the design and preparation stages of JICA development projects, and that project designs and the projects themselves will continue contributing to sustainable development throughout the life of each project.

2. Intended Users

The intended users of this Guidance document are primarily managers of JICA project management divisions involved in JICA financial project (loan projects, grant aid projects) and technical cooperation project, as well as contractors (including consultants).

The major changes in this edition are as follows:

Part I: Implementing Climate Risk Assessments and Considering Adaptation measures

- Clarification of objectives of climate risk assessments, target projects, intended users, and criteria for JICA to confirm from results of climate risk assessments and consideration of adaptation
- Clarification of assessment details for technical cooperation projects, as well as the period covered by assessments
- Listing of considerations for climate risk assessments using Climate-FIT
- Changes in steps for implementing climate risk assessments
- Revisions to requested report content
- Revisions to approaches for dealing with uncertainty
- Other changes, including consistency in terminology

Part II: Sectoral Viewpoint for Climate Risk Assessments and Adaptation measures consideration

- Revisions to tables of components of climate risks

Part III: Reference Materials

- Updates reference materials

Contents

Part I. Guidance for conducting Climate Risk Assessment and considering Adaptation Measures

Part I Guidance for conducting Climate Risk Assessment and consideration of Adaptation Measures

1. Objectives and Target Projects

1.1. Objectives of Climate Risk Assessment and Consideration of Adaptation

The objectives of implementing climate risk assessments and considering adaptation in development projects conducted by JICA are as follows:

- To ensure that project designs and details contribute to sustainable development by continuing to generate the expected benefits and outcomes throughout the life of development projects.
- To assess risks, to the extent possible, during project planning and preparation stages, and to consider measures to address those risks, based on an approach of simultaneously addressing both development and climate change challenges as part of the global agenda.

1.2. Target Projects

The climate risk assessments and adaptation measures based on this Guidance document apply, in principle, to development projects conducted by JICA, including loan projects, grant aid projects, and technical cooperation projects.

1.3. Intended Users

The intended users of this Guidance document are primarily managers of JICA project management divisions involved in JICA financial projects (loan project, grant aid project) and technical cooperation project, as well as contractors (including consultants).

1.4. Criteria for Climate Risk Assessments and Consideration of Adaptation

The following two main criteria are to be used to review the climate risk assessment and adaptation measures in the projects covered by a climate risk assessment as part of a Preparatory Survey for Cooperation, whatever the JICA project scheme may be.

i. Have climate change impacts on the project been ascertained and assessed based on existing data and information gathered through field surveys, etc.?

ii. Based on assessment results, has consideration been made to incorporate any necessary adaptation measures into the project?

Climate risk assessment and consideration of adaptation in Climate-FIT (adaptation) is based on the notion of climate risk/adaptation presented in the Fifth Assessment Report of the IPCC. Under this concept, the "climate risks" in the target project are organized as the result of the interaction between "hazards" (external forces such as dangerous events and trends) and "vulnerabilities" and "exposures" of human and natural systems in the target project. For more information on this concept, see Section 3. Framework for climate risk assessment.

1.5. Climate Risk Assessment in JICA Project-Cycle

Climate-risk assessment and consideration of adaptation measures using the Climate-FIT Adaptation are assumed to be carried out at the stage of the STEP 02 "Feasibility Study" during the implementation processes of the JICA project as shown in Figure 1. This corresponds to the "Preparatory Survey for Cooperation" of Loan and Grant Aid Projects and the "Detailed Planning Survey" of Technical Cooperation Projects. For technical cooperation projects, climate risk assessment and consideration of adaptation measures may be conducted after the beginning of the technical cooperation project in consideration of the respective project contents.

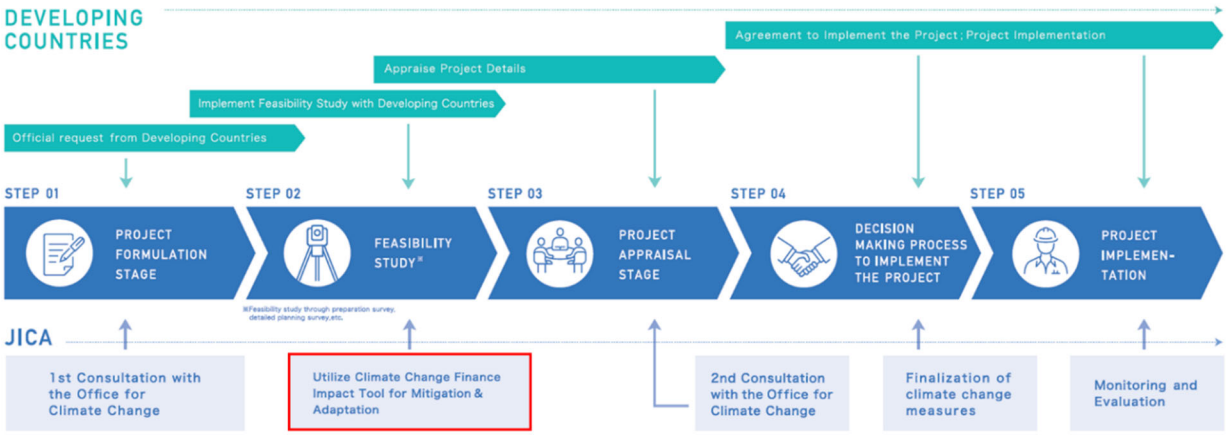


Figure 1 Implementation Processes for JICA Projects and Implementation of Climate-Risk Assessments1

1.5.1. Flow of Climate Risk Assessments and Consideration of Adaptation Measures

The process flow is presented below, from project screening to implementation of the climate risk assessment and consideration of adaptation measures.

1) Financial Assistance Projects (Loan Assistance and Grant Assistance)

1. Screening for climate risk assessment and consideration of adaptation, done by Office for Climate Change.
2. Conducting the Preparatory Investigation is to implement the climate risk assessment and consideration of adaptation measures utilizing the Climate-FIT (Adaptation).
    - In principle, the timing of the climate risk assessment in the preparatory investigation is assumed to be at the initial stage of the investigation, before the outline design.
    - The assessment is to be conducted in a participatory manner, with existing data, policies and information obtained locally compiled, and the assessment done in collaboration with multi-disciplinary experts and local government personnel, etc.
    - An effort should be made to reach a common understanding of the climate risks associated with the project.

3. Including the results of the climate risk assessment and consideration of adaptation measures in the preparatory investigation report.
4. Summary of the Climate Risk Assessment is attached to the Project Plan Record in the Project Division.
5. The Office for Climate Change is to review the project division's attached summary of the project plan/record describing the results of the climate risk assessment and consideration of adaptation measures.

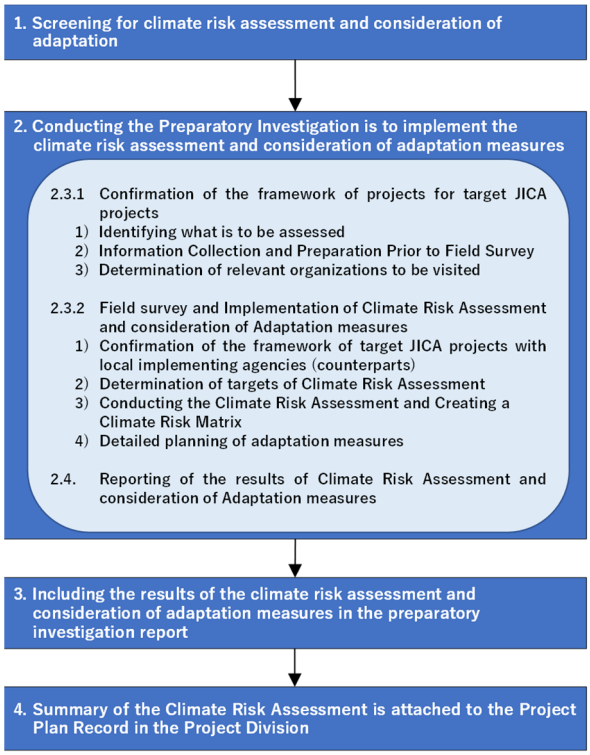


Figure 2 Implementation flow for conducting climate risk assessments and considering adaptation measures

If a consultant is contracted to conduct a preparatory investigation, the project division for the project is to include "Climate Risk Assessment and Consideration of Adaptation Measures" as part of the terms of reference for the preparatory investigation. In that case, the following points should be considered.

- Explain clearly how the project includes a climate risk assessment and consideration of adaptation measures based on Climate-FIT (Adaptation).
- See Section 3.4 "Reporting Climate Risk Assessments" for information to be included in preparatory investigation reports.
- Based on the project details, consider the required personnel resources (person month) to conduct the climate risk assessments and consideration of adaptation measures.

2) Technical Cooperation Projects (Technical Cooperation Projects, Loan Account Technical Assistance)

The Office for Climate Change will select candidate projects to be recommended for climate risk assessment and consideration of adaptation measures. For technical cooperation projects, an assessment is to be made as to whether the technical cooperation activities being implemented are to lead to enhance adaptive capacity for current or future climate change. If a consultant is to be contracted for the project, the specifications of the project contracts are to state that climate risk assessment and consideration of adaptation measures will be implemented after the project commences.

Even if the climate risk assessment and consideration of adaptation measures is going to be conducted after the start of project, it is recommended that information on climate hazard and vulnerability in the target country and region be gathered during the "Preparatory Survey for Cooperation", and consideration be given to the need to consider and incorporate climate risk and adaptation at the project implementation stage.

1.6. Period Covered by the Assessment

Given that climate change has the potential to affect projects over long periods of time (in terms of both risks and opportunities), and the climate will gradually change over time, when assessing climate risk the time frame should be determined in advance (e.g., from 2030 to 2050). When doing so, in principle, it should be the period during which the objective(s) of the JICA project are anticipated to be achieved (the period after project completion, when project benefits are observable and ongoing), and the "future" should be defined as a time frame that is appropriate to assess climate risk relative to the status of the individual project. When collecting and reviewing climate projection information, the collection and review should cover the "future" period defined herein.

1.7. Key Points about Climate Risk Assessments and Consideration of Adaptation Using the Climate-FIT (Adaptation)

The main assumption for climate risk assessment and consideration of adaptation measures using the Climate-FIT (Adaptation) is that climate risk assessment will be done for the JICA project by considering climate hazards, vulnerabilities and exposures, etc., making use of existing materials, information, and data (weather and disaster-related information and data, the results of future climate projections, and information from climate change-related documentation prepared by other countries, etc.).

It is recommended that scientific data and information (see Appendix 3) such as downscaled data be utilized to the extent possible, but it is crucial to coordinate these efforts with the JICA's division.

2. Framework for climate risk assessment

2.1. Overview of the Climate Risk Assessment Framework

According to the Fifth IPCC Report (AR5), climate risks are evaluated based in the interactions of climate-related "hazards" (including external forces: dangerous events and trends) with "vulnerability" and "exposure" of human and natural systems (Figure 3). This concept is basically carried over in the Sixth Assessment Report (AR6). This guidance is a climate risk assessment based on this concept.

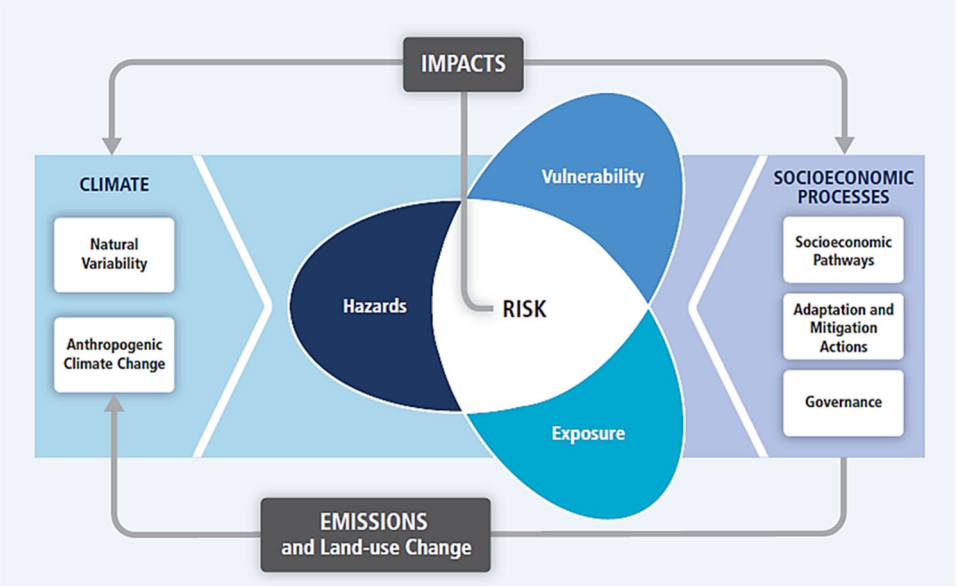


Figure 3 Conceptual Diagram of Factors and Elements Related to Climate Risk

(Source: IPCC AR5, WGII AR5; Figure SPM.1)

2.2. Components, Definitions and Concepts of Climate Risk Assessment

The definition of climate change is defined uniquely by the UNFCCC and IPCC. Since the IPCC definition is used in JICA, climate change risks will be assessed based on the definition of IPCC. The definitions and concepts of terms and components related to climate risk assessment are shown in Table 1, the elements (exposure, hazard, vulnerability, and impact) of Figure 4 will be summarized for the JICA project, and the risks will be investigated.

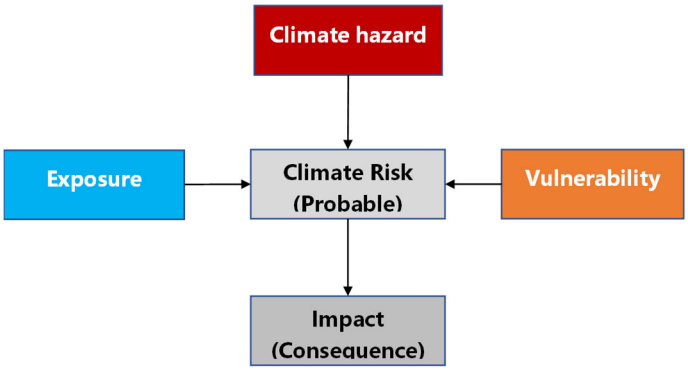


Figure 4 Framework Conceptual Diagram of Climate Risk Assessment

Concept of "Risk" in the implementation of Climate Risk Assessment

The definition of risk in the Fifth Assessment Report (AR5) of the IPCC, as shown in Table 2, is "the potential for consequences where something valuable is at stake and where the outcome is uncertain."

On the other hand, the concept of risk is recognized as a risk not only in terms of the possibility of undesirable outcomes (negative impacts) from an international perspective, but also in terms of the possibility of generating profit opportunities (positive impacts). The international standard for risk management ISO14090 and the international standard for adaptation to climate change ISO31000 and also cover both positive and negative deviations from the expected risk.

Regarding the disclosure of climate-related information, the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD), established by the Financial Stability Board, are also based on the concept of managing climate-related risks and opportunities.

This guidance is based on the notion of IPCC adaptation, and therefore considers risks as potentially undesirable consequences. Its foundation is based on considering the risks that climate change poses to JICA projects themselves (the potential for climate change to interfere with project objectives and prevent project objectives from being accomplished) and aiming to create project plans that are resilient to climate change.

However, there is also the possibility that the JICA project may provide opportunities to contribute to the resolution of climate-related issues faced by the target area of the project and the target systems (e.g., wide-range water supply systems, power systems, and administrative systems). Therefore, where appropriate, both risks and opportunities for the JICA project are regarded as risks in a broad sense, and the consideration of both of these risks will not be prevented. It should also be noted that IPCC definition of adaptation includes those that not only moderate or avoid harm, but also attempt to exploit beneficial opportunities.

Table 1 Definitions and Concepts of Terms and Components Related to Climate Risk Assessment

Component	Definition Source: IPCC AR5	Examples of Climate Risk Assessments using Climate-FIT
Climate change	Climate change refers to a change in climate that usually persists for decades or longer.	
Climate Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this guidance, the term "hazard" means a physical, climate-related physical events or trends, or their physical impacts.	・ Increased frequency and scale of extreme weather events such as floods, droughts, storms, etc. ・ Sea-level rise
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions and services and resources, infrastructure or economic, social or cultural assets in places and settings that may be adversely affected.	・ Structures to be built by the project (roads, bridges, power generation facilities, wastewater facilities, etc.) ・ Facilities, property, homes, natural ecosystems, etc. in areas included in scope of project

Component	Definition Source: IPCC AR5	Examples of Climate Risk Assessments using Climate-FIT
Vulnerability	The propensity or predisposition to adverse effects (undesirable effects). Vulnerability encompassed various concepts and factors such as susceptibility and sensitivity to climate hazards and lack of capacity to cope and adapt.	・ Presence of coastal protection structures and degree of aging ・ Presence of water gates where water ingress may occur ・ Capability/measures to maintain water intake capacity in response to reduced river flow ・ Existence of emergency response plans ・ Capacity to utilize weather-related information ・ Organizational structure and capabilities of implementing agencies ・ Availability of weather insurance
Climate Risk	The potential for adverse consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.	・ Flooding of critical infrastructure, decreased capacity due to sea level rise ・ Reduced water supply capacity
Impact	Effects on natural and human systems. In this report, the term "impact" is used primarily to refer to the impacts of extreme climate and climate change on natural and human systems. Impacts generally refer to impacts on life, livelihoods, health, ecosystems, economies, society, culture, services and infrastructure resulting from the interaction of climate change or dangerous climate events that occur within a particular period of time with vulnerabilities of the society or system to which they are exposed. **Impacts are also expressed as (undesirable) consequences and consequences.**	・ Significant soil erosion ・ Inundation of power generation/other facilities, power supply disruptions from sea-level rise, storm surge, flooding ・ Decreased crop yields.
Adaptation	Adaptation is the process of coordination for real or projected climate and its impacts. Adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.	

2.3. Steps for Climate Risk Assessments and Consideration of Adaptation

Below is an outline of the flow of climate risk assessments and consideration of adaptation measures for JICA projects. Responsible members of the survey team are to advance these activities, in communication with technical team members and personnel from local implementation agencies, etc.

2.3.1. Preliminary Information Collection and Compilation

1) Confirmation of the framework of projects for target JICA projects

The framework of the JICA project at the time of commencement of the JICA study should be confirmed in advance in order to consider the information needed for the climate risk assessment. The following 6W points are to be confirmed:

- Project objectives and goals (Why)
- Project activities and inputs to achieve project objectives and goals (What)
  - Implementing entity (Who)
  - Location and region where the project is to be carried out (Where)
  - Beneficiaries of the target project (For whom)
  - Timing of implementation of the project (When)

Assessing climate risk, the above-mentioned 6W should be confirmed and adjusted with local stakeholders, so that the risk assessment can be carried out with a shared understanding of the JICA project framework in cooperation with local stakeholders.

When assessing climate risk, stakeholders involved in the target JICA project should be considered, and how to communicate with these stakeholders involved in the implementation of the climate risk assessment should be discussed in advance.

2) Identifying what is to be assessed

In conducting the climate risk assessment and considering adaptation, all aspects of the project that can be covered by assessment (project components, activities, etc.) are to be ascertained and summarized.

3) Information Collection and Preparation Prior to Field Survey

Keeping in mind the framework and scope of the project being assessed, information collection plans should be prepared for the preparatory survey (for grant assistance projects) and the detailed planning survey (for technical assistance projects), considering the information required for the climate risk assessment and consideration of adaptation measures.

Information gathered in the Nature Condition Survey and the Environmental and Social Consideration Survey, and baseline information on project plans used to examine project objectives and effectiveness indicators include a large amount of information that can be used in climate risk assessment. For this reason, information that is scheduled to be collected under these survey scopes should be confirmed and organized. When doing so, keep the framework of climate risk components described in the above in mind and summarize what information items pertaining to "climate hazards," "exposures," "vulnerabilities," "climate risks," and "impacts" are included in the target JICA project. When such information is available to some extent in domestic work, organize an outline of the information related to each of these elements.

Based on a desk survey of existing materials, organize the information to be collected and confirmed in the field survey. When doing so, consider what information may be necessary in addition to the information gathered in the Nature Condition Survey and the Environmental and Social Consideration Survey and establish a plan for gathering additional information at the field. When collecting

information and data about past natural disasters, climate projections, vulnerability, risks and impacts of climate change etc. for the project sites and target countries, results of projects and research conducted at target country/region by national government agencies, research organizations, academic institutions, and relevant international donors should be also reviewed.

Table 2 Examples of Information Items Collected in Preparation for Climate Risk Assessment

Examples of Information Items to Collect[2]	**Factors involved in the corresponding climate risk assessment[3]**
・ Project Plan Contents (Request Contents, etc.) ・ Information on related infrastructure and ancillary facilities required for the project (access roads, water supply pipes, etc.) ・ Topography of the target land (low land, coastal areas, mountainous areas, etc.) ・ Location of the target project (traffic access, land use in the vicinity, etc.) ・ Socio-economic conditions (beneficiary population, economic activities, etc.) in the areas covered by the project	Aspects to be assessed Exposure
<Previous climate, disaster records, data> ・ Information on the past and current weather and sea conditions of the target site ・ Disaster information such as records of natural disasters, hazard maps, etc. of the target area ・ Content of IPCC Fifth Assessment Report and Sixth Assessment Report ・ Relevant statements of the country's Nationally Determined Contribution (NDC), Long-term Low Emission Development Strategies (LT-LEDS, LTS), National Communication (NC) or National Adaptation Plan (NAP) ・ Content of climate change impact assessment and vulnerability assessment reports for the country or region concerned **<Future Climate Forecasts>** ・ Information on future climate and disasters at the target site (also considering forecasts in IPCC RCPs scenarios and SSP scenarios (Refer Page 28) ・ Downscaled climate forecasting information (regional climate forecasting data)	Climate Hazard
・ Organizational structure, human resources, and financial conditions of implementing agencies ・ Natural environment (forests are deteriorating or declining) ・ Socio-economic conditions (industrial structure, employment status, income level, etc.) of the target area ・ Legal systems, policies and guidelines for adaptation to the impacts of climate change in the target areas (adaptation plans, etc.) ・ Relevant statements in the assessment of the impacts of climate change and the assessment of vulnerabilities of the country or region concerned ・ Previous Climate and Disaster Response Records (Damage Records and Recovery Work Records, etc.) held by implementing agencies	Vulnerability
・ Relevant statements of the country's NDC, LT-LEDS, NC or NAP ・ Relevant statements in the assessment of the impacts of climate change and the assessment of vulnerabilities of the country or region concerned	Climate risk
・ Content of IPCC Fifth Assessment Report and Sixth Assessment Report pertaining to the region concerned (Refer Part III, Reference) ・ Relevant descriptions of the country's NDC, LT-LEDS, NC or NAP ・ Climate and disaster response records (damage records, etc.) held by implementing agencies	Impact

[2] The following items are examples. Based on the content and characteristics of the JICA project, the information required for assessing climate-risk of the project should be scrutinized and collected.

[3] The corresponding elements may vary depending on the content of the information.

4) Determination of relevant organizations to be visited

Existing information gathered and organized through the above-mentioned desk survey shall be examined, and information required to be gathered and investigated from relevant organizations shall be examined through on-site surveys. The organizations to be visited shall be organized, and an on-site survey plan shall be prepared. If there are offices of international or national organizations engaged in the related activities in the project area, these should also be visited and interviewed. The survey information of other team members shall also be confirmed, and duplications should be avoided by utilizing the survey results of other team members, and the scope between team members shall be confirmed.

2.3.2. Field survey and Implementation of Climate Risk Assessment and consideration of Adaptation measures

In addition to gathering information planned in advance through visits to relevant organizations, visits will be made to the site where the project is to be implemented. Hearings will be held with residents in the neighborhood of the target area and local governments, etc. in order to understand the general conditions of the target area and, if necessary, hold supplementary hearings. (Supplementary confirmation of hazards, exposures, vulnerabilities, etc. identified in the Desk Survey). Based on the information gathered and surveyed for climate risk assessment, described above, the team members responsible for climate risk assessment will conduct climate risk assessment while communicating with other engineering team members, local implementation agency officials, and others. Hereinafter, the process of the implementation will be described.

1) Confirmation of the framework of target JICA projects with local implementing agencies (counterparts)

Review the 6W to be assumed for climate-risk assessment for the target JICA project and the assessment framework based on the 6W with the relevant parties, such as local implementing agencies. Establish common understanding of the climate risk assessment. This will ensure that the direction of the climate risk assessment will not deviate from its original purpose.

- "6W" related to the project planning content shall be clarified while interviewing the parties concerned with the project (Whom, Where, When, What, Who, Why: for whom, where, when, and who will do it?"
- Identify what type of project will be carried out in what type of location, the goals of the project, project implementers and beneficiaries, etc. The characteristics of the climate at the site of the project are summarized based on the information gathered above.

> For example, clarifying whether the project goals are an increase in rice productivity or an improved livelihood of the local populations will change the direction of discussions on whether the adaptation measures to be discussed later are related to rice production technology or whether measures including different means of livelihoods can be considered. For this reason, the Government of Japan will proceed while paying attention to the framework of projects so as not to shift the direction of the study.

2) Determination of targets of Climate Risk Assessment

Identifying the targets for the climate risk assessment from the all aspects that were organized in the preliminary study considering both the results of discussions with the counter parts and site visits and the below concept of climate risk assessment and consideration of adaptation measures in JICA projects.

Climate risk can prevent the project from achieving its expected value and performing its expected functions that were decided at the planning stage due to the extreme events caused by the climate hazards (e.g., high temperature, low rain, heavy rain, storms, droughts, floods, and sea level rises).

- The target facility or asset becomes structurally unable to perform its function (physical dysfunction)
- Excessive demand caused by climate change or use under conditions exceeding assumptions may cause deterioration of the target functions and assets, resulting in a state in which intended services and functions cannot be provided in advance (lowering of service level)
- Large costs are incurred in maintenance and management (deterioration of economy in use)

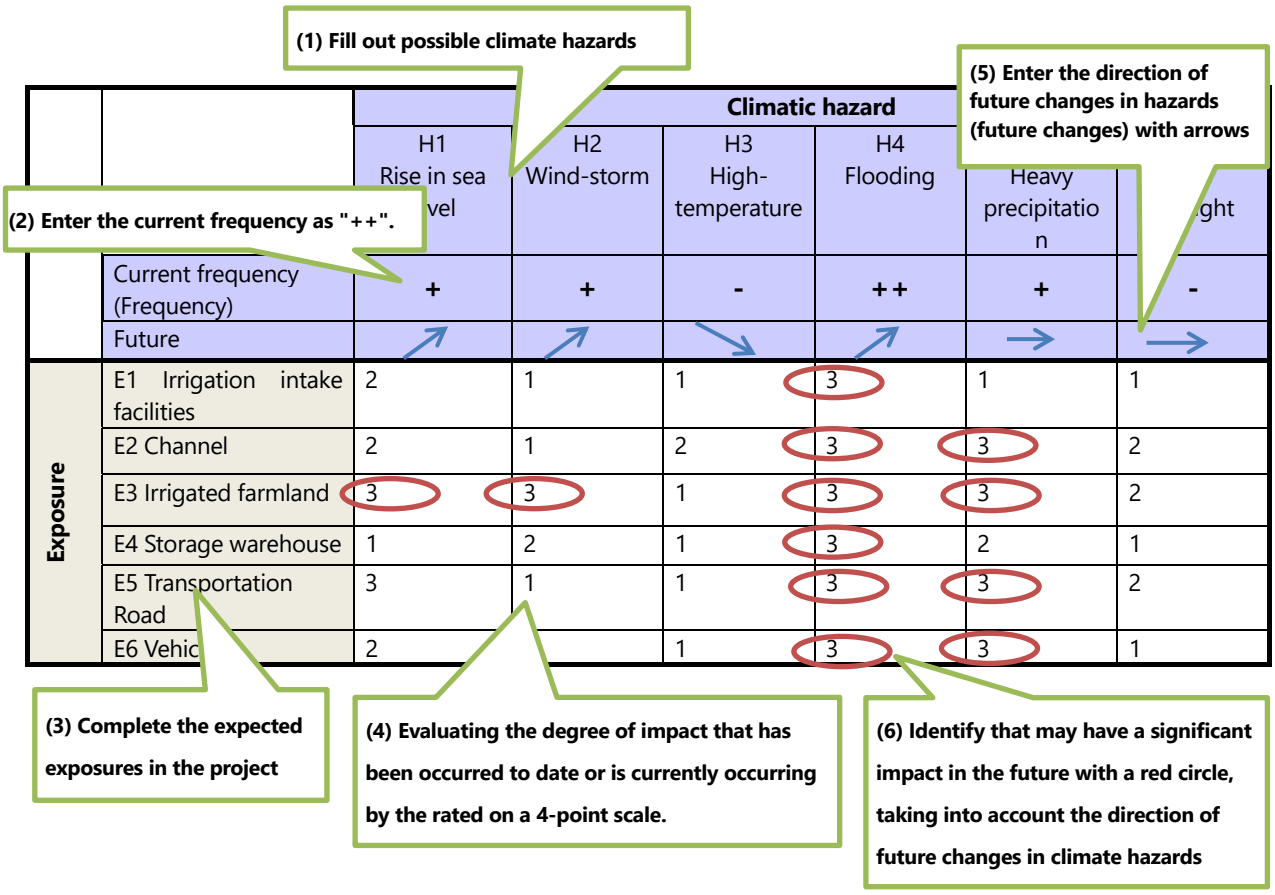
Adaptation measures are measures that enable the JICA project to generate the project's value, anticipated functions and benefits, based on the climate risk assessment.

3) Conducting the Climate Risk Assessment and Creating a Climate Risk Matrix

Using the steps outlined below, a climate risk assessment is to be conducted and a climate risk matrix created.

The following methodologies may be considered for conducting the climate risk assessment, but they are to be considered based on the actual project details and coordination with local counterparts.

- The members of the group responsible for climate risk assessment shall hold individual interviews and discussions with local organizations, such as members of other organizations and implementing agencies, and compile the results.
- Using the prepared information, technical experts and local officials will gather and study in a workshop format. It is expected that the provision of time for discussions with relevant technical personnel, local implementation agencies, climate-related agencies, local governments, etc. will lead to a shared understanding of climate risks for the target JICA project.



		Climatic hazard					
		H1 Rise in sea level	H2 Wind-storm	H3 High-temperature	H4 Flooding	Heavy precipitation	ght
	Current frequency (Frequency)	+	+	-	++	+	-
	Future	↗	↗	↘	↗	→	→
Exposure	E1 Irrigation intake facilities	2	1	1	3	1	1
	E2 Channel	2	1	2	3	3	2
	E3 Irrigated farmland	3	3	1	3	3	2
	E4 Storage warehouse	1	2	1	3	2	1
	E5 Transportation Road	3	1	1	3	3	2
	E6 Vehic	2		1	3	3	1

Figure 5 Image of Climate Risk Matrix

The procedure for conducting climate risk assessment and consideration of adaptation measures using the Climate Risk Matrix is described below.

(1) Consider and export "hazards" related to the target JICA project

Consider "hazards" that may be relevant to the project based on weather conditions at the target site. Review past, current, and future climate forecasts and consider possible climate scenarios due to climate change during the project period in the project area.

- Reference the technical engineer for the target JICA project and confirm the validity of the gathered information on the natural conditions of the project area (climate, hydrology, natural disasters, etc.). Discuss the relevant information on climate, hydrology, and natural disasters. Brainstorm a list of other information that could be relevant.
- Utilize the prepared weather and climate-related information (Collected and analyzed data/information such as weather data, climate forecasts etc.)
- From the list, choosing the hazards that are likely to be relevant to the project and are likely to occur during the project planning period in the target area.

Temperature	Rise in average temperature, the generation of heat waves and high temperatures, and the generation of cold waves
Rainfall	Changes in annual rainfall, shifts in rainfall seasons, and intensive torrential rainfall Flooding caused by increased rainfall

Solar radiation	Changes in solar radiation
Wind	Changes in wind speed, changes in wind direction characteristics, and storms

<Example>

		Climatic hazard					
	(1) Enter possible hazards	**H1 Rise in sea level**	**H2 Wind-storm**	**H3 High-temperature**	**H4 Flooding**	**H5 Heavy precipitation**	**H6 Low sunlight**
	Current frequency (Frequency)						
	Future						
Exposure	E1 Irrigation intake facilities						
	E2 Channel						
	E3 Irrigated farmland						
	E4 Storage warehouse						
	E5 Transportation Road						
	E6 Vehicle						

(2) Consider and fill out the frequency of hazards

The hazards listed above will be described on the scale shown in Table 3 below, after confirming and examining the frequency of occurrence thus far and at present, respectively.

Table 3 Scale of hazard frequency assessment

Frequencies	Description and Definitions
++	Frequently occurring thus far or at present
+	Sometimes occurring thus far or at present
-	Has hardly occurred thus far or at present

In the case the assessment of a hazard according to the scale in the above table differs from person to person, and it is difficult for the concerned parties to reach an agreement, a concrete definition of the assessment scale may be decided within the survey team as an option. In such a case, the report shall also contain this revised assessment scale.1

Table 4 Examples of defining criteria for JICA project covered by the scale of hazard frequency assessment

Frequencies	Description and Definitions	Examples of establishment of concrete standards for target JICA projects
++	Frequently occurring thus far or at present	More than 10 occurrences in the past 20 years
+	Sometimes occurring thus far or at present	More than 5 occurrences in the past 20 years
-	Has hardly occurred thus far or at present	Fewer than one occurrence in the past two 20 years

<Example>

(2) Enter the frequency of occurrences thus far or at present

		Climatic hazard					
		H1 Rise in sea level	H2 Wind-storm	H3 High-temperature	H4 Flooding	H5 Heavy precipitation	H6 Low sunlight
	Current frequency (Frequency)	**+**	**+**	**-**	**++**	**+**	**-**
	Future						
Exposure	E1 Irrigation intake facilities						
	E2 Channel						
	E3 Irrigated farmland						
	E4 Storage warehouse						
	E5 Transportation Road						
	E6 Vehicle						

(3) Select and enter potential "exposures" in the target JICA project

Selecting and entering the targets elements which are likely to be exposure by climate hazards in the target area during the project planning period from the evaluation targets in the target project that have been identified and clarified in advance into the climate matrix. New facilities to be built in the project shall also be considered as for an exposure. Discuss with the individual facilities in the project plan (including target area and system facilities and equipment effected by climate change), technical engineers in charge of the project, and experts in charge of the project's activities to determine if they are likely to have a relationship and choose the relevant components. If during any subsequent stage of climate risk assessment, a component appears to be of little relevance or insignificance, it may be revised later.

<Example>

(3) Complete the expected exposures in the project

		Climatic hazard					
		H1	H2	H3	H4	H5	H6
	(Frequency)						
	Future						
Exposure	**E1 Irrigation intake facilities**						
	E2 Channel						
	E3 Irrigated farmland						
	E4 Storage warehouse						
	E5 Transportation Road						
	E6 Vehicle						

(4) Evaluate the current "impact"

Confirm and examine whether or not the combination of exposure and hazard has caused/occurred, and assess the degree of impact of what is or has happened. The scale of the evaluation is as shown in Table 5.

If it is difficult to evaluate the impact that has already occurred at the time of the survey for a new JICA

project, check the following information, for example, and consider the impact level indirectly as the impact level that would have occurred had the target JICA project currently existed.

- Impacts that have occurred in similar facilities operated by the implementing agency of the target JICA project
- Impacts that have occurred at similar facilities in the region where the project was implemented
- Impacts that have occurred in similar facilities located in similar locations in the target country

Table 5 Evaluation Scale for current impact levels

Scale of the impact level	Description and Definitions
3	Events and impacts that have occurred thus far have been so difficult that they cannot be addressed and handled.
2	Events and impacts that have occurred to date have been moderately difficult to manage and deal with.
1	It has not been so difficult to manage the events and impacts that have occurred thus far. The resulting impact was minor and was managed to some extent.
0	The impacts of events that have occurred to date have been negligible.

There may be cases where the degree of difficulty in dealing with the impacts differs from person to person, and it is difficult for the concerned parties to reach an agreement using the evaluation scale "currently occurring impacts" in the table above. In these cases, a more specific definition of the evaluation scale may be decided within the survey team, as in the case of the frequency of hazards. In such cases, the report shall also contain the revised assessment scale. If the impacts that had already been occurred are considered to be critical climate risk to the project, it is recommended to confirm the details of the impacts through interviews with relevant local organizations and residents living in the area. In addition, it is also necessary to confirm whether there are any similar researches/studies being conducted in neighboring areas or countries. It is better to determine whether the same kinds of impacts are likely to occur in the future or not through these studies. Based on that, it is recommended to conduct climate risk assessments and consider adaptation measures.

Table 6 Examples of Definitions of Standards for JICA projects

Scale of the impact level	Description and Definitions	Examples of establishment of concrete standards for target JICA projects
3	Events and impacts that have occurred so far have been so difficult that they cannot be addressed and handled.	The entire area of the premises was flooded, and water could not be supplied for more than several months before recovery.
2	Events and impacts that have occurred to date have been moderately difficult to manage and deal with.	The site was partially flooded and the facility could not be operated, but it was restored in about one week and the water supply could be resumed.
1	It has not been so difficult to manage the events and impacts that have occurred thus far. The resulting impact was minor and was managed to some extent.	The site was partially flooded and there was a temporary shutdown of the facility. The facility was immediately recovered and the water supply was resumed.
0	The impacts of events that have occurred to date have been negligible.	The site was temporarily partially flooded, but the operation of the facility was not affected, and the water supply could be continued.

<Example>

		Climatic hazard (Climate Hazard)					
			H2 Wind-storm	H3 High-temperature	H4 Flooding	H5 Heavy precipitation	H6 Low sunlight
	Current frequency (Frequency)		+	-	++	+	-
	Future						
Exposure (Exposure)	E1 Irrigation intake facilities	**2**	**1**	**1**	**3**	**1**	**1**
	E2 Channel	**2**	**1**	**2**	**3**	**3**	**2**
	E3 Irrigated farmland	**3**	**3**	**1**	**3**	**3**	**2**
	E4 Storage warehouse	**1**	**2**	**1**	**3**	**3**	**2**
	E5 Transportation Road	**1**	**2**	**1**	**3**	**2**	**1**
	E6 Vehicle	**2**	**1**	**1**	**3**	**3**	**1**

(4) The degree of impact that is currently occurring is evaluated in four stages.

Events that have occurred so far and now are the result of a combination of "climate hazard" and "exposure," and how much of the effect was confirmed and examined.

(5) Check and examine the direction of future changes in "climate hazards" (future trends) and describe them with arrows.

- Utilize basic information gathered in preparation for the climate risk assessment.
- There may be no information on projection forecasts. In this case, enter the arrow after considering discussing with experts and counterparts.
- Use climate forecast data from the target country's climate agency or climate change agency if its available.
- Some future forecasts by region, such as temperature and rainfall, can be confirmed somewhat conveniently on the Internet, and will be utilized as needed.

For future projections of climate hazards and other relevant information, refer also to "3. Understanding the Future Climate and Impacts of the Target Area and Reference Information Resources" after p. 26 of this guidance.

<Example>

		Climatic hazard					
			H2 Wind-storm	H3 High-temperature	H4 Flooding	H5 Heavy precipitation	H6 Low sunlight
	Current frequency (Frequency)	+	+	-	++	+	-
	Future	↗	↗	↘	↗	→	→
Exposure	E1 Irrigation intake facilities	**2**	**1**	**1**	**3**	**1**	**1**
	E2 Channel	**2**	**1**	**2**	**3**	**3**	**2**
	E3 Irrigated farmland	**3**	**3**	**1**	**3**	**3**	**2**
	E4 Storage warehouse	**1**	**2**	**1**	**3**	**3**	**2**
	E5 Transportation Road	**1**	**2**	**1**	**3**	**2**	**1**
	E6 Vehicle	**2**	**1**	**1**	**3**	**3**	**1**

(5) Enter the direction of future changes in climate hazards

(6) Select a combination of "climate hazard" and "exposure" to be considered

Based on the degree of impact assessed in the table from 0 to 3, consider the direction of future changes in hazards, and select the impact (= risk) that may be significant in the future for the project from the following viewpoints.

- Among the impacts that have been assessed to be "3" in the current situation, some of these impacts are likely to be more severe in the future.
- Among the impacts that have been assessed to be "3" in the current situation, some of these impacts are likely to continue to be of similar severity in the future.
- Although the degree of impact is "2" at in the current situation, considering the direction of future changes in climate hazards, it is likely that the some of these impacts will be as significant as "3" in the future.

For example, the following viewpoints can be used as a reference when considering which risk to include in the matrix as the impact (risk) that can be significant in the future in the target JICA project.

<Example>

		Climatic hazard (Climate Hazard)					
		H1 Rise in sea level	H2 Wind-storm	H3 High-temperature	H4 Flooding	H5 Heavy precipitation	H6 Low sunlight
	Current frequency (Frequency)	+	+	-	++	+	-
	Future	↗	↗	↘	↗	→	→
Exposure	E1 Irrigation intake facilities	2	1	1	3	1	1
	E2 Channel	2	1	2	3	3	2
	E3 Irrigated farmland	3	3	1	3	3	2
	E4 Storage warehouse	1	2	1	3	3	2
	E5 Transportation Road	1		1	3	2	1
	E6 Vehicle	2		1	3	3	1

(6) Taking into account the direction of future changes in hazards, consider and select the impact (= risk) that may be significant in the future in the project (circled with red).

Points to be considered for selection

- Potential and frequency of occurrence: How often does the impact occur during the period in which the objective of the target JICA project is expected to be fulfilled (whether the impact is moderate, but may occur frequently from the previous occurrence condition, etc.)
- Magnitude of impact on project objectives in the event of an occurrence: How likely is the impact to affect the target JICA project (even if the frequency is small, it may have a serious impact, etc.)
- Condition of response to impacts: To what extent is it possible to respond to the impacts based on the level of impacts that have already occurred (is it difficult to respond to the impacts, and is it not possible to adequately respond to the impacts?)
- Speed at which the impact becomes apparent: For example, the possibility of flooding and interrupting target projects and facilities is considered to be a relatively early manifestation of the impact of flooding. The risk of inflow of soil and sand into reservoirs due to heavy rainfall does

not immediately materialize, but if the risk of inflow of soil and sand into reservoirs due to heavy rainfall has a significant impact on the purpose of reservoirs due to gradual inflow, the speed of materialization of the impact is considered to be relatively slow.

(7) Consider "Vulnerability" of "Exposure" Factors

Regarding combinations of "climate hazards" and "exposure" to be carefully considered for the selected project, "vulnerabilities" should be considered that may contribute (or have already contributed) to "climate risks" that may be significant in the future.

Table 7 Identification of vulnerabilities that contribute to climate risk generation

	(A)	(B)	(C)
	Combination of "climate hazards" and "exposures" to be considered	**Vulnerabilities contributing to climate risks** (Susceptibility to and capacity to cope with impacts)	**Possible major future climate risks**
1	Example of Risk Entry) H1 (sea level rise) +E3 (paddy fields) Possible salt water ingress on irrigated farmland due to sea level rise.. <Key points to document> • Describe exposure/hazard combinations, and possible impacts.	(Example) There is a weir/barrage to keep salt water out of irrigated farmland, but frequent failures allowed saltwater ingress at failure points <Key points to document> • Consider sensitivity to impacts • Consider ability to respond to impacts For example, what actions have been taken in the past when an impact has occurred due to a given climate hazard?	

In column A, indicate the combination of "climate hazards" and "exposures" that require attention, and resulting impacts. In column B, indicate the sensitivity if the situation occurs and ability to respond to impacts (vulnerability). Vulnerability should be considered based on the following two perspectives:

- The impacts listed in column (A) are described in terms of their susceptibility and sensitivity to hazards.
- Enter an assessment of the ability to respond to impacts. For example, confirm and describe what measures have been taken to deal with the impacts that have occurred in the past and the present. This part will be confirmed mainly through local surveys, interviews with counterparts and target areas, and records of implementation measures.

(8) Determination of possible major future climate risks

- For the "combination of "climate hazards" and "exposures" that require attention, and resulting impacts" from column A, based on "sensitivity if the situation occurs and ability to respond to impacts (vulnerability)" from column B, if it is deemed to be a significant climate risk for the project, select that item as the future climate risk for the target project.
- In column C, summarize the selected climate risk.

Table 8 Identification of possible major future climate risks of the project

	(A)	(B)	(C)
	Combination of "climate hazards" and "exposures" to be considered	**Vulnerabilities contributing to climate risks** (Susceptibility to and capacity to cope with impacts)	**Possible major future climate risks**
1	Example of Risk Entry) H1 (sea level rise) +E3 (paddy fields) Possible saltwater ingress on irrigated farmland due to sea level rise. <Key points to document> - Describe exposure/hazard combinations, and possible impacts.	(Example) There is a weir/barrage to keep salt water out of irrigated farmland, but frequent failures allowed saltwater ingress at failure points <Key points to document> - Consider sensitivity to impacts - Consider ability to respond to impacts For example, what actions have been taken in the past when an impact has occurred due to a given climate hazard?	(Example) H1 (sea-level rise) + E3 (paddy field) Damage from saltwater ingress on irrigated farmland could increase due to ongoing sea level rise. <Key points to document> - Only combinations with vulnerabilities that have been considered and be selected as potential major future climate risks for the project should be noted. - Leave blank for items that were not selected.

(9) Creating Climate Risk Trees

Based on the final selection of impacts (climate risks) that are likely to be significant in the future for the target project, create and organize a climate risk tree as shown in Figure 6 below.

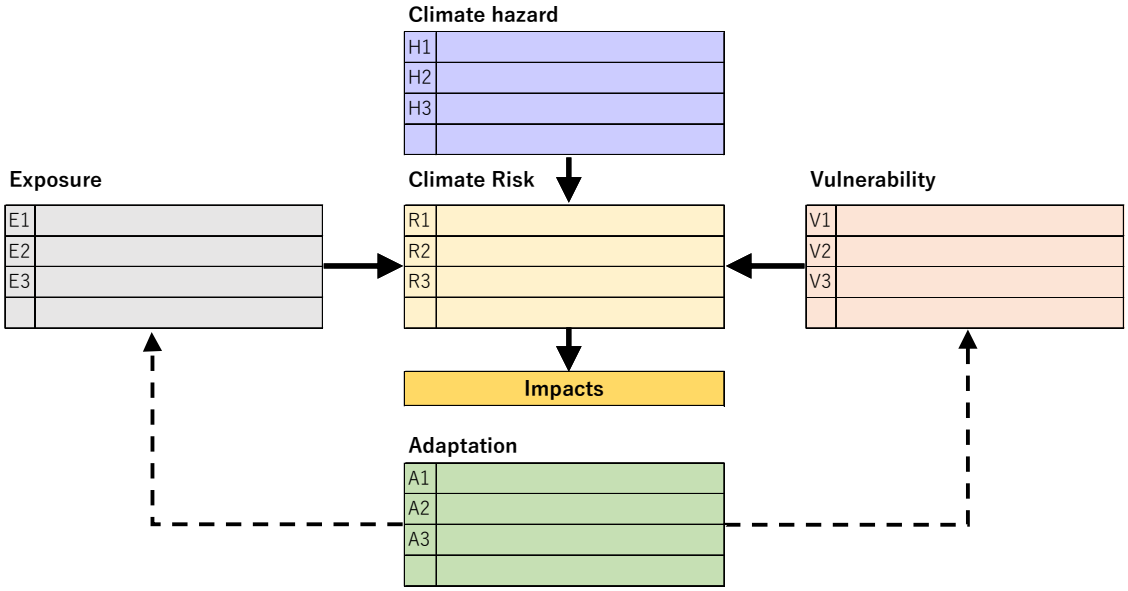


Figure 6 Climate Risk Tree

1. Enter the final selection of "climatic risks" in "Risk."
2. "Exposure" should include elements describing the selected "climatic risks" as exposure.
3. "Climate Hazard" should include elements describing the selected "climatic risks" as hazards.
4. "Vulnerability" should include elements of the selected "climatic risks" considered as "vulnerabilities" that may contribute to the development of impacts.

5. Check the logic from climate hazard to risk for the climate risk tree that has been completed. Again, return from risk to climate hazard to see if the logic is sound.

(10) Consideration of Adaptation Measures

Consider possible measures (= adaptation measures) to reduce the final selection of "climate risks" and fill in Table 9 below for adaptation measures.

Table 9 Adaptation measures Review Table

Risk	**Impact climate risks (ultimately selected) that are likely to be significant in the future for the target JICA project**	**Adaptation measures for climate risk**	Corresponding SDGs items No.
1	Enter a summary of the selected "climate risks"	Adaptation measure 1 Enter adaptation measures to address climate risk (such as what to do and possible measures)	1, 11
		Adaptation measure 2	6
2		Adaptation measure 1	2
		Adaptation measure 2	7,14

- When filling out the adaptation measures in the table above, note the climate risks, hazards, and exposures associated with each adaptation option to make it easier to understand which items correspond.
- The adaptation measures considered need not be narrowed down at this stage, and all adaptation measures that may have been considered should be described. They will be considered more deeply in future investigations, such as the Preparatory Survey for Cooperation.
- For each adaptation, describe how the adaptation measure addresses "vulnerabilities" that contribute to climate risk.
- For each adaptation measure, the corresponding SDGs goal(s) is/are also to be listed.

As a next step, consider the priority of the adaptation measures listed, based on the criteria of urgency, economy performance, effectiveness, and feasibility, and finally make the selection of adaptation measures as a result of this consideration of climate risk assessment and adaptation measures.

At this stage, it is acceptable to have multiple adaptation measures. Since it is assumed that the climate risk assessment will be conducted at the initial stage of preparatory surveys and during the detailed planning survey (the initial stage for technical cooperation projects), the climate risk assessment is to be considered in greater detail, as required, at later stages after the preparatory surveys, taking into account the adaptation measures that were considered as candidates at this stage.

Table 10 Assessment criteria for adaptation measures

Perspective of valuing adaptive options	Description and Definitions
Urgency	Is it urgent to implement the adaptation measure? Or does there seem to still be some leeway?
Economic performance	Is the cost of implementing such adaptation measures realistic? Is it possible to expect an effect that is worth the cost?
Effectiveness	Is the chosen adaptation plan an effective tool for the expected climate risk?
Feasibility	Is it technically feasible (technical perspective) and systematically feasible (policy and institutional perspectives). Is it possible from an environmental perspective?

Compare the candidate adaptation measures to ensure that the residual risk is acceptable for the project. Discuss, analyze, and evaluate the effectiveness of adaptation measures regarding the likelihood of occurrence and impact of risks, as well as the feasibility from a cost-effective, technical, and social standpoint.

Figure 7 is an example of a table that is one of the organizational methods for visualizing the effects of adaptation measures and the evaluation of the degree of difficulty in realizing them (including economic aspects).

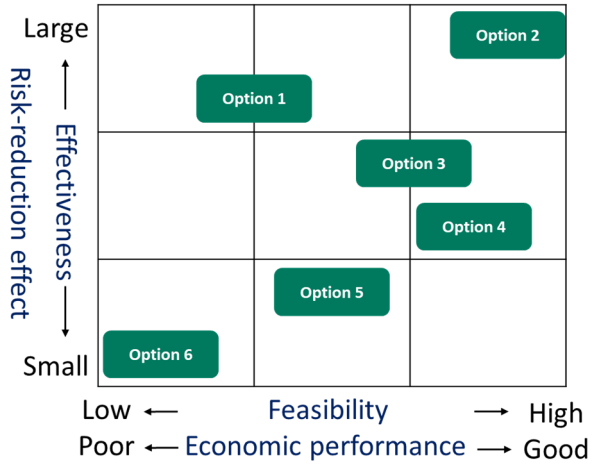


Figure 7 Evaluation criteria of adaptation measures (Including Economic Perspectives)

(11) Fill in the climate risk tree with adaptation measures

Fill in the Climate Risk Tree created in (9) with adaptation measures determined to be of high priority. It is noted that Adaptation measure do not address the climate hazards in the climate risk tree (climate stabilization is achieved by mitigation measures) and therefore will address exposures or vulnerabilities.

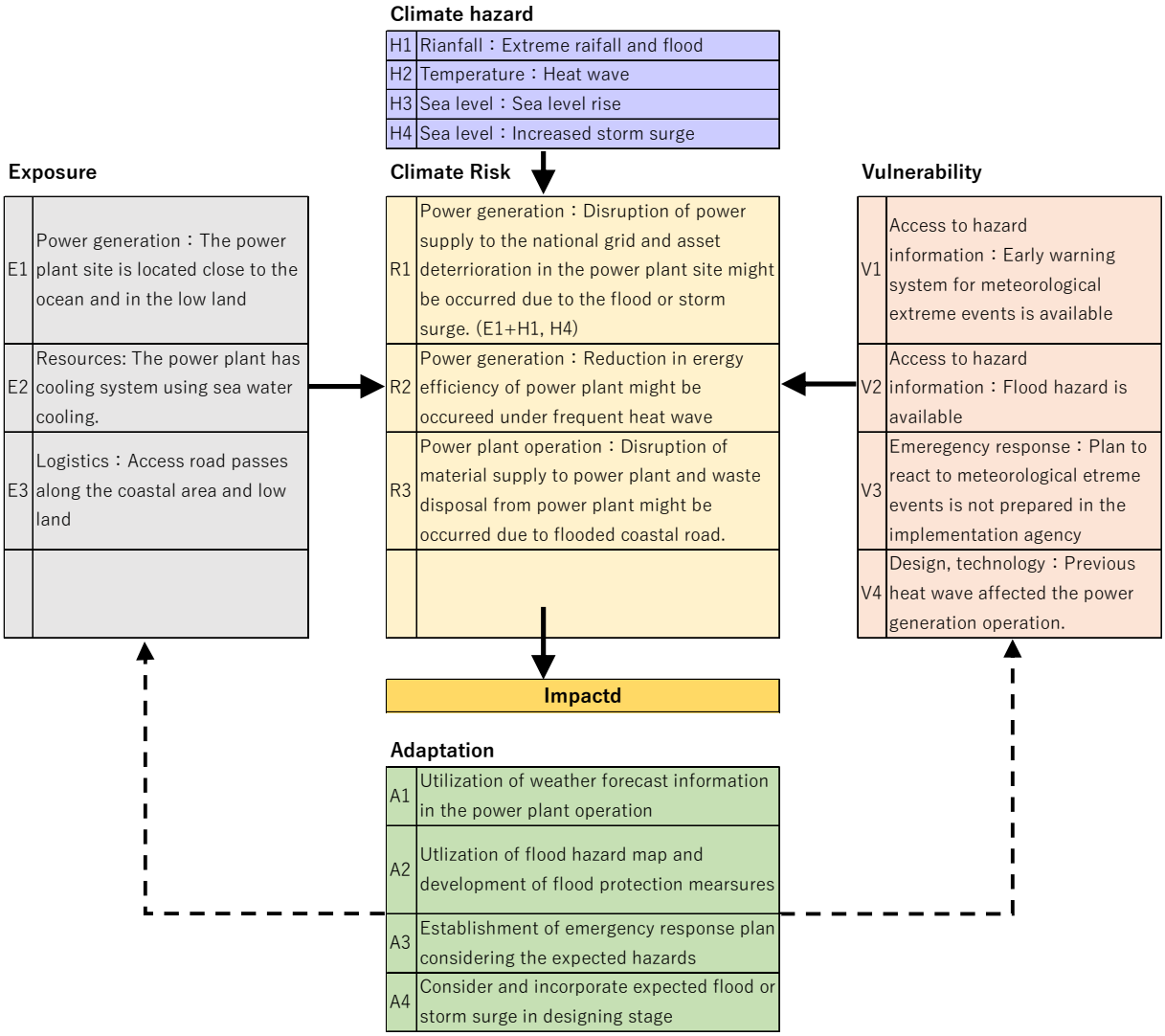


Figure 8 Completing the Climate Risk Tree Including Adaptation Measures

4) Detailed planning of adaptation measures

After selecting an adaptation measure deemed to be of high priority, the next step is to consider a more concrete plan for the adaptation measure, as required during the second half of the Preparatory Survey for Cooperation.

References

Example 1: Water Supply Facilities in Local Areas

- Business objectives: Improve access to safe water at target sites and thereby contribute to improving the living environment, such as reducing the risk of aquatic diseases.
- Expected Results:
  - Pipe water supply facilities are established at about 20 sites.
  - Technical guidance on the maintenance and management of water supply facilities will be provided.
  - Basic information for sustainable maintenance and management of water supply facilities is compiled.
- Project: Deep well drilling, construction of pipeline water supply facilities (water source facilities and water distribution facilities), maintenance and maintenance equipment

		Hazard				
		H1 Flood	H2 Lightning			
		Likely to occur in upstream states	Affects exisiting facilities at the target site			
	Current status of hazard occurrence (frequencies)	+	+			
	Prospects for the future of the Hazard	↗	↗	**Vulnerability**	**Climate Risk**	**Potential Adaptation Options**
Exposure	E1 Elevated water tank To be installed at higher elevation from the ground	0 →	0 → The impact of lightning are not expected.			
	E2 Solar pumping facilities To be installed on the ground	1 ↗ Multiple facilities are planned in the upstream region and may be affected by flooding	2 ↗ Thre have been about 10 cases in the past in which controllers of solar water supply systems have failed. The time required for recovery is up to two days.	In anticipation of the damage caused by lightning strikes during the rainy season, the operation company has prepared sufficient spare parts for the operation and maintenance of past projects.	・The possibility of damage due to lightning strikes on solar pumping facilities is also assumed in this project. Frequency and locations of lightning occurrence would change in the future. ・Damage by flooding may occur in the upstream area.	・Preparations for damage caused by lightning strikes at solar pumping facilities have been made in previous projects. Therefore, similar measures could be taken in this project as well, and the occurrence of lightning strikes should be monitored. If any changes in lightning occurrence are observed, consideration should be given to such changes. ・Since there is a possiblity of flood damage in the upstream region, the
	E3 Water distribution facilities To be installed on the ground	1 ↗ Multiple facilities are planned in the upstream region and may be affected by flooding	0 → The impact of lightning are not expected.			

Example 2: Flood Alarm System

- Project Goals: Strengthen the Integrated Data Management Capabilities of the Meteorological Agency's Hydrology Department and the Flood Prediction Alarm Centers in the target area.

- Expected Results:
  - Strengthening of the capacity of the Japan Meteorological Agency's hydrology department to develop a flood forecasting and warning system.
  - Strengthening of the quality control and storage capacity of climate data at flood forecasting warning centers in the Meteorological Agency's hydrology department and target areas.
  - Standardization of the organizational structure and operation guidelines of the flood forecast warning center in the target area and the development standard (draft) of equipment and facilities according to the level of the flood forecast warning system.
  - Strengthening of flood forecasting warning capability for target watersheds in the Climate Department of the Japan Meteorological Agency.
  - Increased data management capability required for flood forecasting warnings at the flood forecasting warning center of the target area.

- Project Plan:
  - Implementation of activities to strengthen the capacity of the Japan Meteorological Agency to prepare plans for the development of flood forecast warning systems
  - Implementation of activities to strengthen the quality control and storage capacity of climate data at flood forecasting warning centers in the Meteorological Agency's hydrological department and target areas
  - Implementation of activities related to the standardization of the organizational structure and operational guidelines of the flood forecast warning center, and standards for maintenance of equipment and facilities according to the level of flood forecast warning system
  - Implementation of activities to strengthen flood forecasting warning capability for target watersheds of the Meteorological Agency's hydrological department
  - Implementation of activities to foster the data management capability required for flood forecasting warnings at flood forecasting warning centers in target watersheds

		Hazard				
		H1 Flood	H2 Change in rainfall paterns			
	Current status of hazard occurrence (frequencies)	++	++			
	Prospects for the future of the Hazard			**Vulnerability**	**Climate Risk**	**Potential Adaptation Options**
Exposure	E1 Quality control and Storage capacity of Climate data and Flood Prediction Alarm Centers in the Meteorological Agency's Hydrology Department and target areas	0 Sometimes values at the headquarters and at branch offices are observed to be different due to data transfer errors, etc. Some of them are not known to be corrected. These issues are expected to have some impacts on the flood warning forecast.	0 Implementation agency faces challenges on confirmation of the occurrence of flash flood caused by the certain amount of rainfall and its intensity in the upstream region, and utilization for warning. They may no t be possible to confirm and consider to data based on the rainfall pattern and the amount of rainfall that change wiht the climate change.	・Quality control is implemented through manual checking of stored data, but there are no quality control criteria.	Floods and changes in rainfall data due to climage change may occur in the future. If it is impossible to confirm and examine data of a tendency different from that of the past regarding quality control of data, there is a possiblity that an appropriate forecast alarm might not be issued.	Capacity will be strengthened so that ovservational data can be reviewed in a timely manner and standards in response to climate change can also be reviewed.
	E2 Organizational structure and operation guidelines of flood forecast warning centers in the target areas, and standards for the development of equipment and facilities.	1 The lack of standards for regional flood warning centers has led to differences in service levels across centers.	2 The lack of standards for regional flood warning centers has led to differences in service levels across centers.	There is no standard for information transmission method in the regional flood warning center in the flooding, and it is planned to be formulated in the project.	With regard to the establishment and operation of local flood forecasting warning centerd, changes in flood and rainfall data due to climate change may occur in the future. In the event of a different trend of flooding or rainfall pattern, it might not be possible to issue an appropriate early warning.	Enhance capacity to consider standards for climate change in the establishment and operation guidelines of regional centers in a timly manner.
	E3 Observation equipment used to collect hydrometeorological data	1 Althought the installation of observation equipment is expanding, it is insufficient in the target basin, and it is not sufficient to prepare for the occurrence of floods.	0 Althought the installation of observation equipment is expanding, it is insufficient in the target basin, and it is not sufficient to prepare for the changes in rainfall pattern.	Although the number of the installed observation equipment are increasing, they are absolutly shortage in quantity.	Due to the inability of data collecting and analyzing, it is difficult to take appropriate response measures and to make out appropriate warning signals.	Increase the number of observation equipment installtation.

2.4. Reporting of the results of Climate Risk Assessment and consideration of Adaptation measures

2.4.1. Reporting

The results of the climate risk assessment and adaptation study for the target project are assumed to be included in the following report. Specific locations in the report will be adjusted with other items in each project as appropriate.

JICA project schemes	Type of report
Loan aid projects	・ Preliminary Cooperation Survey Report (Progress Report, Draft Final Report, etc.)
Grant Aid Projects	・ Preliminary Cooperation Survey Report (Progress Report, Draft Final Report, etc.)
Technical cooperation projects	・ Detailed Plan Establishment Investigation Report ・ Inception Report, Progress Report, Project Completion Report, etc. (Report after Project Start)
Other (Private Partnership Projects, etc.)	・ Interim report of investigation, work completion report, etc.

2.4.2. Report Content

It is envisioned that the report on the climate risk assessment and consideration of adaptation will contain the following content in a chapter entitled "Climate Risk Assessment and consideration of Adaptation Measures."

1) Results of climate risk assessment

- Briefly describe "climate hazard" "exposure," "vulnerability," and "climate risk" pertaining to the results of the climate risk assessment, together with the climate risk matrix and climate risk tree that were prepared.
- Regarding "climate hazards" "exposure" "vulnerability" and other items, confirm that they have been covered in sections on "natural conditions" and "socio-economics, facilities and equipment" in the report of the preparatory survey for the project.

2) Possible "adaptation measures" considered based on results of the climate risk assessment

- Briefly describe the "adaptation measures" that were considered based on the results of the climate risk assessment, also prioritizing them in terms of urgency, economic performance, effectiveness, and feasibility.
- In survey-related interim term reports (progress reports, etc.) summarize and describe what information is needed for consideration, regarding the inclusion of provisionally prioritized candidates for adaptation measures in the project plan.
- Also, briefly describe whether the "adaptation measures" considered have been integrated into project plans, facilities and facilities plans, etc. If not finally incorporated into the project plan, etc., include an explanation of the reason(s) why.
- Describe the results of explanation and discussion about the results of climate risk assessment and adaptation measures.

3) Materials/documentation used for climate risk assessment and consideration of adaptation measures

- Include information such as titles and URLs for materials referenced in the assessment of climate risk and the consideration of adaptation measures.

Table 11 Review points for the results of Climate Risk Assessment and consideration of adaptation measures

	Category	Viewpoint of confirming in the JICA
1	Assessment elements	Have all aspects of the project (project components, activities, etc.) that could be relevant for a climate risk assessment been ascertained and described?
2	Climate Hazard	Given the situation of the target country or region, have climate hazards that should be considered in a climate risk assessment (heat waves, torrential rainfall, storms, droughts, flood, sea level rise, etc.) been identified and considered?
3	Exposure	Among the assessment elements, have the items (project components, activities, etc.) that could be exposed to "climate hazards" been identified and considered?
4	Vulnerability	Have the vulnerabilities to "climate hazards" that involve "exposure" been ascertained and described?
5	Climate risk	Have the potential significant future impacts on the project been considered and the results explained, using "climate hazards," "exposures" and "vulnerabilities" pertaining to the project?
6	Adaptation measures	Have "adaptation measures" for to address potentially significant impacts on the project been considered and explained?
7	Communication with Counterparts on Climate Risk Assessment	How have the climate risk assessment and adaptation measures been discussed with the partner organizations (counterparts) of the target project? (Example) • This study was carried out jointly with the counterpart during the execution process of the climate risk assessment. • The results of the climate risk assessment carried out by the survey team were explained to the counterpart, and an understanding was reached.

3. Understanding of the future climate and impacts of the target region and reference information resources

3.1. Understanding of the current and future climates

Climate risk assessment will evaluate the current frequency of climate hazards and the future frequency of climate hazards when considering climate hazards (heavy rains, high temperatures, droughts, etc.) related to the target JICA project. Future climate hazards are based on confirming future climate forecasts in accordance with the RCP Scenarios used in the Fifth Assessment Report (AR5) and the SSP Scenarios used in the Sixth Assessment Report (AR6) of the IPCC.

RCP (Representative Concentration Pathways) scenarios

The RCP scenario refers to a scenario in which one representative route (representative concentration route) of future levels of greenhouse gas stabilization, and the course taken to reach those levels, is selected based on policy measures to mitigate greenhouse gas emissions.

The IPCC Fifth Assessment Report provides climate forecasts and impact assessments based on this category of scenarios. For the RCP scenario, four scenarios were selected: the "High Reference Scenario" (RCP8. 5), where radiative forcing continues to increase after 2100; the "Low Stabilization Scenario" (RCP2. 6), where radiative forcing peaks by 2100 and then declines; and the "High Stabilization Scenario" (RCP6. 0) and "Medium Stabilization Scenario" (RCP4. 5), which are located between these scenarios and stabilize after 2100.

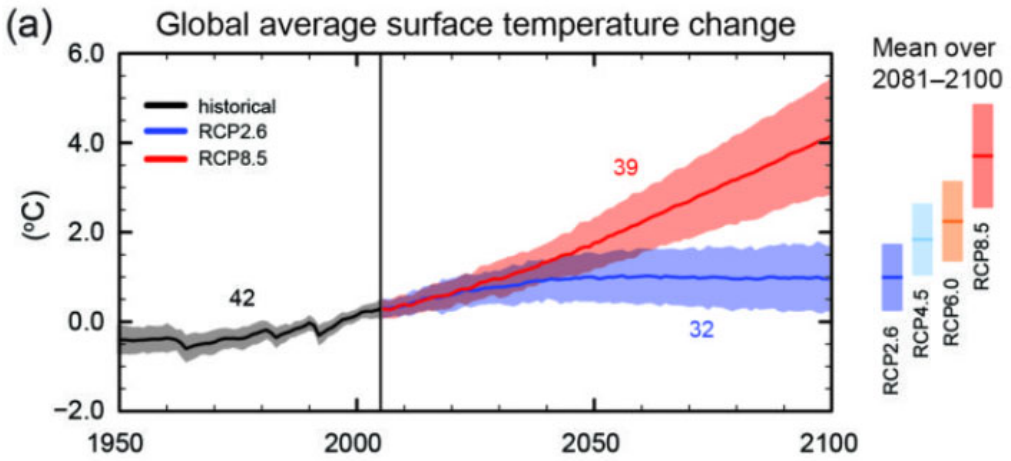


Figure 9 Global Average Ground Temperature Changes over 1986-2005 Average

Time series simulated by CMIP5 models (1950 to 2100)

(Source: AR5 WG1 Figure SPM.7)

Table 12 RCP Scenarios

Name of the scenario	Summary	Amount of temperature rise (Increase in global average surface temperature from 2081 to 2100 relative to 1986 to 2005 average)
RCP 2.6	Low stabilization scenario The radiative forcing at the end of the 21st century is assumed to be 2.6W/m2 (peaking at about 3W/m2 before 2100, then declining to about 2.6W/m2 by around 2100). Expectation to reduce the temperature rise to less than 2℃ compared with pre-industrialization times	0.3℃~1.7℃
RCP 4.5	Medium Stabilization Scenario Radiative forcing at the end of the 21st century is assumed to be 4.5W per m2	1.1℃~2.6℃
RCP 6.0	High-level stabilization scenario The radiative forcing at the end of the 21st century is assumed to be 6.0W per m2	1.4℃~3.1℃
RCP 8.5	High-level reference scenario Assuming no policy mitigation	2.6℃~4.8℃

Shared Socioeconomic Pathway (SSP) Scenarios

AR6 (Working Group I Report), published in 2021, uses the following five scenarios for cross-sectoral use, mainly from new socio-economic scenarios that combine "Shared Socioeconomic Pathways" scenarios and radiative forcing.

Table 13 SSP Scenarios[4]

Scenario	Summary	Projection of average temperature for the period 2081-2100 (Annual average temperature increase relative to the 1850-1900)
SSP1-1.9	A scenario with sustainable development where the temperature rise can be kept below 1.5°C - Assuming that policies are introduced to reduce the temperature rise to below 1.5°C (relative to pre-industrial levels) by 2100, with CO2 emissions expected to reach net zero in the middle of the 21st century.	Best estimate (°C): 1.4°C Very likely range (°C): 1.0 to 1.8°C
SSP1-2.6	A sustainable development scenario with the temperature rise kept below 2°C - Assuming that policies are introduced to reduce the temperature rise to below 2.0°C (relative to pre-industrial levels) by 2100, with CO2 emissions expected to reach net zero in the second half of the 21st century.	Best estimate (°C): 1.8°C Very likely range (°C): 1.3 to 2.4°C
SSP2-4.5	A middle-of-the road development scenario with climate policies introduced - Includes nearly the maximum emissions, aggregated from Nationally Determined Contributions (NDCs) up to 2030.	Best estimate (°C): 2.7°C Very likely range (°C): 2.1 to 3.5°C
SSP3-7.0	A scenario with regional rivalry, without climate policy introduced - Emissions of aerosols and other GHGs besides CO2 are also high	Best estimate (°C): 3.6°C Very likely range (°C): 2.8 to 4.6°C
SSP5-8.5	A fossil fuel-dependent development scenario with maximum emissions and without climate policy introduced	Best estimate (°C): 4.4°C Very likely range (°C): 3.3 to 5.7°C

[4] Source: Publication of the Report of Working Group I of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (Natural Science Basis) Reference Materials (Overview of IPCC and expressions used in the report), Ministry of the Environment Japan, http://www.env.go. jp/press/109850/116630.pdf and the IPCC WG1 AR6 Report.

When confirming information on future climate forecasts (such as temperature and rainfall), first obtain data on the applicable scenario (such as SSP2-4.5, RCP4. 5) and forecast models for the scenario. Then, after referencing the relevant climate components, obtain data on future forecasts. It is recommended that multiple climate scenarios and climate models should be reviewed.

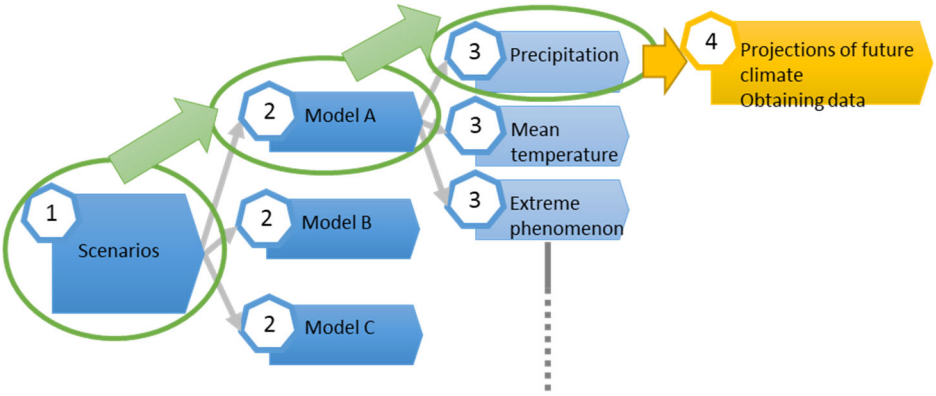


Figure 10 Image of Identification of Future Climate Forecast Information

Information resources available for future climate forecasts and climate risk assessments

Table 14 and Table 15 provide information on future climate forecasts, historical weather data, hazards and vulnerabilities that can be used for climate risk assessment, and exposure information (for specific instructions on how to navigate each site, see Appendix 3: Overview of online information platform for Climate Risk Assessment). Appendix 1: Examples of Climate-Related Indicators for reviewing hazard provides reference indicators for considering hazards based on data such as temperature and rainfall.

Climate risk assessment will be carried out in combination with information obtained locally, making appropriate use of such online information platforms. Consider which RCP scenarios to use with climate forecasts, based on the opinions of technical engineers within the survey team and relevant parties of the implementing agencies.

Table 14 Online information platform on current climate and future climate projection, and other relevant information for climate risk assessment (Part 1)

Site name	Preparation and Management Organization	Publication information																						Specification					Site overviwe	URL
		Hazard (Climate related)					Hazard (including direct impacts of climate factors)					Socio-Economic Relations					Geographic and natural environment-related									Interactive map	Target area		Resolution			
		Historical temperature	Historical precipitation	Historical wind speed	Historical sea surface temperature	Future climate (projection)	Flood / inundation	Drought	Storm / cyclone	Land slide	Sea level rise	Population / population density	Water stress	Urban / human settelement area	Imprevious surface	Land use / crop land	Elevation / topography	Sea surface currents	Water body / seasonality / depletion	Fires	Natural productivity	Soil moisture	Evaporation over land	Vegetation / land cover	Effect		All over world	Particular region	National level	Regional level		
Climate Change Knowledge Portal (CCKP)	World Bank	○	○			○	○	○	○	○	○	○				○				○					○	○	○		○	○	World Bank's Climate Change Information Portal Site. Countries and main watersheds provide climate information, hazard-related information, and summary information on the impacts of climate change.	https://climateknowledgeportal.worldbank.org/
Climate Inspector	National Center for Atmospheric Research					○																			○	○			○	The point selection may graphically display the temperature and rainfall forecast for AR5 RCP sceneario. Data can be saved in CSV formart for Excel.	https://gisclimatechange.ucar.edu/inspector
Climate Information Platform (CIP)	Climate System Analysis Group	○	○			○																			○		○		○	Predictive data obtained by downscaling past meteorological observation data and global climate model (GCM) at meteorological observation stations in the continent of Africa can be displayed graphically.	https://cip.csag.uct.ac.za/webclient2/app/
Adaptation Layer (We-adapt)	Stockholm Environment Institute	○	○			○																			○	○			○	Previous meteorological observation data at meteorological stations around the world other than Afica and forecast data obtained by downscaling GCM can be displayed graphically.	https://www.weadapt.org/placemarks/maps
KNMI Climate Explorer	Royal Netherlands Meteorological Institute	○	○			○																				○			○	Local weather data, future climate data, and the processing of these data can be performed on the web. It is used in various climate change impact assessments and climate change-related reports. It is possible to use a wealth of data and display the calculation results on maps and graphs. In addition to GCMs, future projections can also display RCM projection information.	https://climexp.knmi.nl/start.cgi
IPCC Atlas	Intergovernmental Panels on Climate Change (IPCC)	○	○			○	○	○	○	○	○														○	○			○	Current and future climate change conditions can be analyzed spatially and temporally, and displayed using previously observed and projected climate change information, from the Working Group I report of the IPCC Sixth Assessment Report.	https://interactive-atlas.ipcc.ch/
ClimoCast	Ministry of the Environment Japan, National Institute for Environment studies	○	○			○																			○	○		○		An online tool for viewing future regional climate projections based on the latest climate data (CMIP6 data). Allows one to compare four major emission scenarios (SSP1-2.6 to SSP5-8.5) and compare results of 10 different climate models, and to download the corresponding data (CSV).	https://a-plat.nies.go.jp/ap-plat/cmip6/global.html
Climate Impact Viewer	Ministry of the Environment Japan, National Institute for Environment studies, Office for Coordination of Climate					○																			○					Displays the results of climate change impact assessments in various sectors, for current climate, water resources, vegetation, agriculture, health, etc.	https://a-plat.nies.go.jp/ap-plat/asia_pacific/index.html
ClimatView - a tool for viewing monthly climate data	Japan Meteorological Agency, WMO	○	○																											Provides global monthly climate data (statistics on monthly average temperature, annual precipitation, monthly average of daytime temperature highs and lows, and standard precipitation index (SPI), for all monitoring sites where data are available)	http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/climatview/frame.php

Table 15 Online information platform on current climate and future climate projection, and other relevant information for climate risk assessment (Part 2)

Site name	Preparation and Management Organization	Publication information																						Specification					Site overviwe	URL
		Hazard (Climate related)					Hazard (including direct impacts of climate factors)					Socio-Economic Relations					Geographic and natural environment-related								Effect	Interactive map	Target area		Resolution			
		Historical temperature	Historical precipitation	Historical wind speed	Historical sea surface temperature	Future climate (projection)	Flood / inundation	Drought	Storm / cyclone	Land slide	Sea level rise	Population / population density	Water stress	Urban / human settelement area	Imprevious surface	Land use / crop land	Elevation / topography	Sea surface currents	Water body / seasonality / depletion	Fires	Natural productivity	Soil moisture	Evaporation over land	Vegetation / land cover			All over world	Particular region	National level	Regional level		
ClimPACT	**UNSW, Climate extremes, WMO, GCF**																												An application developed using the open source package "R" that uses weather data (daily minimum and maximum temperatures, daily precipitation) to calculate the frequency, duration and intensity of various extreme events relevant to each field, on a monthly or yearly basis. It is also available on the web	https://climpact-sci.org/
Global Surface Water Explorer	**Europian Commision**						○												○							○	○			○	Sites that map waters and submerged waters during the period 1984 to 2018.	https://global-surface-water.appspot.com/map
Aqueduct Water Risk Atlas	**World Resources Institute**						○	○					○						○							○	○			○	Current and future (2030, 2040) water-related risk information can be displayed on the map. 1) Water stress 2) Groundwater table decline 3) Interannual variation 4) Seasonal variability 5) Drought 6) Flood risk	https://www.wri.org/aqueduct/
Permanent Service for Mean Sea Level (PSMSL) Data Explorer	**United Kingdom National Oceanography Centre**										○															○	○			○	The changes over time of current and past observed data of sea level around the world can be graphically displayed. It can be used as a reference information for consideration of sea level rise.	https://www.psmsl.org/data/obtaining/map.html
Earth Observing System Data and Information System (EOSDIS) Worldview	**National Aeronautics and Space Administration**	○		○	○				○	○		○		○	○	○	○			○	○	○	○	○		○	○			○	Various maps can be displayed on the basis of the images of the Earth Observation Systems Satellites (EOSDIS) provided by the NASA. Information such as population density, population prediction, vegetation, land use, altitude, wind, ocean current, landslide, temperature, and rainfall can be displayed on the map.	https://worldview.earthdata.nasa.gov/
ESA Climate Change Initiative (CCI) Land Cover website	**European Space Agency**														○			○					○			○	○			○	Global land-coverage maps (land cover map) based on satellite-image analysis from 1992 to 2015 provided by the European Space Agency can be displayed. Exposure to hazards and vulnerabilities at project sites can be exploited.	http://maps.elie.ucl.ac.be/CCI/viewer/index.php
ALOS Global Digital Surface Model "ALOS World 3D - 30m" (AW3D30)	**Japan Aerospace Exploration Agency**															○										○	○			○	Altitude maps Digital Surface Model (DSMs) can be displayed based on JAXA provided satellites (ALOS) images. It is possible to grasp the outline of the topography in the vicinity of the target land. It can be used to investigate exposure to hazards and	https://www.eorc.jaxa.jp/ALOS/jp/dataset/aw3d30/aw3d30_j.htm

3.2. Grasping data other than meteorological data

Sector	Information source	
	International agencies	Local
Agriculture, Forestry and Fisheries	● FAOSTAT (FAO) - Statistical database of agriculture, forestry and fisheries, food aid, land use, and population related to global food and agriculture, forestry and fisheries - Approximately 240 countries, up to 50 years of data available http://www.fao.org/faostat/en/	Local Ministry of Agriculture, Forestry and Fisheries Annual Report
Fishery	● FISHSTAT(FAO) Fisheries Statistics Database http://www.fao.org/fishery/statistics/software/fishstatj/en	Annual Report of Local Fisheries Competent Ministries and Agencies, etc.
Economic indicator	● World Bank Open Data (World Bank) Data on changes in production, trade and demand structures and macroeconomic conditions in more than 200 countries and regions (GDP, percentage of GDP by industry), http://data.worldbank.org/	Local Statistics Bureau
Economic forecast	● World economic outlook (International Monetary Fund) IMF's World Economic Forecast Report (published twice a year) http://www.imf.org/en/publications/weo	Annual Report of the Ministry of Economy, Trade and Industry
Forest area	● Global Forest Resources Assessment Global Forest Resources Assessment http://www.fao.org/forest-resources-assessment/en/	Annual Report of Ministries and Agencies Competent with Local Forests, etc.

4. Points to Consider in Implementing Climate Risk Assessment

4.1. Concept of Responding to Uncertainties

Uncertainties are associated with future forecasts and impacts of climate change and future social trends, and therefore there are uncertainties in this risk assessment. On the other hand, choosing an adaptation measure with respect to risk reduction alone may result in enormous costs. Therefore, it is important to judge comprehensively the degree of uncertainty and the cost of implementation when selecting an adaptation measure.

In addition, it is necessary to be able to respond more flexibly to climate change over time, such as by reviewing additional options through discussions with stakeholders and reviewing an adaptation implantation plan at every step, such that only the best options are chosen.

Uncertainties in climate projections may include the following factors: In all cases, research is still being conducted to quantify and reduce uncertainty.

- **Uncertainties in Greenhouse Gas Emissions Scenarios**
  To project future climate change, assumptions must be made about how future greenhouse gas emissions will change. AR5, published in 2015, uses Representative Concentration Pathways (RCP) scenarios as emission scenarios to determine future atmospheric concentrations of anthropogenic greenhouse gases.

  AR6 (Working Group I Report) published in 2021, uses five scenarios for cross-sectoral use, mainly from new socio-economic scenarios that combine "Shared Socioeconomic Pathways" scenarios and radiative forcing.

  For all scenarios, it is desirable to envision multiple scenarios for greenhouse gas emissions, as greenhouse gas emission scenarios will vary greatly depending on humanity's future socioeconomic development choices.

- **Climate Model Uncertainties**
  Climate model is a generic term for simulation software that computes the behavior of climate system components such as atmosphere, oceans, and land. Climate models include Global Climate Models (GCMs), which simulate the climate of the entire Earth, and Regional Climate Models (RCMs), which only simulate specific regions. Climate models are used to make future climate projections using a variety of physical equations for the climate system, and many parameters such as temperature, wind speed, cloud cover, soil moisture, and sea water salinity, etc. It is desirable to assume multiple models for different regions and uses, as there are various climate models for different regions and applications, and the outputs of these models also vary.

  Climate models also involve uncertainties due to aspects of current science that are not sufficiently understood in terms of the physical processes involved in climate change.

- **Internal Climate Change Uncertainties**
  Natural climate variability is the inherent uncertainty of the climate system and the internal variation naturally present in the climate system. El Nino and La Nina are also among the uncertainties of natural climate variability.

  Also, the contribution of the above three factors to uncertainty will vary depending on the time

period and spatiotemporal scale over which the forecast is made[5].

Besides the above uncertainties, there is uncertainty in impact assessments conducted in each sector. For example, the outputs of models that analyze storm surges and high waves will differ due to differences in parameters used. For impact assessments of inundation due to flood scenarios, the potential (uncertainty) exists for tide levels, wave heights, and assumptions about the scale and path of future tropical storms and typhoons to differ from assumptions.

Therefore, for climate risk assessments and consideration of adaptation measures, it is desirable to take note of the existence of the uncertainties indicated so far, and to collect the best available information and data and make assessments of multiple GHG emission scenarios, multiple climate models, and impact assessments in each sector, taking into account the nature of the project being considered and the level of reduction of the climate change impacts being sought.

However, the climate risk assessments and consideration of adaptation measures in the context of Climate-FIT do not require accurate future climate projections and climate change impact assessments. It is recommended to keep in mind the existence of the above-mentioned uncertainties and approaches to deal with them when compiling and analyzing information, assessing climate risk, and considering adaptation measures while coordinating with the project division. On the other hand, if it is possible to conduct a detailed risk analysis using existing studies, data, tools, etc.,[6] it does not exclude the use of such detailed analysis to conduct an elaborative climate risk assessment and adaptation measures consideration.

[5] Source: Japan Climate Change 2020: Observation and Prediction Assessment Report on Atmosphere, Land and Ocean (Detailed Version) December 2020, Japan Meteorological Agency, Ministry of Education, Culture, Sports, Science and Technology, p221 Appendix 1.3 Uncertainty of future projections, https://www.data.jma.go.jp/cpdinfo/ccj/2020/pdf/cc2020_shousai.pdf

[6] E.g. Utilizing "Database for Policy Decision making for Future Climate change (d4PDF)" etc.

Part II. Sectoral Viewpoints for the Climate Risk Assessment

Part II. Sectoral Viewpoint for the Climate Risk Assessment

5. Sectoral viewpoint for implementing the Climate Risk Assessment

5.1. Agriculture sector

5.1.1. Overview and Concept of Climate Risk in the Agriculture sector

Growth of agricultural crops requires a specific temperature or more depending on cultivars and varieties, and if the temperature is too high, the growth rate may be reduced. In general, there is an optimum temperature at which the growth rate is greatest for each crop, and the change in temperature due to climate change may become an inappropriate environment for crops. In addition, since the moisture, temperature, and the like required for each stage of crop growth (germination, flowering, enlargement, etc.) differ, the change in the growth environment of crops due to climate change may ultimately affect the productivity and quality of the crop. In addition to crops themselves, climate change may also change the outbreak of pests by promoting the growth of weeds that inhibit crop growth and by changing the growth environment for pests. This change in climate could have a variety of impacts on agriculture and food production.

According to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), "Climate change is already having diverse adverse impacts on human systems, including water security, food production, health and welfare, land, housing, and infrastructure. However, there are regional differences in these impacts, indicating that while some regions are experiencing adverse effects, both adverse and positive impacts have been observed within the region.[7]

For example, in the three countries of Kenya, Malawi, and Niger, GDP depends on agricultural income, but in future climate change scenarios, the loss of maize yield due to drought is expected to increase in Malawi in both absolute and GDP ratios. Given the 30 percent share of agriculture in GDP, it is possible that GDP will exceed the threshold to maintain resilience from national economies and poverty. In Kenya and Niger, on the other hand, agriculture accounts for 30% and 38% of GDP, respectively, but in the same anthropogenic climate change scenario, losses are expected to decrease.[8][9]

The impacts of climate change in the agricultural sector are thus highly regional, and it is desirable to obtain information on the five elements of future climate forecast data (including downscale data) and climate risk, not only at the national level, but also at the project target area as much as possible, and to conduct more concrete studies in accordance with the project.

In developing countries, rural populations are also exposed to a variety of stress factors other than climate, such as lack of investment in agriculture, issues related to land and natural resource policies, and environmental degradation processes such as water pollution. For rural households and communities in agriculture to respond to these complex climate risks, adaptation measures, such as land and the natural resources of the region, flexible regional systems, knowledge and information, and the availability of alternative livelihood strategies, are expected to contribute to the resilience of the region to climate change in the agricultural sector. For example, the following are examples of adaptation measures in the agricultural

[7] IPCC, 2022: Summary for Policymakers, Climate Change 2022: Impacts, Adaptation and Vulnerability, WGII, 2022/2/28.
[8] Jayanthi, H, 2014: Estimations using satellites for agricultural drought risks arising from artificial climate-change scenarios for Africa rainwater crops. 2015 Background Report for Comprehensive Disaster Prevention Report.
[9] UNISDR, 2015, United Nations White Paper on Disaster Reduction 2015

Administration, finance, extension agencies	Numbers of administrative/financial/extension agencies, and services provided

Table 18 Example of vulnerability for a project in the agriculture sector (major crops)

Vulnerability to be considered	Examples of items to confirm and consider
Physical infrastructure	Location of facilities
	Status/condition of facilities (quantity, capacity)
	Resilience to climate hazards (degree of aging)
	Status/condition of facilities for securing and managing water resources
	Status/condition of means of transport to markets, etc.
Farmland	Location of farmland
	Soil fertility
	Water retention
	Status of agricultural water availability
Crops	Resilience to Temperature change
	Resilience to Water shortages
	Resilience to changes in growing period
Growers, collectives, etc.	Capacity to manage cultivation and water resources
	Crop/variety substitution programs and capacity building
	Understanding of climate change, etc.
	Prevention of insect pests, knowledge of countermeasures, availability coping methods, etc.
Administration, finance, extension agencies	Status of breeding systems (high temperature resistant varieties, drought resistant varieties, etc.) for variety improvement
	Availability of agricultural insurance (index insurance, etc.)
	Availability of public funds, lending programs, etc.
	Availability of weather forecast information (seasonal forecasts, early warning systems, etc.)
	Availability of personnel capable of dealing with climate change issues
	Availability of human resources development programs
	Presence of community-based organizations (CBOs, NGOs) that can provide support with a focus on agricultural production

Table 19 Example of climate risks for a project in the agriculture sector (major crops)

Object of risk	Examples of climate risks
Physical infrastructure	Damage to the agricultural infrastructure (irrigation equipment, agricultural roads, collection facilities, warehouses, etc.)
Farmland	Soil erosion of farmland
	Occurrence of salt damage
Crops	Decreased yield due to water shortages, high/low temperatures, pest outbreaks, etc.
Growers, collectives, etc.	Increases in unit production costs (fertilizer, irrigation, pesticides, seeds, labor, etc.)
	Decrease of crop yield
	Economic losses due to decreased yields
	Changes in revenues from agricultural production due to insect pests, etc. (economic losses)
Administration, finance, extension agencies	Reduced food security due to decreases in crop yields

Table 20 Example of adaptation measures for a project in the agriculture sector (major crops)

Category	Examples of adaptation measures
Physical infrastructure	Enhanced capacity of irrigation facilities, etc.
	Revise/update design standards
	Relocate facilities

	Improve/upgrade water resources infrastructure (install dams and small rainfall supply reservoirs, etc.)
	Improve/upgrade early warning systems
	Improve weather information provision systems
Farmland	Encourage water resources reuse, use groundwater (wells, capacity building)
	Soil management techniques, such as conservation tillage and measures to prevent soil erosion and loss of soil moisture due to drought
Growers, collectives, etc.	Develop/introduce high-temperature and drought-resistant varieties
	Utilize/introduce water-saving farming and innovative agricultural techniques
	Diversify crop types (mixed cultivation, fallow crops, agroforestry)
	Crop substitution
	Utilize weather monitoring data
Administration, finance, extension agencies	Climate change observation and education
	Enhance research for climate change projections, etc.
	Informative and educational activities on climate change to farmers and collectives
	Promote legislative change for water resource and farmland conservation
	Provide public funding (grants, subsidies, etc.) for climate change responses
	Strengthen organization/capacity of ministries and agencies relevant to climate change, etc.
	Develop/promote agricultural insurance programs
Other	Tree planting and forest conservation in water catchment areas

< Horticultural crops>

Table 21 Example of climate hazards for a project in the Agriculture sector (horticultural crops)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Temperature changes (to temperatures not suited to target crops)	Past temperature changes (by year, month, day; especially, changes during the growing season, affecting yield and quality)
Heat waves, cold waves	Annual average temperature, Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
Storms	Conditions (timing, duration, scale) of storm occurrence (including lightning)
Torrential rainfall	Frequency of torrential rainfall events (timing, duration)
Flood, inundation	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Drought, water shortage occurrence (timing, duration, scale)
Solar irradiance	Changes in solar irradiance
Landslides	Occurrence of landslides, Accumulated rainfall
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise
	Salt water intrusion

Table 22 Example of exposure for a project in the agriculture sector (horticultural crops)

Object of exposure	Examples of items to survey and confirm
Physical infrastructure	Status/condition (quantity, capacity)
	Specifications (width, length, depth, incline)
	Equipment price (asset value)
	Access route to a market
Farmland	Area
	Price of farmland
Crops	Type of crop
	Growing period
	Planting area
	Number of harvests
	Yield and quality
Growers, collectives, etc.	The number of growers
	Number of collectives, etc.
Administration, finance, extension agencies	Numbers of administrative/financial/extension agencies, and services provided

Table 23 Example of vulnerability for a project in the agriculture sector (horticultural crops)

Vulnerability to be considered	Examples of items to confirm and consider
Physical infrastructure of horticultural facilities (greenhouses, etc.)	Location of facilities
	Robustness of facilities
	Availability of wastewater facilities
Crops	Resistance to climate change (temperature change, water shortages, etc.)
	Growing location/season for horticultural crops (especially leaf vegetables, fruits)
	Resilience to changes in planting/harvesting times
	Physical damage to horticultural crops (leaf vegetables, fruits, etc.), decreased product value due to poor appearance
Growers, collectives, etc.	Capacity to manage cultivation and water resources
	Crop/variety substitution programs and capacity building
	Understanding of climate change, etc.
	Prevention of insect pests, knowledge of countermeasures, availability coping methods, etc.
Administration, finance, extension agencies	Status of breeding systems (high temperature resistant varieties, drought resistant varieties, etc.) for variety improvement
	Availability of agricultural insurance (index insurance, etc.)
	Availability of public funds, lending programs, etc.
	Availability of weather forecast information (seasonal forecasts, early warning systems, etc.)
	Availability of personnel capable of dealing with climate change issues
	Availability of human resources development programs
	Presence of community-based organizations (CBOs, NGOs) that can provide support with a focus on agricultural production

Table 24 Example of climate risks for a project in the agriculture sector (horticultural crops)

Object of risk	Examples of climate risks
Physical infrastructure of horticultural facilities (greenhouses, etc.)	Water ingress due to failed water drainage near greenhouses
Crops	Changes in horticultural crop yields (leaf vegetables, fruits, etc.),
	decreased value of products (due to substandard appearance)
Growers, collectives, etc.	Increases in unit production costs (fertilizer, irrigation, pesticides, seeds, labor, etc.)
	Decrease of crop yield

	Economic losses due to decreased yields
	Changes in revenues from agricultural production due to insect pests, etc. (economic losses)
Administration, finance, extension agencies	Reduced food security due to decreases in crop yields

Table 25 Example of adaptation measures for a project in the agriculture sector (horticultural crops)

Category	Examples of adaptation measures
Physical infrastructure of horticultural facilities (greenhouses, etc.)	Enhanced capacity of irrigation facilities, etc.
	Revise/update design standards
	Relocate facilities
	Improve/upgrade water resources infrastructure (install dams and small rainfall supply reservoirs, etc.)
	Improve/upgrade early warning systems
	Improve weather information provision systems
Crops	Temperature control in horticultural greenhouses
Growers, collectives, etc.	Develop/introduce high-temperature and drought-resistant varieties
	Utilize weather monitoring data
Administration, finance, extension agencies	Climate change observation and education
	Enhance research for climate change projections, etc.
	Informative and educational activities on climate change to farmers and collectives
	Promote legislative change for water resource and farmland conservation
	Provide public funding (grants, subsidies, etc.) for climate change responses
	Strengthen organization/capacity of ministries and agencies relevant to climate change, etc.
	Develop/promote agricultural insurance programs

< Livestock productions>

Table 26 Example of climate hazards for a project in the agriculture sector (Livestock productions)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Temperature changes (to temperatures not suited to target crops)	Past temperature changes (by year, month, day; especially, changes during the growing season, affecting yield and quality)
Heat waves, cold waves	Annual average temperature, Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
Storms	Conditions (timing, duration, scale) of storm occurrence (including lightning)
Torrential rainfall	Frequency of torrential rainfall events (timing, duration)
Flood, inundation	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Drought, water shortage occurrence (timing, duration, scale)
Solar irradiance	Changes in solar irradiance
landslide	Occurrence of landslides, Accumulated rainfall
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise
	Salt water intrusion

Table 27 Example of exposure for a project in the agriculture sector (Livestock productions)

Object of exposure	Examples of items to survey and confirm
Livestock sheds/barns	Number of livestock sheds/barns
	Asset value of livestock sheds/barns
	Number of animals raised
Feed crops	Area and yield of feed crops
	Quality of feed crops

Table 28 Example of vulnerability for a project in the agriculture sector (Livestock productions)

Vulnerability to be considered	Examples of items to confirm and consider
Livestock sheds/barns	Location of livestock sheds/barns
	Wind speed/direction
	Sun exposure or shade
	Availability of heat exhaust and temperature control capabilities
Supply of feed	Type of feed crop, growing location, growing season
	Supply quantity and available timing of feed crops (grasses, grains)
	Climate changes resistance of feed crops (grasses, grains) to temperature changes, water shortages, etc.
	Incursion of invasive grasses (toxic to livestock)
Livestock	Resistance to climate changes such as temperature changes and water shortages
	Access to water resources
Growers, collectives, etc.	Availability of knowledge/means of animal husbandry techniques, disease prevention, parasite prevention
Administration, finance, extension agencies	Availability of services for livestock vaccination, animal husbandry techniques, diseases/parasite prevention options

Table 29 Example of climate risks for a project in the Agriculture sector (Livestock productions)

Object of risk	Examples of climate risks
Livestock	Changes in feed supply quantity, livestock health, feed availability Reduced growth rates (due to high temperatures)
Changes in product quality Disease outbreaks	Quality of eggs, milk
Disease outbreaks	Disease outbreaks, parasite outbreaks
Economic losses	Changes in livestock revenues due to changes in yields (meats, eggs, milk volume, etc.), changes in numbers of animals that can be raised, disease outbreaks, etc.

Table 30 Example of adaptation measures for a project in the Agriculture sector (Livestock productions)

Category	Examples of adaptation measures
Breeding techniques	Change type of feed crop, secure supply of clean water
	Livestock health management with a focus on disease prevention, preparedness
	Temperature control in cattle barns (cool by evaporation using sprinklers, create tree shade, etc.)

5.2. Water Resources: Water Supply

5.2.1. Climate Risks in the Water Resources (Water Supply)

Water resources are used as resources such as agricultural water, industrial water, and domestic water. About 70% of the total water intake is used as agricultural water (most of them is as irrigation water), about 20% is used as industrial water, and about 10% is used as domestic water. The impacts of climate change on water resources can be attributed to changes in the intensity and frequency of rainfall, changes in runoff due to such changes, changes in snow precipitation and snow melting times due to increase temperatures, and saltwater of rivers and groundwater in coastal areas due to rising sea levels. Current water use and water supply infrastructures are planned, developed, and operated based on the current climate. Changes in the assumption climate due to climate change may have an impact on the way water is used, and on the water supply infrastructure.

According to IPCC's AR6, "There is strengthened evidence since AR5 that the global water cycle will continue to intensify as global temperatures rise (high confidence), with precipitation and surface water flows projected to become more variable over most land regions within seasons (high confidence) and from year to year (medium confidence). The average annual global land precipitation is projected to increase by 0–5% under the very low GHG emissions scenario (SSP1-1.9), 1.5–8% for the intermediate GHG emissions scenario (SSP2-4.5) and 1–13% under the very high GHG emissions scenario (SSP5-8.5) by 2081–2100 relative to 1995–2014 (likely ranges). Precipitation is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and limited areas in the tropics in SSP2-4.5, SSP3-7.0 and SSP5-8.5 (very likely)."[10]

It is projected that climate change, even with conventional treatments, may reduce the quality of raw tap water and pose a risk to drinking-water quality, due to the interaction of factors such as increased sediment, nutrient, and pollutant loads caused by elevated temperatures and heavy rainfall, increased concentrations of pollutants during droughts, and obstacles to treatment facilities during floods. (IPCC AR5)

The following is an example of the impact of climate change on the water supply and sewerage sector.

- Coastal areas: Salt water intrusion into surface and groundwater due to sea level rise and increased storms
- Melting of glaciers: Many of the rivers into which glaciers and snow-melted water flow, with increased flow rates and early peak times of spring flow.
- Temperature Increase: Decrease in Water Supply from Evaporation of Surface Water
- Urban Water Supply Systems: Demand-Side Management to Ensure Sufficient Water Supply and Water Quality, Enhancement of Capacity to Manage Reduced Freshwater Availability, and Reduction of Flood Risk

[10] IPCC AR6 Climate Change 2021: The Physical Science Basis Summary for Policymakers, B.3.1

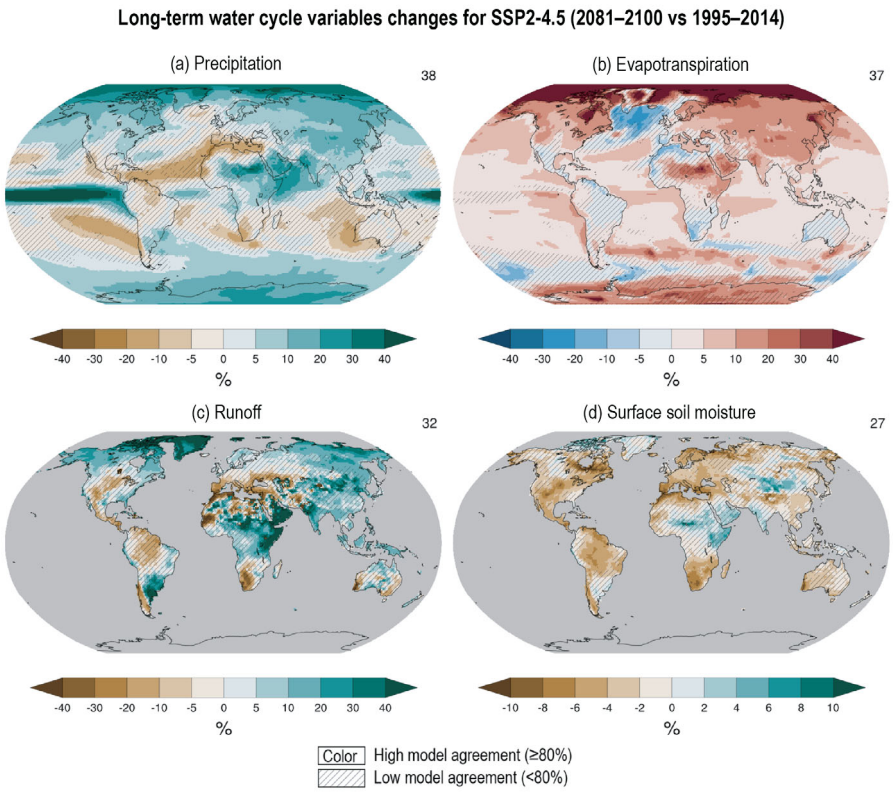


Figure 11 Water cycle variables changes[11]

(Source: IPCC AR6 WGI Technical Summary, Box TS.6, Figure1, 2021)

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.2.2. Components of Climate Risk in the Water Resources (Water Supply)

Table 31 Example of climate hazards for a project in the Water Resources (Water Supply)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
Torrential rainfall	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Annual maximum T-day rainfall
	Annual maximum T-hour rainfall
Storms	Frequency of storm
	Strength (Wind speed)
Flood, inundation	Annual rainfall

[11] Box TS.6, Figure 1 in IPCC, 2021: Technical Summary. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Chen, D., M. Rojas, B.H. Samset, K. Cobb, A. Diongue Niang, P. Edwards, S. Emori, S.H. Faria, E. Hawkins, P. Hope, P. Huybrechts, M. Meinshausen, S.K. Mustafa, G.-K. Plattner, and A.-M. Tréguier, 2021: Framing, Context, and Methods. InClimate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 147–286, doi:10.1017/9781009157896.003.]

	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 32 Examples of exposure for a project in the Water Resources (Water Supply)

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Water storage, water intake, water purification facilities, water distribution facilities, etc.	Reservoirs (total capacity, effective water storage, percentage of water storage capacity in relation to demand, etc.)
		Each type of facility
		Numbers of facilities
		Facility valuations
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Water resources	Water quality in reservoirs and rivers, etc.
		Water quantity in reservoirs and rivers, etc.
		Groundwater quality and quantity
	Water catchment area	Forest area in water catchment area
		Percent of forest cover in water catchment area

Table 33 Example of vulnerability for a project in the Water Resources (Water Supply)

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Water storage, water intake	Location and condition of reservoirs and facilities
		Location of water intake (depth from surface)
	water distribution facilities	Water pressure
		Efficiency of water supply network (water leakage rate)
		Installation status of water meters (to check for leaks, etc.)
	water purification facilities	Location of water purification facilities
		Installation status of emergency power supplies at water purification facilities
		Soil at water purification facility site
Soft infrastructure	Knowledge and information	Availability of information on climate change in the target area
		Availability of assessment of vulnerability of drinking-water supply to climate change impacts in
		Availability of River Flow Forecasts
		Availability of weather forecast information (Note: Seasonal forecast, early warning, etc.)
		Lack of piping drawings/information
	Technology	Extent of deployment of technology for climate change adaptation
		Presence or absence of risk monitoring initiatives
		Efficient and impartial use of climate information and weather forecasts

		Initiatives to protect watersheds
		Lack of specific methods to respond when water leaks occur
	Organizational and institutional Capacity	Integration of Climate Change into Relevant Sector Policies
		Availability of information on current and future climate risks at local agencies
		Availability of information on current and future climate risks at local agencies
		Availability of funds to cover the costs of necessary climate change measures found in the Climate
		Level of Knowledge and Training of Key Persons in Climate Change Issues and Mainstreaming
		Capability to operate/maintain equipment/facilities
		Capacity building for personnel to operate/maintain equipment/facilities
Surroundings	System, structure, etc.	Conservation area within water catchment
		Existence of protections for water sources
	Water resources	Amount of increase in water demand in entire water catchment area
		Volume and increase/decrease of water reserves in water catchment forest and entire water catchment area
		Whether or not water resources management is being implemented for the entire water catchment area

Table 34 Example of climate risks for a project in the Water Resources (Water Supply)

Object of risk		Examples of climate risks
Hard infrastructure	Water storage, water intake, water purification facilities, water distribution facilities, etc.	Equipment damage
		Reduced capacity
		Mixing of rainwater, sewage, etc.
		Changes in annual operating and maintenance costs per unit at drinking water supply facilities
Soft infrastructure	Project-related organization and personnel	Reduction in proper water supply capacity
		Suspension of proper operations/maintenance of equipment/facilities
		Reduced operational/maintenance capacity
Surroundings	Access to resources	Restrictions/access to safe water
		Changes in water supply/demand balance
		Changes in the number of months in which there was no shortage of water supply annually, and the reduction and improvement of reliability associated therewith
		Changes in the number of days per year in which water is cut off for 12 hours or more per day (suspension of water supply), and the associated increase or decrease in reliability
	Health and Hygiene	Increased prevalence of waterborne diseases
		Increase and decrease in the mortality rate of children under 5 years of age (the number of deaths per 1,000 live births) due to changes in the supply of sanitary water
	Soil	Soil erosion in the watershed
	Water resources	Water quality deterioration (changes in turbidity, BOC, phosphorus, nitrogen, etc.)
		Restriction or suspension of water intake due to large amounts of sediment inlet
		Changes in groundwater levels and water quality
		Decrease in glaciers
		Increase/decrease in annual available water resources

Table 35 Example of adaptation measures for a project in the Water Resources (Water Supply)

Category		Examples of adaptation measures
Hard infrastructure	Water storage, water intake, water purification facilities, water distribution facilities, etc.	Securing backup power supplies for water treatment facilities and pumping facilities
		Relocate/install at higher elevations
		Facility design incorporating multiple water intake options in anticipation of frequency of torrential rainfall events (e.g, if projections are for frequent torrential rainfall, increase the intake pond capacity, considering high turbidity levels of intake water)
		Select water distribution pipe locations to avoid areas where floods may occur
		Install water-tight doors, transfer critical machinery/equipment to higher ground
		Repair/refurbish aging facilities, etc.
		Upgrade (raise/build out dam)
		Capacity building
Soft infrastructure	Project-related organization and personnel	Incorporate climate change risk into investment design plans
		Formulate business continuity plan (BCP)
		Formulate water utilization management strategy for entire water catchment area
		Formulate water intake plan to account for changes in precipitation and river flow
		Collection of climate-related data, and data on disaster-related events and intensity/frequency of climate hazards
		Bolster operations and implementation of maintenance of equipment/facilities
		Enhance personnel capacity to operate/manage facilities
		Budget measures for operational management and human resources development
		In light of future intensification of climate hazards: (1) change land use plans (do not install treatment facilities, water distribution/supply pipes), (2) revise infrastructure design standards
Surroundings	Water resources	Protect forests in water catchment area
		Improve monitoring capacity for water sources
		Retain vegetation upstream in watershed
		Diversify water sources/supply sources to supply water

5.3. Environmental management: Sewage

5.3.1. Climate Risks in the Environmental management (Sewage)

The impacts of climate change in the sewerage are considered to be insufficient drainage capacity, increased removal of nutrients for the control of eutrophication, risk of flooding, and increased demand for recycled water. In addition, in many cases, rainwater drainage facilities is set for rainfall that occurs about once every five or ten years in the sewage system that is responsible for inland water drainage in urban areas. According to the Ministry of the Environment and the Japan Meteorological Agency, rainfall due to heavy rainfall is projected to increase by about 10% in the RCP2.6 scenario and about 25% in the RCP8.5 scenario by the end of the 21st century in Japan. While rainfall with strong rainfall intensity increases, it is predicted that the number of non-rainfall days with little rainfall will also increase, and it is also expected to increase in damage by flood and frequency of drought. Some of the impacts of climate change on sewerage are given below.

Rise in temperature and water temperature

- Water pollution in closed waters
- Prolongation of the time of development of red tide due to the increase of phytoplankton
- Increasing demand for nutrient removal for eutrophication control (sewage may be a major source of nutrients, thus increasing the need for advanced treatment)

Decrease in rainfall (drought)

- Increasing demand for recycled water
- Increase in sewage contamination rate due to decrease in water supply

Occurrence of heavy rain (flooding due to heavy rain)

- Increased risk of flooding
- Frequent flooding in coastal urban areas
- Increase in flood damage
- Insufficient drainage capacity of urban rainwater
- Increase in direct flow of untreated sewage from sewerage pipes into rivers

When evaluating the possibility of the above-mentioned impacts, the following measures will be taken: to examine the possibility of an increase in rainfall intensity (e.g., short-term heavy rainfall of 50mm or more per hour); to examine the possibility of a prolongation of rainfall duration (duration of strong rainfall intensity); and to examine the possibility of an increase in the occurrence of inundation damage due to the effects of sea level rise.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.3.2. Component of Climate Risk in the Environmental management (Sewage)

Table 36 Example of climate hazards for a project in the Environmental management (Sewage)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
Torrential rainfall	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Annual maximum T-day rainfall
	Annual maximum T-hour rainfall
Storms	Frequency of storm
	Strength (Wind speed)
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 37 Examples of exposure for a project in the Environmental management (Sewage)

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Sewage treatment facilities, piping, etc.	Scale of equipment/facilities (in terms of numbers, types)
		Processing capacity
		Asset value of equipment/facilities
Soft infrastructure	Project-related organization and personnel	Composition/personnel/roles of project-related organization structure
Surroundings	Sewage inflow	Water quality of inflowing sewage (e.g., contaminant content ratios)
		Sewage inflow volume

Table 38 Example of vulnerability for a project in the Environmental management (Sewage)

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Sewage treatment facilities, piping, etc.	Location, ground height
		Geology at site/location
		Pipe routing
		Resilience to changes in pollutant load
		Resilience to changes in sewage volume
		Availability/grasp of information on weather/climate change

Soft infrastructure	Knowledge and information	Level of climate change awareness
		Implementation of vulnerability assessments
	Technology	Availability of processing technology capable of responding to variations in water volume and quality
		Availability of technology to mitigate changes in water volume/quality
	Organizational and institutional Capacity	Integration of climate change into policies of relevant sectors
		Monitoring/analysis of climate information
		Availability of funds to cover the costs of necessary climate change measures found in the Climate
		Level of Knowledge and Training of Key Persons in Climate Change Issues and Mainstreaming
		Routine maintenance/repair systems for equipment/facilities
		Personnel capacity building for maintenance/repair of facilities
		Budget for maintenance/repair and human resources development
		Whether or not there are design standards taking climate change into account

Table 39 Example of climate risks for a project in the Environmental management (Sewage)

Object of risk		Examples of climate risks
Hard infrastructure	Sewage treatment facilities, piping, etc.	Reduced performance or shutdown due to damage to processing facilities
		Reduced performance due to inflow of sewage exceeding processing capacity
		Damage/reduced capacity of water collection facilities, piping, etc.
		Reduced quality of processed water quality, discharge of untreated water
		Water contamination due to the inflow of untreated water
Soft infrastructure	Project-related organization and personnel	Change (deterioration) in project profitability due to change (increase) in water treatment costs
Surroundings	Health and Hygiene	Deterioration of public health due to unsanitary water environment

Table 40 Example of adaptation measures for a project in the Environmental management (Sewage)

Category		Examples of adaptation measures
Hard infrastructure	Sewage treatment facilities, piping, etc.	Securing backup power supplies for water treatment facilities and pumping facilities
		Relocate facilities
		Perform regular facilities inspection
		Establishment of a program to reduce water infiltration in water pipes
		Improve the treatment capacity of sewage treatment facilities (to ensure operation even in the event of floods, etc.)
		Measures against leakage of sewerage pipes, improvement of water collection efficiency (inspection and replacement of aged water pipes and filters, etc.)
Soft infrastructure	Project-related organization and personnel	Monitor the level of quality and evaluate the need to review new or source protection plans
		Improvement of monitoring capacity for water sources of rivers to which sewerage is discharged (leading to easy understanding of changes in water quality, ease of judgment in operation, and study of improvement of facilities)
		Formulation of plans and mechanisms for promoting the improvement of water utilization

		efficiency in areas subject to water supply
		Formulate plans for reducing sewage treatment (introduction of efficient water utilization technology, etc.)
		Collection of climate-related data, and data on disaster-related events and intensity/frequency of climate hazards
		Formulate business continuity plans (BCPs)
		Bolster operations and implementation of maintenance of equipment/facilities
		Enhance personnel capacity to operate/manage facilities
		Budget measures for operational management and human resources development
		In light of future intensification of climate hazards: (1) change land use plans (do not install treatment facilities, water distribution/supply pipes), (2) revise infrastructure design standards

5.4. Disaster prevention Sector

5.4.1. Climate Risk in the Disaster Prevention Sector

According to the United Nations Strategic Bureau for Disaster Reduction (UNISDR), climate change has changed the geographic distributions, frequencies, and intensities of climate-related hazards, and poses a threat to vulnerable poor countries and civils living in those regions to absorb the losses arising from hazards and to impede their ability to recover from the impacts of disasters.

Climate change is believed to increase the uneven distribution of risks from disasters, and the impact of disasters is further directed towards poor communities in developing countries. The concept of disaster prevention measures in the area of disaster prevention is not "climate hazard and natural events = disasters," but "if the vulnerability and exposure to disasters increase, they pose a threat that increases the damage covered by disaster prevention measures."[12]

Examples of vulnerabilities and exposures in disaster prevention measures are as follows.[13]

- Social and economic factors: poverty, lack of urban planning, rapid urbanization, lack of knowledge and awareness, organizational response capacity
- Physical Factors: Improper Land Use Plan, Improper Infrastructure Improvement
- Environmental factors: environmental deterioration, ecosystem deterioration (coastal areas, river basins, wetlands, etc.)

The Sendai Framework for Disaster Reduction 2015-2030 adopted at the Third World Conference on Disaster Reduction states that climate change and disaster risk are as follows.

"Disasters are becoming more intensified and more frequent and many due to climate change, significantly impeding progress towards sustainable development. In all countries, the exposure of people and property is increasing faster than the reduction of vulnerabilities, resulting in new risks and continually increasing disaster losses associated with significant short-term, medium-term, and long-term economic, social, cultural, and environmental impacts, health at the local and community levels. Repeated small-scale disasters and slow-onset disasters, particularly affecting communities, households, and SMEs, account for a large percentage of total losses, and all countries, particularly developing countries with significantly higher mortality and economic losses, are faced with increased potential hidden costs and challenges to fulfill their financial and other obligations."

There is a need at all levels to strengthen efforts to reduce exposure and vulnerabilities, to prevent the creation of new disaster risks, and to be accountable for the creation of disaster risks. Further action focused on potential disaster risk factors is needed, with the consequences of poverty and inequality, climate change, unplanned and rapid urbanization, inadequate land management, and the combination of population change, weak organizational structure, lack of risk information, lack of regulations and incentives for private investment in disaster risk reduction, complex supply chains, limited availability of technology, unsustainable use of natural resources, worsening ecosystems, and factors of global epidemics. In addition, we will continue to strengthen good governance on disaster risk reduction at national, regional and global levels, and continue to improve preparedness and domestic coordination for disaster response, reconstruction and reconstruction. "The post-disaster recovery and reconstruction stages need to be utilized in ""better reconstruction (Build Back Better)""

[12] UNISDR, 2009, "United Nations White Paper on Disaster Reduction 2009," Disaster Risks and Poverty in Climate-Change

[13] UNISDR. 2014.12,「Global Initiatives on Disaster Prevention and Disaster Mitigation: Discussion on the Hyogo Framework for Action and Succession Framework: Women's Participation in Disaster Prevention and Reconstruction and Leadership Publication

using strengthened and internationally cooperative approaches" (Sendai Framework for Disaster Reduction 2015-2030 (https://www.mofa.go.jp/mofaj/files/000081166.pdf)

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate. Especially in the disaster prevention sector, since the initial purpose of projects and cooperation often includes adaptation to climate change, such as responding to flood damage caused by climate change, it is also appropriate to implement or further enhance what was originally planned in the project or cooperation as an adaptation measure.

5.4.2. Component of Climate Risk in the Disaster Prevention Sector

Table 41 Example of climate hazards for disaster prevention/risk reduction projects (weather-related disasters, water-related disasters)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
Torrential rainfall	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Annual maximum T-day rainfall
	Annual maximum T-hour rainfall
Storms	Frequency of storm
	Strength (Wind speed)
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 42 Example of exposure for disaster prevention/risk reduction projects (weather-related disasters, water-related disasters)

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Disaster prevention equipment/facilities	Status/condition of facilities (quantity, capacity)
		Asset values of equipment, etc. (assessed value, etc.)
		Equipment service life
		Historical disaster records (records of water ingress, etc.)
Soft infrastructure	Disaster prevention/risk reduction organization/personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Residents, property, industries	Population
		Land uses
		Status of asset concentration

Table 43 Example of vulnerability for disaster prevention/risk reduction projects (weather-related disasters, water-related disasters)

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Disaster prevention equipment/facilities	Location of equipment/facilities (distance from slopes of rivers, coasts, mountains, etc.)
		Terrain, slope angle, ground elevation
		Resilience to climate hazards (degree of aging)
		Status of measures to protect critical services such as electrical power
		Whether or not there are facilities for weather and flood forecasting
Soft infrastructure	Disaster prevention/risk reduction organization/personnel	Whether or not there are systems/personnel to respond to weather/flood forecasts
		Status of hazard maps for water ingress, flooding, landslide disasters
		Whether or not there are government/community systems for sharing disaster-related information
		Whether or not business operators and related institutions have disaster response systems and staff capacity
		Whether disaster prevention organizations and personnel can continue their activities
Surroundings	Residents, property, industries	Ground height of housing and industrial facilities, etc.
		Whether or not there are information sharing systems and evacuation plans in the community
		Status of corporate/organizational business continuity plans (BCPs)
		Level of understanding of weather and flood forecasting and other information
		Level of understanding of hazard maps and other information related to disaster prevention

Table 44 Example of climate risks for disaster prevention/risk reduction projects (weather-related disasters, water-related disasters)

Object of risk		Examples of climate risks
Hard infrastructure	Disaster prevention equipment/facilities	Damage or shutdown of equipment/facilities due to occurrence of climate hazards, etc.
		Shutdown of equipment, etc. to fuel shortages
Soft infrastructure	Disaster prevention/risk reduction organization/personnel	Reduced performance or suspension of disaster-prevention related organizations/systems
		Suspension of disaster prevention information provision, etc.
		Lack of personnel, understaffing, etc.

Surroundings	Residents, property, industries	Adverse human impacts (death and health damage) and physical impacts (building damage, traffic disruptions) due to damage to equipment/facilities, including water ingress to surrounding areas
		Delays in evacuation (especially for the elderly) due to lack of information availability
		Water ingress leading to stoppages in business operations

Table 45 Example of adaptation measures for disaster prevention/risk reduction projects (weather-related disasters, water-related disasters)

Category		Examples of adaptation measures
Hard infrastructure	Disaster prevention equipment/facilities	Revise/update facilities, equipment design, specifications
		Relocate equipment/facilities
		Improve/expand equipment/facilities (expansion, upgrading)
		Conduct an aging survey of equipment/facilities, and maintain/refurbish
		Implement measures to secure critical services, including electrical power
		Improve/upgrade early warning systems
		Maximize the utilization of existing facilities
		Pre-release from dams (create guidelines for pre-release, conduct temporary release from water supply dams)
Soft infrastructure	Disaster prevention/risk reduction organization/personnel	Enhance resources (human/physical/economic) related to climate change countermeasures
		Establish subsidy program to relocate away from areas of high climate risk
		Formulate private sector business continuity plan (BCP) for climate disasters
		Created disaster-related information sharing systems with local residents with hazard maps, etc.
		Build disaster response systems and improve personnel capacity, through disaster prevention training, etc.
		Take measures to prevent spread of damage and secondary disasters from anticipated climate risks
Surroundings	Residents, property, industries	Improve the surrounding environment to prevent secondary disasters (disaster prevention measures for wastewater/waste, water supply/sewerage, water catchment areas, conservation forests, etc.)
		Encourage housing to be built raised up on pilings
		Renovation of hospital facilities, etc. (e.g., locate emergency/ambulance entrance on second floor or above)
		Relocate critical facilities
		Promote disaster/climate change awareness/understanding to local residents (train facilitators)

5.5. Forest and Natural Environment Conservation

5.5.1. Climate Risk in the Forest and Natural Environment Conservation Fields

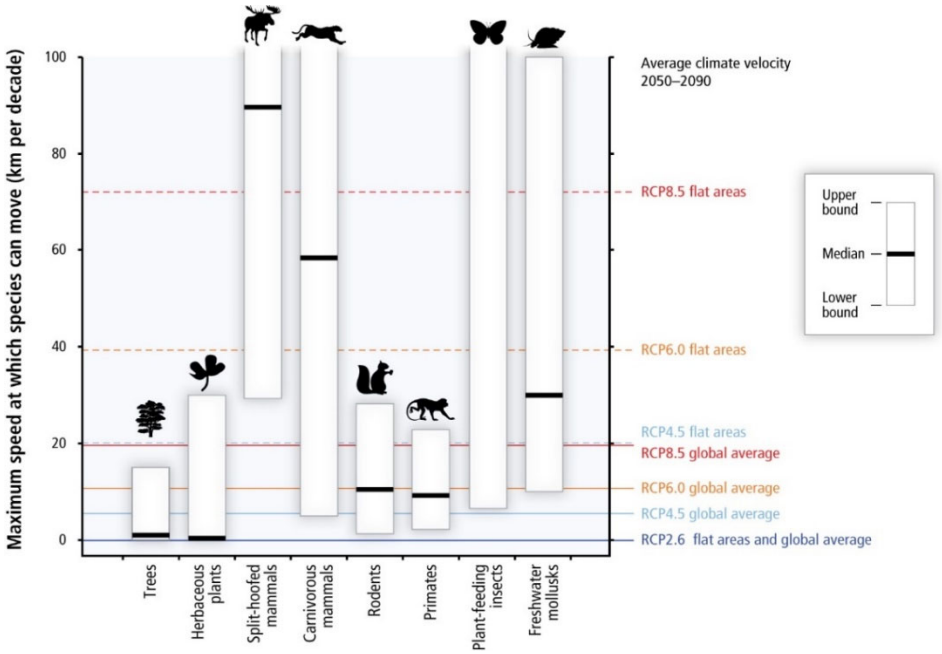
Ecosystems, including forests, and to be a threat, particularly in scenarios such as RCP6.0 and RCP8.5. Direct anthropogenic impacts, such as land-use change, pollution, and water resource development, are projected to continue to pose threats to many freshwater and terrestrial ecosystems worldwide over the next 2040 (IPCC AR5).

Forest

It is anticipated that rising temperatures, drought-induced tree death, and the associated increase in forest death will occur in many regions over the 21st century. The withering of forests poses risks to carbon storage, biodiversity, wood production, water quality, amenity and economic activity.

Conservation of Natural Environment

Although some species are predicted to adapt to new climates, species that cannot adapt fast enough are predicted to have reduced populations or to become extinct in part or in their entire habitats. Appropriate management activities, such as maintenance of genetic diversity, assistance in migration and dispersion of species, skillful response to disturbance conditions (e.g., fires and floods) and reduction of other stress factors, can reduce, but not eliminate, the risks of climate change to land and freshwater ecosystems and enhance the natural capacity of ecosystems and species to adapt to changing climates.



Maximum speed at which species can migrate2

(Source: IPCC AR5, WG2, SPM.5)

Species with maximum velocities below the lines shown in the figure are expected to be difficult to respond to changing climates without human intervention.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.5.2. Components of Climate Risk in the Forest and Natural Environment Conservation Sector

Table 46 Example of climate hazards for a project in the Forest and Natural Environment Conservation Sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Annual average temperature
	Monthly average temperature
	Warm Index, Cold Index[14]
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Monthly rainfall
	Duration of rainfall
Flood, inundation	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Changes in monthly rainfall
	Dryness or aridity index
	Drought, water shortage occurrence (timing, duration, scale)

Table 47 Example of exposure for a project in the Forest and Natural Environment Conservation Sector

Object of exposure	Examples of items to survey and confirm
Forests	Type of vegetation
	Forest area
	Vegetation coverage
Land	Area
	Land use classification (water surface, forest, grassland, farmland, grazing, urban, bare land, etc.)
Ecosystems (terrestrial, freshwater, coastal, marine, etc.)	Species and population numbers that live in the target area
	Area and range of habitats
	Connectivity and continuity of habitats of species in target area
	Ecosystem services
	Biodiversity
Project-related organization and personnel	Composition/personnel/roles of project-related organization structure

Table 48 Example of vulnerability for a project in the Forest and Natural Environment Conservation Sector

Vulnerability to be considered	Examples of items to confirm and consider
Forest	Location of forests
	Area of annual forest loss from anthropogenic pressures (forest reduction rate)
	Whether or not vegetation is capable of adapting to changes in temperature, precipitation, etc.
	Forest age, tree species composition
	Survival and viability rates of seedlings
	Status of swidden (slash-and-burn) agriculture in and around the target area
Land	Terrain

[14] Applicable in some areas such as Southeast Asia

	Ground elevation and slope
	Soil types
	Changes in land use at target site (e.g., potential change in protected areas)
	Location of steep slopes, etc.
	Occurrences of landslides/sediment-related disasters, floods, etc.
Ecosystem	Whether or not species can adapt to changes in temperature, precipitation, etc.
	Numbers and ratios of rare species in target area
	Ecosystem services
	Biodiversity
	Whether or not there are refugia for species
Project-related organization and personnel	Availability of forest/natural change monitoring techniques/data (sanitary images, GIS data, etc.)
	Availability of vulnerability assessment to climate change impact in ecosystem
	Availability of land cover maps and geospatial data on rare species distribution
	Availability of prioritization information on species at risk from climate change
	Acknowledgement of existing local adaptation strategies/knowledge
	Practices of monitoring risks (know about risks and monitor it, including climate information)
	Practicing species specific management
	Availability of funding to cover the costs of the necessary climate change measures identified during climate risk assessment
	Level of knowledge and training of key personnel in climate change issues and mainstreaming process

Table 49 Example of climate risk for a project in the Forest and Natural Environment Conservation Sector

Object of risk	Examples of climate risks
Forest	Loss of forest area
	Changes in vegetation
	Changes in preferred species
Land	Slope collapse
	Occurrence of mud/rockslides
	Habitat loss
	Changes in habitat quality (deterioration)
Ecosystems	Changes in preferred species
	Changes in species abundance (numbers of species in an area)
	Changes in species distribution (Habitat shift)
	Occurrence of non-native species spread [invasive species]
	Relative abundance
	Diseases spread among the species
	Shifts in phenological phases in plants/animals
	Decline of ecosystem services
Project-related organization and personnel	Changes in the volume and quality of operations related to forest and natural environment conservation, and changes in revenues
	Reduced income due to deterioration of tourism resources that rely on the natural environment

Table 50 Example of adaptations measure for a project in the Forest and Natural Environment Conservation Sector

Category	Examples of adaptation measures
Forest	Tree planting/afforestation
	Forest management (regular logging, tree-thinning, etc.)

	Biodiversity conservation
	Vegetation monitoring
Land	Establish conservation areas
	Create management strategies for conservation areas
	Landslide prevention measures on steep slopes
	Regulate land use
Ecosystems	Ecosystem monitoring
	Practicing habitat and land scape management
	Development of corridors, remove barriers for dispersal to increase connectivity
	Develop environmental conservation technologies/techniques
	Conserve species outside of current habitat
	Establish protected areas and relocate species
Project-related organization and personnel	Improve data for future climate projections under climate change, and conduct monitoring
	Capacity building for monitoring weather-related information and demographics
	Reduce external factors that lead to deterioration of natural environment (development, environmental pollution, etc.)
	Develop sustainable income sources such as eco-tourism

5.6. Infrastructure: Power System (Generation, Transmission and Distribution)

5.6.1. Infrastructure: Climate Risk in Power System (Power Generation, Transmission and Distribution)

Power generation

Climate change is projected to reduce the energy demand for heating in the housing and commercial sectors and increase the energy demand for cooling. In the baseline scenarios assessed in the AR5, direct CO2 emissions from the energy-supply sector are estimated to be approximately two to three times the 2010 14400 million tonnes/year level by 2050, unless the rate of improvement in energy consumption is significantly greater than the previous rate of improvement.

Climate change is expected to have different impacts on energy sources and technical, depending on energy sources (e.g., hydro, wind, solar), technology processes (e.g., cooling), or location (e.g., coastal areas, flood plains).

More serious and frequent extreme weather events (storms, floods, etc.) can increase the variability of losses and losses in various regions. In developing countries in particular, insurance schemes may be required to raise more risk-based capital and provide affordable insurance.

Power transmission and distribution

Climate change is also expected to affect integrity and reliability for pipelines and power grids. Climate change may require changes in design standards for the construction and operation of pipelines and transmission and distribution systems.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.6.2. Components of climate risk for electricity (power generation, transmission and distribution)

Table 51 Example of climate hazards for a project of electricity (power generation, transmission and distribution)

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Annual average temperature
	Annual maximum temperature
	Annual minimum temperature
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
	Seasonal rainfall pattern
Torrential rainfall	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall

	Annual maximum T-day rainfall
	Annual maximum T-hour rainfall
Wind	Change of wind speed
	Prevailing wind
	Change in wind direction characteristics
Storms	Frequency of storm
	Strength (Wind speed)
Changes in sunlight	Changes in solar irradiance
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 52 Example of exposure for a project of electricity (power generation, transmission and distribution)

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Equipment related to power generation, transmission, distribution, etc.	Status/condition of facilities (quantity, capacity)
		Asset values of equipment, etc. (assessed value, etc.)
		Historical disaster records (records of water ingress/flooding, etc.)
		Equipment service life (years)
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.

Table 53 Example of vulnerability for a project of electricity (power generation, transmission and distribution)

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Equipment related to power generation, transmission, distribution, etc.	Facilities, equipment site, equipment location, ground height, geological features
		Availability of fresh or sea water for cooling equipment
		Facility resistance to higher air and water temperatures
		Resilience of entire facility against soil erosion, coastal erosion, etc.
Soft infrastructure	To communicate and obtain information	Availability of information on climate risk relating to current and future climate change
		Whether or not monitoring/analysis are being done regarding current and future climate information
	System and design	Availability of early warning systems for extreme weather events
		Whether or not weather risk is being monitored
		Status of consideration/creation of adaptation plans for extreme weather
		Degree of diversification electrical power source mix
	Role of related organizations	Whether or not climate-related data and disaster information are being collected
		Whether or not equipment/facilities are under operational control
		Capacity building for personnel to operate/maintain equipment/facilities
		Budgetary measures for operations/maintenance and human resources development
		In light of future intensification of climate hazards: (1) change land use plans (do not build power plants, substations, transmission facilities), (2) revise infrastructure design standards

Table 54 Example of climate risk for a project of electricity (power generation, transmission and distribution)

Object of risk		Examples of climate risks
Hard infrastructure	Thermal power station	Affecting availability of freshwater for cooling (all thermal systems).
		Higher temperatures resulting from climate change may increase the temperature of water abstracted for power station cooling, reducing plant efficiency and therefore potentially affecting energy supplies.
		Damage to infrastructure. Increased sea levels and storm surges could damage coastal infrastructure、Possible soil erosion and damage to facilities
		Wider pollutant dispersion
	Wind power station	Changes in wind speed can reduce generation (turbines cannot operate in very high or very low
		Changes in temperature can reduce generation (turbines cannot operate in very high or very low)
		Damage to infrastructure、Changes in storm damage on wind turbines
	Photovoltaic power plant	Lowers cell efficiency and energy output
		Decrease in voltage, cell generation efficiency, and output volume due to rising temperatures
		Increase in power generation associated with lower temperatures, resulting in excessive out-of-specification voltages
		Can wash away dust (short term) but reduces panel efficiency (less solar radiation)
		Snow accumulation on panel reduces efficiency
		Increased efficiency and output with cooling effect of wind
		Rapid fluctuations in cloud cover can destabilize grid
		Can damage systems (e.g., lightning strikes)
	Transmission and distribution	Can reduce electricity carrying capacity of lines
		Transmission efficiency - lower capacity of electrical transmission as they are de-rated in order to maintain appropriate operating conditions
		Can increase losses within substations and transformers
		Heavy rains and flooding can undermine tower structures through erosion
		Snow and ice can damage transmission and distribution lines (e.g., through sagging)、Strong winds
		Drought can increase dust damage
		Flooding can damage underground cables and infrastructure in general、Ice storms can do
		High temperatures, storms, erosion, or flooding can damage control systems through loss of information and communications technology service or reduce quality of service
		Overheating of equipment (Transformers and transmission lines)
Soft infrastructure	Role of related organizations	Reduced institutional capacity for operations/maintenance of power generation operations
		Shortage of personnel to respond to equipment failures, etc.

Table 55 Example of adaptation measure for a project of electricity (power generation, transmission and distribution)

Category		Examples of adaptation measures
Hard infrastructure	Thermal power station	Enhanced protection facilities and regular monitoring of fuel storage facilities, including coal stockpiles

		Improve water use efficiency throughout the facility (reduce water withdrawals and use smaller amounts of water to generate electricity)
		Consider diversification of water sources, such as securing new water sources
		Redesign of cooling facilities (water recovery from heat exchangers, reduction of evaporation losses, promotion of secondary use of wastewater, introduction of dry cooling towers, etc.)
		Choose sites that take into account expected temperature rising during the lifetime of the turbines.
		Wastewater system improvements, water main rehabilitation
	Wind power station	Installation of turbines designed to withstand high winds / gusts / changes in wind direction
		Installation of tall wind turbines
		Site set up to account for changes in wind speed/direction due to projected climate change during the turbine's equipment life
		Consider development and commercialization of vertical-axis wind turbines
		Selection based on the impact of extreme weather (temperature changes, precipitation changes, etc.) on turbines and blades
	Photovoltaic	Configuration of solar cells and modules designed to withstand high temperatures and short peak periods
		Proper selection of panel angles to prevent dust and dust accumulation associated with high winds and storms. Select modules that are self-cleaning
		Select sites with low likelihood of dust, ash, snow accumulation
		Consider structural equipment that can withstand high winds, gusts, and storms from the construction phase.
		Assure free space (panels and mounting) so snow can slide off panel.
		Decentralization of the location of solar panels and the grid to which they are connected in order to be able to respond to cloud fluctuations
		Installing microinverters on each panel to increase stability and increase output.
	Transmission and distribution	Specify cabling and components that can deal with high moisture content and flooding.
		Specify more effective cooling for substations and transformers.
		Specify certified information and communications technology (ICT) components that are resilient to higher temperatures and humidity.
		Build a resilient high-capacity transmission system.
		Design improved flood protection measures for equipment mounted at ground level in substations.
		Protect masts, antennae, switch boxes, aerials, overhead wires, and cables from precipitation (water ingress, snow melt); wind; snow (weight); unstable ground conditions (flooding, subsidence); and changes in humidity.
		Reinforce existing transmission and distribution (T & D) structures and build underground distribution systems.
		Increase the system's ability to return to normal operations rapidly if outages do occur.
		Change routes of overhead lines along roads away from trees, rigorously prune trees, use covered and/or insulated conductors, and use more underground cables, especially in wooded areas.
		Increase decentralized energy generation (with less T&D grid requirements).
		Include lightning protection (earth wires, spark gaps) in the distribution network.
		Increasing the height of overhead lines
		Replacing underground cables with larger cables
		Widespread introduction of 'smart' network technology

Soft infrastructure	Role of related organizations	Create and implement system for implementation and monitoring of weather changes
		Introduce control plans/systems for power generation facilities to respond to monitoring of weather change conditions
		Implement maintenance of power generation equipment at appropriate frequency and timing
		Diversification of power generation facilities/methods and locations of power plants
		Establishment and implementation of building code with disaster prevention measures
		Implementation of flood control measures (levees, dams, reservoirs, flood barriers, etc.)
		Implementation of coastal protection works in coastal areas (e.g., installation of breakwaters and seawalls)
		Select installation sites in accordance with land use plans that take climate change into account
		Identification of the range of climate change potential scenarios projected during the life of infrastructure facilities and development of policies to address them

5.7. Infrastructure: Hydropower

5.7.1. Climate Risk for Hydroelectric Power Generation

Hydroelectric power accounts for 16% (3,894TWh) of the world's power generation in 2014. According to the International Energy Agency (IEA), as climate change mitigation measures are being promoted in various countries, the share of thermal power plants is decreasing, and low-carbon power sources, especially renewable energy generation, is expected to increase. Hydroelectric power generation is projected to contribute most to low-carbon power generation, it is expected to account for 6,891TWh (20% of global power generation) to 5,984TWh (14% of global power generation) in 2040, and demand for hydroelectric power generation is projected to expand in the future.[15]

The impacts of climate change are expected to be climate hazards that affect the water cycle, such as changes in precipitation patterns and surface waters, and changes in the frequency and intensity of thermal waves and droughts, and may have negative impacts on hydroelectric projects. The impacts of climate change on precipitation patterns and temperature changes on hydroelectric power projects can be roughly divided into evaporation of surface water, reduction of runoff due to drought, increase of runoff due to flooding, and inflow of sediment and sand (ADB, 2012). Simulation results of the impact of heat waves on global hydroelectric power have reported that in the mid-century (2040-2069), 86% of hydroelectric power plants forecast a significant decrease in power supply capacity. According to the study, the most affected areas of hydropower plants are Australia, and South Africa and Europe. A decrease in power generation capacity may lead to social impacts such as an increase in electricity costs and an increase in power outages.[16][17]

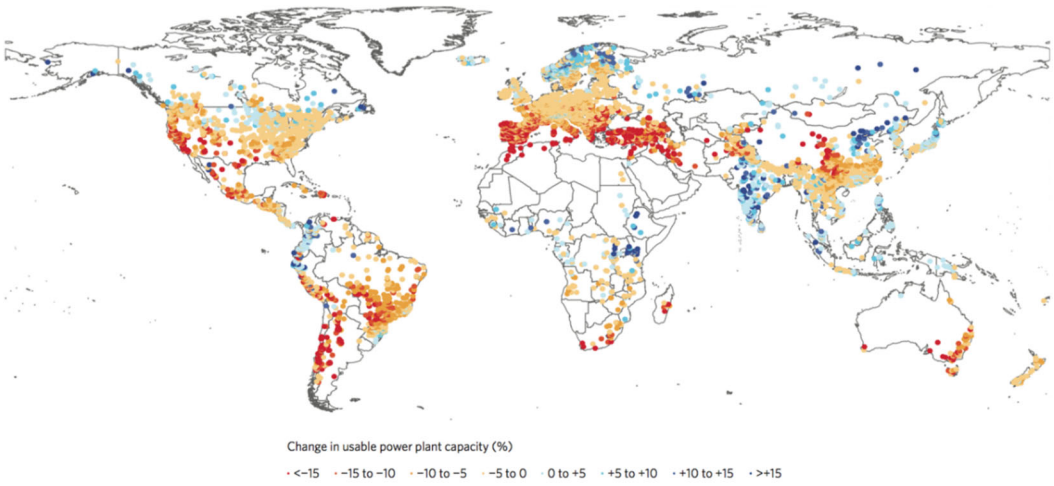


Figure 12 Future projection forecasts of annual usage of hydroelectric power plants due to climate-change and changes in water resource utilization in 2050 in RCP8.5 scenarios

(Source: van Vliet et al. (2016).)

Some of the adaptation measures in hydroelectric power generation are;

- Development of Hydrological Future Forecasting Methods Including Climate Change Impacts and Management and Operation Methods Using the Results
- Formulation of water resource management strategies for the entire watershed, including the downstream environmental and human use of water

[15] International Energy Agency (IEA),2016," World Energy Outlook 2016"
[16] Asian Development Bank(ADB), 2012, "Climate Risk and Adaptation in the Electric Power Sector"
[17] Van Vliet, M. T. H. et al. (2016) Power-generation system vulnerability and adaptation to changes in climate and water resources, Nature Climate Change

- Management/improvement of land upstream of waters to prevent floods, erosion, sediment runoffs, and landslides (including afforestation)
- Cost-effective design (new plant) and renovation (existing plant) for climate risk identified at the site

The useful life of hydroelectric power plants is as long as 50 to 100 years, and it is desirable to understand future weather forecasts affecting operations and power generation, and to consider adaptation measures at an early stage when climate risks are considered to be present.
The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.7.2. Components of the Climate Risk for Hydroelectric Power Generation

Table 56 Example of climate hazards for a project of Hydroelectric Power Generation

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Annual average temperature
	Annual maximum temperature
	Annual minimum temperature
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall amount	Annual rainfall
	Monthly rainfall
	Seasonal rainfall pattern
Torrential rainfall	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Annual maximum T-day rainfall
	Annual maximum T-hour rainfall
Storms	Frequency of storm
	Strength (Wind speed)
Changes in sunlight	Changes in solar irradiance
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 57 Example of exposure for a project of Hydroelectric Power Generation

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Facilities related to power generation etc.	Status/condition of facilities (quantity, capacity)
		Asset values of equipment, etc. (assessed value, etc.)
		Equipment service life (years)
	Water storage/distribution-related facilities	Water storage capacity
		Water storage surface area
		Water catchment surface area
		Quantities/capacity of water intake/discharge facilities
Soft infrastructure	Power generation-related organization/personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Surrounding environment incl. water catchment area	Type of vegetation
		Forest area
		Land uses

Table 58 Example of vulnerability for a project of Hydroelectric Power Generation

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Facilities related to power generation etc.	Site/location
		Ground height
		Ability to maintain operations in response to changes in flow volume
	Water storage/distribution-related facilities	Ground, soil quality, slope conditions around the reservoir
		Sediment buildup
		Location/height of water intake facilities
		Location of installed waste distribution pipes
Soft infrastructure	Ability to maintain and manage power generation and other facilities	Whether or not monitoring/analysis is being done for changes in supply volume of water resources
		Availability of information on climate risk relating to current and future climate change
		Capacity/system to respond to changes in water storage and flow volumes
		Whether or not maintenance/upkeep are being done for equipment/facilities
		Capacity building for personnel to operate/maintain equipment/facilities
	Weather forecasting and forecasting capabilities	Ability to collect/analyze climate-related data and disaster information
		Existence of human resources development programs
	Planning and institutional capacity of relevant organizations for power generation projects	Revised land use and infrastructure design standards
		Whether or not areas have been designated for water source recharge and water resource conservation
		Status of consideration/creation of adaptation plans for extreme weather
		Degree of diversification electrical power source mix
		Consideration/planning for surrounding area and upstream land conservation management (forest conservation to reduce erosion damage, etc.)
		Availability/utilization approaches of early warning systems for extreme weather events (including changes in water supply/demand)
		Whether or not weather risk is being monitored (observation/monitoring of climate risk)
Surroundings	Catchment areas and other surrounding environments	Ability to respond to changes in water resources in water conservation forests and entire water catchment area
		Whether or not water resources management can be implemented for entire water catchment area
		Land uses

Table 59 Example of climate risk for a project of Hydroelectric Power Generation

Object of risk		Examples of climate risks
Hard infrastructure	Facilities related to power generation etc.	Damage/losses to infrastructure equipment due to flooding and glacial lake outbursts
		Decrease in the number of operating days that can fully demonstrate power generation capacity
	Water storage/distribution-related facilities	Increase and decrease in annual total power generation due to droughts and heavy rainfall
		Decrease in the usable life of the reservoir and the life of the facility
		Increased sediment inflow into the reservoir due to soil erosion
Soft infrastructure	Business operation	Increase in costs per power generation (including operating, maintenance, and capital costs) (e.g., $ 49-110/MWh on average)

Surroundings	Downstream	Ecosystem degradation/loss downstream of hydroelectric power plants due to changes in water volume
		Occurrence of water overtopping from the dam (frequency of water flow from the spillway)

Table 60 Example of adaptation measures for a project of Hydroelectric Power Generation

Category		Examples of adaptation measures
Hard infrastructure	Facilities related to power generation etc.	Change the number and type of turbines suitable for projected flow rates
	Water storage/distribution-related facilities	Re-development of dams, including raising of dams
		Maintaining dam functionality by eliminating sediment from the dam
		Construction or augmentation of reservoirs
		Modification of flood discharge elevation rates and introduction of additional flood discharge crests
		Design/build more robust dams/infrastructure facilities
Soft infrastructure	Operation and Planning	Incorporating climate change risk into investment design planning
		Formulate business continuity plan (BCP)
		link multiple dam's operation
		Enhance power generation modeling capabilities under different climate change scenarios
		Development of management and operational rules for hydrological forecasting methods and adaptation measures considering climate change impacts
		Develop basin-wide water use management strategies that take into account the downstream environmental and social environment (human water use)
		Analyze range of climate change projection scenarios over the lifetime (life) of a hydroelectric plant
		Consider improving energy output by creating reservoir management plans that take into account changes in precipitation and river flows
	Designing	Conduct site selection/design in consideration of future hazards
		Raise the reservoir level of the dam if inflows are projected to increase. Build a smaller dam further upstream (restructuring the capacity of the dam complex)
		Design for increased inflows to dams due to glacier melt
	Role of Administrative Agencies	Collection of climate-related data and disaster information
		Strengthen implementation of equipment and facility maintenance management
		Strengthening the maintenance and management capacity of staff
		Ensuring budget for maintenance and human resource development
		Revision of (1) land use planning (not building power plants, substations, and transmission facilities) and (2) infrastructure design standards in light of future intensification of climate hazards.
	System development	Effective utilization of water utilization and flood control capacity by upgrading dam operation methods
		Development of a sewage removal system to ensure continuous operation during heavy rainfall
Surrounding	Improvement of surrounding environment	Implement restoration/improvement/management (including tree planting) of upstream natural environment to reduce flooding, soil erosion, sedimentation, landslides

5.8. Infrastructure: Road sector

5.8.1. Infrastructure: Climate Risk on Road sector

Road infrastructure is vulnerable to freezing and thawing cycles, paved roads are vulnerable to extreme air temperatures, and unpaved roads and bridges are vulnerable to extreme precipitation. In particular, transportation infrastructures on ice or permafrost are highly vulnerable (IPCC AR5). Followings are the example of expected impacts on road sector by Climate Change.

Reduction and destruction of operability of important road infrastructure facilities due to extreme weather

- Closure of roads due to sediment landslides and mud flow into roads, and the consequent social impacts
- Safety deterioration of roads due to inflow of sediment and landslide, and damage to infrastructure. Closure of transportation instruments and reduction in return on investment due to road closures
- Flooding causes river migrations in fans and flooding of roads

Thunderstorm rain and sea level rise in coastal areas

- Progression of corrosion due to increased salinity
- Road erosion, seawater inundation, or seawater influx into groundwater due to increased waves and floods, and the incidence of groundwater flooding associated therewith
- Damage to coastal infrastructure protection equipment, including roads, due to the increase in storm surges and high waves. Induction of collapse of abutments and embankments.

Effects of temperature and precipitation pattern changes

- Deterioration of construction efficiency due to shortage of water supply during construction
- Penetration of water into the filler due to increase in groundwater content and the collapse of roads associated therewith
- Permanent flooding of roads due to surface waters and groundwater flooding (increase water level)
- Damage to bridges due to increased debris flow in the catchment of water

Damage to the infrastructure due to strong winds

- Damage of vertical signs (signs, etc.) due to strong winds
- Increase in accidents and road closures caused by fallen trees

The following are examples of adaptation measures for hard and soft surfaces in the road sector.

Hardware Adaptation Measures

- Rehabilitation of infrastructure to ensure protection, redesign or relocation of road facilities
- Protect roadway corridors by installing physical protection structures such as revetments and levees (such as revetment equipment)
- Introduction of enhanced drainage systems that can cope with heavy rains and flooding
- Consider future temperature changes when selecting asphalt cements and emulsions

Soft adaptive options

- Provides road access to hospitals and shelters, and enables the distribution of medical supplies, especially in emergencies
- Improve early warning systems and hazard maps for floods, storms, and soil engineering risks

When introducing it into the actual target area, consider the technical feasibility, cost-effectiveness,

geographic conditions of the area, and socio-economic characteristics of the population served by the roads.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.8.2. Components of the Climate Risk in the Road Sector

Table 61 Example of climate hazards for a project in the Road sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Torrential rainfall	Frequency of torrential rainfall
Storms	Frequency of storm
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
Changes in sunlight	Changes in solar irradiance
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 62 Example of exposure for a project in the Road sector

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Roads and bridges	Road length, road width
		Traffic volumes
		Road network layout
		Bridge numbers, lengths, clearances
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.

Table 63 Example of vulnerability for a project in the Road sector

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Roads	Road locations, distances from coastlines and steep slopes
		Ground elevations of roads
		Soil moisture levels and soil quality in road vicinity
		Existence of alternative means of transportation/routes, diversity of transportation routes

		Status/presence of drainage ditches
	Bridges	Bridge structures/materials
		Aging condition of bridges
Soft infrastructure	Project-related organization and personnel	Maintenance guidelines and other maintenance factors
		Workforce
		Status/presence of equipment/materials for maintenance/repair

Table 64 Example of climate risk for a project in the Road sector

Object of risk		Examples of climate risks
Hard infrastructure	Roads	Collapse or damage due to ground subsidence or landslides
		Flooded roads due to flooding/submersion
		Decline/deterioration of pavement strength
		Damage/destruction due to forest fires
		Shorter service life
		Overcapacity of the wastewater system (flooding of wastewater)
		Damage or damage to signs, lights, etc.
	Bridges	Decreased stability of bridge deck
		Damage or damage to suspended bridges, signboards, and elevated structures due to changes in wind speed
		Corrosion of metal beams
		Thermal Expansion of Bridge Joints and Paving Surfaces
		Damage/washout of bridge piers/footings
Soft infrastructure	Project-related organization and personnel	Reduced institutional capacity for operations/maintenance of road operations
		Shortage of personnel to respond to roads/bridge damage

Table 65 Example of adaptation measure for a project in the Road sector

Category		Examples of adaptation measures
Hard infrastructure	Infrastructure development	Rebuilding structures for the protection of infrastructure equipment (expressways, roads, underground tunnels, bridges, drainage systems, etc.)
		Redesign or relocation of road facilities
		Building of revetment structures that protect roads such as breakwaters and levees
		Improve drainage capacity to respond to heavy rain and erosion damage
		When asphalt cement and asphalt emulsion are selected, future temperature change prediction is taken into consideration.
		Ensuring road access to hospitals and shelters, and enabling the distribution of medical supplies, especially in emergencies.
Soft infrastructure	System and design	Predict vulnerabilities and weather risk impacts when developing a master plan for road construction.
		Ensure adequate road space to serve as a buffer area for floods, droughts, and other extreme weather.
		Introduction of early warning system on flood, storm, and ground structure risk, improvement of hazard map

5.9. Infrastructure: Railway sector

5.9.1. Infrastructure: Climate Risks in Railway sector

In Japan, in recent years, there have been cases in which meteorological conditions have a great influence on the operation of railways, such as the implementation of planned suspension of operation of railways at the time of a typhoon attack and flooding of vehicle bases. In the railway business, weather conditions such as wind speed, rainfall, temperature, and humidity affect train operations and their safety, comfort, maintenance and management, the number of passengers, and revenues from the business. The impact of climate change on railway operations needs to be investigated by combining the components constituting the system, such as railway equipment, with various climate factors (temperature, rainfall, wind, lightning, snowfall, etc.) related to them. Climate change may also capture not only risks but also opportunities for the railway business in question. Examples of impacts of climate change on railway operations include the following.

- The railway line is destroyed, covered by sediment, and the embankment collapses (heavy rain, flood, snowfall, etc.)
- Failure of signal systems, communication and power systems (flooding, freezing, lightning strikes, etc.)
- Vehicle failure (flood flooding, abnormally high temperature, snowfall, etc.)
- Damage to buildings such as station buildings (flooding, destruction by strong winds, etc.)
- Derailment and rollover of trains (impacts on railway lines due to floods, strong winds, high waves, landslides, and high temperatures)
- Increase in maintenance and management costs (e.g., increase in electricity consumption due to increase in average air temperature)
- Suspension of train operation and disturbance of the timetable (heavy rain, strong wind, snowfall, flood, fog, lightning, etc.)

Railways in Japan are moving along with disasters, and various technologies from project planning to operation, systems, and standards have been studied and accumulated. The assessment of climate-risk in the target JICA projects should also be carried out while referring to the viewpoints that have been examined in the experiences of disaster response in the railway projects in Japan.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.9.2. Components of the Climate Risk in the Railway sector

Table 66 Example of climate hazards for a project in the Railway sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Torrential rainfall	Frequency of torrential rainfall
Storms	Frequency of storm
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
Changes in sunlight	Changes in solar irradiance
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 67 Example of exposure for a project in the Railway sector

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Railway track components (tracks, berths, sheds, railcar inspection/repair facilities, operational safety equipment, substation electrical conduits, railway crossings, etc.)	Status/condition of facilities (length, quantities, capacities)
		Asset values
	Railcars	Quantities, specifications
		Asset values
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Users (passenger, freight)	Rail user volumes
		Rail cargo volumes

Table 68 Example of vulnerability for a project in the Railway sector

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Railway track components (tracks, berths, sheds, railcar inspection/repair facilities, operational	Locations of various facilities, distances from coastline and steep slopes
		Ground elevations
		Soil quality and slope gradient
		Resilience to climate hazards for each type of facility

	safety equipment, substation electrical conduits, railway crossings, etc.)	Status of installation and capacity of wastewater equipment, air-conditioning systems, etc.
		Whether or not systems are in place to monitor damage at various facilities
		Preparedness of systems for continuous operation in the event of extreme weather (e.g. emergency power supply, etc.)
	Railcars	Railcar durability and service life
		Status of heating/cooling equipment installation
		Operational performance in extreme weather
		Equipment ability to deal with hotter temperatures and changes in precipitation patterns
Soft infrastructure	Project-related organization and personnel	Status of disaster response plans
		Status of railway operators' enrolment in disaster insurance for extreme weather, etc.
		State of know-how (e.g., BCP) to continue operations in event of extreme weather
		Whether or not there are weather monitoring systems in place
		Status of preparation of response manuals, etc. in the event of extreme weather
		Diversity of alternative connection/transportation options in event of an emergency
Surroundings	Users (passenger, freight)	Status of heating/cooling equipment installation
		Response plans and systems in the event of extreme weather

Table 69 Example of climate risk for a project in the Railway sector

Object of risk		Examples of climate risks
Hard infrastructure	Railway track components (tracks, berths, sheds, railcar inspection/repair facilities, operational safety equipment, substation electrical conduits, railway crossings, etc.)	Increase in flood damage of infrastructure equipment and vehicles
		Buckling of railway tracks
		Damage to drainage systems, tunnels and bridges
		Damage to guidance signs such as catenaries and traffic lights
		Damage to electric wires and cables
		Damage of fallen trees on trucks and overhead lines
	Railcars	Reduced service life
		Railcar damage due to natural disasters
Soft infrastructure	Project-related organization and personnel	Delay of railway, suspension of operation
		Increase in lost services and lost goods handled by staff and passengers (due to flood damage to trucks and reduced access to transportation)
		Damage to railway facilities/railcars, economic losses due to suspension of rail operations
		Increased cost of dealing with damage and accidents due to extreme weather
		Increase in maintenance operations and personnel costs
		Thermal stress to workers/passengers by extreme weather events
		Damage to the surrounding supply chain network due to railway operation restrictions/interruptions
Surroundings	Users (passenger, freight)	Stress, risk to life for passengers/staff due to extreme weather
		Cargo shipment stoppages

Table 70 Example of adaptation measure for a project in the Railway sector

Category		Examples of adaptation measures
Hard infrastructure	Railway track components (tracks, berths, sheds, railcar inspection/repair facilities, operational safety equipment, substation electrical conduits, railway crossings, etc.)	Construction of slope stabilizing structure on slope
		Realignment of railway routes or route changes (including tunnel routes)
		Installation and operation of equipment capable of detecting slope collapse and debris flow, and introduction of a system for transmitting information to temporarily stop traffic
		Install/upgrade heating and cooling equipment
		Install/upgrade wastewater facilities
		Flood Prevention Measures at the Subway Entrance
		Installation and operation of evacuation guidance systems under the ground
		Repair of steel bridges
	Railcars	Installation and enhancement of air conditioning facilities
		Introduce more robust railcars
		Manufacture railcars with standard specs (to improve ease of railcar substitution/replacement)
		Enforcement of regular maintenance to maintain quality
Soft infrastructure	Project-related organization and personnel	Preparation of hazard maps and notification to government agencies and railway users.
		Introduction and operation of emergency response guidance that identifies detours and alternative means of operation
		Implement detailed vulnerability mapping of infrastructure facilities and railway track locations
		Implement detailed vulnerability mapping of infrastructure facilities and railway track locations
		Strengthening monitoring of weather conditions and monitoring of infrastructure equipment conditions
		Create a GIS-based extreme weather alarm system and weather forecast map
		Establish weather emergency response plans with multiple railway operators and multiple transportation companies

5.10. Infrastructure: Airport

5.10.1. Infrastructure: Climate Risks at Airports

Airports in developing countries can be found in various settings (mountains, flatland, coastal areas, island countries, etc.), so it is crucial to first understand the airport siting conditions in order to conduct a climate risk assessment. Climate change impacts in the airport sector reflect these differences in siting conditions, and could include many come in many forms, such as decreased safety of airport operations due to changes in rainfall and rainfall patterns and stronger winds, and flood damage and impacts to infrastructure facilities at airports close to sea level on islands and coastal areas, due to sea-level rise. For airports located near the coast, it is also important to read the ports section below.

Sea level rise and flood damage

According to the International Civil Aviation Organization (ICAO), there are more than 40 airports located below the sea level 3m worldwide, and flooding damage to airports can occur as climate-related sea-level rises and rainfall increases. Countries such as the Netherlands and Bangladesh where the entire country is located at a low sea level are not limited to airports, but are also expected to be affected by flooding throughout the country. At airports located in these locations, runways and taxiways may not be available at high tides, or may not be available per se. In addition, it may affect traffic access operations such as terminal buildings, aprons, access roads, and rails. In airports sited near rivers, flood damage can occur due to torrential rains and changes in rainfall patterns. In areas where rainfall is reduced, potential risks include the possibility that rainwater will not be sufficient for airport operations, disruptions may occur due to reduced visibility from dust, and equipment/facilities could be damaged by dust.
Since the design life span of terminal buildings exceeds about 50 years and runways exceed about 100 years, it is desirable to evaluate the risks caused by climate change in the planning of infrastructure facilities with a view to 50 to 100 years from now. In areas where rainfall is decreasing, the supply of rainwater required for airport operations may be insufficient, dust damage may increase, and the resulting confusion may arise.

Change in average temperature

Changes in mean air temperature, such as elevated temperatures, may result in limitations on the effective load of the aircraft at elevated temperatures, the need for long runways for long-distance flight, increased noise damage associated with increased rising rates, and increased cooling demands for airports and air conditioning equipment within the aircraft.

As described above, climate risks related to airports may have various impacts, such as impacts on passenger demand due to seasonal changes, shifts in tourist sites, increased infrastructure costs such as protection equipment at airports in coastal areas, increased air conditioning costs, and airport closures.

Also, international airports on small islands are mostly coastal or within a few kilometers of the coast, and the road network, which is the ground access to the airport, often runs along coastal coasts. Under climate change sea-level rise scenarios, many of them may be affected by flooding, flooding, and physical damage associated with coastal flooding and erosion.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used as a reference from the viewpoint of consideration when appropriate.

5.10.2.Component of Climate Risk in the Airport Sector

Table 71 Example of climate hazards for a project in the Airport sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Changes in temperature (Annual, Monthly, daily)
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall	Annual rainfall
	Monthly rainfall
Fog	Frequency of fog
Torrential rainfall	Frequency of torrential rainfall
Storms	Frequency of storm
Wind	Change of wind speed
	Prevailing wind
	Change in wind direction characteristics
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise

Table 72 Example of exposure for a project in the Airport sector

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Airport-related facilities (runways, parking lots, control facilities, passenger facilities, warehouses, logistics facilities, drainage facilities, etc.), access facilities (road, rail)	Size of each structure/facility (numbers, specs)
		Asset value of each facility (assessed value)
	Equipment, etc. (cargo handling machinery, vehicles, etc.)	Size of each structure/facility (numbers, specs)
		Asset value of each facility (assessed value)

Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Passengers	Number of airport users
	Aircraft, cargo	Cargo Volume
		Cargo type

Table 73 Example of vulnerability for a project in the Airport sector

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Airport-related facilities (runways, parking lots, control facilities, passenger facilities, warehouses, logistics facilities, drainage facilities, etc.), access facilities (road, rail)	Location, topography (coast, estuary, river), and geology
		Ground height of site
		Status/condition of breakwaters, protection
		Deterioration status of coastal conservation facilities and port facilities, frequency of repairs
		Installation and operational status of wastewater facilities
		Presence of refrigeration and cold storage facilities
		Road network in port area (resilience to rainfall and high-temperature damage)
		Monitoring of tide levels/ground levels
		Availability of radar or other support systems for aircraft takeoff/landing, etc
	Equipment, etc. (cargo handling machinery, vehicles, etc.)	Locations/siting of facilities
		Ground elevations
		Durability of equipment, etc.
Soft infrastructure	Project-related organization and personnel	Status of disaster response plans (BCP, etc.)
		Whether or not there are weather monitoring systems in place
		Preparedness of systems for continuous operation in the event of extreme weather (e.g. emergency power supply, etc.)
Surroundings	Passengers	Status of heating/cooling equipment installation
		Response plans and systems in the event of extreme weather
	Aircraft, cargo	Whether or not there are reinforcement measures to secure cargo
		Cargo storage and management systems

Table 74 Example of climate risk for a project in the Airport sector

Object of risk		Examples of climate risks
Hard infrastructure	Airport-related facilities (runways, parking lots, control facilities, passenger facilities, warehouses, logistics facilities, drainage facilities, etc.), access facilities (road, rail)	Equipment damage, water/flood damage
		Structures, pavement/buildings, containers, cargo, etc. being washed away
		Increase in corrosion rate of port structures (due to increase in mold, mycotococin, mites, etc. due to increase in rainfall)
		Poor visibility due to increased rainfall or mist
		Delays/cancellations of flight departures/arrivals due to poor visibility
		Delays/cancellations of flight departures/arrivals due to strong winds exceeding cross-wind limits
		Heat-caused degradation/warping of airport pavement and concrete facilities
		Exceeding the standards of the drainage system
		Reduced or halted airport/logistics functions
		Stoppages of passenger or cargo flows due to damage to access facilities
		Damage to aircraft

	Equipment, etc. (cargo handling machinery, vehicles, etc.)	Damage caused by overturned cargo handling machinery
		Loss of radar and radio equipment
		Constraints imposed on range of vehicle/rail mobility range on airport grounds (due to rainfall intensity exceeding drainage design standards, flooding, etc.)
Soft infrastructure	Project-related organization and personnel	Delays and suspension of port and harbor operations
		Delays or stoppages in business operations, increased insurance costs related to business operations
		Decreased customer confidence in services
		energy costs increasing
		Stoppage of human flow and logistics due to airport closure
		Human casualties and health hazards due to flooding, heat waves, etc.
		Decreased occupational safety (increased slip and fall accidents)
Surroundings	Passengers	Stoppage of human flow and logistics due to airport closure
		Inundation, heat waves, etc., resulting in human suffering and health hazards
	Aircraft, cargo	Container and other cargo spills
		Cargo damage/losses due to flooding, high temperatures, etc.

Table 75 Example of adaptation measure for a project in the Airport sector

Category		Examples of adaptation measures
Hard infrastructure	Airport-related facilities (runways, parking lots, control facilities, passenger facilities, warehouses, logistics facilities, drainage facilities, etc.), access facilities (road, rail)	Establish disaster prevention/resilience standards based on airport's importance
		Build/upgrade structures giving consideration to future natural hazards
		Enhanced drainage system
		Install navigation support systems to enable take-off/landing even in adverse weather conditions
		Monitoring of weather and marine conditions
		Forecasting and providing information on the impact of storm surge and high waves
		Raise road surface level to reduce risk of flooding
		Review design strength of pavement and concrete facilities
	Equipment, etc. (cargo handling machinery, vehicles, etc.)	Take measures to secure aircraft/equipment and prevent tipping
Soft infrastructure	Project-related organization and personnel	damages associated with climate change and enhancements to prevent disasters from occurring)
		Monitoring of waves and sea level
		Disaster risk assessment and dissemination through hazard maps, etc.
		Consideration of the optimal renewal of facilities, etc., taking life cycle costs into account
		Improvement of local disaster preparedness through councils and other organizations
		Provide climate change training within businesses
Surroundings	Passengers	Develop evacuation plans and conduct training
		Improve local disaster resilience through committees and organizations
	Aircraft, cargo	Promote measures to secure/stabilize containers, etc.

5.11. Infrastructure: Ports and harbors

5.11.1. Infrastructure: Climate Risks in Port and Harbor Sector

Besides being located on coastlines, ports in developing countries can also be found in various other settings, such as inland as river ports and as ports on island countries, so it is crucial to first understand the port siting conditions. In addition, ports serve as the infrastructure forming the basis for logistics and supply chains for various industries, so attention must be paid to the roles and functions of these ports when considering climate change impacts in the port sector. For example, the focus of impact assessments will be different for a country's prominent and major ports that handle large volumes of container traffic, ports mainly for passengers and/or tourists, and smaller regional ports.

Climate change projections relating to ports: Since ports and harbors are the infrastructure that will serve as the base of the logistics supply chain for various businesses, it is desirable to evaluate climate risks while considering the roles and functions of the target ports and harbors when considering the impact of climate change in the port and harbor sector. According to the IPCC's Sixth Assessment Report, "rising air temperature and sea temperatures" and "rising sea levels" are projected and it is almost very likely that mean sea level will continue to rise during the 21st century. It is feared that the coastal areas will be affected by an increase in strong typhoons (i.e., an increase in wind speed, an increase in high tide anomalies, and an increase in wave strength) and an increase in tide level, respectively. The Ministry of Land, Infrastructure, Transport and Tourism's "Impact of Climate Change and Direction of Adaptation in Coastal Areas (Ports and Harbors)" compiled in 2015 considers the hazards and impacts in ports and harbors as follows.

Increased tidal anomalies and waves: IPCC's Sixth Assessment Report anticipates factors affecting tropical cyclones, cyclones development and power maintenance, such as an increase in global mean temperature and sea temperature. It is necessary to examine the impact on ports and harbors, since the increase of strong typhoons and the like will affect the increase of storm surges and waves.

Sea level rise: When sea level rise becomes apparent, it is assumed that the coastal areas (ports and harbors) will be greatly affected. Therefore, it is necessary to consider the impact on ports and harbors while monitoring changes in coastal sea level and also considering the maximum sea level rise. The increase in global mean sea level likely to occur by 2100 compared to the 1995-2014 average ranges from 0.32 to 0.62 m under the low GHG emissions scenario (SSP1-2.6) and from 0.44 to 0.76 m under the moderate scenario (SSP2-4.5) m, and 0.63 to 1.01 m under the very high scenario (SSP5-8.5).[18]

Impact of climate change on coastal areas (ports and harbors) due to factors affecting coastal areas (ports and harbors)

- **Seawalls and breakwaters:** Damage to breakwaters and breakwaters due to wave heights and tidal anomalies exceeding design conditions is still occurring. It is feared that further damage will increase with the increase of high waves and tidal deviations under climate in the future.
- **Calmness :** If a breakwater is damaged, the calmness in the port deteriorates, and there are concerns about deterioration of port functions (lowering of cargo handling capacity utilization rate), stagnation of logistics, and adverse effects on the economy until the breakwater is restored. In addition, even under normal conditions, changes in wave height, direction, and frequency can adversely affect the wave calmness level within a port, with negative impacts on ship docking

[18] Based on the IPCC Sixth Assessment Report, Working Group I Summary for Policymakers Tentative Translation (Ministry of Education, Culture, Sports, Science and Technology and Japan Meteorological Agency)

and reductions in cargo handling efficiency.

- **Loading area and industrial land (outside levee):** Considering the increase of strong typhoons and the rise of sea level at the same time (simulation of storm surge inundation when a typhoon of the scale of a room typhoon arrives when the sea level rises by 0.82m), the depth of flooding outside levee will greatly increase, and damage to industrial and logistics functions may be expanded. Even if the depth of immersion is several 10cm, it takes considerable time to recover if the power section of the cargo handling machine is immersed, and if it is an empty container, it floats at a depth of several 10cm . Therefore, it is feared that this would have a significant impact on the cargo handling and industrial sites (outside the levee).
- **In-levee land:** As external force increases due to climate change, the flood area and average flood depth rapidly increase, and the growth is larger than that of the outside levee.
- **Cargo handling machines:** Increases in strong typhoons and storms are expected to increase wind speeds and may cause disasters due to runaway.
- **Vessel routes and moorages/anchorages/berths:** Increases in precipitation and river runoff associated with climate change may increase the amount of sediment supplied from rivers, which may increase the amount of sediment sediment deposited on river routes and accommodations in estuaries. Increased sea level may cause changes in waves and flows in tidal flats and shallow lands, and may affect sediment transportation trends in tidal flats and shallow lands and burial of sea routes and stays. In ports and harbors in the open ocean, the increase in wave height at the time of timely changes due to typhoons and low atmospheric pressure may cause changes such as deepening of the travel limit water depth, resulting in burial of the sea routes, etc. due to increased sediment movement.

Factors determining impacts on river ports based on climate change impacts on rivers and inland regions.

- **River levels:** There are concerns that port and logistics functions will be impaired by the inability of ships to navigate if river levels rise and fall frequently due to floods and drought.
- **Vessel routes and moorages/anchorages/berths:** There are concerns that changes in rivers could interfere with vessel navigation, such as lower water levels in rivers and changes in sediment supply altering water depths and the shape of river bottoms.

In addition, changes in the area of tidal flats and shallow lands and the decrease in undergirder spatials of floodgates and bridges due to increase sea level are also considered to be concerns. As adaptation measures for climate change impacts, various adaptation measures can be considered, such as the development of structures that take into account future external natural forces, the setting of protection levels according to the importance of the background, assessment of disaster risks, and dissemination through hazard maps.

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. However, as previously stated, the considerations will vary depending on the port location, size and functions. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed that these tables will be used for reference as appropriate when conducting climate risk assessments.

5.11.2. Component of the Climate Risk in the Port and Harbor Sector

Table 76 Example of climate hazards for a project in the Port and Harbor Sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Changes in temperature (Annual, Monthly, daily)
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall	Annual rainfall
	Monthly rainfall
Fog	Frequency of fog
Torrential rainfall	Frequency of torrential rainfall
Storms	Frequency of storm
Wind	Change of wind speed
	Prevailing wind
	Change in wind direction characteristics
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves(timing, scale)
	Sea-level rise
	Changes in tidal variation (increased range)
	Wave changes (intensification), (wave height, wave direction, wave frequency)

Table 77 Example of exposure for a project in the Port and Harbor Sector

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Port-related facilities (quays, seawalls, cargo areas/equipment, warehouses, logistics facilities, drainage facilities, etc.), port area transportation facilities (roads and bridges)	Size of each structure/facility (numbers, specs)
		Asset value of each facility (assessed value)
	Moorages/anchorages/berths, vessel routes	Water depth
		Surface area
		Length
	Facilities, etc. (cargo handling equipment, vehicles, etc.)	Size of each facility (numbers, specs)
		Asset values of equipment/facilities (assessed value, etc.)
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.
	Port users	Number of users, timing of use, frequency of use, etc.

Surroundings	Port cargo	Volume handled, cargo type, etc.
	Tidal flats, seagrass beds, sandy beaches	Location, size, etc.

Table 78 Example of vulnerability for a project in the Port and Harbor Sector

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Port-related facilities (quays, seawalls, cargo areas/equipment, warehouses, logistics facilities, drainage facilities, etc.), port area transportation facilities (roads and bridges)	Location, topography (coast, estuary, river), and geology
		Status/condition of breakwaters, protection
		Deterioration status of coastal conservation facilities and port facilities, frequency of repairs
		Ground height of site
		Installation and operational status of wastewater facilities
		Whether or not design methodologies for breakwaters/seawalls/embankments are based on predicted wave heights and/or high tide variation
		Presence of refrigeration and cold storage facilities
		Road network in port area (resilience to rainfall and high-temperature damage)
		Monitoring of tide levels/ground levels
		Insufficient clearance under bridges
	Moorages/anchorages/berths, vessel routes	Locations of moorages/anchorages/berths, vessel routes
		Length
		Water depth
		Maintenance and management systems related to dredging, etc.
	Facilities, etc. (cargo handling equipment, vehicles, etc.)	Locations/siting of facilities
		Ground elevations
		Durability of equipment, etc.
		Features/functions
		Aging condition
Soft infrastructure	Project-related organization and personnel	Status of disaster response plans (BCP, etc.)
		Whether or not there are weather monitoring systems in place
		Preparedness of systems for continuous operation in the event of extreme weather (e.g. emergency power supply, etc.)
Surroundings	Port users	Status of heating/cooling equipment installation
		Response plans and systems in the event of extreme weather
	Port cargo	Whether or not there are reinforcement measures against torrential rains, flooding, etc.
		Whether or not there are reinforcement measures to secure cargo
		Cargo storage and management systems
	Tidal flats, seagrass beds, sandy beaches	Changes in area covered, vegetation

Table 79 Example of climate risk for a project in the Port and Harbor Sector

Object of risk		Examples of climate risks
Hard infrastructure	Port-related facilities (quays, seawalls, cargo areas/equipment, warehouses, logistics facilities, drainage facilities, etc.), port	Equipment damage, water/flood damage
		Erosion/washing away of structures, pavement, and buildings, etc.
		Increase in corrosion rate of port structures (due to increase in mold, mycotococin, mites, etc. due to increase in rainfall)

	area transportation facilities (roads and bridges)	Reduced water calmness due to changes in wave heights, damage to breakwaters, etc.
		Extended flood conditions due to lack of drainage capacity
		Reduced or halted port/logistics functions
		Vessel traffic impossible due to reduction of undergirded space
	Moorages/anchorages/berths, vessel routes	Sediment buildup in moorages/vessel routes, and insufficient water depth
	Facilities, etc. (cargo handling equipment, vehicles, etc.)	Truck buckling of port railways
		Increased opportunities for delays and shutdowns in the operation of port cargo handling machines
		Runaway of port cargo handling machines (container cranes, etc.) due to strong winds and thunderstorms
		Damage to Navigation System and Communication Equipment in Ports and Harbors
		Increase in cryopreservation due to an increase in temperature
		Increased opportunities for delays and shutdowns in the operation of port cargo handling machines
		Restrictions on the range of transportation of vehicles/harbor railways in ports (when rainfall intensity exceeds the drainage design standard, flood occurs, etc.)
Soft infrastructure	Project-related organization and personnel	Reduced cargo handling efficiency
		Increase in insurance costs pertaining to the operation of port and harbor businesses
		Decreased reliability of port services from customers
		Increase in energy costs (due to increased refrigeration associated with increased air temperature)
		Decreased market access in neighboring areas due to port closures
		Increase in transportation costs in and outside ports and harbors
Surroundings	Port users	Danger and adverse health impacts due to overtopping waves, flooding, heat waves, etc.
		Decrease in occupational safety (increase in slippage and falling accidents)
	Port cargo	Container/cargo instability
		Cargo damage/losses due to flooding, high temperatures, etc.
	Tidal flats, seagrass beds, sandy beaches	Loss of shallow areas and tidal flat area due to changes in sea level and wave conditions Impacts on ecosystems

Table 80 Example of adaptation measure for a project in the Port and Harbor Sector

Category		Examples of adaptation measures
Hard infrastructure	Port-related facilities (quays, seawalls, cargo areas/equipment, warehouses, logistics facilities, drainage facilities, etc.), port area transportation facilities (roads and bridges)	Establishment of protection levels according to the importance of the backgrounds
		Construction of structures that take into account future external natural forces
		Maintenance of the functions of mooring facilities and breakwaters (review of external forces and breakwaters cross sections, etc.)
		Strategic improvements in coastal protection facilities, considering locations with high disaster risk and past renewal timing
		Improve drainage systems

		Securing drainage functions in cooperation with related organizations/bodies
		Monitoring of weather and sea weather,
		Forecasting and providing information on the effects of storm surges and surges
		Bottom-up of road facilities for flood countermeasures
	Moorages/anchorages/berths, vessel routes	Dredging/sedimentation prevention of the vessel routes, etc.
		Monitoring of waves and sea level
		Forecasting and providing information on the effects of storm surges and surges
		Signage/designation of no-go zones and times
		Preventive/mitigative measures against sediment buildup in vessel routes/moorages by dredging, jetties, etc.
	Facilities, etc. (cargo handling equipment, vehicles, etc.)	Anti-sway measures for cranes in strong winds
		Use of privately-owned facilities (parapet walls, terminals, warehouses, greenspace, etc.)
Soft infrastructure	Project-related organization and personnel	Establishment and expansion of the Port Business Continuity Plan (Port and Harbor BCP) (reviewing possible damages due to climate change, and adding assumptions on situations where it is difficult to continue port and harbor functions due to strong winds, waves, and other factors that do not lead to disasters)
		Monitoring of waves and sea level
		Establishment of Climate Change Risk Assessment Method and Utilization to Port and Harbor BCP
		Consideration of the idea of optimal renewal, etc. in consideration of life cycle costs
		Improvement of Disaster Prevention Capabilities in Local Communities through Organizations such as Councils
		Implementation of Climate Change Training in Business Companies
Surroundings	Port users	Develop evacuation plans and conduct training
		Improve local disaster resilience through committees and organizations
	Port cargo	Promote measures to secure/stabilize containers, etc.
	Tidal flats, seagrass beds, sandy beaches	Monitoring of waves and sea level
		Forecasting and providing information on the effects of storm surges and surges
		Develop quantitative assessment methods for disaster risk reduction functions of coastal ecosystems

5.12. Infrastructure: Industrial Area

5.12.1. Climate Risk in Industrial Area Sector

The major flood that occurred in the Chao Praya River in Thailand in 2011 flooded seven major industrial areas (industrial zones), where many manufacturing facilities of Japanese companies were located, resulting in more than 800 deaths and more than $40 billion in economic damage. In particular, these industrial parks played a part in the world's supply chain, and the central of the supply chain due to inundation had a major impact on the world economy, especially in the manufacturing industries such as hard disk drives, cameras, and automobiles. Private businesses have been taking measures to avoid and mitigate the impact of natural disasters on foreign business activities, but it is projected that large-scale disaster risks due to climate change will increase in the future. For this reason, it is necessary to accurately evaluate the impact of interruptions in the global supply chain caused by disasters, etc. and to take appropriate measures.[19]

Climate change impacts on industrial parks have direct impacts and indirect impacts on other systems outside the industrial park, as follows. It is necessary to consider not only the impacts that occur only in industrial parks, but also the effects of related infrastructure and services outside industrial parks, such as logistics and energy supply. In addition, the vulnerabilities of the industry sectors themselves to which businesses operating in industrial parks belong may have an impact.

Table 81 Direct and Indirect Impacts of Climate Change on Industrial Areas

Direct and indirect	Examples of the impacts
Direct influence	・ Facilities and infrastructure within industrial parks are affected by floods and storms (e.g., damage to infrastructure such as private roads, buildings, water, and electricity). ・ Working environment of employees is affected by the rise in average temperature
Indirect impacts	・ Energy suppliers and suppliers of materials to industrial parks are affected (e.g., abnormally high temperatures and flooding cause the system of electricity suppliers outside the industrial park to stop, reducing production within the industrial park).

Potentially affected by hazards

For example, the following may be influenced by hazards in and out of industrial areas.

- Sites for industrial areas (location, site planning, etc.)
- Infrastructure services related to industrial areas (water supply, power supply, wastewater treatment, waste management, etc.) Business operators operating in industrial areas (production, etc. of products of business operators located on the premises)
- Products produced in industrial areas (such as products stored on the premises)
- Distribution (distribution of products produced in industrial areas, etc.)
- Employees working in industrial areas

The following tables provide examples of parameters for each category, as a reference for climate risk assessments for JICA projects in each sector. Note that it is not necessary to cover all items listed here, and this is not an exhaustive list. Based on the characteristics of each project, it is assumed to be used

[19] "Policy on Scientific Knowledge and Climate Risk Information for the Promotion of Climate Change Adaptation Measures (Interim Report)," March 2017, Subcommittee on Climate Change Impact Assessment, Global Environment Subcommittee of the Central Environment Council

as a reference from the viewpoint of consideration when appropriate.

5.12.2. Components of Climate Risk in the Industrial Area Sector

Table 82 Example of climate hazards for a project in the Industrial Area Sector

Category	Examples of items to check and consider for current numbers and future projections, etc.
Changes in temperature	Changes in temperature (Annual, Monthly, daily)
Heat waves, cold waves	Annual average temperature
	Monthly average temperature
	Timing/duration of heat wave/cold waves (timing, duration, scale)
Changes in rainfall	Annual rainfall
	Monthly rainfall
Fog	Frequency of fog
Torrential rainfall	Frequency of torrential rainfall
Storms	Frequency of storm
Wind	Change of wind speed
	Prevailing wind
	Change in wind direction characteristics
Flood, inundation	Annual rainfall
	Monthly rainfall
	Daily rainfall
	hour rainfall
	Peak flow of rivers
	Maximum annual flood flow
	Flood occurrence (timing, duration, scale)
Drought, Water shortages	Annual average temperature
	Monthly average temperature
	Number of rainless days
	Monthly Rainfall Change
	Drought, water shortage occurrence (timing, duration, scale)
landslide	Monthly rainfall
	Daily rainfall
	hour rainfall
	Accumulated rainfall
	Snake Curve
Storm surges, high waves	Occurrence of storm surges, high waves (timing, scale)
	Sea-level rise

Table 83 Example of exposure for a project in the Industrial Area Sector

Object of exposure		Examples of items to survey and confirm
Hard infrastructure	Industrial park infrastructure, related facilities, etc.	Size of each structure/facility (numbers, specs)
		Asset value of each facility (assessed value)
Soft infrastructure	Project-related organization and personnel	Size of organization (personnel numbers, structure), roles, etc.
Surroundings	Companies/occupants in industrial parks	Tenant businesses in industrial parks
	Workforce at industrial parks	Numbers of workers at industrial parks

Table 84 Example of vulnerability for a project in the Industrial Area Sector

Vulnerability to be considered		Examples of items to confirm and consider
Hard infrastructure	Industrial park infrastructure, related facilities, etc.	Location (distance from coastline, river, etc.), ground height
		Resilience to climate hazards for each type of facility/equipment

		Status/development of drainage systems
		Installation of disaster prevention equipment, such as water-block plates, fire-prevention facilities disaster prevention equipment
Soft infrastructure	Project-related organization and personnel	Existence of industrial sector zoning plans in accordance with environmental conditions
		Degree of planned rainwater drainage system setup and maintenance implementation
		Design and construction of buildings with appropriate lightning strike countermeasures
		Level of understanding of climate change, etc.
		Response system (including personnel, etc.) in the event of extreme weather events, etc.
Surroundings	Companies/occupants in industrial parks	Understanding of climate change, etc.
		Status of BCP formulation for climate change and extreme weather.
		Response systems (including personnel) in the event of extreme weather, etc.
		Financial capacity to tackle climate change and extreme weather, etc.

Table 85 Example of climate risk for a project in the Industrial Area Sector

Object of risk		Examples of climate risks
Hard infrastructure	Infrastructure and related equipment in industrial parks	Damage or damage to roads and storage facilities due to floods, high temperatures, etc.
		Flooding of buildings
		Overload of the wastewater treatment system, exceeding the allowable amount
		Deterioration of coastal erosion in port and harbor facilities (such as quays, breakwaters, quays, and tidal levees)
		Unable to pass through connected roads from wharf or wharf
		Short-circuiting of the underlying electrical equipment
		Clogging of drainage outlets due to storms and storms
		Flooding of equipment and tanks and floatation above the water surface
		Diffusion of contaminated soil and substances due to floods, etc.
		Damage or damage to wharfs and port infrastructure due to increased tidal levels of rapidly moving seawater and rivers
		Increase in corrosion rates due to flooding, flooding, and elevated temperatures
		Changes in thermal stress and radiation stress due to temperature listing
Soft infrastructure	Project-related organization and personnel	Increased costs due to the need for more repair/refurbishment of facilities/equipment, maintenance frequency, reinforcement
		Increased maintenance costs
		Increased insurance costs
Surroundings	Tenant businesses	Disaster for business tenants in industrial parks
		Adverse human impacts on industrial park grounds
		Water damage from flooding and heavy rains, plant production stoppages due overflow of waste due to water ingress
		Restricted/delayed access to various markets, sales channels from industrial parks
		Insufficient or interrupted raw material supply
		Increased costs due to the need for more repair/refurbishment of facilities/equipment, maintenance frequency, reinforcement
	Workforce at industrial parks	Greater occurrence of natural disasters
		Occurrence of adverse human impacts

	others	The standard for coastal flood protection by existing breakwaters and protection works due to sea level rise and storm will be insufficient.
		Decrease in investment recovery from financial institutions due to the introduction of climate change impacts into the decision-making process
		The supply chain is cut off on a global scale, with the production and supply of major parts delivered to manufacturers around the world stopping.
		Implementation of more climate change questions and response confirmations by insurance underwriters in port and harbor facilities
		Reduction of usable estimates for industrial use (groundwater and surface water)
		Increase in monetary losses due to suspension of business activities such as plant operation and suspension of transportation due to floods
		Decline in productivity and profitability due to ICT losses and turmoil
		Increase in exposure opportunities to mortgage lenders (increase in collateral opportunities for mortgaged liabilities, etc.)
		Increased opportunities and amounts for the insurance industry due to flooding
		Decrease in domestic firms' production due to increased turmoil in the supply chain due to extreme weather.
		Prevalence of new diseases within workers with changes in disease patterns due to climate change
		Increased conflict with vulnerable communities in the vicinity where livelihoods are adversely affected by climate change (e.g., artificial fisheries)
		Changes in national socioeconomic conditions affected by climate change (e.g., increased poverty and anxiety in citizens caused by loss of land and water stress) have a negative impact on the

Table 86 Example of adaptation measures for a project in the Industrial Area Sector

Category		Examples of adaptation measures
Hard infrastructure	Infrastructure development	Construction, introduction, and replacement of buildings and machinery that are resilient to climate change impacts (e.g., waterproofing and flooding measures)
		Relocation of buildings located in places where setback zones are established or where there is concern about the impact
		Introduce and strengthen facilities that protect the most important/expensive equipment and underground facilities (such as underground water pumps and sealed sewers) from flood damage
		Introduction and construction of heat-resistant roofs (such as a 30-degree roof gradient and the use of heat resistant materials) in storage facilities and buildings in industrial parks against storms and high-temperature damage
		Introduction and installation of movable barriers (as countermeasures against floods and strong winds)
		Relocate the ground height of the building to a high location
		Reduction and remodeling of exposure through relocation of critical infrastructure (or movement to high sea level)

		Periodically maintain roads to prevent underground erosion
		Enhancement of building shading, ventilation and cooling functions to lower indoor temperatures. Introduce cooling processes and machines into the production processes of products at ICT facilities and factories.
		Introduction of renewable energy supplies from industrial parks and neighboring areas to ensure sustainable electricity backup in the region and to prevent negative impacts on the grid and other power generation facilities
Soft infrastructure	Water-use	Introduce and develop an appropriate wastewater treatment system with flood countermeasures. (Separation of Rainwater Treatment and Sewage System, etc.)
		Improvement of water storage facilities in industrial parks and the introduction of reuse technology (introduction of small-water irrigation technology (drip irrigation, use of rainwater, reuse of miscellaneous wastewater, etc.) to increase water efficiency in production processes
	Land development	Periodically perform maintenance and cleaning of drainage channels to ensure drainage function
		Greening in industrial parks and expanding the area of water plants in order to suppress the heat island phenomenon
	Disaster Prevention Measures	Measures shall be taken to prevent the leakage of chemical substances and pollutants even in the event of a flood.
		Implement measures to improve, strengthen, and increase the status of securing water sources used in each plant (introduction of water treatment and regeneration systems, etc.)
		Improve disaster prevention functions of storage facilities for hazardous substances
		Establishment and expansion of Business Continuity Plan (BCP) (revision of assumed damage due to climate change, addition of assumptions of situations in which it is difficult to continue port and harbor functions and industrial park functions due to strong winds, waves, etc. although not leading to disasters)
		Review and formulate policies for cooperation with municipalities in the event of disasters (in charge of joint directors, in charge of organizational management, etc.)
	Economic aspect	Increase credit line limit by implementing energy conservation measures
	Policies and regulations	Additional implementation of assessments based on climate change impacts in mandatory environmental impact assessment processes
		Establishment of provisions on minimization of buffer zones/areas where residential construction is impossible in the vicinity of industrial zones
		Promotion of the Initiative for Climate Change Risk Reduction between the Public and Private Sectors (Collaboration with Local Governments, etc.)
	Operation and design	Establishment of supervisory agencies and staff responsible for implementing measures to adapt to climate change impacts in industrial parks, formulation of overall management plans, and review of current standards and regulations
		Additional implementation of assessments based on climate change impacts in mandatory environmental impact assessment processes

		Introduce early warning system as disaster prevention measures due to climate change effects in industrial parks
		Land selection and development planning taking into account climate change impacts
		Development and implementation of rehabilitation plans in already affected areas/regions (incentives for the transfer of vulnerable industries, transfer compensation, etc.)
		Reduction of closed spaces and surfaces in industrial parks and installation of water storage sites in public land
		Optimize the orientation of buildings (avoid solar radiation on walls-(east/west walls suppress the effects of low-intensity sunlight, etc.)
		Take measures to prevent erosion of slopes when planning land (planting shrubs and trees, etc.)
		Study and formulation of response plans up to shutdown plans (shutdown operations) in the event of an emergency
		Train relevant planning agencies/sectors on how to identify climate change risks and incorporate them into projects (planning, decision-making, construction projects, etc.).
		Assess vulnerabilities to climate change-related risks at business bases in major industries during industrial park development
		Introduction of design and building standards with high vulnerability to climate change by the government, and determination of specifications for industrial buildings on site
		To avoid structures susceptible to strong wind vibrations and to ensure adequate fixation
		Integrate climate change aspects into the company's risk and innovation management process (e.g., supply risk) and identify critical components
		Investigate potential business opportunities arising from climate change in industrial parks and consider their introduction (cooling technology, etc.)
Surroundings	Companies/occupants in industrial parks	Increase the diversity and efficiency of securing raw materials in production processes (securing suppliers in neighboring areas) so as not to rely on suppliers that may be vulnerable to climate change impacts. In the same way, we will ensure diversity in sales channels for products in industrial parks.
		Development of sustainable, climate-insensitive products in industrial parks
		Diversification of Industrial Sectors in Industrial Parks
		Sharing identified climate risks with suppliers and discussing measures
		Introduction of climate insurance against climate change impacts such as weather index insurance
		Consideration of new work plans to avoid thermal stress among outdoor workers (provision of drinking water, provision of evacuation places for workers, provision of collective places with disaster prevention measures, etc.)
		Promotion of diverse industries, including small-and medium-sized agriculture, to stabilize the supply of foodstuffs within industrial parks
	Workforce at industrial parks	Measures shall be taken to prevent the leakage of chemical substances and pollutants even in the event of a flood.

Part III. Reference material

- **References**
- **Appendix 1: Examples of Climate-Related Indicators for reviewing hazard**
- **Appendix 2: Climate Risk Assessment Framework: Component Definitions based on IPCC AR5**
- **Appendix 3: Overview of online information platform for Climate Risk Assessment**

Part III. Reference material

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IPCC: Working Group I, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Physical Science Basis)
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Appendix 1: Examples of Climate-Related Indicators for reviewing hazard

Example of Climate Hazard Indicators

Category	Index ID	Index name	Unit	Definition of Indicators	Reference
Temperature	AMT	Mean annual temperature	℃	Annual average daily temperature	
	MMT	Monthly average temperature	℃	Monthly average daily temperature	
	MMTmax	Monthly average maximum temperature	℃	Monthly mean daily maximum temperature	
	MMTmin	Average monthly minimum temperature	℃	Monthly mean daily minimum temperature	
	TN10p	Cold night (Cool nights)	%	Percentage of days with daily minimum temperatures below the 10th percentile	ETCCDI
	TX10p	Cool Day (Cool days)	%	Percentage of days with daily maximum temperatures exceeding the 10th percentile	ETCCDI
	TX90p	Day of Global Warming (Warm days)	%	Percentage of days with daily maximum temperatures exceeding the 90th percentile	ETCCDI
	DTR	Mean daily difference	℃	Monthly mean difference between daily maximum and minimum temperatures	ETCCDI
Rainfall	APR	Annual rainfall	Mm	Total annual rainfall	
	MPR	Monthly rainfall	Mm	Total monthly rainfall	
	RX1day	Maximum daily rainfall	Mm	Maximum daily rainfall per month	ETCCDI
	R10	Number of intense rainy days	Days	Annual number of days with daily rainfall of 10mm or more	ETCCDI
	R20	Number of very strong rainy days	Days	Annual number of days with a daily rainfall of 20mm or more	ETCCDI
	NPR	Number of dry days	Days	Annual Days with Daily Rainfall Less than 1mm	
	CDD	Number of consecutive drying days	Days	Maximum number of consecutive days of a day with a daily rainfall of less than 1mm	ETCCDI
	CWD	Number of consecutive rainfalls	Days	Maximum number of consecutive days with daily rainfall of 1mm or more	ETCCDI
	R95p	High Wetness Day (Very wet days)	Mm	Total annual rainfall for days with daily rainfall exceeding the 95th percentile	ETCCDI
Sunshine	MSh	Monthly sunshine hours	Hours	Monthly total sunshine time	
	ASh	Annual sunshine time	Hours	Total annual sunshine time	
Humidity	ARH	Annual average relative humidity	%	Annual average daily relative humidity	
	MRH	Monthly average relative humidity	%	Monthly average daily relative humidity	

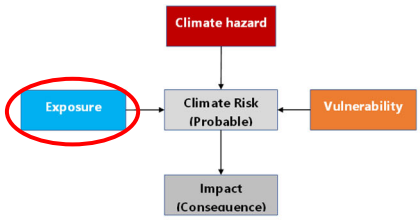
References to Detailed Definitions for the ETCCDI Index: http://etccdi.pacificclimate.org/list_27_indices.shtml

NOTE)

- TN10p: Percentage of daily minimum temperature to total annual days below the 10th percentile for baseline periods (e.g., 1961-1990 as defined by WMOs). The unit of this index is %.
- R10: Number of days of intense rainfall (wet days) counted. This index is highly correlated with annual and seasonal rainfall in most climates [T. C. Peterson, 2001]. [T.C. Peterson, 2001]
- CDD affects vegetation and ecosystems. Potential indicators of drought. Reductions in CDDs reflect a more humid climate if wet days become more frequent [T.C. Peterson, 2001]. [T.C. Peterson, 2001]
- Sunshine time: Direct sunlight intensity exceeding 120W/m2

Appendix 2:
Climate Risk Assessment Framework: Component Definitions based on IPCC AR5

1) Exposure



e.g.
- People, economic activity, and infrastructure in low-lying coastal zones
- Farmers in drylands
- People exposed in urban areas to flood events
- Coral reefs

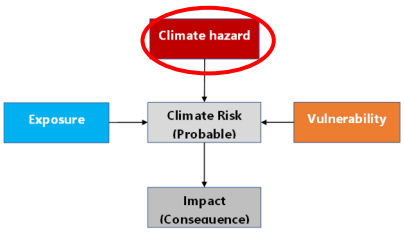
Exposure

The presence of

- People, livelihoods,
- Species or ecosystems,
- Environmental functions, services, and resources,
- Infrastructure, or economic, social, cultural assets

in places and settings that could be adversely affected.

2) Climate Hazard



e.g.
- Warming trend
- Extreme temperature
- Extreme precipitation
- Sea level rise
- Flood
- Drought

Hazard

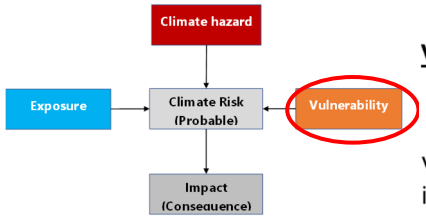
The potential occurrence of

Climate-related physical event, trend, or their physical impact

that may cause
- Loss of life, injury, or other health impacts,
- Damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Note: The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

3) Vulnerability



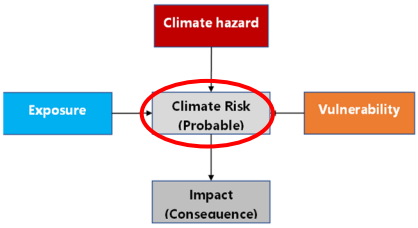
e.g.
- Lack of capacity in water management
- Limited climatic range of which species can live in
- Limited institutional capacities
- overwhelmed drainage networks

Vulnerability

The propensity or predisposition to be affected.

Vulnerability encompasses a variety of concepts and elements including
- Sensitivity or susceptibility to harm
- Lack of capacity to cope and adapt.

4) Risk



Risk

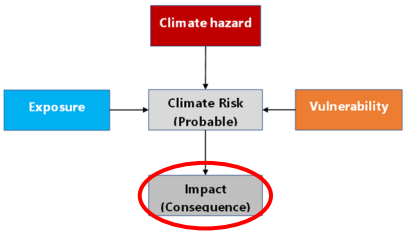
Risks of climate-change impacts

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values.

Risk results from the interaction of vulnerability, exposure, and hazard.

e.g.
- Risk of property damage
- Risk of loss of human lives
- Risk of supply chain disruption
- Risk of decreases in agricultural production
- Risk of loss of biodiversity

5) Impact



Impact

Effects on natural and human systems of extreme weather and climate events and of climate change.

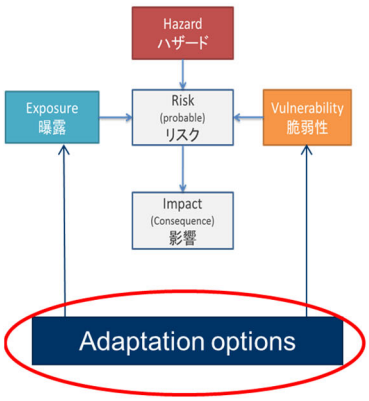
Impacts generally refer to effects on
- Lives, livelihoods, health,
- Ecosystems,
- Economies, societies, cultures, services,
- Infrastructure

due to the interaction of
- climate changes or hazardous climate events occurring within a specific time period
- the vulnerability of an exposed society or system.

Impacts are also referred to as consequences and outcomes.

e.g.
- Property damage
- Loss of human lives
- Supply chain disruption
- Decreases in agricultural production
- Loss of biodiversity (species)

6) Adaptation measures



Adaptation options

The array of strategies and measures

that are available and appropriate for addressing adaptation needs.

They include a wide range of actions that can be categorized as
- Structural (design etc.)
- Institutional (operation, management etc.)
- Social

e.g.
- Promote water savings and efficient use
- Early warning systems
- Improved drainage
- Insurance
- Building standards & practices

Appendix 3: Overview of online information platform for Climate Risk Assessment

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Climate Change Knowledge Portal (CCKP)
URL	https://climateknowledgeportal.worldbank.org[20]
Preparation and Management Organization	World Bank
Information to be included	• Past and Future Climate Information (Temperature, Rainfall) by Country and Major Basins • Hazard-related information (droughts, floods, cyclones, sea level rise, etc.) • Impact of Climate Change (Agriculture, Water Resources, Health and Hygiene Sectors)
COVERAGE	All over the world

1) Summary

World Bank's Climate Change Information Portal Site. Countries and main watersheds provide climate information, hazard-related information, and summary information on the impacts of climate change. This can be used to summarize climate and climate-related information for the countries covered by the project and for wide-area areas, including the target areas.

Country profiles can be downloaded from the below sites.

Climate Risk Country Profiles（WB）: https://climateknowledgeportal.worldbank.org/country-profiles [21]
Climate Risk Country Profiles（ADB）: https://www.adb.org/publications/series/climate-risk-country-profiles[22]

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Climate Inspector
URL	https://gisclimatechange.ucar.edu/inspector[23]
Preparation and Management Organization	National Center for Atmospheric Research (NCAR:National Center for Atmospheric Research)
Information to be included	Future forecasts of temperature and precipitation (Changes from 1986-2005) Predictive data calculated by the Global System Model (CESM) Atmospheric Model developed by the American Atmospheric Research Centre
COVERAGE	All over the world

1) Summary

Points on the map may be selected and the temperature and rainfall forecast data for multiple RCP scenarios of the area containing the point may be graphically displayed. Data can be stored in CSV format for Excel. An estimate of the change in the annual average and an estimate of the monthly mean can be obtained.

[20] https://climateknowledgeportal.worldbank.org /, accessed at 2023/3/3
[21] World Bank Group, Climate Change Knowledges Portal site, accessed at 2023/3/3
[22] ADB, Climate Risk Country Profile, accessed at 2023/3/3
[23] https://gisclimatechange.ucar.edu/inspector, accessed at 2023/3/3

Monthly average estimates can be helpful in finding out how current seasonal variations will be in the future. It should be noted that the datasets used are data for IPCC AR5 and CMIP5.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Climate Information Platform (CIP)
URL	http://cip.csag.uct.ac.za/webclient2/app/[24]
Preparation and Management Organization	Cape Town University Climate System Analysis Group (CSAG: Climate System Analysis Group)
Information to be included	Past temperatures and precipitation, future temperatures and precipitation
COVERAGE	All over the world

1) Summary

Predictive data obtained by downscaling past meteorological observation data and global climate model (GCM) at meteorological observation stations in the continent of Africa can be displayed graphically. Statistical downscale data for approximately 10 GCM models based on the Third Combined Model Intercomparison Project (CMIP3) or the Fifth Combined Model Intercomparison Project (CMIP5) can be displayed.[25]

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	KNMI Climate Explorer
URL	https://climexp.knmi.nl/[26]
Preparation and Management Organization	Royal Netherlands Meteorological Research Institute (KNMI:Royal Netherlands Meteorological Institute)
Information to be included	• Meteorological data and future climate data (mainly temperature and precipitation) • Processing of Weather Data on the Web
COVERAGE	All over the world

1) Summary

This site is used in various climate change impact assessments and climate change-related research reports. It can acquire past and current weather data and future climate data from various locations and process these data on the Web. The weather data can be utilized, and the calculation result can be displayed in a map and a graph. Future forecasts can display global climate models (GCMs) as well as forecasts of regional climate models (RCMs).

[24] http://cip.csag.uct.ac.za/webclient2/app/, accessed at 2023/3/3
[25] Uncertainties in forecasts are determined by comparing the results of forecasts that differ for each model.
[26] https://climexp.knmi.nl/ , accessed at 2023/3/3

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	IPCC Atlas
URL	https://interactive-atlas.ipcc.ch/[27]
Preparation and Management Organization	Intergovernmental Panel on Climate Change (IPCC)
Information to be included	Data used for IPCC AR6 WGI
COVERAGE	All over the world

1) Summary

Current and future climate change conditions can be analyzed spatially and temporally, and displayed using previously observed and projected climate change information, from the Working Group I report of the IPCC Sixth Assessment Report. The displayed results can also be obtained in PDF or PNG file format. The data used for the analysis is based on the data provided by the IPCC Data Distribution Center (IPCC-DDC).

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	ClimoCast
URL	https://a-plat.nies.go.jp/ap-plat/cmip6/global.html[28]
Preparation and Management Organization	Ministry of the Environment Japan, National Institute for Environment studies,
Information to be included	CMIP6 data
COVERAGE	All over the world

1) Summary

An online tool for viewing future regional climate projections based on the latest climate data (CMIP6 data). Allows one to compare four major emission scenarios (SSP1-2.6 to SSP5-8.5) and compare results of 10 different climate models, and to download the corresponding data (CSV).

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Climate Impact Viewer
URL	https://a-plat.nies.go.jp/ap-plat/asia_pacific/index.html[29]
Preparation and Management Organization	Ministry of the Environment Japan, National Institute for Environment studies, Office for Coordination of Climate Change Observation
Information to be included	Results of the research funded by the Environment Research and Technology Development Fund (ERTDF), S-10, S-14
COVERAGE	All over the world

1) Summary

Displays the results of climate change impact assessments in various sectors, for current climate, water resources, vegetation, agriculture, health, etc. Allows visual comparison of future projections in different sectors and time scales.

[27] Data Distribution Centre of IPCC, accessed at 2023/3/3

[28] https://a-plat.nies.go.jp/ap-plat/cmip6/global.html , accessed at 2023/3/3

[29] https://a-plat.nies.go.jp/ap-plat/asia_pacific/index.htm l, accessed at 2023/3/3

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	ClimatView - a tool for viewing monthly climate data
URL	http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/climatview/frame.php[30]
Preparation and Management Organization	Japan Meteorological Agency, WMO
Information to be included	Monthly climate data (monthly average temperature, annual precipitation, monthly average of daily maximum and minimum temperatures)
COVERAGE	All over the world

1) Summary

Provides global monthly climate data (statistics on monthly average temperature, annual precipitation, monthly average of daytime temperature highs and lows, and standard precipitation index (SPI), for all monitoring sites where data are available).

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	ClimPACT
URL	https://climpact-sci.org/[31]
Preparation and Management Organization	The University of New South Wales, Climate extremes, World Meteorological Organization (WMO), Green Climate Fund(GCF)
Information to be included	Meteorological data (daily minimum and maximum temperatures, daily precipitation), frequency, duration and intensity of various extreme events related to each sector
COVERAGE	All over the world

1) Summary

An application developed using the open source package "R" that uses weather data (daily minimum and maximum temperatures, daily precipitation) to calculate the frequency, duration and intensity of various extreme events relevant to each field, on a monthly or yearly basis. It is also available on the web at ClimPACT. The indicators used were selected by a team of experts comprised of WMO and other organizations through discussions with experts in various fields, and include more than 60 indicators, which can be used for calculations.

The following is a summary of some of the indicators provided by ClimPACT that may be helpful when considering climate hazards in the Climate-FIT (adaptation) climate risk assessment.

[30] http://ds.data.jma.go.jp/gmd/tcc/tcc/products/climate/climatview/frame.php , accessed at 2023/3/3
[31] https://climpact-sci.org/ , accessed at 2023/3/3

Category		Examples of items to check and consider for current numbers and future projections, etc.	ClimPACT indices	Note
Temperature	Changes in temperature	Average annual temperature	TMm	Average annual temperature
		Annual maximum temperature	TXx	Annual maximum temperature
		Annual minimum temperature	TNn	Annual minimum temperature
		Monthly average temperature	TMm	Monthly average temperature
		Monthly maximum temperature	TXx	Monthly maximum temperature
		Monthly minimum temperature	TNx	Monthly minimum temperature
	Extreme events	Heat wave (high temperature)	HWF,HWD,HWM,HWA	Heat wave index(Occurance, duration, amplitude)
		Occurrence of cold wave	CWF,CWD,CWM,CWA	Cold wave index(Occurance, duration, amplitude)
Rainfall	Chanes in rainfall	Annual rainfall and snowfall	PRCPTOT	Accumulated precipitation
		Monthly rainfall/snowfall	PRCPTOT	Accumulated precipitation
		Number of days without precipitation	Rnnmm	Number of days with precipitation exceeding XX (mm). XX=1mm and the value that comes out is the number of days with precipitation, 365 - number of days without precipitation
		Cumulative rainfall (to account for soil index)		Rx1d,Rx5d: Annual maximum daily precipitation, annual maximum 5 consecutive days
	Seasonal change	Changes in rainfall patterns (seasonality of rainfall)		
	Extreme events	Occurrence of heavy rainfall	Rx1d,Rx5d	
		Occurrence of floods		
		Occurrence of drought	CDD, PRCPTOT, SPI, SPEI	Number of consecutive days without precipitation, Accumulated precipitation, Standardized Precipitation Index, Standardized Precipitation Evaporation Index
		Occurrence of drought	CDD, PRCPTOT, SPI, SPEI	Number of consecutive days without precipitation, Accumulated precipitation, Standardized Precipitation Index, Standardized Precipitation Evaporation Index

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Global Surface Water Explorer
URL	https://global-surface-water.appspot.com/map[32]
Preparation and Management Organization	European Commission (European Commission)
Information to be included	Range, seasonality, and past changes in waters and submerged areas
COVERAGE	All over the world

1) Summary

Sites that map waters and submerged waters during the period 1984 to 2018. It can be used to investigate flooding, flooding risks, and water resources of the project target area. It is possible to read information such as that the flood area is expanding or decreasing, and that the presence of water is changing to seasonality at the point where water is always present.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Aqueduct Water Risk Atlas
URL	https://www.wri.org/aqueduct[33]
Preparation and Management Organization	World Resources Institute
Information to be included	Mapping of water-related risk information (Floods, droughts, seasonal and annual changes in water supply, water stress, etc.)
COVERAGE	All over the world

[32] https://global-surface-water.appspot.com/map , accessed at 2023/3/3

[33] https://www.wri.org/aqueduct, accessed at 2023/3/3

1) Summary

Current and future (2030, 2040) water-related risk information can be displayed on the map.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Permanent Service for Mean Sea Level (PSMSL) Data Explorer
URL	http://www.psmsl.org/data/obtaining/map.html[34]
Preparation and Management Organization	United Kingdom National Oceanography Centre (NOC: National Oceanography Centre)
Information to be included	Sea level rise, sea level
COVERAGE	All over the world

1) Summary

The changes over time of current and past observed data of sea level around the world can be graphically displayed. It can be used as a reference information for consideration of sea level rise.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	Earth Observing System Data and Information System (EOSDIS) Worldview
URL	https://worldview.earthdata.nasa.gov/[35]
Preparation and Management Organization	National Aeronautics and Space Administration (NASA)
Information to be included	• Climate-related: Past temperature, rainfall • Socioeconomic: Population Density and Population Forecasts • Geographical and natural environment: vegetation, land use, altitude, wind, ocean current, landslide, etc.
COVERAGE	All over the world

1) Summary

Various maps can be displayed on the basis of the images of the Earth Observation Systems Satellites (EOSDIS) provided by the NASA. Information such as population density, population prediction, vegetation, land use, altitude, wind, ocean current, landslide, temperature, and rainfall can be displayed on the map.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	ESA Climate Change Initiative (CCI) Land Cover website
URL	http://maps.elie.ucl.ac.be/CCI/viewer/index.php[36]
Preparation and Management Organization	European Space Agency
Information to be included	Land-covering map (land cover map)
COVERAGE	All over the world

1) Summary

Global land-coverage maps (land cover map) based on satellite-image analysis from 1992 to 2020 provided

[34] https://psmsl.org/data/obtaining/map.html , accessed at 2023/3/3
[35] https://worldview.earthdata.nasa.gov/ , accessed at 2023/3/3
[36] http://maps.elie.ucl.ac.be/CCI/viewer/index.php , accessed at 2023/3/3

by the European Space Agency can be displayed. Exposure to hazards and vulnerabilities at project sites can be exploited.

Climate Change Impact Information Site List (Resources for Climate Risk Assessment)

Name of the site	ALOS Global Digital Surface Model ALOS World 3D (Global High-Accuracy Digital 3D Maps)
URL	https://www.eorc.jaxa.jp/ALOS/aw3d30/l_map_v1903.htm[37]
Preparation and Management Organization	Japan Aerospace Exploration Agency
Information to be included	Altitude map (DSL)
COVERAGE	All over the world

1) Summary

Altitude maps Digital Surface Model (DSMs) can be displayed based on JAXA provided satellites (ALOS) images. It is possible to grasp the outline of the topography in the vicinity of the target land. It can be used to investigate exposure to hazards and vulnerabilities.

[37] https://www.eorc.jaxa.jp/ALOS/jp/dataset/aw3d30/aw3d30_j.htm , accessed at 2023/3/3

Japan International Cooperation Agency
Office for Climate Change
Global Environmental Department