Japan International Cooperation Agency (JICA)

Climate Finance Impact Tool for Adaptation

JICA Climate-FIT (Adaptation)

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Office for Climate Change

JICA Global Environment Department

Final Report for Study on Mainstreaming Climate Change Considerations into JICA Operation (Adaptation) by NIPPON KOEI CO., LTD.

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List of Abbreviations

ADB	Asian Development Bank
AGCM	Atmospheric Global Climate Model / Atmospheric General Circulation Model
AOGCM	Coupled Atmosphere-Ocean Global Climate Model/ Atmospheric Ocean General Circulation Model
CBD	Convention on Biological Diversity
COP15	Fifteenth Conference of Parties
CMIP3	phase 3 of the Coupled Model Intercomparison Project
DAC	Development Assistance Committee
DALYs	Disability Adjusted Life Years saved
EB	Environmental Benefits
EPOC	Environment Policy Committee
FAO	Food and Agriculture Organization
GCM	Global Climate Model / General Circulation Model
GEF	Global Environment Facility
GIS	Geographic Information System
GIZ	Gesellschaft für Internationale Zusammenarbeit
GTZ	Gesellschaft für Technische Zusammenarbeit
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	IPCC Forth Assessment Report
IUFRO	International Union of Forest Research Organization
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
LDC	Least Developed Countries
MLIT	Ministry of Land, Infrastructure and Transportation
MoE-J	Ministry of the Environment Japan
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
OGCM	Oceanic Global Climate Model / Ocean General Circulation Model
RCM	Regional Climate Model
SH	Saved Health
SRES	Special Report on Emissions Scenarios
SW	Saved Wealth
TOR	Terms of References
UFW	Unaccounted-For-Water
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization

Chapter 1 Outline of the Survey

1.1 Background and Objectives of the Survey

The 16th Conference of the Parties (COP16) of the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Cancun Agreements. The agreements clearly state the commitment by developed countries to provide financial support to developing countries in the field of climate change, which include i) collective commitment approaching USD 30 billion for three years from 2010 to 2012 (as Fast-start finance) and ii) joint mobilization of USD 100 billion per year by 2020 (as Long-term finance). The direction of future framework on climate change after 2013 is still under discussion. It is considered that Official Development Assistance (ODA) will continue to be actively utilized as part of the support for the developing countries in the field of climate change. For assistance in the climate change sector, the Cancun Agreements request vulnerability reduction, sustainability and increase in adaptability and resistance, particularly in least developed countries (LDC), the Alliance of Small Island States (AOSIS), and Africa.

Taking into account the above situations, JICA is faced with the task to tackle adaptation during the planning stages of country assistance strategies and individual projects to ensure planning and implementation of appropriate adaptation-related projects based on vulnerability assessment.

This survey presents a reference document that discusses issues for mainstreaming climate change adaptation during the planning stages of country assistance strategies and individual projects by summarizing them as "concepts" and "guidelines".

This report has been prepared for adaptation measures as part of the ‘‘Study on Mainstreaming Climate Change Considerations into JICA Operation’’. The reports for survey on mitigation measures and national and regional climate impacts are prepared in separate volumes.

1.2 Selection of Target Sub-sectors and Review of Existing Resources

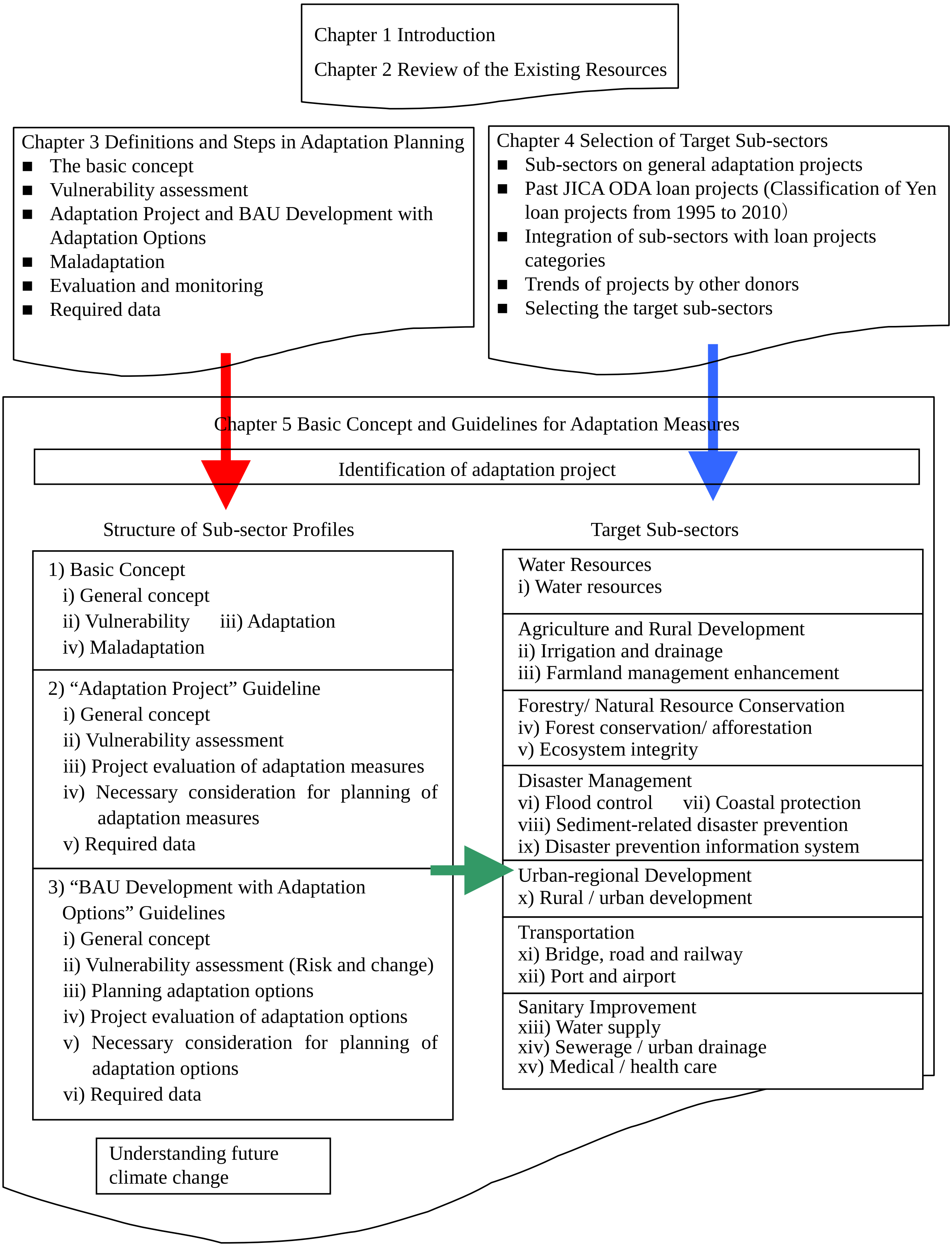
Based on the review of past JICA ODA loan projects and the trend of other donors’ assistance, 15 sub-sectors were chosen as potential areas of future JICA ODA loan assistance. In order to establish the concepts and guidelines for designing the adaptation measures, existing documents on vulnerability assessment and adaptation measures prepared by other donors and funding agencies were reviewed.

1.3 Basic Concept and Guidelines for Adaptation

For the selected 15 sub-sectors, basic concept and guidelines, which include the contents shown in Section 1.4, are prepared. Definitions and interpretations of technical terms are presented in Chapter 3. In developing countries, it can be easily anticipated that there exists great limitation in data availability In order to overcome this difficulty, the presented guidelines allow flexibility in data selection.

Understanding the future climate change, which is a common step for considering adaptation measures in all sub-sectors, is presented in a separate section (Chapter 5 0.Understanding Future Climate Change).

1.4 Framework of the Report



Chapter 2 Review of the Existing Resources

2.1 Existing Reports on Adaptation Activities by JICA

(1) JICA's Assistance for Adaptation to Climate Change[1]

The report summarizes the result of researches implemented in the fiscal year 2006 in order to systematically understand how to position JICA’s role in cooperation and promotion of assistance for adaptation to climate change.

Since the report was prepared before the JICA-JBIC merger in October 2008, the contents and most examples raised in the report as adaptation activities are for technical assistance implemented by pre-merger JICA. The report mainly focuses on two basic concepts for adaptation activities: a) human security-oriented assistance and b) capacity development-oriented assistance.

Table 2.1 outlines the report contents, while Table 2.2 summarizes the key different features between the report’s and this survey’s focuses.

Table 2.1 Outline of JICA’s Assistance for Adaptation to Climate Change

<table>
<tr><td>Outline of adaptation measures</td><td>Outline of climate change
Adaptation is not clearly defined; however, there is wide recognition about the need for adaptation measures.
Relationship between development assistance and adaptation measures
Significance of JICA’s engagement to adaptation measures</td></tr>
<tr><td>International trend for adaptation</td><td>Trend of discussion at international conferences
Trend of efforts to support adaptation measures in developing countries by Japan, developed countries, international organizations, etc.</td></tr>
<tr><td>Adaptation-related projects of JICA</td><td>The report counts past JICA projects that contribute to adaptation. These projects were not classified and implemented as “Adaptation” measures.
<table>
<tr><td colspan="2">Technical cooperation</td></tr>
<tr><td>Water resources</td><td>11 projects</td></tr>
<tr><td>Agriculture and rural development</td><td>84 projects</td></tr>
<tr><td>Forestry/ natural resource conservation</td><td>14 projects</td></tr>
<tr><td>Disaster management (including coastal protection)</td><td>7 projects</td></tr>
<tr><td>Urban-regional development</td><td>2 projects</td></tr>
<tr><td>Transportation</td><td>4 projects</td></tr>
<tr><td>Health</td><td>16 projects</td></tr>
<tr><td>Tourism</td><td>2 projects</td></tr>
<tr><td>Promotion of small and medium enterprises and supporting industries</td><td>2 projects</td></tr>
<tr><td>Electricity, energy</td><td>1 projects</td></tr>
<tr><td>Resources, energy conservation</td><td>4 projects</td></tr>
<tr><td>Global environment</td><td>14 projects</td></tr>
<tr><td>Grant Aid</td><td>33 projects</td></tr>
</table>
</td></tr>
</table>

[1] JICA.(2007). JICA's Assistance for Adaptation to Climate Change

Adaptation in each target sector	The chart below summarizes the contents of adaptation activities expected in each target sector. **Sector** / **Expected principal adaptation activity** Water resources: Proper management, development, utilization of water resources, and water and sanitary improvement Agriculture and rural development: Upgrading irrigation facilities, crop development, local participation in rural development, adaptations for climate extremes Forestry/ natural resource conservation: Cultivation of trees resistant to diseases and pests, mangrove conservation, forest disaster prevention, afforestation in degraded land of arid region Disaster management: Coastal protection, river basin disaster management, sediment-related disaster prevention, assistance for disaster prevention planning Urban-regional development and transportation: Development planning, infrastructure construction Health: Malaria prevention, waterborne (infectious) disease control, adaptations for high risk area Others (training, volunteer): Tropical disease prevention, water resources management technology in arid region, wind and flood prevention against precipitation increase, cultivation of agricultural crops, ecosystem conservation

Sector	Expected principal adaptation activity
Water resources	Proper management, development, utilization of water resources, and water and sanitary improvement
Agriculture and rural development	Upgrading irrigation facilities, crop development, local participation in rural development, adaptations for climate extremes
Forestry/ natural resource conservation	Cultivation of trees resistant to diseases and pests, mangrove conservation, forest disaster prevention, afforestation in degraded land of arid region
Disaster management	Coastal protection, river basin disaster management, sediment-related disaster prevention, assistance for disaster prevention planning
Urban-regional development and transportation	Development planning, infrastructure construction
Health	Malaria prevention, waterborne (infectious) disease control, adaptations for high risk area
Others (training, volunteer)	Tropical disease prevention, water resources management technology in arid region, wind and flood prevention against precipitation increase, cultivation of agricultural crops, ecosystem conservation

Table 2.2 Key Different Features between JICA's Assistance for Adaptation to Climate Change and this Survey

Items	JICA's Assistance for Adaptation to Climate Change	This Survey
Focused Aid Schemes in Selection of Target Sectors	Technical Assistance	Loan Assistance
Structures	After the review of climate change impacts, general concept of adaptation measures, and trends of global and Japan's assistance, it outlines adaptation measures in each target sector.	After the review of approaches and methodologies toward adaptation measures undertaken by other major donors, it outlines definitions and formulation process for adaptation measures to be adopted by JICA's assistance scheme, and finally describes the guidelines for each target sub-sector.
Descriptions for Each Sector	It discusses possible adaptation measures and way forward for the measures based on the review of the past implemented cases in technical assistance scheme.	It outlines a concept of "Adaptation Project" as well as "Business-as-usual (BAU) Development", which incorporates adaptation options in response to anticipated climate change impacts. Furthermore, it presents the guidelines to formulate assistance project in both cases for each target sub-sector.

(2) Handbook on Climate Change Adaptation in the Water Sector[1]

This handbook provides JICA's guideline in implementing adaptation activities as ODA project in developing countries for the water sector, which is greatly influenced by climate change. Outline of the Handbook is as shown in Table 2.3.

[1] JICA.(2010). Handbook on Climate Change Adaptation in the Water Sector

Table 2.3 Outline of the Handbook on Climate Change Adaptation in the Water Sector

Approach	5 basic concepts for approach to implementing sustainable actions under uncertainty of the future climate 1) Human security 2) Engagement with the society 3) Building a sustainable adaptive society 4) Disaster risk management 5)"Zero victim" goal of flood control
Methods for forecasting extreme events with climate change	The report presents concepts for utilizing projected results from IPCC Fourth Assessment Report, etc. Specifically, the report discusses the following prediction methods with consideration to the uncertain nature of climate forecasting. ・Downscaling of AGCM20 ・Downscaling of GCM ・Bias-correction on AGCM20 ・GCM ensemble averaging ・Simple statistical downscaling of GCM
Impact assessment analysis	The following 3 steps are explained as methods for impact assessment. Examples are used to explain procedures in each step. 1) Climate change prediction 2) Monitoring of existing facilities and current adaptation mechanisms 3) Impact assessment
Adaptation planning	The report describes adaptation measures typically planned in the water sector. 1) River basin governance 2) Meteorological/hydrological observation, warning, evacuation 3) Flood control 4) Integrated water resources management 5) Coastal protection 6) Protection of the socially vulnerable and the poor 7) Disaster insurance 8) Monitoring/maintenance
Capacity development assistance	In addition to the business-as-usual technical assistance, it explains the need for capacity development at various levels such as individuals, organizations and society for adaptation to climate change.

2.2 Wise Adaptation to Climate Change[1]

The report was prepared by the "Committee on Climate Change Impacts and Adaptation Research", which was established in October 2007 by the Ministry of the Environment, Japan. In the report, priority was given to adaptation activities resulting from conscious efforts and interventions by humans, in addition to the definition by IPCC AR4. In other words, the report has mostly targeted adaptation that is undertaken based on the decision of policymakers in national and local governments, and adaptation that is driven by individuals, communities, etc.

The contents shown in Table 2.4 are discussed in every chapter for the following 8 sectors: Food, Water Environment and Water Resources, Natural Ecosystems, Disaster Prevention and Large Coastal Cities, Health, Citizen's Life and Urban Life, Developing Countries, and Others. Among the discussed points, 2) and 3) are focused on Japan. Methods and tools for vulnerability assessment and case studies are shown in 4) for some sectors. In addition to adaptations in developed countries including Japan, adaptations that can be used worldwide are shown in 5).

[1] MoE-J.(2008). Kikouhendou heno Kashikoi Tekiou (in Japanese)

Table 2.4 Contents in Each Sector

1) Mechanism of impacts 2) Observed impacts 3) Projected impacts 4) Vulnerability assessment 5) Adaptation measures 6) Future challenges

Chapter 8 deals with adaptation in developing countries, presenting overarching points shown in Table 2.5 .

Table 2.5 Overarching Points on Adaptation in Developing Countries

Approach to Adaptation	According to the case studies of adaptation (McGray et al. 2007), adaptations are divided into three categories as follows: 1) Activities seeking to address economic development which collaterally contributes to adaptation to climate change as a result 2) Activities seeking to incorporate climate information into design and implementation of development action 3) Activities seeking to address impacts associated exclusively with climate change There are 2 major approaches to deal with the relationship between adaptation and development. The first approach is to address specific risk caused by climate change, so called the "climate risk oriented approach". The other is the approach to reduce vulnerability through capacity development for many climate and non-climate change related tasks, so called "vulnerability oriented approach".
Necessary Actions	The following actions are regarded as necessary in the planning and implementation of adaptation: 1) Integration of adaptation into development and poverty prevention. 2) Evaluation and utilization of existing adaptation methods. Numerous adaptations have been conducted in the past to cope with natural climate fluctuation in Asia. Strengthening of the measures, evaluation of its limitations, and integration of these with new technology and methods are needed. 3) Mainstreaming of adaptation in related sectors Natural resources, agriculture, disaster, and health sectors are typically vulnerable to climate change. The strategy and plans of these sectors should be implemented in consideration of climate risk (known as “mainstreaming of adaptation”). 4) Promotion of co-benefit type adaptation; avoidance of maladaptation 5) Involvement of stakeholders 6) Awareness raising and capacity development

2.3 Major Reports by Other Development Aid Agencies, etc.

2.3.1 OECD

(1) Addendum on the Climate Change Adaptation Marker[1]

OECD introduced "New Marker on Climate Change Adaptation" since February 2010. An activity should be classified as adaptation-related if it intends to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing the adaptive capacity and resilience.

[1] OECD/DAC.(2010). ADDENDUM ON THE CLIMATE CHANGE ADAPTATION MARKER. DCD/DAC(2007)39/FINAL/ADD3

(2) Integrating Climate Change Adaptation into Development Co-operation – Policy Guidance [1]

In this report, the OECD Environment Policy Committee (EPOC) and Development Assistance Committee (DAC) discuss about the need for integration of climate change adaptation into local development planning processes and their approaches. Because of the high vulnerability to climate change and scarce resource availability, assistance to developing countries in the aspect of planning should be flexible for climate change adaptation. Therefore, integration of climate change adaptation into the development policy is introduced as a key factor (Table 2.6).

Table 2.6 Outline of "Integrating Climate Change Adaptation into Development Co-operation - Policy Guidance"

Executive Summary	Objectives and target audience(co-operation agencies, policy makers) and structure of guidance
Weather, Climate Variability and Climate Change	Overall future climate change is outlined in reference of the projection based on the IPCC reports
Vulnerability of the Developing World to Climate Change	High vulnerability to climate change and impacts on societies in developing countries are assumed. In this section, sensitivity, adaptive capacity and adaptation are defined as follows: Sensitivity: Sensitivity is the degree to which a system can be affected, either negatively or positively, by changes in climate. This includes change in mean climate and the frequency and magnitude of extremes. The effect may be direct (for example, a change in crop yield due to a change in temperature) or indirect (such as damage caused by increased frequency of coastal flooding due to sea level rise). Sensitivity also includes exposure which considers the nature and magnitude of climate change and whether a system would be affected by such change. Adaptive capacity: Adaptive capacity is a system's ability to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities or to cope with consequences. Vulnerability: Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change, and the degree to which a system is exposed, along with its sensitivity and adaptive capacity.
	Adaptation: Adaptation is defined as adjustment in human and natural systems, in response to actual or expected climate stimuli or their effects that moderate harm or exploit beneficial opportunities.

[1] OECD/DAC.(2009).Integrating Climate Change Adaptation into Development Co-operation – Policy Guidance

Adapting to the Impacts of Climate Change	The report topic mainly focuses on classification of adaptation to climate change and differences between the regular development planning and adaptation planning. Adaptation is classified as follows: ・Bear losses ・Share losses ・Modify the threat (include flood control works such as dams, dikes, and levees) ・Prevent effects. For example, in agriculture, increased irrigation water. ・Change in use (a farmer may choose to substitute a more drought tolerant crop) ・Change of location ・Research ・Encourage behavioral change through education, information and regulation
	How is adaptation different from regular development? In principle, a range of development activities oriented towards reduced poverty and improved nutrition, education, infrastructure and health would be synergistic with adaptation to climate change. For example, in order to respond to the impact of climate change on coral reefs or the increased risk of glacial lake outburst floods, targeted adaptation activities need to be developed.
	Maladaptation: In this policy guidance, maladaptation is defined as business-as-usual development which, by overlooking potential impacts, inadvertently increases exposure and/or vulnerability to climate change. Maladaptation could also include actions undertaken to adapt to climate impacts that do not succeed in reducing vulnerability, but increase it instead.
Operationalizing Adaptation: From Theory to Action	Step1: Identifying current and future vulnerabilities and climate risks; Step2: Identifying adaptation measures; Step3: Evaluating and selecting adaptation options; and Step4: Evaluating "success" of adaptation.
Integrating Climate Change Adaptation at National, Sectoral and Project Level	The report topic explains how we integrate the adaptation into development at national, sectoral and project level.

2.3.2 UNDP

(1) Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures [1]

The key issue, especially for non-Annex I parties, is how to develop national strategies for adaptation to climate change that are easy to integrate into sustainable development plans. Most national vulnerability and adaptation studies to date have focused on the selection of climate change scenarios and impact studies. The main objective of the guidebook and the technical papers is to assist and provide guidance to developing countries in identifying, prioritizing, and shaping potential adaptation options into a coherent strategy that is consistent with their sustainable development and other national priorities.

In consideration of the objective above, the report explains each step of adaptation design process. Adaptation to climate change comprise of five consecutive processes for task identification, project formation and follow-up. It explains what to implement in each process. The four steps, excluding the implementation step, are as shown in Table 2.7.

[1] UNDP.(2004). Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures

Table 2.7 Steps to Design Adaptation-related Project in "Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures"

Step1: Scoping and designing an adaptation-related project	1)Identify scope of project and define the objectives -Prioritize key systems -Review policy process -Determine project objectives and outcomes 2) Establish the project team 3)Review and synthesize existing information on vulnerability and adaptation In this step, baseline project (vulnerability and adaptation without project) shall be clearly defined. -Develop indicators -Review and synthesize existing information 4) Design the adaptation project -Select approaches and methods -Develop synthesis plan -Develop monitoring and evaluation strategy -Develop the terms of reference
Step2: Assessing current vulnerability	1) Assess climate risks and potential impacts 2) Assess socio-economic conditions 3) Assess adaptation experience 4) Assess vulnerability
Step3: Assessing future climate risks	1) Characterize climate trends, risks and opportunities 2) Characterize socio-economic trends, risks and opportunities Characterize socio-economic trends with respect to both plan being executed and not being executed (baseline) 3) Characterize natural resource and environmental trends 4) Characterize adaptation barriers and opportunities
Step4: Formulating an adaptation strategy	1) Synthesize previous components/studies on potential adaptation options 2) Identify and formulate adaptation options 3) Prioritize and select adaptation options 4) Formulate the adaptation strategy

(2) Mapping Climate Change Vulnerability and Impact Scenarios – A Guidebook for Sub-National Planners[1]

This UNDP guidebook targets adaptation planning policy makers at sub-national scale for identifying adaptation and mapping vulnerability to climate change. In this guidebook, vulnerability assessment measure is coherently described in the order shown in Table 2.9. The definitions of "Vulnerability", "Sensitivity" and "Adaptive Capacity" used in the guidebook are shown in Table 2.8.

[1] UNDP.(2010). Mapping Climate Change Vulnerability and Impact Scenarios – A Guidebook for Sub-National Planners

Table 2.8 Definitions Related to Mapping Climate Change Vulnerability and Impact Scenarios

Vulnerability	vulnerability = exposure to climate hazards and perturbations x sensitivity – adaptive capacity
Hazard	A physically defined source of potential harm, or a situation with a potential for causing harm, in terms of human injury, damage to health, property, environment, and other things of value, or some combination of these (CARICOM, 2003).
Perturbations	Small variations from the norm in the physical system, typically of lesser magnitude than a hazard, but possibly of longer duration. Perturbations may retrospectively be identified as incremental change.
Sensitivity	The extent to which a unit analysis reacts to stimuli. Climate terms, biomes, ecosystems, countries and sectors are all examples of units, which may have different levels of sensitivity exposed to the same climate hazard (depending on the scale of the analysis).
Adaptation	Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities. (same as OECD 2009）
Adaptive Capacity	The potential or capability of a system to adjust its characteristics or behavior to anticipate, cope with and respond to climate variability and change.

Table 2.9 Evaluation Steps of Mapping Climate Change Vulnerability and Impact Scenarios

Evaluating Points	Vulnerability Assessment	Step 1: Determine Project Hazards and Sensitivity -Assess past and present climate trends and risks -Assess past and present sensitivity by sector -Assess future exposure to climate hazards and perturbations -Assess future sensitivity to climate change STEP 2: Determine Project Adaptive Capacity -Identify proxies or indicators for adaptive capacity -Identify other stresses that can interact with climate change as driving forces of system change STEP 3: Integrate and Map Vulnerability -Use of geographic information systems -Use of expert judgment and tracing paper
	Adaptation formulation	STEP 4: Identify, Assess, and Review Adaptation Options Identify adaptation options -Expert judgment -Spatial analogues Assess adaptation options -Cost-benefit analysis -Risk assessment Review vulnerability and adaptation options

2.3.3 USAID

(1) Adapting to Climate Variability and Change – A Guidance Manual for Development Planning[1]

The USAID Global Climate Change Team developed this Adaptation Guidance Manual to assist missions and other partners to understand how climate change may affect their project outcomes, and

1 USAID.(2007). Adapting to Climate Variability and Change – A Guidance Manual for Development Planning

identify adaptation options to be integrated into the design to implement more resilient projects.

Six necessary steps shown in Table 2.10 are defined for integration of adaptation into the planned project. Also, in conducting the adaptation analysis (Step 3), criteria for analyzing adaptations are provided based on the case study (Table 2.11).

Table 2.10 Implementation Steps in Adapting to Climate Variability and Change

Step 1	Screen for vulnerability Preliminary assessment of whether climate variability or change could compromise the integrity, effectiveness, or longevity of a project
Step 2	Identify adaptations Work with stakeholders to identify alternative designs or management practices
Step 3	Conduct analysis Examine the consequences of climate variability and change as well as the effectiveness, costs, and feasibility of adaptations
Step 4	Select course of action Meet with stakeholders to review results of the analysis. Determine if changes in a current project design are required, or if a proposed project should feature new adaptations.
Step 5	Implement adaptations
Step 6	Evaluate adaptations

Table 2.11 Criteria for Analyzing Adaptations in Adapting to Climate Variability and Change

Criteria for analyzing adaptations	Cost, effectiveness, ease of implementation, acceptability to local stakeholders, acceptability to USAID, endorsement by experts, timeframe for implementing the adaptation, institutional capacity, adequacy for current climate, size of beneficiaries group

2.3.4 GTZ (GIZ)

(1) Climate Change Information for Effective Adaptation – A Practitioner's Manual[1]

This manual is developed to get climate change and related information necessary for practitioner's decision-making in adaptation options by administrative organizations or NGOs.

It comprises Part I (Background) and Part II (Practical Steps) with an additional Annex. Part I discusses the cause of climate change, climate change scenario, outline of future projection model and vulnerability concept.

Part II discusses the practical steps for accessing climate change adaptation. Table 2.12 below shows some especially important concepts among these.

[1] GTZ(GIZ).(2009). Climate Change Information for Effective Adaptation – A Practitioner's Manual

Table 2.12 Outline of Points in Climate Change Information for Effective Adaptation

<table>
<tr><td rowspan="2">Access to climate change information</td><td>Important factors related to climate change are shown below:

Increased temperature (including seasonal changes)
More intensive and frequent storms
Sea level rise
More heat waves
More cold spells
More droughts
More flooding, and more extreme floods
More extreme rains (including seasonal changes)
Change in annual or seasonal water availability
Accelerated melting of glaciers
Melting of permafrost</td></tr>
<tr><td>Three methods in accessing information:

1) Rapid literature assessment
-Rather than generating your own climate change information, try to find existing materials on the internet or obtain them from resource persons or institutes.
-Define your geographical, temporal and sectoral areas of interest. As the body of literature on climate change is overwhelming, your search should be as focused as possible.
-Check literature and online databases; filter out what you need
-Consult experts, government officials, scientists and consultants
-Bring together the information gained in a comprehensive and transparent manner, and make it available to others.

2) Using online data analysis tools
For climate change data processing, the online tools below can be used.
-SERVIR
-Climate Change Explorer (weADAPT)
-World Bank Climate Change Portal
-CI: grasp

3) Comprehensive assessment using climate change expertise
If you cannot find the necessary climate change information for your needs, it is necessary to conduct analysis by yourself including requesting scientists to analyze regional climate change by RCM. The costs of such assessments can vary a lot. If new model runs are necessary, this can take months or even years, and can cost a five or six digit figure. You can also use the existing RCM tailored for developing countries.
It is noted that the number of RCM for developing countries is increasing.</td></tr>
</table>

Interpreting	1) General rules -Use information about historic climate variability and change (especially extreme events), as well as adaptation experiences as a starting point -Bring together different stakeholders -Try to gather different regional scenarios 2) Uncertainty and data interpretation -Differentiate between uncertainties of models and of the emission scenarios -Do not assume that uncertainty means there will be no change. -There will always be an inherent, irresolvable uncertainty involved in climate change projections. Uncertainty must be managed and should not overcome decision makers. -Rather than using a single model, try to use “possibility ranges”. 3)Uncertainty and identification of adaptation measures -Be aware that adaptation to climate change is not the only area of planning affected by uncertainty. -Try to find “no regret” or “low regret” adaptation activities (ideally a “win-win-win” situation for mitigation, adaptation and sustainability). -Try to identify flexible and reversible options. -Take into account the time dimension of impacts, i.e., “when are the impacts expected?” or “is action necessary today?”
Communication	-Avoid alarmism – base your statements on sound scientific findings. -Stress the importance both of interpreting climate change and of managing uncertainty -Be exact about timescales -Get support from experts

(2) Climate Proofing for Development – Adapting to Climate Change, Reducing Risk[1]

Similar to section (1), this guide is designed to consider climate change adaptation in development planning at various levels – national, sectoral, local and project.

Especially, it covers climate change adaptation not just at the project level but also at planning level. It should be noted that climate change impact and planning time scale are specified in this guide as presented in Figure 2.1.

[1] GTZ(GIZ).(2010). Climate Proofing for Development – Adapting to Climate Change, Reducing Risk

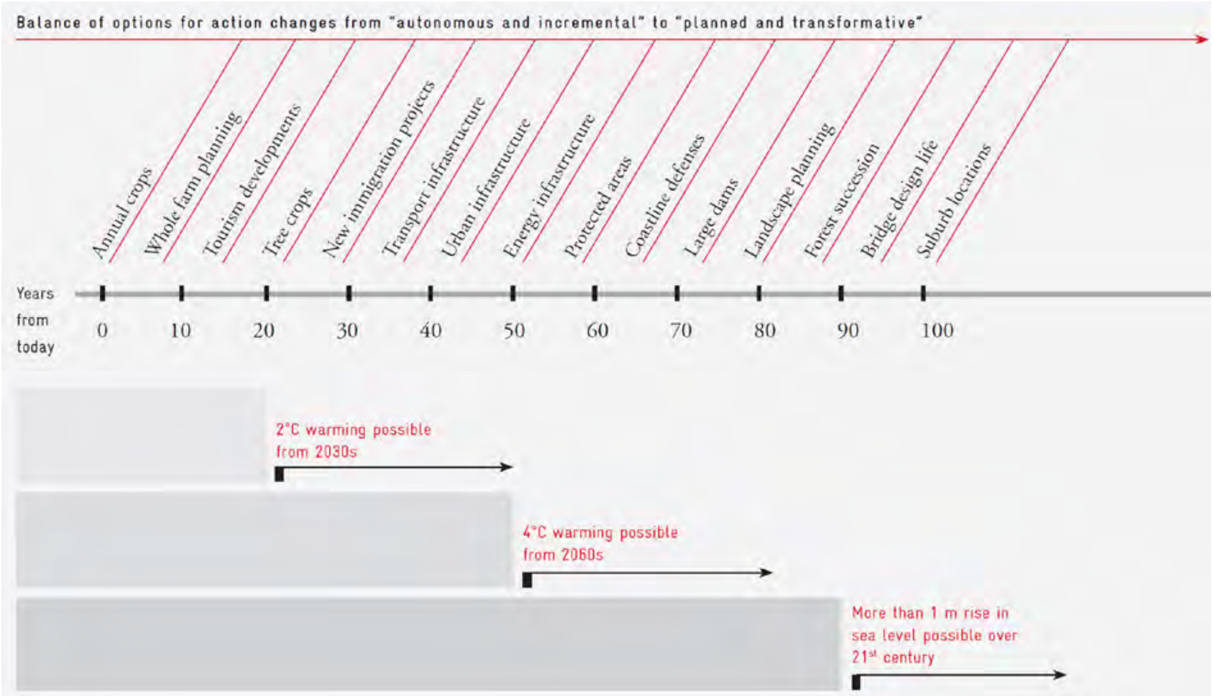


Figure 2.1 Planning Horizons - Today's Decisions Shape the Future[1]

2.3.5 Adaptation Fund

(1) Project Level Results Framework and Baseline Guideline Document (Mar. 2011)[2]

The document aims to show the indicators for performance measurement of the adaptation projects assisted by the fund. The results of the project should be analyzed in the following five steps, i.e., goal, impact, secondary outcomes (if applicable), outcome, and output. Expected results and measured indicators are shown in Table 2.13.

Table 2.13 Expected Results and Indicators in Adaptation Fund Results Framework

EXPECTED RESULTS	INDICATORS
Goal: Assist developing country parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change in meeting the costs of concrete adaptation projects and programs, in order to implement climate-resilient measures.	
Impact: Increased resiliency to climate variability and change at the community, national, and regional levels.	
Outcome 1: Reduced exposure at national level to climate-related hazards and threats	1. Relevant threat and hazard information generated and disseminated to stakeholders on a timely basis
Output 1: Risk and vulnerability assessments conducted and updated at a national level	1.1. Number and type of projects that conduct and update risk and vulnerability assessments
	1.2 Quality of relevant risk and vulnerability Assessments
	1.3 Early warning systems developed

[1] Stafford Smith et al. 2010 (GTZ, 2010, P.7 Figure 1)

[2] This survey does not refer to the new version of the document which was approved on 14th AFB meeting. Some of the "results" and "indicators" are amended and guidance for the evaluation of indicators is appended in the new version.

EXPECTED RESULTS	INDICATORS
Outcome 2: Strengthened institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses	2.1 Number of targeted institutions with increased capacity to minimize exposure to climate variability risks
	2.2 Number of people subjected to reduced risk due to extreme weather events
Output 2.1: Strengthened capacity of national and regional centers and networks to rapidly respond to extreme weather events	2.1.1. Number of staff trained to respond to and mitigate impacts of climate-related events
	2.1.2. Capacity increase of staff from targeted institutions trained to respond to and mitigate impacts of climate related events
Output 2.2: Targeted population groups covered by adequate risk reduction systems	2.2.1. Percentage of population covered by adequate risk reduction systems
	2.2.2. Number of people affected by climate variability
Outcome 3: Strengthened awareness and ownership of adaptation and climate risk reduction processes at the local level	3.1. Percentage of targeted population aware of predicted adverse impacts of climate change, and of appropriate responses
	3.2. Modification in targeted population behavior
Output 3: Targeted population groups participating in adaptation and risk reduction awareness activities	3.1.1 Number and type of risk reduction actions or strategies introduced at local level
	3.1.2 Number of news outlets in the local press and media that have covered the topic
Outcome 4: Increased adaptive capacity within relevant development and natural resource sectors	4.1. Development sectors' services responsive to evolving needs from the changing and variable climate
	4.2. Physical infrastructure improved to withstand climate change and variability-induced stress
Output 4: Vulnerable physical, natural and social assets strengthened in response to climate change impacts, including variability	4.1.1. Number and type of health or social infrastructure developed or modified to respond to new conditions resulting from climate variability and change (by type)
	4.1.2. Number of physical assets strengthened or constructed to withstand conditions resulting from climate variability and change (by asset types)
Outcome 5: Increased ecosystem resilience in response to climate change and variability-induced stress	5. Ecosystem services and natural assets maintained or improved under climate change and variability-induced stress
Output 5: Vulnerable physical, natural and social assets strengthened in response to climate change impacts, including variability	5.1. Number and type of natural resource assets created, maintained or improved to withstand conditions resulting from climate variability and change (by type of assets)
Outcome 6: Diversified and strengthened livelihoods and sources of income for vulnerable people in targeted areas	6.1 Percentage of households and communities having more secure (increased) access to livelihood assets
	6.2. Percentage of targeted population with sustained climate-resilient livelihoods
Output 6: Targeted individual and community livelihood strategies strengthened in relation to climate change impacts, including variability	6.1.1.Number and type of adaptation assets (physical as well as in terms of knowledge) created in support of individual or community livelihood strategies
	6.1.2. Type of income sources for households generated under climate change scenario
Outcome 7: Improved policies and regulations that promote and enforce resilience measures	7. Climate change priorities are integrated into national development strategy
Output 7: Improved integration of climate resilience strategies into country development plans	7.1. Number, type, and sector of policies introduced or adjusted to address climate change risks
	7.2. Number or targeted development strategies with incorporated climate change priorities enforced

Furthermore, during the preparation process of the document, it indicates in Annex A to adopt a set of indicators to assess the impact of and monitor the progress of adaptation actions proposed by implementing entities. Eventually, the proposed indicators seem not to be adopted by Adaptation Fund, however their general outlines are presented in Table 2.14.

Table 2.14 General Outline of Impact Indicators proposed for the Project by Adaptation Fund

Overview	The following 3 indicators are proposed as objective method of determining impact effectiveness of adaptation actions under the Adaptation Fund. 1) Saved Wealth 2) Saved Health 3) Environmental Benefits It is proposed that a set of indicators will both help to comparing several proposed projects and pre-estimating for budgeting purpose.
1) Saved Wealth (SW)	SW is the indicator that quantifies an economic value or vulnerability which would have saved or conserved by adaptation actions. It measures the economic values for assets (infrastructure or private property) that would have been damaged by the climate change impacts according to occurrence probability of the impacts.
2) Saved Health (SH)	SH measures impacts on people’s health using DALYs (Disability Adjusted Life Years saved) which is an initially established method in the health sector. It quantifies how much of the health or life expectancy are saved by the project. DALYs = Years of life lost due to premature mortality (YLL) + Years lived with disability (YLD) YLL ＝ Number of death x Average life expectancy; YLD ＝ Number of incident cases x Disability weight x Average duration of disability.
3) Environmental Benefits	Environmental benefits are qualitative indicators to assess positive, negative, or neutral impacts on ecosystem in the project area.
Combined Impact Indicator	The following methods are suggested as indicators of comparative evaluation in project selection process. a) Divide SW and SH by project cost and obtain unit values as SW* and SH* per project cost. b) Compute SW*ave and SH*ave as the average value of SW* and SH* respectively, for the proposed each project. c) Combined impact indicator for each project ＝ (SW* / SW*ave) + (SH* / SH*ave) Furthermore, it is proposed that budget from the fund be allocated to those indicating higher values of the above indicators

Chapter 3 Definitions and Steps in Adaptation Planning

3.1 Study Method

Related literatures reviewed in Chapter 2 show the concept for adaptation, definition of related terms, and basic analytical steps to formulate an adaptation project.

This chapter presents the definition, general steps and study items to be carried out in each step based on the reviewed information, which will be used in the project level guidelines for each sub-sector in Chapter 5.

3.2 Definitions

As reviewed in Chapter 2, the terms "adaptation", "vulnerability", etc. have different definitions. The definitions in this survey are examined as follows:

(1) Adaptation

Table 3.1 shows the various definitions for the term "Adaptation." Given that the adaptation projects studied in this survey is subject to OECD adaptation marker, the definition of OECD is adopted. According to the OECD's definition, adaptation is defined as "the activity to reduce vulnerability." Therefore, vulnerability assessment is crucial for determining adaptation measures.

Table 3.1 Definition of Adaptation

Agencies	Reference	Definition
JICA	JICA's Assistance for Adaptation to Climate Change[1]	Adaptation is not clearly defined but the definition in IPCC AR4 is introduced.
IPCC	IPCC AR4[2]	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
OECD	Addendum on the Climate Change Adaptation Marker[3]	Activities which intends to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience.
OECD	Integrating Climate Change Adaptation into Development Co-operation – Policy Guidance[4]	Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities.
UNDP	Mapping Climate Change Vulnerability and Impact Scenarios[5]	Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities. (same as OECD)
GTZ (Currently GIZ)	Climate Change Information for Effective Adaptation[6]	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (same as IPCC)
MoE-J	Wise Adaptation to Climate Change[7]	In addition to the definition by IPCC AR4, the priority is given to adaptation that is intentionally implemented by humans. In other words, it emphasizes adaptation measure that is undertaken at the decision of policymakers in national and local governments, and/or that is intentionally undertaken by individuals or communities, etc.

(2) Vulnerability

The term "vulnerability" has various definitions by many authorities as shown in Table 3.2. They commonly define "vulnerability" to be determined by several components comprising of climate change as an external forcing, sensitivity of the system and adaptive capacity of the system. Since none of the components are quantified for assessment by any development agency so far, the style or the formula has little importance in practice. However, this report adopts the UNDP definition that is well formalized using the terms adopted by OECD.

Table 3.2 Definition of Vulnerability

Agencies	Reference	Definition
JICA	JICA's Assistance for Adaptation to Climate Change	Vulnerability = almost equal External Force / [Resistance (Adaptive capacity) – Sensitivity]
IPCC	IPCC AR4[8]	Vulnerability is the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
OECD	Integrating Climate Change Adaptation into Development Cooperation–Policy Guidance	Vulnerability is the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (same as IPCC AR4)
UNDP	Mapping Climate Change Vulnerability and Impact Scenarios	Vulnerability = Exposure to climate hazards and perturbations x Sensitivity – Adaptive capacity
UNDP	Adaptation Policy Frameworks for Climate Change : Developing Strategies, Policies and Measures[9]	Vulnerability = Risks (predicted adverse climate impacts) – Adaptation
MoE-J	Wise Adaptation to Climate Change	Vulnerability is the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (same as IPCC AR4)

(3) Adaptive Capacity

Adaptive capacity is basically defined as the ability to reduce negative impacts of climate change as shown in Table 3.3. This survey adopts the definition of OECD which includes the ability to take advantage of opportunities.

Table 3.3 Definition of Adaptive Capacity

Agencies	Reference	Definition
JICA	JICA's Assistance for Adaptation to Climate Change	Not clearly defined.
OECD	Integrating Climate Change Adaptation into Development Cooperation–Policy Guidance	Adaptive capacity is a system's ability to adjust to climate change, including climate variability and extremes, to moderate potential damage, to take advantage of opportunities or to cope with consequences.
UNDP	Mapping Climate Change Vulnerability and Impact Scenarios	The potential or capability of a system to adjust its characteristics or behavior to anticipate, cope with and respond to climate variability and change.

3.2.2 Maladaptation

The definition of Maladaptation by OECD is adopted as presented in Table 3.4.

Table 3.4 Definition of Maladaptation

Agencies	Reference	Definition
OECD	Integrating Climate Change Adaptation into Development Cooperation–Policy Guidance	Business-as-usual developments which, by overlooking climate change impacts, inadvertently increases exposure and vulnerability to climate change. Actions undertaken to adapt to climate impacts that do not succeed in reducing vulnerability, but increase it instead.
UNDP	Mapping Climate Change Vulnerability and Impact Scenarios	Faulty or inadequate adaptation
MoE-J	Wise Adaptation to Climate Change	Inadequate study or consideration which result to insufficient effects of adaptation and impacts to other sustainable development

3.3 Vulnerability Assessment

The purpose of adaptation is to reduce the vulnerability to climate change. In this context, identification and assessment of the vulnerability on the target system is crucial in adaptation planning. Although there is no universal definition, it is considered that vulnerability is regarded as the relationship between a) the risk of the system in the context of climate change and b) its sensitivity and adaptive capacity against climate change.

UNDP (2010)[5] discusses the procedures for vulnerability assessment and adaptation planning applicable to local-level development. Table 3.5 shows steps in vulnerability assessment (Steps 1-3) and adaptation planning (Step 4).

The UNDP Guidebook aims to build regional master plan covering multiple sectors. To ensure the comprehensive process of vulnerability assessment at the regional level, cross-sectoral adaptation measures are considered.

In this survey, the emphasis is on adaptation measures at project level in target sectors. Therefore, the evaluation steps shown in the UNDP Guidebook have been integrated and revised to suit the purpose of this survey (Table 3.6).

Table 3.5 Evaluation Steps of Mapping Climate Change Vulnerability and Impact Scenarios (Reprint)

Items to be discussed	Vulnerability assessment	STEP 1:DETERMINE AND PROJECT HAZARDS AND SENSITIVITY Assess Past and Present Climate Trends and Risks Assess Past and Present Sensitivity by Sector Assess Future Exposure to Climate Hazards and Perturbations Assess Future Sensitivity to Climate Change STEP 2:DETERMINE AND PROJECT ADAPTIVE CAPACITY Identify Proxies and Indicators for Adaptive Capacity Identify other Stresses that can Interact with Climate Change as Driving Forces of System Change STEP 3:INTEGRATE AND MAP VULNERABILITY Use of Geographic Information Systems Use of Expert Judgment and Tracing Paper
	Adaptation formulation	STEP 4:IDENTIFY, ASSESS, AND REVIEW ADAPTATION OPTIONS Identify Adaptation Options Expert Judgment Spatial Analogues Assess Adaptation Options Cost-Benefit Analysis Risk Assessment Review Vulnerability and Adaptation Options

Source: Part of the report in UNDP (2010)

Table 3.6 Steps and Summary of Evaluation for Vulnerability Assessment in Target Sectors (Adaptation Project)

Step 1 Identification of the Hazards and Sensitivity to Climate Change	1) Assess Past and Present Climate Trends and Risks Identification of past and current conditions and changes with regard to climate parameters (weather, sea level, fire etc.) and impacts to each sector. Research shall be done by analyzing past data and interviewing stakeholders.
	2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Identification of the future trends in climate change with regard to the climate parameters relating to the sensitivity of the target sector. In assessment of climate change, review the climate change scenario, analysis model and target year in climate change adaptation policy of the target country and confirm with counterpart agencies. In the absence of climate change adaptation policy, extract the necessary climate parameters from IPCC assessment models and process them with ensemble average or downscaling if necessary. b) Study Other Factors related to Socio-economic Changes Review of development planning and regulations in the target country and area in order to identify the factors related to future socio-economic changes.

	3) Assess Future Sensitivity to Climate Change a) Study Past Damage Identification of past disasters in the target sector in relation to climate parameters. b) Study Present Condition of Facilities and Measures Description of the conditions of the existing facilities related to the project at target sectors or areas. c) Assess Future Sensitivity to Climate Change Identification of the future sensitivity to climate change of the target sector in consideration of socio-economic change variables based on past climate change related disasters, climate parameters, future climate change, presence and absence of facilities and their functions.
Step 2 Identification of Adaptive Capacity to Climate Change	4) Assess Adaptive Capacity to Climate Change a) Identification of Adaptive Capacity Identification of the conditions of the facilities, organizations, information and education systems as the adaptive capacity to climate change. b) Clarify Exacerbating Factors for Climate Change Impacts Identification of the situation and degree of factors (poverty, education level, etc.), which increase future vulnerability if combined with climate change
Step3 Assessment of Vulnerability	5) Assess Vulnerability Assessment of the vulnerability to climate change in the target area in consideration of factors in Steps 1 and 2. Identification of variations of vulnerability within the target area (in case there are substantial differences)

3.4 Adaptation Project and Business-as-usual (BAU) Development Project

Adaptation-related projects can be classified into two types. One type is projects whose principal purpose is adaptation to climate change. The other type is the business-as-usual (BAU) development projects which take into account climate change aspects in designing and implementing the project. This Survey names the former as "Adaptation Project" and the latter as "BAU Development with Adaptation Options." Separate guidelines are prepared for each type of project in a single sector.

The definition of "Adaptation Project" and "BAU Development with Adaptation Options" is shown in Table 3.7. The basic concepts of the two types of adaptation are shown in Figures 3.1 to 3.4. Although conceptually separate, drawing a clear line between the two types is not realistic. A project which was not intended for adaptation may end up contributing entirely to adapting to climate change. For instance, implementation of irrigation project can result in reduction of climate change vulnerability if located in a region where the agriculture development sector faces high climate risks. The guidelines presented in this survey offer steps for typical projects for each of the two types. In the real world, it is possible that there are projects which may fall in-between the two types. In addition, only one of the two types may exist in some sub-sectors.

Table 3.7 Definition of the Two Types of Adaptation-related Projects

	Adaptation Project	BAU Development with Adaptation Options
Definition	Projects formed to reduce the climate change vulnerability in the existing system such as projects to improve existing facility to cope with the increased vulnerability caused by the change of external forcing due to climate change.	Projects which is not mainly aimed to reduce the vulnerability, but is designed to adapt to the impacts of the climate change in achieving its main objective, such as development and rehabilitation of infrastructure projects that are planned or designed with consideration to increasing external forcing stemming from climate change.
Example	- Drainage of the glacial lake with the risk of collapse by global warming - Extension of existing irrigation system to address the crop damage caused by the increase of frequency and intensity of drought. - Disaster prevention project to strengthen the resilience against potential hazards concerned when inundation of road network is anticipated due to increased flood risk by climate change.	- Mangrove afforestation project with consideration to the sea level rise for coastal protection and ecosystem conservation. -Flood control project whose main purpose is to contribute to economic development, but with consideration to external forcing caused by increased frequency of extreme events and rainfall. - Road construction project which takes into account potential flood damage caused by climate change to design the route and related facilities.

3.5 Evaluation and Monitoring of Adaptation Measures

3.5.1 Evaluation (Project Evaluation)

Similar to the evaluation of BAU development project, evaluation (economic evaluation) based on cost-benefit analysis can be applied to adaptation measures, if the adaptation measures bring benefit to the system under the current climate conditions. For adaptation measures specialized in coping with climate change or those whose benefits are different from those of BAU development, it is necessary to identify other evaluation items and indicators which allow assessment of improvements in the sensitivity of the system or adaptive capacity.

3.5.2 Monitoring and Review

If the same items and indicators in Section 3.5.1 above are applicable during the monitoring and review stage, then these can be used. In the case of a project that addresses long-term change and extreme events caused by climate change, it may be difficult to measure impacts of climate change and benefits of adaptation measures using the items and indicators described in Section 3.5.1 above. In such cases, alternative indicators are needed to evaluate the improvement in sensitivity and adaptive capacity.

For instance, the performance and achievement of adaptation activities can be evaluated by some indicators that measure progress towards adaptation objectives. Such alternatives include: the number of projects adjusted to incorporate climate change risks; the number of stakeholders involved in capacity building activities for vulnerability reduction; and the number of stakeholders served by new or expanded climate information management systems such as early warning systems and forecasting

(Brooks & Frankel-Reed 2008, cited in OECD 2009, p.129).

In this survey, possible alternative indicators for monitoring are presented for each type of project.

Figures 3.1 and 3.2 show the basic concepts for “Adaptation Project” and “BAU Development with Adaptation Options” in the irrigation sector. Figures 3.3 and 3.4 illustrate the basic concepts of the types of adaptation projects in the flood control sector.

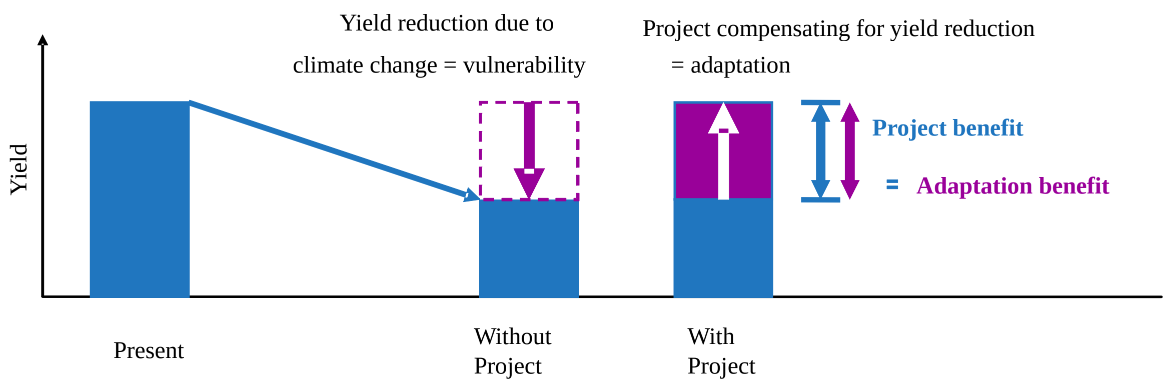


Figure 3.1 Basic Concept of “Adaptation Project” in the Irrigation Sector

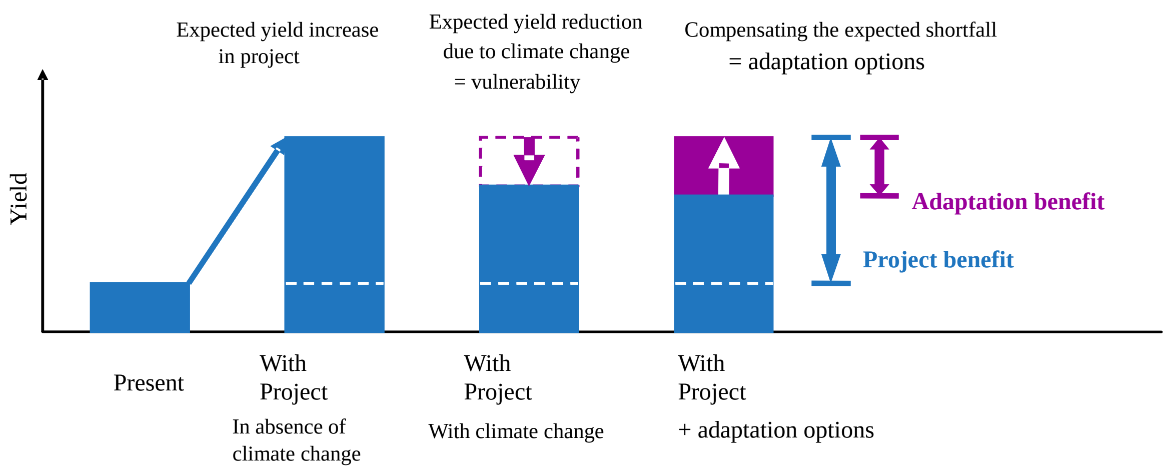


Figure 3.2 Basic Concept of “BAU Development with Adaptation Options” in the Irrigation Sector

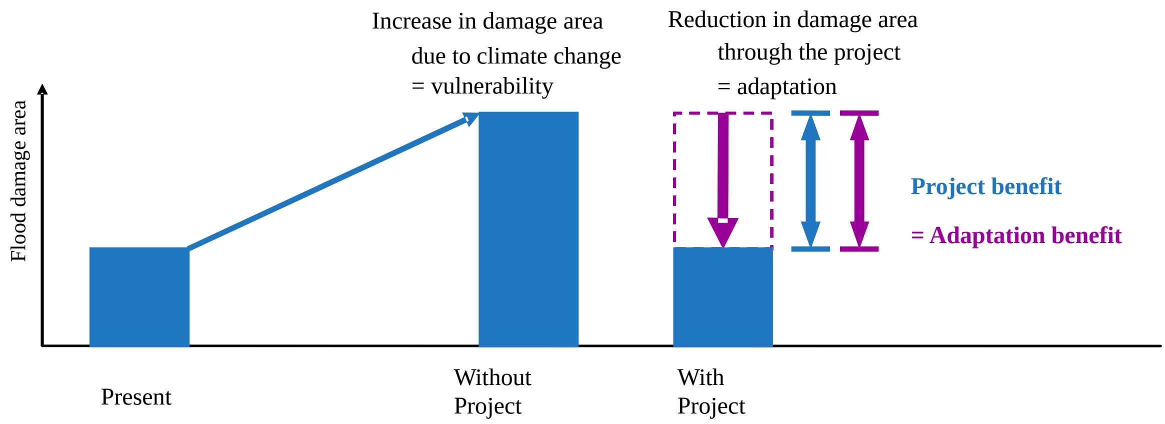


Figure 3.3 Basic Concept of "Adaptation Project" in the Flood Control Sector

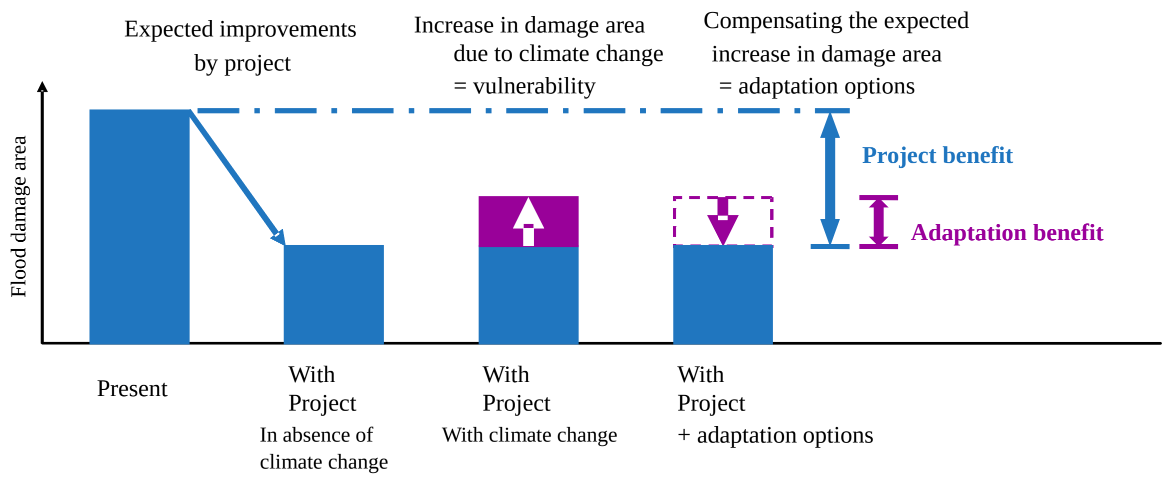


Figure 3.4 Basic Concept of "BAU Development with Adaptation Options" in the Flood Control Sector

[1] JICA. (2007). JICA's Assistance for Adaptation to Climate Change
[2] IPCC. Glossary of Terms used in the IPCC Fourth Assessment Report WGII. http://www.ipcc.ch/pdf/glossary/ar4-wg2.pdf
[3] OECD/DAC. (2010). ADDENDUM ON THE CLIMATE CHANGE ADAPTATION MARKER
[4] OECD/DAC. (2009). Integrating Climate Change Adaptation into Development Co-operation – Policy Guidance
[5] UNDP. (2010). Mapping Climate Change Vulnerability and Impact Scenarios
[6] GTZ(GIZ). (2009). Climate Change Information for Effective Adaptation
[7] MoE-J. (2008). Kikouhendou heno Kashikoi Tekiou (in Japanese)
[8] IPCC. (2007).WG2 Summary for Policymakers. E. Systematic observing and research needs http://www.ipcc.ch/publications_and_data/ar4/wg2/en/spmsspm-e.html
[9] UNDP. (2004). Adaptation Policy Frameworks for Climate Change : Developing Strategies, Policies and Measures

Chapter 4 Selection of Target Sub-Sectors

In this chapter, target sub-sectors are selected for discussion in Chapter 5. The following items were considered for selection of the sub-sectors.

・Past JICA ODA loan projects

・Potential for formulating future adaptation projects

The process of selection is as shown in Figure 4.1.

The segmentation unit described as “detailed classification” in the process is equivalent to the concept of “sub-sector”. In order to avoid confusing “sub-sectors” used to categorize the typical adaptation measures studied in this report, it is named as “detailed classification”.

1. Categorize the general adaptation project and remake the sectors and detailed classifications.
2. Establish sector and sub-sector categories that cover all yen loan projects from 1995 to 2010.
3. Establish sub-sector by integrating similar or related sub-sectors.
4. Compare yen loan projects with adaptation projects by other donors and check whether adaptation sub-sectors supported by other donors are included.
5. Select the target sub-sector

Figure 4.1 Selection Process of Sub-sectors

4.1 Categorization of Sectors and Detailed Classifications based on Typical Adaptation Measures

First of all, in order to categorize based on past JICA ODA Loan projects, the sectors or sub-sectors to be tentatively classified should be established. Then the adaptation projects shown below are extracted and the sectors or detailed classifications to include these projects are established.

a) JICA's Assistance for Adaptation to Climate Change[1]

b) IPCC AR4 WGII Technical Summary[2]

c) Reports by Ministry of the Environment Japan, Global Warming and Adaptation[3], 2009

d) Principle on Climate Change Adaptation, Ministry of the Environment Japan[4], 2010.11

4.2 Identification of Sectors and Detailed Classifications based on Past JICA ODA Loan Projects

Further, past JICA ODA loan projects from 1995-2010 was categorized into detailed classification. New classification was created for those projects which did not fall into existing classification. In addition, adaptations measures not described in any of the above a)-d) have been allocated to one of the detailed classification. As a result, several detailed classifications (shaded areas in the table), did not have any adaptation projects allocated. These classifications were excluded from consideration in this survey in principle. Although some detailed classifications did not include any JICA ODA loan projects in the past, these were not extracted since these may become potential sub-sectors of future JICA ODA loan project when these detailed classifications are integrated with other classifications to formulate a single sub-sector.

The summary is shown in Table 4.1. Some adaptation projects are counted in multiple classifications. Therefore, the total number of projects adds up to 1,293.

[1] JICA.(2007). JICA's Assistance for Adaptation to Climate Change
[2] http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ts.html
[3] http://www.env.go.jp/earth/ondanka/knowledge.html#03_ondankenkyu
[4] http://www.env.go.jp/press/press.php?serial=13167

Table 4.1 Adaptation Cases and JICA Loan Projects Implemented in Each Small Classification

Sector		Small Classification		Adaptation Cases	Projects
1	Water resources	01	Proper management of water resources	Introduction of the system accommodating water distribution within an area in a dry spell, dissemination of drought information, water demand management through measuring and pricing, capacity building for sustainable water utilization, water level observation, and water regulating dam	2
		02	Water resources development, facility improvement	Construction of water intake structure, development of water storage facilities, desalination of seawater, rainwater harvesting, rehabilitation of dam, and construction of headrace	14
		03	Utilization of water resources	Utilization of recycled wastewater, reclaimed water and rainwater, raising awareness for water-saving, diffusion of water-saving equipment, and leakage reduction	2
		04	Water and sanitary improvement	Development of safe drinking water and public health, development/enhancement of private electric generator in purification plant, selection of consolidated evaluation on raw water quality characteristic and its suitable purification process, and eutrophication prevention	0
2	Agriculture and rural development	01	Irrigation and drainage	Improvement of reclaimed land and drainage, irrigation and hydroponic culture, water-saving irrigation, development and improvement of irrigation facilities, and irrigation with recycled wastewater	56
		02	Cultivation management (assistance in farmland management), enhancement of water users association	Conservation of soil moisture by mulching, pest control and crop monitoring, intercrops, change of farming timing, facility introduction to avoid high temperature injury, change of cropping season, retention of crop residues, sericulture, crop diversification, agricultural extension, and strengthening of water users association	13
		03	Crop variety development	Switching to heat resistant varieties, development of drought- tolerant varieties, development and promotion of alternative crops, and development of wind-resistant varieties	3
		04	Information system	Providing weather forecast information	0
		05	Livestock	Change in stock raising density, technique development for infertile breeder during summer, impact assessment for heat stress on infertility, development of mitigation technique to reduce genital function stress, environmental control for animal housing, change in rangeland and grass field rotation, and biogas plant construction	1
		06	Fisheries	Fishing port rehabilitation, fishery resource management, and technical support	4
		07	Agro-economy	Utilization of mutual aid system, grain storage and development of emergency food service facilities, establishment of grain bank, debt relief, and income diversification	1

Sector		Small Classification		Adaptation Cases	Projects
2	Agriculture and rural development	08	Development of sustainable agriculture	Land development with soil conservation, soil conservation, development of small-scale irrigation facilities, and afforestation and forest conservation	2
		09	Development/ improvement of farmland		1
		10	Agricultural processing		1
3	Forestry/ natural resource conservation	01	Forest conservation and afforestation	Conservation/restoration of tropical forest, afforestation, and water resource conservation	37
		02	Land conservation	Erosion control works of the slope, relief work for sediment discharge, sand dune fixation work for anti-desertification, grassland improvement by seeding grasses, construction of sabo dam and riverbank protection as conservation measures to prevent soil erosion, and soil conservation	15
		03	Mangrove conservation	Mangrove conservation	0
		04	Lakefront/ coastal protection/ restoration	Lakefront /coastal protection/restoration, and prevention work for shore erosion/sedimentation	3
		05	Ecosystem (biodiversity) integrity/ restoration	Conservation of coral reef and rare species	5
4	Disaster management	01	Coastal protection	Development/improvement of coastal protection facilities, preparation of contingency plan for sea level rise and forecast and warning system, swamp protection, hazard mapping for tsunami, storm surge and inland waters, development of evacuation space, and procurement of disaster prevention ships	3
		02	River disaster prevention (flood control)	Dike construction, dike reinforcement in hazard area (flood prone area), utilization and life extension of existing facilities, understanding the current protection level, improvement and development of flood protection infrastructure, development of retarding basin and regulating pond, measures for riverbed degradation, river improvement, rehabilitation of embankment, and development of pumping station, flood gate, drainage and floodway	35
		03	Disaster-relief		1
		04	Information system	Upgrading of monitoring system (long-term, on a real-time basis), and precautions for emergency including early-warning system	1
		05	Development of human resources, environmental management ability	Capacity building of community organizations, information service for disaster risk, assessment of disaster risk, development of maintenance ability for facility managers, information system for hazard mapping and information service for flood disaster history, and maritime training	4
		06	Urban disaster prevention	“Flood tolerance” building, development of sewerage system, and change in building style	0
		07	Forest disaster prevention		0

Sector		Small Classification		Adaptation Cases	Projects
4	Disaster management	08	Sediment management	Development of soil conservation facilities (same as 302)	0
		09	Land use management		0
5	Urban-regional development	01	Rural development	Basic infrastructure of water supply and sanitation facilities, production facilities, health-related facilities, and educational facilities	38
		02	Urban development	Water supply facilities, drainage facilities, wastewater disposal facilities, housing	2
6	Transportation	01	Road and bridge	Improvement and rehabilitation of road, construction and rehabilitation of bridge and tunnel, and road disaster management	164
		02	Airport		35
		03	Port	Development, improvement, expansion, upgrading, rehabilitation, and dredging of port	36
		04	Railway	Improvement of tracks and rehabilitation of facilities	83
		05	Marine transportation	Development of marine safety facilities, study and improvement of sea ship, development of canal, and dredging of river	7
		06	Others		1
		07	Logistic facilities		1
7	Medical and health care	01	Development of Basic adaptive capacity	Awareness raising on health control, and preparation and diffusion of health guidance manual for heat disorder	0
		02	Measures for high risk area	Study on the outbreak and distribution condition of vectors	0
		03	Heat prevention	Adjustment of clothing and activity level, temperature warning system in national and local regions, increase in fluid intake, development of shelter for heat disorder prevention, and mitigation of heat island effect by afforestation	0
		04	Malaria control	Vaccination, study on the emergence of insecticide resistance, development of human resources to plan vector mosquito control, vector control (mosquito, etc.,), and providing information for vector control	0
		05	Waterborne infectious disease control	Improvement of sanitary facilities, development of new vaccine for infectious disease, and development of water supply and sewage system	1
		06	Medical care	Rotating medical care system, and medical equipment	15
8	Architecture	01	Architecture		31
9	Mining and manufacturing	01	Manufacturing		4
		02	Factory and plant		6
		03	Mining		3
10	Government administration	01	Finance		25
		02	Environmental issues		50
		03	Topographic survey and mapping		1
		04	General government		5

Sector		Small Classification		Adaptation Cases	Projects
10	Government administration	05	Assistance in policy-making system		57
		06	Assistance for rehabilitation and reconstruction		0
11	Energy	01	Energy saving		2
		02	Energy supply		18
		03	Electric power generation and supply		195
		04	Renewable energy		14
		05	Energy facilities		2
12	Human resources	01	Education	Education, educational equipment, personnel development, scholarship offers, overseas education, education continuance, and training	42
		02	Medical education	Training	13
13	Public works	01	Water supply	Water supply, water service, and raw water transmission	95
		02	Urban health		9
		03	Sewerage and drainage	Sewerage, municipal effluent, and regional drainage	79
14	Commerce	01	Tourism		7
15	Communications and broadcasting	01	Telecommunications		17
		02	Broadcasting		11
99	Others	01	Instauration		1
		02	Poverty program, improvement of livelihood	Community development, microcredit, rural finance, social development program, improvement of livelihood, and participatory development	19

4.3 Integration of Detailed Classifications into Target Sub-sectors

Similar or related detailed classifications used in the above process were integrated into 8 sectors and 20 sub-sectors shown in Table 4.2. Table 4.3 shows the integration process into sub-sectors.

Table 4.2 Integrated Sub-sectors

Sector	Sub-sector
Water resources	Water resources management
	Water resources development
	Water resources utilization
Agriculture and rural development	Irrigation, drainage
	Enhancement of agricultural management (cultivation management, breed, irrigation association)
	Livestock and fisheries
Forestry/natural resource conservation	Forest conservation, afforestation (planting grass seeds)
	Ecosystem integrity
Disaster management	Flood control
	Coastal protection
	Sediment-related disaster prevention
	Information system
Urban-regional development	Rural community improvement
	Urban community improvement
Transportation	Transportation infrastructure
Sanitary improvement	Water supply
	Sewerage, drainage
	Medical, health care
Others	Village development, enhancement of local community
	Development of human resources

Table 4.3 Integration into Sub-sectors

<table>
<tr><th rowspan="2">Sector</th><th rowspan="2">Suggested Sub-sector</th><th rowspan="2">Adaptation Cases</th><th colspan="4">JICA Loan Category</th></tr>
<tr><th colspan="2">Small Classification</th><th colspan="2">Projects</th></tr>
<tr><td rowspan="3">Water resources</td><td>Water resources management</td><td>Introduction of the system accommodating water distribution within an area in a dry spell, dissemination of drought information, water demand management through measuring and pricing, capacity building for sustainable water utilization, water level observation, and water regulating dam</td><td>101</td><td>Proper management of water resources</td><td>2</td><td>2</td></tr>
<tr><td>Water resources development</td><td>Construction of water intake structure, development of water storage facilities, desalination of seawater, rainwater harvesting, rehabilitation of dam, and construction of headrace</td><td>102</td><td>Water resources development, facility improvement</td><td>14</td><td>14</td></tr>
<tr><td>Water resources utilization</td><td>Utilization of recycled wastewater, reclaimed water and rainwater, raising awareness for water-saving, diffusion of water-saving equipment, and leakage reduction</td><td>103</td><td>Utilization of water resources</td><td>2</td><td>2</td></tr>
<tr><td rowspan="7">Agriculture and rural development</td><td>Irrigation and drainage</td><td>Improvement of reclaimed land and drainage, irrigation and hydroponic culture, water-saving irrigation, development and improvement of irrigation facilities, and irrigation with recycled wastewater</td><td>201</td><td>Irrigation and drainage</td><td>56</td><td>56</td></tr>
<tr><td rowspan="4">Farmland management enhancement (cultivation management, varieties, water users association)</td><td>Conservation of soil moisture by mulching, pest control and crop monitoring, intercrops, change of farming timing, facility introduction to avoid high temperature injury, change of cropping season, retention of crop residues, sericulture, crop diversification, agricultural extension, and strengthening of water users association</td><td>202</td><td>Cultivation management (assistance in farmland management), enhancement of water users association</td><td>13</td><td rowspan="4">18</td></tr>
<tr><td>Switching to heat resistant varieties, development of drought- tolerant varieties, development and promotion of alternative crops, and development of wind-resistant varieties</td><td>203</td><td>Crop variety development</td><td>3</td></tr>
<tr><td>Providing weather forecast information</td><td>204</td><td>Information system</td><td>0</td></tr>
<tr><td>Land development with soil conservation, soil conservation, development of small-scale irrigation facilities, and afforestation and forest conservation</td><td>208</td><td>Development of sustainable agriculture</td><td>2</td></tr>
<tr><td rowspan="2">Livestock and fishery</td><td>Change in stock raising density, technique development for infertile breeder during summer, impact assessment for heat stress on infertility, development of mitigation technique to reduce genital function stress, environmental control for animal housing, change in rangeland and grass field rotation, and biogas plant construction</td><td>205</td><td>Livestock</td><td>1</td><td rowspan="2">5</td></tr>
<tr><td>Fishing port rehabilitation, fishery resource management, and technical support</td><td>206</td><td>Fisheries</td><td>4</td></tr>
</table>

<table>
<tr><th rowspan="2">Sector</th><th rowspan="2">Suggested Sub-sector</th><th rowspan="2">Adaptation Cases</th><th colspan="4">JICA Loan Category</th></tr>
<tr><th colspan="2">Small Classification</th><th colspan="2">Projects</th></tr>
<tr><td rowspan="4">Forestry/ natural resource conservation</td><td rowspan="2">Forest conservation/ afforestation (planting grass seeds)</td><td>Conservation/restoration of tropical forest, afforestation, and water resource conservation</td><td>301</td><td>Forest preservation and afforestation</td><td>37</td><td rowspan="2">37</td></tr>
<tr><td>-</td><td>407</td><td>Forest disaster prevention</td><td>0</td></tr>
<tr><td rowspan="2">Ecosystem integrity</td><td>Mangrove conservation</td><td>303</td><td>Mangrove conservation</td><td>0</td><td rowspan="2">5</td></tr>
<tr><td>Conservation of coral reef and rare species</td><td>305</td><td>Ecosystem (biodiversity) integrity/ restoration</td><td>5</td></tr>
<tr><td rowspan="7">Disaster management</td><td>Flood control</td><td>Dike construction, dike reinforcement in hazard area (flood prone area), utilization and life extension of existing facilities, understanding the current protection level, improvement and development of flood protection infrastructure, development of retarding basin and regulating pond, measures for riverbed degradation, river improvement, rehabilitation of embankment, and development of pumping station, flood gate, drainage and floodway</td><td>402</td><td>River disaster prevention (flood control)</td><td>35</td><td>35</td></tr>
<tr><td rowspan="2">Coastal protection</td><td>Lakefront /coastal protection/restoration, and prevention work for shore erosion/sedimentation</td><td>304</td><td>Lakefront/ coastal protection/ restoration</td><td>3</td><td rowspan="2">6</td></tr>
<tr><td>Development/improvement of coastal protection facilities, preparation of contingency plan for sea level rise and forecast and warning system, swamp protection, hazard mapping for tsunami, storm surge and inland waters, development of evacuation space, and procurement of disaster prevention ships</td><td>401</td><td>Coastal protection</td><td>3</td></tr>
<tr><td rowspan="2">Sediment-related disaster prevention</td><td>Prevention work for erosion of the slope, relief work for sediment discharge, sand dune fixation work for anti-desertification, grassland improvement by seeding grasses, construction of sabo dam and riverbank protection as conservation measures to prevent soil erosion, and soil conservation</td><td>302</td><td>Land conservation</td><td>15</td><td rowspan="2">15</td></tr>
<tr><td>Development of soil conservation facilities (same as 302)</td><td>408</td><td>Sediment management</td><td>0</td></tr>
<tr><td rowspan="2">Information system</td><td>Providing weather forecast information</td><td>204</td><td>Information system</td><td>0</td><td rowspan="2">1</td></tr>
<tr><td>Upgrading of monitoring system (long-term, on a real-time basis), and precautions for emergency including early-warning system</td><td>404</td><td>Information system</td><td>1</td></tr>
</table>

Sector	Suggested Sub-sector	Adaptation Cases	JICA Loan Category			
			Small Classification		Projects	
Urban-regional development	Rural development	Basic infrastructure of water supply and sanitation facilities, production facilities, health-related facilities, and educational facilities	501	Rural development	38	38
	Urban development	"Flood tolerance" building, development of sewerage system, and change in building style	406	Urban disaster prevention	0	2
		Water supply facilities, drainage facilities, wastewater disposal facilities, housing	502	Urban development	2	
Transportation	Transportation infrastructure	Improvement and rehabilitation of road, construction and rehabilitation of bridge and tunnel, and road disaster management	601	Road and bridge	164	290
		Development, improvement, expansion, upgrading, rehabilitation, and dredging of port	603	Port	36	
		Improvement of tracks and rehabilitation of facilities	604	Railway	83	
		Development of marine safety facilities, study and improvement of sea ship, development of canal, and dredging of river	605	Marine transportation	7	
Sanitary improvement	Water supply	Development of safe drinking water and public health, development/enhancement of private electric generator in purification plant, selection of consolidated evaluation on raw water quality characteristic and its suitable purification process, and eutrophication prevention	104	Water and sanitary improvement	0	95
		Water supply, water service, and raw water transmission	1301	Water supply	95	
	Sewerage and drainage	Sewerage, municipal effluent, and regional drainage	1303	Sewerage and drainage	79	79
	Medical/ health care	Awareness raising on health control, and preparation and diffusion of health guidance manual for heat disorder	701	Development of Basic adaptive capacity	0	16
		Study on the outbreak and distribution condition of vectors	702	Measures for high risk area	0	
		Adjustment of clothing and activity level, temperature warning system in national and local regions, increase in fluid intake, development of shelter for heat disorder prevention, and mitigation of heat island effect by afforestation	703	Heat prevention	0	
		Vaccination, study on the emergence of insecticide resistance, development of human resources to plan vector mosquito control, vector control (mosquito, etc.,), and providing information for vector control	704	Malaria control	0	
		Improvement of sanitary facilities, development of new vaccine for infectious disease, and development of water supply and sewage system	705	Waterborne infectious disease control	1	
		Rotating medical care system, and medical equipment	706	Medical care	15	

<table>
<tr><th rowspan="2">Sector</th><th rowspan="2">Suggested Sub-sector</th><th rowspan="2">Adaptation Cases</th><th colspan="4">JICA Loan Category</th></tr>
<tr><th colspan="2">Small Classification</th><th colspan="2">Projects</th></tr>
<tr><td rowspan="4">Others</td><td>Village development, enhancement of local community</td><td>Community development, microcredit, rural finance, social development program, improvement of livelihood, and participatory development</td><td>9902</td><td>Poverty program, improvement of livelihood</td><td>19</td><td>19</td></tr>
<tr><td rowspan="3">Human resources development</td><td>Capacity building of community organizations, information service for disaster risk, assessment of disaster risk, development of maintenance ability for facility managers, information system for hazard mapping and information service for flood disaster history, and maritime training</td><td>405</td><td>Development of human resources, environmental management ability</td><td>4</td><td rowspan="3">59</td></tr>
<tr><td>Education, educational equipment, personnel development, scholarship offers, overseas education, education continuance, and training</td><td>1201</td><td>Education</td><td>42</td></tr>
<tr><td>Training</td><td>1202</td><td>Medical education</td><td>13</td></tr>
</table>

4.4 Trends of Projects by Other Donors

The trend of adaptation measure projects for climate change implemented by other donors is investigated and verified as to whether the adaptation projects not in the suggested sub-sector were implemented, then summarize the differences in trends between JICA projects and other projects.

4.4.1 World Bank

In the World Bank database[1], 143 projects are considered as adaptation measures as a result of screening the 635 of climate change-related projects (as of the end of February 2011) through excluding those seemingly-related projects to mitigation measure such as energy and industrial development sectors. Finally, the remaining 143 projects are classified into each target sub-sector in this survey. Table 4.4 presents the result of the screening and classification.

Many of the World Bank projects tend to fall into the forest or transportation sectors, of which projects are possibly classified into mitigation measures, while its assistance trend for adaptation measures is unclear.

4.4.2 GEF

From GEF's database[2], 645 projects whose focal area is climate change and implemented after 2000 are extracted. Among these, 88 adaptation related projects are extracted based on the project name and explanations and classified into the suggested sub-sectors in accordance of each project explanation shown in Table 4.4.

GEF projects seem to focus on water resources, agriculture, disaster management, government, and human resources. In the sectors of disaster management, government, and human resources, many adaptation projects aim at moderating the vulnerability of the government or community and other stakeholders.

4.4.3 ADB

From ADB's database[3], 23 loan projects related to adaptation measures are extracted. These 23 projects are classified into the suggested sub-sectors in accordance with each project explanation shown in Table 4.4.

ADB projects seem to focus on disaster management and the government sectors. Similar to GEF, many adaptation projects are awareness programs for climate change or capacity enhancement. In the agriculture, water resource, and rural development sectors, indirect support is provided by increasing adaptive capacity through enhancement of research institutes.

[1] http://www.worldbank.org/
[2] http://www.gefonline.org/
[3] http://www.adb.org/Climate-Change/projects.asp#promoting

Table 4.4 Comparison of Suggested Sub-sectors with Sub-sectors of WB, GEF, ADB Projects

Sector	Suggested Sub-sector	World Bank		GEF		ADB	
	Sub-sector	Sub-sector	Nos.	Sub-sector	Nos.	Sub-sector	Nos.
Water resources	Water resources management			Water resources management	8	Water resources management	3
	Water resources development			Water resources development	1	Water resources development	1
	Water resources utilization						
Agriculture and rural development	Irrigation and drainage	Irrigation and drainage	5				
	Farmland management enhancement (cultivation management, varieties, water users association)			Farming support	10	Farming support	2
				Sustainable agriculture	2		
		Research development	12				
	Livestock and fishery	Livestock	3	Livestock	3		
		Agriculture administration	3				
		Agricultural processing	7				
						Others	1
Forestry/ natural resource conservation	Forest conservation/ afforestation (planting grass seeds)	Forest	47	Forest conservation/ afforestation	1		
				Forest disaster prevention	1		
	Ecosystem integrity						
						Coastal protection	3
				Development of human resources, Environmental management ability	24	Development of human resources, Environmental management ability	3
Disaster management	Flood control	Flood control	6	Flood control	1		
	Coastal protection			Coastal protection	2		
	Sediment- related disaster prevention						
	Information system			Information system	4	Information system	1
						Land use management	1
Urban-regional development	Rural development	Housing	1				
	Urban development						

Sector	Suggested Sub-sector	World Bank		GEF		ADB	
	Sub-sector	Sub-sector	Nos.	Sub-sector	Nos.	Sub-sector	Nos.
Transportation	Transportation infrastructure	Transportation by ship, port	4			Port	1
		Railway	4				
		Road	6				
		General transportation	15				
		Transportation administration	5				
Sanitary improvement	Water supply	Water supply	3				
	Sewerage and drainage	Sewerage	2				
	Medical/ health care	Sanitary	1	Medical education		Medical education	
Others	Village development, enhancement of local community						
	Human resources development	Primary education	1	Education	10		
		Vocational training	1				
Government administration				Environmental issues	13	Environmental issues	1
				General administration	1		
Energy				Renewable energy	1		
Finance		Finance	2				
Overall water resources management (water resource, sewage water, flood control)		Overall water resources management	14				
		Government administration	1				

4.5 Selection of Target Sub-sectors

Based on the classification conducted above, and clarification of the potential of adaptation measures in each sub-sector, the following 15 sub-sectors shown in Table 4.5 were selected.

Table 4.5 Sub-sectors for Adaptation Measures

Sub-sector
1. Water Resources
2. Irrigation and Drainage
3. Farmland Management Enhancement
4. Forest Conservation/ Afforestation
5. Ecosystem Integrity
6. Flood Control
7. Coastal Protection
8. Sediment-related Disaster Prevention
9. Disaster Prevention Information System
10. Rural / Urban Development
11. Bridge, Road and Railway
12. Port and Airport
13. Water Supply
14. Sewerage / Urban Drainage
15. Medical / Health Care

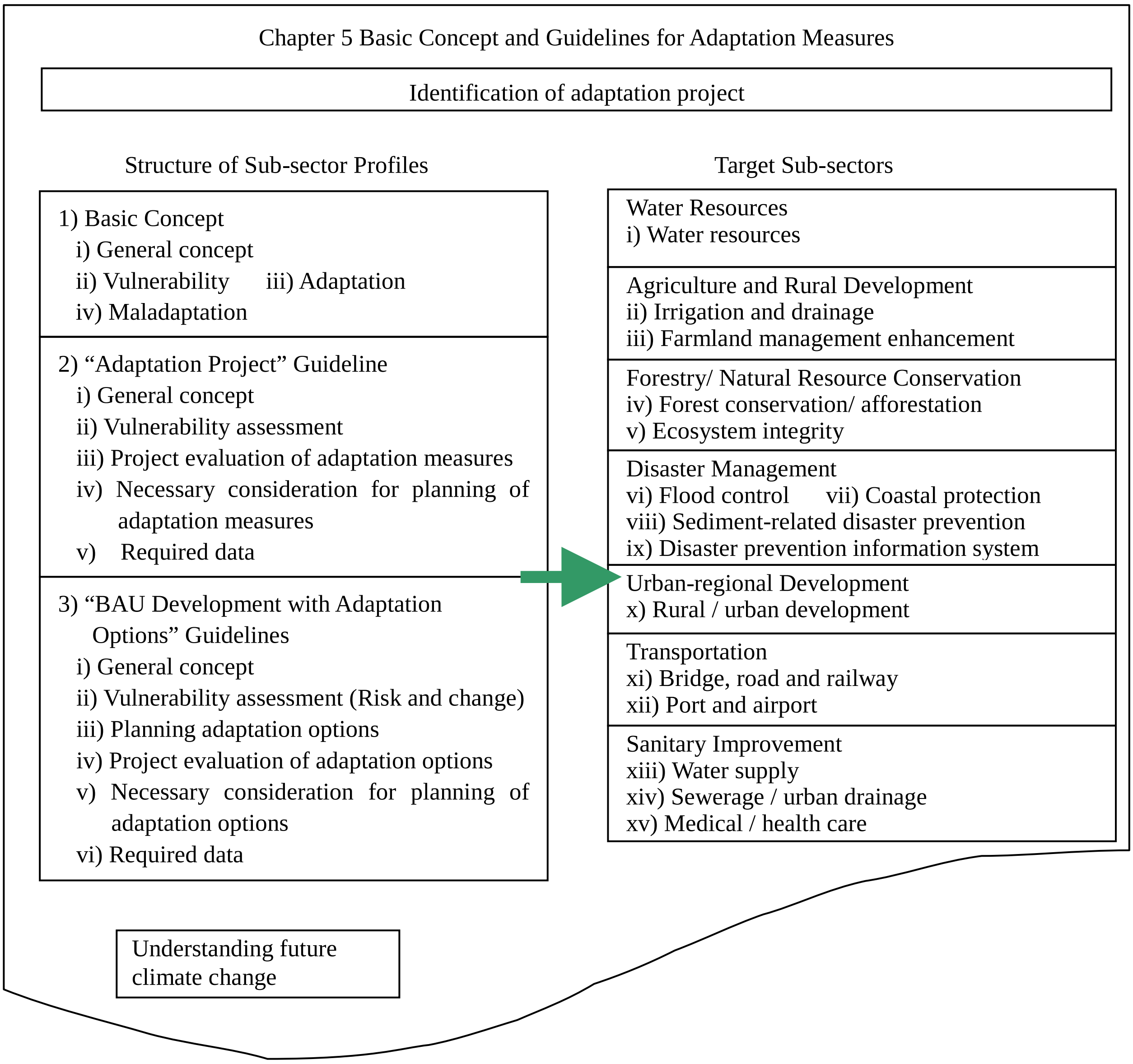
Chapter 5 Basic Concept and Guidelines for Adaptation Measures

This chapter shows how to formulate the adaptation measures.

In Figure 5.1, a workflow shows how to identify an adaptation project. If it is identified as an adaptation project, the project is classified as either "Adaptation Project" or "BAU Development with Adaptation Options", and how it should be further examined during project preparatory survey.

Subsequently, the section on "Basic Concept," summarizes vulnerability to climate change in each sub-sector as well as adaptation measures to cope with such vulnerability and maladaptation.

The sections about "guidelines" summarizes the direction of project preparatory survey, etc. for typical adaptation projects examined in this survey, with due consideration to future potential of formulating JICA ODA loan project in the target sub-sector.



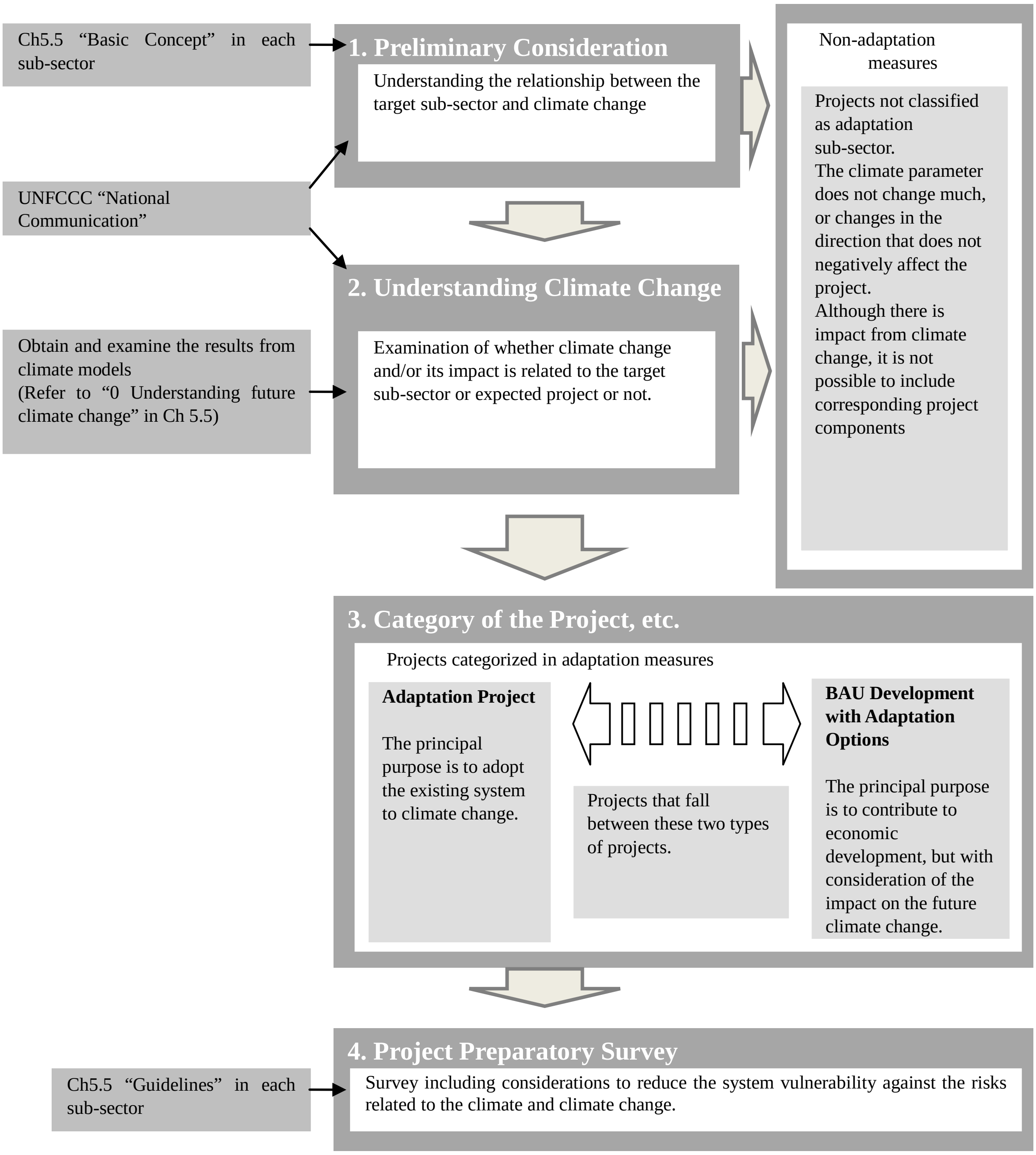


Figure 5.1 Process of Formulating Adaptation Measures

5.1 Basic Concept

Table 5.1 summarizes the structure and the contents of the adaptation concept in each sub-sector.

Table 5.1 Structure of the Adaptation Concept

A. General Concept	General description and introductions for climate change impact and adaptation in the target sub-sector
B. Vulnerability	As defined in the Section 3.2, the vulnerability to climate change in this report is shown below: Vulnerability = Exposure to climate hazards and perturbations x Sensitivity – Adaptive capacity The expected vulnerability to climate change in the target sub-sector is summarized below: 1) Major Climate Change Impacts on the Target Sub-sector This shows the climate parameters related to the target sub-sector and how climate change influences said sub-sector. In this report, both change of external force related to the target sub-sector caused by climate change, and its probability of impact to the target sub-sector (sensitivity) are explained. 2) Other Factors that Influence the Target Sub-sector Associated with Climate Change Impacts When socio-economies as well as climate dynamically change, the impacts on the target sub-sector could increase with the synergy effects. Thus, these socio-economic factors are mentioned here. 3) Adaptive Capacity to Climate Change It shows the adaptive capacities such as organization, ability and budget for combating climate change. When the adaptive capacity is high, the vulnerability becomes low. 4) Spatial Distribution of Vulnerability Vulnerability factors are heterogeneously distributed in the target system. It examines the spatial distribution of vulnerability, because some area is much more influenced by climate change.
C. Adaptation Measures	It mainly shows the major structural and non-structural measures, which are expected to be applied in the loan assistance.
D. Maladaptation	Maladaptation is defined as the project activities which increase the vulnerability. 1) Business-as-usual development, which by overlooking climate change impacts, inadvertently increases exposure and/or vulnerability to climate change. 2) Actions undertaken to adapt to climate impacts that do not succeed in reducing vulnerability, but increase it instead. In this step, it shows the related maladaptation in the target sub-sector, which requires attention.

5.2 Guidelines

Respective guidelines on “Adaptation Project “and “BAU Development with Adaptation Options” are shown for each sub-sector. As explained in Chapter 3, it is difficult to clearly distinguish these types in actual projects. The guidelines in this survey correspond to typical example for each type in each sub-sector.

As defined in Section 3.2, the adaptation in this survey is defined as “reducing vulnerability”. Thus, vulnerability assessment becomes crucial for examination of adaptation measures. This report presents the vulnerability assessment in detail for “Adaptation Project”, while also presenting minimum considerations that should be given to vulnerability for the “BAU Development with Adaptation Options”. Among the parameters influencing vulnerability, the “Assess Future Exposure to Climate Hazards and Perturbations”, which means the change of external force, is solely examined for "BAU Development with Adaptation Options". Table 5.2 presents comparison of both concepts.

Table 5.2 Concept Comparison between “Adaptation Project” and “BAU Development with Adaptation Options”

Adaptation Project	BAU Development with Adaptation Options
Projects formed to reduce the climate change vulnerability in the existing system such as projects to improve existing facility to cope with the increased vulnerability caused by the change of external forcing due to climate change.	Projects which is not mainly aimed to reduce the vulnerability, but is designed to adapt to the impacts of the climate change in achieving its main objective, such as development and rehabilitation of infrastructure projects that are planned or designed with consideration to increasing external forcing stemming from climate change.

5.2.1 Adaptation Project

The process for formulating "Adaptation Project" is shown in Figure 5.2.

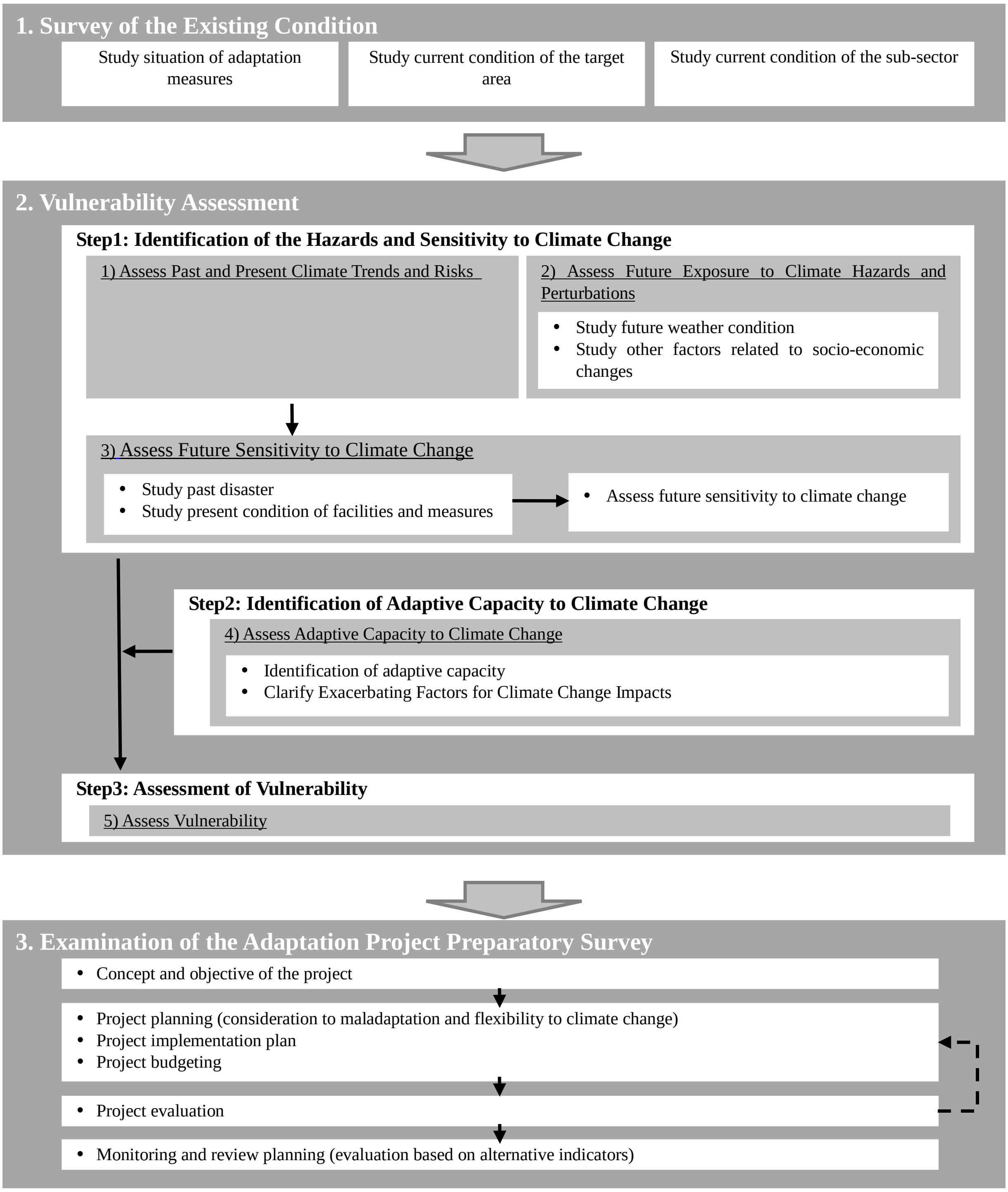


Figure 5.2 Formulation Process for "Adaptation Project"

Guidelines in each sub-sector summarizes the items (overall vulnerability assessment, flexibility in adaptation examination, maladaptation consideration, evaluation items for project evaluation and monitoring) which require examination in addition to those considered in business-as-usual development projects. The guidelines on “Adaptation Project” include the following items shown in Table 5.3.

Table 5.3 Evaluation Items for Guidelines on “Adaptation Project”

A. General	The necessity, description and impact of the adaptation project in the target sub-sector
B. Vulnerability Assessment	STEP 1: 1) Assess past and present climate trends and risks 2) Assess future exposure to climate hazards and perturbations a) Study future weather conditions b) Study other Factors related to socio-economic changes 3) Assess future sensitivity to climate change a) Study past damage b) Study present condition of facilities and measures c) Assess future sensitivity to climate change STEP 2: 4) Assess adaptive capacity to climate change a) Identification of adaptive capacity b) Clarify exacerbating factors for climate change impacts STEP 3: 5) Assess Vulnerability
C. Project Evaluation of Adaptation Measures	Project evaluation Major alternative indicators used during monitoring and review
D. Necessary Consideration for Planning of Adaptation Measures	1) Monitoring and review 2) Flexibility to climate change 3) Consideration to Maladaptation
E. Required Data	Required data for the vulnerability assessment and project evaluation, which are additional when compared to business-as-usual development project evaluation

5.2.2 BAU Development with Adaptation Options

The process for formulating “BAU Development with Adaptation Options” is shown in Figure 5.3. Vulnerability assessment is simplified compared to the procedure for “Adaptation Project” as shown in the chart below.

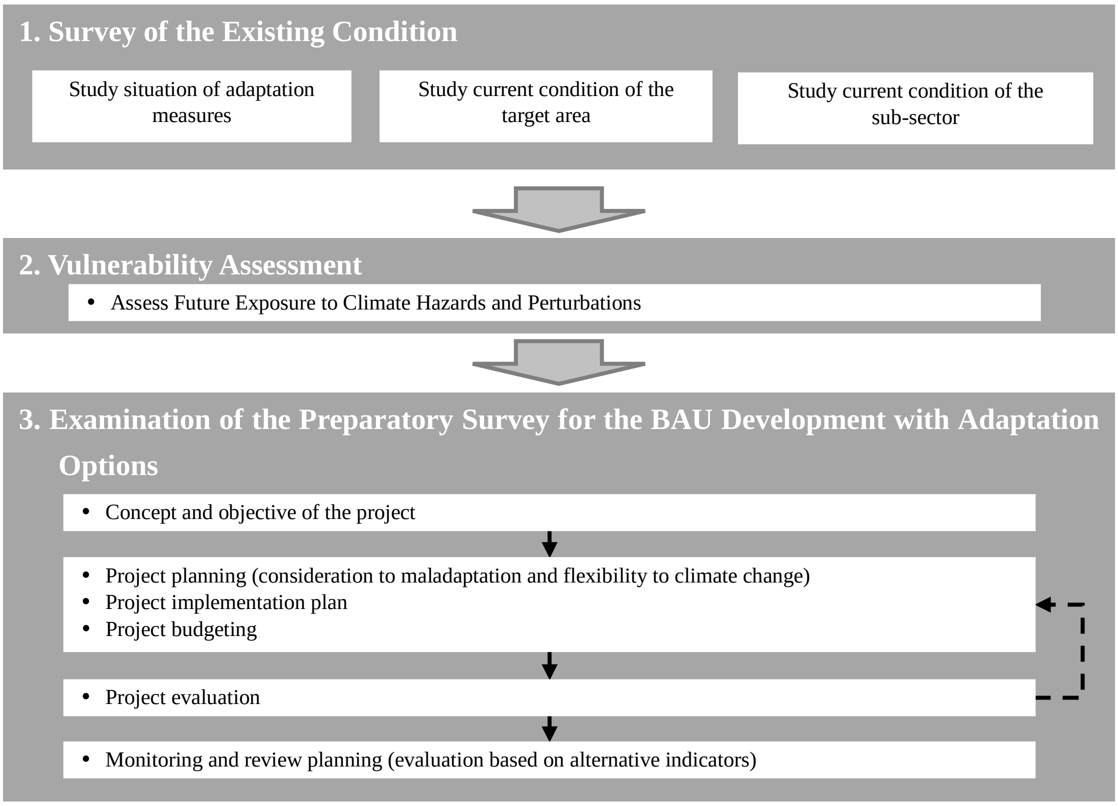


Figure 5.3 Formulation Process for "BAU Development with Adaptation Options"

The following additional actions are required for "BAU Development with Adaptation Options" as compared to the "Business-As-Usual Development":

-Vulnerability assessments

-Planning adaptation options

-Consideration of flexibility to climate change and maladaptation

-Project evaluation (additional cost and effect for the adaptation options)

-Monitoring and review planning (evaluation based on alternative indicator)

Based on the above discussion, additional considerations for BAU Development with Adaptation Options are summarized in guidelines for each sub-sector (see Table 5.4) the section related to the policy in sub-sector. Other general considerations for "BAU Development" projects are omitted.

Table 5.4 Evaluation Items for Guidelines on "BAU Development with Adaptation Options"

A. General	The necessity, description and impact of the BAU Development with Adaptation Options in the target sub-sector
B. Vulnerability Assessment (Risk and Change)	Assess future exposure to climate risk and change
C. Planning Adaptation Options	Develop the adaptation options in consideration of climate change
D. Project Evaluation of Adaptation Options	Project evaluation Major alternative indicators used during monitoring and review
E. Necessary Consideration for Planning of Adaptation Options	1) Monitoring and Review 2) Flexibility to climate change 3) Consideration to Maladaptation
F. Required Data	Required data for the vulnerability assessment and project evaluation, which are additional when compared to business-as-usual development project evaluation

5.3 Reviewed Documents for Each Target Sub-sector

Table 5.5 summarizes the reference documents for policy making in each sub-sector. Details are classified for each sub-sector.

Table 5.5 Reference Documents for Each Sub-sector

Sector	Sub-sector	Reference Documents
Water resources	1 Water resources	・ IPCC. (2007). AR4 WGII Report ・ JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development ・ GTZ. (2008). Water and Adaptation to Climate Change: Consequences for Developing Countries ・ Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2008). Integrated Water Resource Management addressing Climate Change and Other Risks (Interim Report)
Agriculture and rural development	2 Irrigation and drainage	・ GTZ. (2008). Climate Change and Agriculture: Threats and Opportunities ・ Ministry of Agriculture, Forestry and Fisheries, Japan. (2008). Nogyo Noson ni okeru Chikyu Ondanka Taiousaku no Arikata (in Japanese)
	3 Farmland management enhancement	・ GTZ. (2008). Climate Change and Agriculture: Threats and Opportunities. ・ Ministry of Agriculture, Forestry and Fisheries, Japan. (2008). Nourinsuisan-sho Chikyu Ondanka Taisaku Sogo Senryaku (in Japanese)
Forestry/ natural resource conservation	4 Forest conservation/ afforestation	・ Ministry of the Environment, Japan.(2008). Kikouhendou heno Kashikoi Tekiou (in Japanese), Chapter 4 Natural Ecosystem ・ IPCC. (2007).AR4 WGII Report ・ David L. Spittlehouse, Robert B. Stewart. (2003). Adaptation to Climate Change in Forest Management. BC Journal of Ecosystems and Management. Vol. 4. No.1 ・ FAO / Intercooperation (Swiss). (2005).Adaptation of Forest Ecosystems and the Forest Sector to Climate Change ・ UNDP.(2010). Mapping Climate Change Vulnerability and Impact Scenarios - A Guidebook for Sub-National Planners
	5 Ecosystem integrity	・ Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou (in Japanese), Chapter 4 Natural Ecosystem ・ IPCC. (2007).AR4 WGII Report ・ The Ramsar Convention on Wetland (2002) Climate Change and Wetlands: Impacts, Adaptation, and Mitigation (Resolution VIII.3) ・ Secretariat of Convention of Biological Diversity. (2009). Connecting Biodiversity and Climate Change - Mitigation and Adaptation-. CBD Technical Series No.41 ・ IBRD / WB. (2008). Climate Change, and Adaptation - Nature-Based Solutions from the World Bank Portfolio

Sector	Sub-sector	Reference Documents
Disaster management	6 Flood control	・JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development ・Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2010). Practical Guidelines on Strategic Climate Change Adaptation Planning -Flood Disasters-
	7 Coastal protection	・JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development ・USAID. (2009). Adapting to Coastal Climate Change: A Guidebook for Development Planners
	8 Sediment-related disaster prevention	・Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2008). Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming (Policy Report)
	9 Disaster prevention information system	・WMO, the Earth Institute, Global Humanitarian Forum, Zain, and Ericsson. (2008). Weather Info for All Initiative 2008-2012.
Urban-regional development	10 Rural / urban development	・Japan Society of Civil Engineers, (2009). Chikyu Ondanka ni Idomu Doboku Kougaku － Dai 4 pen: Chikyu Ondanka ni taisuru Tekiousaku. (in Japanese). ・Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 7 Kokumin Seikatsu / Toshi Seikatsu Bunya. (in Japanese).
Transportation	11 Bridge, road and railway	・Highway Agency. (2010), The Highway Agency's Interim Climate Change Risk Assessment ・Network Rail. (2010), Network Rail Interim Climate Change Adaptation Report ・Rail Safety & Standards Board. (2008). Assessing the Impact of Climate Change on Transport Infrastructure
	12 Port and airport	・Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2009). Chikyu-Ondanka ni Kiinsuru Kiko-Hendo ni Taisuru Kowan-Seisaku no Arikata: Toshin (in Japanese).
Sanitary improvement	13 Water supply	・Ministry of the Environment, Japan. (2008). Kikouhendo heno Kashikoi Tekiou: Chapter 3 Mizu Kankyo / Mizu Shigen Bunya (in Japanese). ・UNEP (1998) Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies; Chapter 6.
	14 Sewerage / urban drainage	・Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 3 Mizu Kankyo / Mizu Shigen Bunya. (in Japanese). ・JICA (2010) Handbook for Climate Change Adaptation in Water Sector. ・National Geographic official website (Japanese). (2011). Chikyu Ondanka ga Umidasu Mittsu no Igaina Heigai - Gesui niyoru Inryousui no Osen (in Japanese): http://www.nationalgeographic.co.jp/news/news_article.php?file_id=20110302002 ・Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 3 Mizu Kankyo / Mizu Shigen Bunya. (in Japanese)
	15 Medical / health care	・WHO. (2003). Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change. ・Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 6 Kenkou Bunya. (in Japanese).

5.4 Assumptions for Preparing Guidelines for Target Sub-sectors

During preparation of the guidelines in each sub-sector, typical project outline for “Adaptation Project” and for “BAU Development with Adaptation Options” with future potential of becoming JICA ODA loan project has been presented. Table 5.6 summarizes the description of the assumed projects.

Some sub-sectors have either one of, “Adaptation Project” or “BAU Development with Adaptation Options”.

Table 5.6 Assumed Project of Each Sub-sector

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
1. Water Resources	Adaptation Project	Climate change will bring imbalance between water supply and demand for existing water resources facilities, due to change in precipitation and its pattern, increase of water demand due to temperature rise, etc. In addition, the intensification of flood would damage the facilities.	Adaptation measures against water shortage include: to increase the active capacity of reservoir by structural measures such as raising dam height, excavating reservoir, etc.; to increase water resources by reduction of water leakage, new water resources development and water conveyance; and to reallocate and utilize water resources by improvement of dam management or integrated water resources management. Reinforcement of intake facility will be a countermeasure against flood intensification.	The impacts of climate change on the water resources sub-sector will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Flexibility of water supplier side ・Flexibility of water user side ・Flexibility of water supply and demand adjustment ・Disaster resilience capacity of regulatory agency ・Existence and ability of research and development [Alternative Items] ・Improvement of target return period by expanded facilities ・Improvement of target return period in the target area by new facility development ・Improvement of target return period in the target area by water management improvement ・Changes in the number of beneficiaries ・Changes in the awareness of stakeholders on water supply and water use

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	It is necessary to develop water resources since future water demand will exceed the existing water supply from water resources, such as dam reservoir, water intake at river, groundwater, etc., in association with economic growth. Future climate change impacts such as reduction of water availability due to rainfall change, increase of water demand due to temperature rise, and intensification of the flood scale, shall be considered.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	The expected water supply will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Improvement of target return period of expanded facilities ・Improvement of target return period in the target area by new facility development ・Improvement of target return period in the target area by water management improvement ・Changes in the number of beneficiaries ・Changes in stakeholders' awareness of water supply and water use

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
2. Irrigation and Drainage	Irrigation	Adaptation Project	Climate change impacts, such as decrease in precipitation, change of precipitation patterns, and prolongation of drought, are likely to increase crop damage.	To reduce drought damage by means of development/ expansion/ improvement of irrigation facilities, installation of water saving irrigation, etc.	Crop damage in the event of drought, which will be exacerbated by climate change, will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Activity of agricultural extension office and NGOs ・Disaster resilience capacity of regulatory agency ・Existence and ability of research and development ・Compensation for crop and structural damage by climate disaster ・Financial scheme to farmers ・Socio-economic condition of farmers [Alternative Items] ・Expansion of irrigated area, improvement of target return period ・Improvement of water management ・Implementation situation of participatory irrigated agriculture development ・Changes in the awareness of stakeholders
		BAU Development with Adaptation Options	New irrigation facilities will be constructed, or existing ones will be rehabilitated or expanded in order to improve agricultural productivity. Potential risks of reduction in irrigation efficiency because of water shortage are likely to increase due to climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	The expected irrigated farming will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Expansion of irrigated area, improvement of target return period ・Improvement of water management ・Implementation situation of participatory irrigated agriculture development ・Changes in the awareness of stakeholders

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	Drainage	Adaptation Project	Climate change will increase frequency and intensity of flood, hence the flood damages on crops will increase.	To reduce flood damage on crops by means of development, expansion, and improvement of drainage facilities.	Crop damage in the event of flood, which will be exacerbated by climate change, will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Activity of agricultural extension office and NGOs ・Disaster resilience capacity of regulatory agency ・Existence and ability of research and development ・Compensation for crop and structural damage by climate disaster ・Financial scheme to farmers ・Socio-economic condition of farmers [Alternative Items] ・Expansion of area covered by drainage facilities, improvement of target return period for drainage ・Improvement of drainage management ・Implementation situation of participatory irrigated agriculture development ・Changes in the awareness of stakeholders
		BAU Development with Adaptation Options	New drainage facilities will be constructed, or existing ones will be rehabilitated or expanded in order to reduce flood damage and insufficient drainage. Potential risks of reduction of drainage function because of discharge increase in natural drainage, and intensification and increase frequency of flood, are likely to increase due to climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Crop damages due to flood will be reduced in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Expansion of area covered by drainage facilities, improvement of target return period for drainage ・Improvement of drainage management ・Implementation situation of participatory irrigated agriculture development ・Changes in the awareness of stakeholders

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
3. Farmland Management Enhancement	Adaptation Project	Climate change impacts, such as conventional farm crops becoming unsuitable to agricultural condition, change of cropping season, exacerbation of quality deterioration after harvesting, are likely to be caused.	To enhance farmland management through alternation/ development of varieties, improvement of cultivation and post harvesting, strengthening of farmers organization, etc.	Crop damage by climate change will be reduced.	[Assessment Items] ・ Future sensitivity to climate change ・ Condition of development and operation of irrigation and drainage facilities ・ Activity of agricultural extension office and NGOs ・ Existence and ability of research and development ・ Compensation for crop and structural damage by climate disaster ・ Financial scheme to farmers ・ Socio-economic condition of farmers [Alternative Items] ・ Improvement of cultivation (review of cropping pattern, condition of farming guidance and dissemination of agricultural knowledge and technology) ・ Improvement of cultivation (installation of greenhouse and precision agriculture, agricultural input) ・ Condition of development and introduction of new crop varieties ・ Strengthening post harvesting (condition of facility installation and operation) ・ Condition of other agricultural support (farmers organization, financial scheme) ・ Changes in the awareness of stakeholders

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	Projects for farmland management enhancement will be implemented. Climate change impacts, such as conventional farm crops becoming unsuitable to change in agricultural condition, change of cropping season, and exacerbation of quality deterioration after harvesting, are necessary to be considered.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Farming practice will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Improvement of cultivation (review of cropping pattern, condition of farming guidance and dissemination of agricultural knowledge and technology) ・Improvement of cultivation (Installation of greenhouse and precision agriculture, agricultural input) ・Condition of development and introduction of new crop varieties ・Strengthening post harvesting (condition of facility installation and operation) ・Condition of other agricultural support (farmers organization, financial scheme) ・Changes in the awareness of stakeholders

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
4. Forest Conservation/ Afforestation	Forest Conservation/ Afforestation	BAU Development with Adaptation Options	In regions where forests are devastated due to human activities such as grazing and fuel woods collection, efforts including reforestation, restoration, and forestry management should be intensified. Such efforts should also include construction of seedling production facilities, distribution of seedlings, and improvement of infrastructure for forestry activities. Changes in temperature and precipitation need to be considered as elements causing impacts on vegetation. Aggravated frequency and severity of forest fire and pest damages may be associated with future climate change.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Even under climate change impacts, forest areas can still be expanded and forest quality may be increased as expected.	[Assessment Items] ・Sensitivity to climate change ・Adaptive capacity to climate change [Alternative Items] ・Forest road length, progress in the introduction of fire extinguishing equipments ・Length of fireproof belts and pest control belts ・Frequency of fire prevention patrol ・Changes in the awareness of stakeholders

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	Mangrove Reforestation	BAU Development with Adaptation Options	Mangrove forests have been significantly deforested for fuel woods production, or paddy field and aquafarm development. In order to restore and conserve the mangrove forests, replanting, construction of seedling production facilities of mangroves, and assistance to sustainable fishery, agriculture and eco tourism for livelihood will be implemented. As future climate change impacts, changes in inundation areas due to sea level rise as well as in tidal current and water temperature should be considered. If sediment inflow from upstream greatly affects mangrove growth, sediment supply volumes need to be considered in association with changes in precipitation or rainfall patterns.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Even under climate change impacts, planted mangroves can take roots and grow as expected.	[Assessment Items] ・Sensitivity to climate change [Alternative Items] ・Maintenance of planted mangrove area ・Capacity building of the bureau responsible for reforestation

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
5. Ecosystem Integrity	Wetland Conservation	Adaptation Project	Ecosystem in lakes and wetlands may be affected by changes in precipitation, rainfall patterns and others resulted in future climate change, which might cause water quality deterioration and physical water area shrinkage associated with change in freshwater inflow, increase in sediment and nutrients inflow, increased secondary products and stratification due to temperature rise. Ecosystem in coastal wetlands may be further affected by sea level rise and associated changes in water depth, tidal level, salinity and tidal current conditions.	In order to reduce nutrients inflow, introduce waste water treatment facilities, plant trees and manage farmlands in the whole catchment area. Also in order to reduce loads such as sediment inflow in the catchment area, plant trees, construct sediment control facilities such as hillside works and sediment dams, and control soil erosion in farmlands. In addition to the above efforts, establish the conservation zones as well as buffer zones to alleviate stresses to ecosystem.	Climate change impacts to ecosystem will be reduced.	[Assessment Items] ・Sensitivity to future climate change ・Risks associated with climate change ・Ecosystem conservation activities [Alternative Items] ・Water quality, sediment load volume ・Installation of watershed management facility ・Changes in the awareness of stakeholders related to ecosystem

Sub-sector		Project Type	Assumption at Guidelines: Necessity of Adaptation	Assumption at Guidelines: Adaptation Measures/Options	Assumption at Guidelines: Outcome of Adaptation Measures/Options	Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		BAU Development with Adaptation Options	The target wetland faces impacts to ecosystem due to water quality deterioration, and shrinkage in wetland area, which resulted from land development in the catchment area, nutrients inflow due to urbanization, increase in sediment inflow, unsustainable fishery, and coastal development. In order to conserve wetland ecosystem, requirements include reduction of inflowing load volume by proper management of the catchment area, introduction of sustainable use, and protection of important zones. Among future climate change impacts, change in precipitation, increase in inflowing load volume due to changed rainfall patterns, and water quality deterioration due to temperature rise need to be considered. For coastal wetlands, changes in water depth, tidal level, and salinity associated with sea level rise, and physical damages due to increased disasters such as cyclones should also be considered.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Even under climate change impacts, wetlands can still be conserved as expected.	[Assessment Items] ・ Sensitivity to future climate change ・ Risks associated with climate change ・ Ecosystem conservation activities [Alternative Items] ・ Water quality, sediment load volume ・ Installation of watershed management facility ・ Changes in the awareness of stakeholders related to ecosystem

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
6. Flood Control	Adaptation Project	The target river had been developed with flood control facilities. However, climate change would change precipitation patterns, increase extreme events, and cause backwater effect by sea level rise. Hence, flood frequency will increase and intensify in the target river basin.	The flood control capacity in the target area shall be strengthened by structural measures such as development of flood control facilities, and non-structural measures such as evacuation.	Flood damage increased by climate change will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Risk of priority protection area ・Community- based disaster management and crisis management ・Disaster resilience capacity of regulatory agency ・Existence and ability of research and development ・Compensation for flood damage ・Land use and land use regulation [Alternative Items] ・Improvement of target return period in the whole river basin or the target area ・Improvement of target return period in priority protection area ・Quantity and quality of land area for storage, infiltration and retarding ・Changes in the number of inhabitants and economical activities in the whole river basin, priority protection area, and flood prone area ・Changes in the awareness of stakeholders on flood disaster

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	It is necessary to increase flood control capacity of the target river, in association with economic growth and land development. Potential risks of flood disasters in larger areas, or in greater magnitudes, are likely to occur in the target river basin and areas. The climate change impacts are expected to increase the amount of precipitation, change rainfall patterns, increase frequency and scale of extreme events, and increase backwater effects due to sea level rise.	Appropriate measures will be implemented within the project with consideration of the increased flood damage associated with climate change.	The expected damages from the flood disaster will be reduced in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change ・Risk of priority protection area [Alternative Items] ・Improvement of target return period in the whole river basin or the target area ・Improvement of target return period in priority protection area ・Quantity and quality of land area for storage, infiltration and retarding ・Changes in the number of inhabitants and economical activities in the whole river basin, priority protection area, and flood prone area ・Changes in the awareness of stakeholders on flood disaster
7. Coastal Protection	Adaptation Project	Climate change will raise the sea water level and increase frequency and intensity of cyclones, which translates to inundation, coastal erosion, storm surge-related damage, and tidal waves at coastal areas. Groundwater level increase associated with sea level rise will exacerbate the risk of ground uplift, buoyancy increase of buried pipes and manholes, and soil liquefaction in coastal areas. Other concerns are coral bleaching and fish death due to sea temperature rise, and decline of preventive measures for coastal areas against coastal erosion and environmental deterioration.	To take countermeasures for inundation, coastal erosion and groundwater level rise; strengthen disaster management; and promote conservation of coastal environment by means of structural and non-structural measures.	Damages due to inundation, coastal erosion, groundwater level increase, storm surges, and tidal waves, induced by climate change will be reduced. Coastal environment will be conserved and coral reefs will be protected against wave forces.	[Assessment Items] ・Future sensitivity to climate change ・Community-based disaster management and crisis management ・Disaster resilience capacity of regulatory agency ・Existence and ability of research and development ・Compensation for storm surge and high wave damage ・Land use and land use regulation [Alternative Items] ・Improvement of target return period/ safety factor of facilities ・Implementation record of projects, such as beach nourishment, mangrove afforestation, transplanting of coral reef. ・Changes in the awareness of stakeholders on coastal protection

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	It is necessary to increase coastal protection capacity, in association with land development in the coastal area due to economic growth. Potential risks of flood inundation, coastal erosion, storm surge and high wave damage are likely to increase in the target coastal areas due to climate change impacts, such as sea level rise and increase of frequency and intensification of cyclones.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	The expected coastal protection function will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Improvement of target return period/ safety factor of facilities ・Implementation record of projects, such as beach nourishment, mangrove afforestation, transplanting of coral reef. ・Changes in the awareness of stakeholders on coastal protection
8. Sediment-related Disaster Prevention	Adaptation Project	Climate change will increase short-term rainfall and continuous precipitation. The change of temporal and spatial distribution in rainfall will change the frequency, scale, and timing of sediment-related disaster, expand the collapse area, and increase the probability for multiple disasters occurring. Direct damage from a sediment-related disaster will increase mainly in the upstream area, while consequential damage due to debris flow will increase in the downstream area. Hence, there are anxieties on land degradation and desertification in the upstream area, and adverse effects to the downstream dams, river channels and estuaries.	In order to strengthen the responsiveness of the target area on sediment-related disaster, appropriate measures shall be implemented. The measures include structure construction, and non-structural approaches such as forecasting, warning, and evacuation, etc.	Sediment-related disaster by climate change will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Risk of priority protection area ・Community-based disaster management and crisis management ・Organizational structure and disaster resilience capacity of regulatory agency ・Existence and ability of research and development ・Compensation for sediment-related disaster ・Land use and land use regulation [Alternative Items] ・Improvement of target safety factor of the target section and facilities ・Changes in the awareness of stakeholders on sediment-related disaster

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	It is necessary to plan or reconsider sediment-related disaster prevention works, in association with economic growth and land development. Potential risks of sediment-related disasters in larger areas, and in greater magnitudes, are likely arising in the target river basin and areas due to climate change. The anticipated climate change impacts are considered to increase the amount of precipitation, change rainfall patterns, and increase the frequency and scale of extreme events such as torrential rainfall and tropical cyclones.	Appropriate measures will be implemented within the project with consideration of the increased sediment-related disaster damage associated with climate change.	The expected damages from the sediment-related disaster will be controlled or reduced in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change ・Risk of priority protection area [Alternative Items] ・Improvement of target safety factor of the target section and facilities ・Changes in the awareness of stakeholders on sediment-related disaster

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
9. Disaster Prevention Information System	Adaptation Project	It is highly possible that the frequency and intensity of natural disasters associated with climate change will increase. The target area is very vulnerable since reliable or properly functioning observation systems for natural phenomenon are not available. The adaptation project for the sub-sector will need to establish observation systems for natural phenomenon which disseminate early warning for evacuation, thereby, minimizing human casualties caused by disasters and reducing overall vulnerability to natural disasters.	Enabling the dissemination of early warning through development and proper operation of observation and monitoring systems for natural phenomenon.	Human casualties due to natural disasters that are associated with climate change will be reduced.	[Assessment Items] ・The past damages on observation and measurement facilities ・Development level of observation and measurement facilities ・Development level of early warning system ・Present budget level related to observation system for natural phenomenon ・Present conditions of human resources and organizational capacity [Alternative Items] ・Conditions of O&M (number of measurement instruments properly functioning, and number of locations for those installed) ・Number of early warnings performed in fact

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
10. Rural / Urban Development	Rural Development	Adaptation Project	Maintaining basic human needs (BHN) in rural areas are exposed to the risk of climate change impacts, which can potentially worsen living environment that would have been achieved without climate change.	Rural infrastructure development and support of rural livelihood will improve and maintain primary living environment in rural areas.	Climate change vulnerability of rural areas will be reduced.	[Assessment Items] ・Future sensitivity to climate change (conditions of rural infrastructures and their functional validities) ・Conditions of rural infrastructures and their functional validities ・Organizational capacity and conditions of residents ・Involvement of the regional / local government department and NGOs concerned ・Socio-economic conditions of rural residents [Alternative Items] ・Improvement of the target return period by expanded and newly developed facilities ・Improvement of the target return period of target areas by O&M improvement ・Changes in the number of beneficiaries ・Changes in stakeholders' awareness on climate change
		BAU Development with Adaptation Options	BAU infrastructure project will be implemented for rural development. However, the anticipated climate change will cause difficulty in maintaining the expected livelihood and living environment in the rural areas, which requires considering the adaptation options to climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	In case the target areas are exposed to climate change, the rural system will function properly and the area can sustain living environment.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Improvement of the target return period by expanded and/or newly developed facilities ・Improvement of the target return period in target area by O&M improvement ・Changes in the number of beneficiaries ・Changes in stakeholders' awareness on climate change

<table>
<tr><th colspan="2" rowspan="2">Sub-sector</th><th rowspan="2">Project Type</th><th colspan="3">Assumption at Guidelines</th><th rowspan="2">Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review</th></tr>
<tr><th>Necessity of Adaptation</th><th>Adaptation Measures/Options</th><th>Outcome of Adaptation Measures/Options</th></tr>
<tr><td rowspan="2"></td><td rowspan="2">Urban Development</td><td>Adaptation Project</td><td>Climate change will affect on regular functions of cities / urban areas, and make it difficult to maintain ordinary livelihood.</td><td>The development of urban infrastructure will improve and sustain primary conditions of urban livelihood.</td><td>Vulnerability of urban areas will be reduced.</td><td>[Assessment Items]
・Future sensitivity to climate change (conditions of urban infrastructures and their functional validities)
・Conditions of urban infrastructures and their functional validities
・Involvement of the municipal government department and NGOs concerned
・Socio-economic conditions of urban residents

[Alternative Items]
・Improvement of the target return period by expanded and/or newly developed facilities
・Improvement of the target return period in target area by O&M improvement
・Changes in the number of beneficiaries
・Changes in stakeholders' awareness on climate change</td></tr>
<tr><td>BAU Development with Adaptation Options</td><td>BAU infrastructure project will be implemented for urban infrastructure development. However, the anticipated climate change will cause difficulty in maintaining the expected living environment in the urban areas, which requires considering the adaptation options to climate change impacts.</td><td>Appropriate measures will be implemented within the project with consideration of the climate change impacts.</td><td>In case the target areas are exposed to climate change, the urban system will function properly and the area can sustain living environment.</td><td>[Assessment Items]
・Future sensitivity to climate change

[Alternative Items]
・Improvement of the target return period by expanded and newly developed facilities
・Improvement of the target return period of target areas by O&M improvement
・Changes in the number of beneficiaries
・Changes in stakeholders' awareness on climate change</td></tr>
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Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
11. Bridge, Road and Railway	Adaptation Project	Climate change would intensify flood, which can cause inundation, slope failures and landslides, affecting roads, railways, and subways. There are certain risks in road and railway functions that are adversely affected or lost due to climate change impacts.	In order to enhance the disaster prevention capacity of bridges, roads and railways, countermeasures such as realignment of route, slope stabilization, enhancement of drainage capacity and flood prevention, and raising, reinforcement or replacement of bridges are required.	The impacts of climate change related to structural damage, traffic restriction and interruption, as well as damage on related facilities and users will be reduced.	[Assessment Items] ・Future sensitivity to climate change ・Alternative transportation means and detour ・Crisis management of regulatory agency and management body ・Disaster resilience capacity of regulatory agency and management body ・Existence and ability of research and development [Alternative Items] ・Improvement of target return period and safety factor of facilities ・Situation of preparation and recognition of hazard map ・Reduction of time for damage detection and suspension of traffic ・Reduction of time for evacuation guidance ・Reduction of time for leading to detour or alternative traffic ・Changes in the awareness of stakeholders
	BAU Development with Adaptation Options	New bridges, roads and railways will be constructed, or existing facilities will be replaced or extended. Potential risks such as the reduction of safety of bridges, inundation damage on roads and railways, slope failure and landslides, and flooding in underground space such as subway are likely to increase due to climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	The safety of facilities and traffic will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change [Alternative Items] ・Improvement of target return period and safety factor of facilities ・Situation of preparation and recognition of hazard map ・Reduction of time for damage detection and suspension of traffic ・Reduction of time for evacuation guidance ・Reduction of time for leading to detour or alternative traffic ・Changes in the awareness of stakeholders

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
12. Port and Airport	Port	Adaptation Project	Climate change will raise sea water level and increase and intensify cyclones, which increase the damage to revetments and port structures, inundation at apron, and damage to buildings, containers, machinery and materials on the apron. Sea level rise will increase buoyancy of buried pipes and manholes, and cause ground uplift of the reclaimed land area. The risk of ground liquefaction will increase.	To strengthen the disaster mitigation capacity of port facilities by development, reinforcement, and raising of revetments and port structures, etc.	The impacts of climate change such as damage to structures, equipment and materials, and inundation, will be reduced, and port function will also be maintained.	[Assessment Items] ・Future sensitivity to climate change ・Alternative transportation means ・Disaster resilience capacity of regulatory agency and management body ・Existence and ability of research and development ・Compensation for storm surge and high wave damage [Alternative Items] ・Improvement of target return period and safety factor of facilities ・Implementation records of projects, such as dredging. ・Changes in the awareness of stakeholders
		BAU Development with Adaptation Options	New ports will be constructed, or existing ports will be expanded for the development in maritime trade. Potential risks of damages on revetments and port structures by sea level rise and extreme events, damages by storm surge and high waves, and ground uplift and buoyancy increase of buried pipes and manholes by sea level rise, are likely to increase in the target port due to climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	Port functions will be maintained in the event of climate change.	[Assessment Items] ・Future sensitivity to climate change ・Alternative transportation means [Alternative Items] ・Improvement of target return period and safety factor of facilities ・Implementation records of projects, such as dredging. ・Changes in the awareness of stakeholders

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	Airport	Adaptation Project	Climate change will increase precipitation, cloud amount and wind speed, and change the bird ecosystem. These conditions are likely to adversely affect the safety of flight operation especially during take-off and landing and cause damage to the airport.	To secure safety during take-off and landing of planes, and structure safety of the airport by mainly development and improvement of airport facilities.	The impacts of climate change on flight operations and structure safety will be reduced.	[Assessment Items] ・ Future sensitivity to climate change ・ Alternative transportation means ・ Disaster resilience capacity of regulatory agency and management body ・ Existence and ability of research and development [Alternative Items] ・ Improvement of target return period and safety factor of facilities ・ Changes in the awareness of stakeholders
		BAU Development with Adaptation Options	New airports will be constructed, or existing ones will be expanded or improved. Potential risks of structural damages and decline of safety in take-off and landing by increase of rainfall, cloud amount and wind speed, and change of avian ecosystem, are likely to increase in the target airport by climate change impacts.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	The safety of flight operation and airport function will be maintained in the event of climate change.	[Assessment Items] ・ Future sensitivity to climate change ・ Alternative transportation means [Alternative Items] ・ Improvement of target return period and safety factor of facilities ・ Changes in the awareness of stakeholders

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
13. Water Supply	Adaptation Project	In an existing watery supply system, its stable operation in the future will be at risk due to anticipated changes in rainfall intensity and patterns brought by climate change. This will reduce the available amount of water from the sources, and the rising temperature will affect the water quality at the source as well as increase per capita water consumption.	It will be necessary to increase water supply capacity through the development / expansion of alternative water sources, reduction of water leakages and the rate of unaccounted-for-water (UFW), and improvement of water treatment capability.	The adaptation measures will be able to prevent or reduce climate change impacts on water supply quantity and quality.	[Assessment Items] ・ Future sensitivity to climate change ・ Organizational capacity and operation conditions of water service providers ・ Available water volume and quality at alternative water sources ・ Awareness of water conservation ・ Socio-economic conditions of the target areas ・ Budget related to climate change impacts on the Water Supply Sub-sector ・ Climate change-related activities of NGO for the Water Supply Sub-sector [Alternative Items] ・ Improvement of target return period of expanded and/or newly developed facilities ・ Changes in beneficiaries' awareness on water conservation ・ Changes in the number of beneficiaries
	BAU Development with Adaptation Options	Due to the anticipated climate change impacts, there will be increased possibility of reduced water supply volume at intake site, poor water quality, and increased water demand caused by the rise of average temperatures.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	This will enable supply of safe and sufficient water to the population in the event of climate change.	[Assessment Items] ・ Conditions of water balance ・ Conditions of water sources ・ O&M system and capacity of water service providers [Alternative Items] ・ Improvement of target return period of expanded and/or newly developed facilities ・ Changes in beneficiaries' awareness on water conservation ・ Changes in the number of beneficiaries

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
14. Sewerage / Urban Drainage	Sewerage	Adaptation Project	Increase in intensity and frequency of rainfall, and temperature rise due to climate change will cause inundation and exacerbated hygienic conditions in urban areas. If areas possess ineffective or insufficient sewerage and urban drainage systems, it will potentially cause outbreaks of infectious diseases such as cholera, typhoid, and diarrhea due to the exacerbated hygienic conditions.	The development of sewerage systems (sewerage treatment plant, installation of sewerage network and pump stations, etc.) will improve the hygiene and living conditions of the environment in the target areas.	Risks of which will worsen the hygiene and living conditions of the environment due to climate change will be reduced, and the morbidity rate of infectious diseases will improve.	[Assessment Items] ・Future sensitivity to climate change ・Condition of preventive activities against infectious diseases by residents in the target areas ・Geographical distribution of existing medical institutions and healthcare centers ・Present conditions and functional validity of the existing sewerage system [Alternative Items] ・Improvement of the target return period by expanded and/or newly developed facilities ・Changes in the number of the patients of infectious diseases ・Changes in number of beneficiaries ・Changes in beneficiaries' awareness on hygiene
		BAU Development with Adaptation Options	In order to improve the hygiene and living conditions in the environment of the target areas or city, the project for development, expansion, and rehabilitation of sewerage and drainage systems will be implemented. Due to the anticipated climate change impacts, increased rainfall intensity is likely to cause inundation damages coupled with increased storm water in drainage systems, and it is highly concerned that hygienic conditions will deteriorate.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	In the event of climate change, the developed sewerage system will function properly.	[Assessment Items] ・Morbidity and mortality rates of infectious diseases ・Present conditions of sewerage and rainwater discharge ・Water quality [Alternative Items] ・Improvement of the target return period by expanded and/or newly developed facilities ・Changes in the number of the patients with infectious diseases ・Changes in the number of beneficiaries ・Changes in beneficiaries' awareness on hygiene

Sub-sector		Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
			Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	Urban Drainage	Adaptation Project	Increase in intensity and frequency of rainfall, and temperature rise due to climate change will cause inundation and exacerbated hygienic conditions in urban areas. If areas possess drainage systems that are malfunctioning or have insufficient capacity, it will potentially cause outbreaks of infectious diseases such as cholera, typhoid, and diarrhea. Storm water contaminated with solid waste and chemical materials will flow into the surrounding bodies of water, therefore seriously affecting water quality.	The development of urban drainage systems (open and closed drainage channels, pump stations, etc.) will improve drainage capacity and hygienic conditions, reduce the risk of floods, and enhance socio-economic activities in the target areas.	Risks of flooding and inundation due to malfunctioning drainage systems will be reduced, and socio-economic activities and the morbidity rate of infectious diseases will be improved.	[Assessment Items] ・Future sensitivity to climate change ・Condition of preventive activities against infectious diseases by residents in the target areas ・Geographical distribution of existing medical institutions and healthcare centers ・Present conditions and functional validity of existing drainage system [Alternative Items] ・Improvement of the target return period by expanded and/or newly developed facilities ・Changes in number of the patients with infectious diseases ・Changes in the number of beneficiaries ・Changes in beneficiaries' awareness on hygiene
		BAU Development with Adaptation Options	In order to improve the hygiene and living conditions in the environment of the target areas or city, the project for development/expansion/rehabilitation of urban drainage systems will be implemented. Due to the anticipated climate change impacts, increased rainfall intensity is likely to cause inundation damages coupled with increased storm water drainage, and it is highly concerned that hygienic conditions will deteriorate.	Appropriate measures will be implemented within the project with consideration of the climate change impacts.	In the event of climate change, the developed drainage system in urban areas will function properly.	[Assessment Items] ・Morbidity and mortality rates of infectious diseases ・Conditions of flood and inundation damages ・Water quality [Alternative Items] ・Improvement of the target return period by expanded and/or newly developed facilities ・Changes in the number of the patients with infectious diseases ・Changes in the number of beneficiaries ・Changes in beneficiaries' awareness on hygiene

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
15. Medical / Health Care	Adaptation Project	Temperature rise due to climate change is likely to shift or expand habitat areas of disease-carrying vectors for infectious diseases. Climate-induced changes in locations and seasons will likely trigger an epidemic of infectious diseases such as malaria and dengue fever. Flood, drought, and crop failure associated with change in rainfall intensities and patterns will increase risks of water- and food-borne diseases. Particularly in the areas with poor healthcare services and facilities as well as poor hygienic conditions, risks of exposure to these infectious diseases are considerably high, which will be exacerbated by climate change impacts.	The adaptation measures will strengthen preventive and responsive actions against infectious diseases and improve health conditions of people in the target areas by developing clinics or general hospitals, upgrading equipment, and strengthening capacity of healthcare personnel.	The framework for treatment will be strengthened for patients whose numbers are increasing due to climate change impacts, and corresponding preventive measures will be undertaken.	[Assessment Items] ・Future sensitivity to climate change ・Population shares of socially-vulnerable groups ・Number of doctors per population ・Number of existing medical institutions / healthcare centers ・Conditions of preventive activities against infectious diseases ・National / regional budgets for medical care and infectious diseases ・Activities by NGOs [Alternative Items] ・Trend of the budgets for disease prevention ・Number of patients

Sub-sector	Project Type	Assumption at Guidelines			Items for Assessment in Project Formulation & Alternative Items for Assessment in Monitoring and Review
		Necessity of Adaptation	Adaptation Measures/Options	Outcome of Adaptation Measures/Options	
	BAU Development with Adaptation Options	It is necessary to upgrade and expand medical / healthcare facilities and equipment in order to provide better healthcare services in the target areas. Climate change impacts are expected to increase infectious disease cases which would have been a minor issue in the target areas.	In the development under the business-as-usual condition, the project may focus on capacity-building for the areas of cardiac and brain surgeries, other internal medicine, trauma care, adult disease, and HIV. In addition to these, adaptation measures to climate change will require preparation for the increasing concern on water and vector-borne diseases.	In case there are serious climate change impacts, sufficient medical or healthcare services will be provided.	[Assessment Items] ・Morbidity rates for infectious diseases ・Mortality rates for infectious diseases ・Conditions of preventive activities against infectious diseases [Alternative Items] ・Trend of the budgets size for disease prevention ・Number of patients

5.5 Basic Concept and Guidelines for Each Sub-sector

"Basic Concept" was prepared for the each sub-sector selected in Chapter 4 and "Guidelines" were prepared for assumed projects as shown in Section 5.4. "Understanding Future Climate Change", which is common to each sub-sector, is also prepared.

0. Understanding Future Climate Change
1. Water Resources
2. Irrigation and Drainage
3. Farmland Management Enhancement
4. Forest Conservation/ Afforestation
5. Ecosystem Integrity
6. Flood Control
7. Coastal Protection
8. Sediment-related Disaster Prevention
9. Disaster Prevention Information System
10. Rural / Urban Development
11. Bridge, Road and Railway
12. Port and Airport
13. Water Supply
14. Sewerage / Urban Drainage
15. Medical / Health Care

0. Understanding Future Climate Change (Common to All Sectors)

1. Basic Concepts	As basis to study adaptation measures, future climate change shall be projected based on outputs from the evaluation model(s) employed in policy-making for climate change in each country. If no evaluation model is established, outputs from the models used in the IPCC Fourth Assessment Report (IPCC AR4) shall be adopted for projection, in principle. In either case, counterpart organization shall be thoroughly consulted to determine the evaluation model and outputs to be employed. Projection outputs are summarized in IPCC AR4; however, it is preferable that the outputs are understood in further detail for application in projects. In this section, the approach to investigate adaptation measures for the assumed or particular project area is discussed in reference to outputs of the global climate model (GCM). When more detailed projection is required per project, one shall perform downscaling (computing using the climate model in a finer grid size) and other approaches in each project. Downscaling can be classified into dynamical downscaling by means of regional climate model (RCM), and the statistical downscaling based on statistics of historical observation data. Existing climate projections can be used wherever available to avoid significant computation loads required in the dynamical downscaling. Descriptions in this section are principally based on the IPCC AR4. As the IPCC Fifth Assessment Report will be issued in September 2014, the latest outputs should be referred to and be used for adaptation, particularly those in the report of Working Group II, which focuses on the provision of scientific knowledge. The following is the timeline of the IPCC Fifth Assessment Report issuance: ・Report of Working Group I (Physical Science Basis) : to be completed in September 2013 ・Report of Working Group II (Impacts, Adaptation and Vulnerability): to be completed in March 2014 ・Report of Working Group III (Mitigation of Climate Change): to be completed in April 2014 ・Synthesis Report: to be completed in September 2014
2. Outline of Climate Change Projection	The following four factors need to be defined to project future climate change: 1) Scenarios 2) Projection model 3) Projection term 4) Projection elements Climate change projection employed in the IPCC AR4 is based on several scenarios in which specific models are used for projecting future climate. It is also important to understand variance in outputs inherent to climatic elements and grid sizes selected for the projection term. **1) <u>Scenarios</u>** <Outline> To project future climate change associated with global warming, anthropogenic GHG emission forecast is required (emission scenarios). GHG emission scenarios largely depend on elements including future population change, socio-economic growth, and technological advancement. IPCC compiles GHG emission scenarios in the special report issued in 2000 (SRES: Special Report on Emissions Scenarios), which were drawn up under the assumption of future socio-economic trends. These scenarios quantitatively show assumed GHG

emission volumes from 1990 to 2100 based on the six classifications below:

- A1FI: Economic growth oriented and globalizing society. Fossil fuel intensive.
- A1T: Economic growth oriented and globalizing society. Predominantly non-fossil energy.
- A1B: Economic growth oriented and globalizing society. Balanced energy mix.
- A2: Economic growth oriented and regionally-oriented society.
- B1: Sustainable, environmentally-balanced and globalizing society with narrower regional gaps.
- B2: Sustainable, environmentally-balanced and regionally-oriented society.

<Scenarios used for experimental climate change projection>

IPCC AR4 includes experimental climate change projection based on scenarios listed in Table 1. Several other scenarios were prepared in addition to aforementioned SRES scenarios. In the report, computed climate data and deviations among scenarios are also disclosed.

Table 1　Major Scenarios and the Assumptions Considered in the Experimental Climate Change Projection

Category	Scenario	Major assumption
SRES Scenario	SRESA1B	Economy rapidly grows and the world population, after reaching the peak in the middle of this century, turns downward. New and more effective technologies are rapidly introduced. The major challenges include the convergence among regional society, production capacity building and increase in cultural and social exchange with narrowing regional gap in per capita income.
	SRESB1	As in Scenario A1, the world population turns downward after reaching the peak in the middle of this century. As material intensity decreases, and clean and resource-efficient technologies are introduced, the industry structure rapidly shifts toward a service and information economy.
	SRESA2	Very heterogeneous society. The major challenges include preservation of self-reliance and local identities. Fertility patterns across regions slowly converge and the global population continuously grows. Economic development is primarily regional-oriented, and per capita economic growth and technological changes are more fragmented and slower compared to other scenarios.
Non-SRES Scenario:	1PTO2X (1% to double)	GHG concentration of the pre-industrial control is assumed to increase by 1% per year until it is doubled. After that, the concentration is assumed constant, which leads to experimental emission setting.
	1PTO4X (1% to quadruple)	GHG concentration of the pre-industrial control is assumed to increase by 1% per year until it is quadrupled. After that, the concentration is assumed constant, which leads to experimental emission setting.
	20C3M	20th Century climate simulation.
	COMMIT	It is assumed that GHG concentration remains constant at the level of AC 2000.
	PICTL	An experimental emission setting in which GHG concentration remains constant at the pre-industrial level.

2) <u>Projection Model</u>

Projection models are roughly classified into a Global Climate Model (GCM or also referred to as General Circulation Model from the perspective of atmospheric circulation analysis) and RCM to be used for regional climate change projection. Coarse computation grid in 0.3 - 4 degrees is used for computation in GCM. In RCM, finer computation grid is used to analyze a certain region with GCM analysis results as external forcing along the boundary.

<u>GCM</u>

<Outline>

Future climate change projection is required for investigating adaptation measures. For this purpose, the global climate projection model called GCM is used. In the IPCC AR4, several GCM projection results are compared as phase 3 of the Coupled Model Intercomparison Project (CMIP3). In CMIP3, 23 climate projections from 17 organizations in 12 countries are disclosed.

Among different computational resolutions of various GCM types, various climatic elements are computed in the grid size of 0.3 - 4 degrees horizontally, and 16-56 layers vertically. GCM is further subdivided into AGCM for atmospheric circulation and OGCM for oceanic circulation. AOGCM, the combination of the two GCM types, is used so that impacts of oceanic circulation can be incorporated with climate change.

IPCC primarily discloses outputs from AOGCM. Since different climatic elements are used in various models, it is crucial to confirm that climatic elements required in the assumed or particular project are surely projected. Furthermore, in case of using the outputs for project level, it should be noted that GCM outputs represents values of the grids that cover wider regions rather than values for project areas.

When data are required in a detailed scale, the possibility for downscaling should be considered to compute data in a finer grid size based on GCM outputs. It is also a matter of consideration whether to use RCM computed data provided by research institutes as described later.

<How to obtain data>

・IPCC

Among CMIP3 data, the datasets essential for impact assessment are provided by Data Distribution Centre (DDC) of IPCC. Users can gain direct access to these datasets via internet or obtain data in DVD.

The use of data is allowed only for non-profit research purposes in academic and research institutes. User registration is required for data download.

<The IPCC DDC web site to download data>

http://www.ipcc-data.org/ar4/gcm_data.html

Tables 2 and 3 list major outputs provided by IPCC. The provided data are basically mean values for 20 or 30 years.

Projected experiment results are provided as mean climatic values based on computed results. Deviation values among different scenarios are also provided.

The scenarios 1PTO2X and 1PTO4X provide deviation to PICTL, while SRA1B, SRA2, and SRB1 provide that to 20th century climate simulation (20C3M).

Table 2 Scenarios Used in Experimental Projection Using Various Climate Models

Center	Country	CMIP I.D.	Scenario							
			PICTL	20C3M	Commit	SRESA2	SRESA1B	SRESB1	1%to2x	1%to4x
Beijing Climate Center	China	BCC-CM1	-	-	-	-	-	○	○	○
Bjerknes Centre for Climate Research	Norway	BCCR-BCM2.0	○	○	○	○	○	○	○	-
National Center for Atmospheric Research	USA	CCSM3	○	○	○	○	○	○	○	○
Canadian Centre for Climate Modelling & Analysis	Canada	CGCM3.1(T47)	○	○	-	-	○	-	○	○
Canadian Centre for Climate Modelling & Analysis	Canada	CGCM3.1(T63)	○	○	-	-	○	○	-	-
Météo-France / Centre National de Recherches Météorologiques	France	CNRM-CM3	○	○	○	○	○	○	○	○
CSIRO Atmospheric Research	Australia	CSIRO-Mk3.0	○	○	○	○	○	○	○	-
CSIRO Atmospheric Research	Australia	CSIRO-Mk3.5	○	○	○	○	○	○	○	-
Max Planck Institute for Meteorology	Germany	ECHAM5/MPI-OM	○	○	○	○	○	○	○	○
Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, and Model and Data group.	Germany / Korea	ECHO-G	○	○	○	○	○	-	○	○
LASG / Institute of Atmospheric Physics	China	FGOALS-g1.0	○	○	○	-	○	○	○	-
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.0	○	○	○	○	○	○	○	○
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.1	○	○	○	○	○	○	○	○
NASA / Goddard Institute for Space Studies	USA	GISS-AOM	○	○	-	-	○	○	-	-
NASA / Goddard Institute for Space Studies	USA	GISS-EH	○	○	-	-	○	-	○	-
NASA / Goddard Institute for Space Studies	USA	GISS-ER	○	○	○	○	○	○	○	○
Instituto Nazionale di Geofisica e Vulcanologia	Italy	INGV-SXG	○	○	-	○	○	-	○	○
Institute for Numerical Mathematics	Russia	INM-CM3.0	○	○	○	○	○	○	○	○
Institut Pierre Simon Laplace	France	IPSL-CM4	○	○	○	○	○	○	○	○
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	Japan	MIROC3.2(hires)	○	○	-	-	○	○	○	-
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	Japan	MIROC3.2(medres)	○	○	○	○	○	○	○	○
Meteorological Research Institute	Japan	MRI-CGCM2.3.2	○	○	○	○	○	○	○	○
National Center for Atmospheric Research	USA	PCM	○	○	-	○	○	-	○	○
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadCM3	○	○	○	○	○	○	-	-
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadGEM1	○	○	-	○	○	-	○	-

Table 3　Data Available in Various Climate Models

Center	Country	CMIP I.D.	Available Projection								
			Specific Humidity	Precipitation	Pressure at Sea Level	Downwelling Shortwave	Temperature	Daily Temperature (Max)	Daily Temperature (Min)	Eastward Wind	Northward Wind
Beijing Climate Center	China	BCC-CM1	-	○	○	-	○	-	-	○	○
Bjerknes Centre for Climate Research	Norway	BCCR-BCM2.0	○	○	○	○	○	○	○	○	○
National Center for Atmospheric Research	USA	CCSM3	○	○	○	○	○	○	○	-	-
Canadian Centre for Climate Modelling & Analysis	Canada	CGCM3.1(T47)	○	○	○	○	○	-	-	○	○
Canadian Centre for Climate Modelling & Analysis	Canada	CGCM3.1(T63)	○	○	○	○	○	-	-	○	○
Météo-France / Centre National de Recherches Météorologiques	France	CNRM-CM3	○	○	○	○	○	-	-	○	○
CSIRO Atmospheric Research	Australia	CSIRO-Mk3.0	-	○	○	○	○	○	○	-	-
CSIRO Atmospheric Research	Australia	CSIRO-Mk3.5	-	-	-	-	-	-	-	-	-
Max Planck Institute for Meteorology	Germany	ECHAM5/MPI-OM	-	○	○	○	○	-	-	○	○
Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA, and Model and Data group.	Germany / Korea	ECHO-G	-	○	○	○	○	-	-	○	○
LASG / Institute of Atmospheric Physics	China	FGOALS-g1.0	○	○	○	○	○	-	-	○	○
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.0	-	○	○	○	○	-	-	○	○
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	USA	GFDL-CM2.1	-	○	○	○	○	-	-	○	○
NASA / Goddard Institute for Space Studies	USA	GISS-AOM	○	○	○	○	○	○	○	○	○
NASA / Goddard Institute for Space Studies	USA	GISS-EH	○	○	○	○	○	-	-	○	○
NASA / Goddard Institute for Space Studies	USA	GISS-ER	○	○	○	○	○	-	-	○	○
Instituto Nazionale di Geofisica e Vulcanologia	Italy	INGV-SXG	-	-	-	-	-	-	-	-	-
Institute for Numerical Mathematics	Russia	INM-CM3.0	○	○	○	○	○	○	○	○	○
Institut Pierre Simon Laplace	France	IPSL-CM4	○	○	○	○	○	-	-	○	○
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	Japan	MIROC3.2(hires)	○	○	○	○	○	○	○	○	○
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	Japan	MIROC3.2(medres)	○	○	○	○	○	○	○	○	○
Meteorological Research Institute	Japan	MRI-CGCM2.3.2	○	○	○	○	○	-	-	○	○
National Center for Atmospheric Research	USA	PCM	-	○	○	○	○	○	○	-	-
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadCM3	○	○	○	○	○	-	-	○	○
Hadley Centre for Climate Prediction and Research / Met Office	UK	UKMO-HadGEM1	-	○	○	○	○	-	-	○	○

・Program for Climate Model Diagnosis and Intercomparison (PCMDI)

PCMDI is an organization collecting and archiving CMIP3 data. Thus, related datasets can be obtained from this organization.

Since PCMDI holds enormous data available for various research purposes; hence, it is the users' responsibility that search and extract necessary data for their own purposes out of the extensive database.

<PCMDI web page to access CMIP3 data>
http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php

<Variance and uncertainty of projection results due to scenarios / models>
The aforementioned scenarios are used as assumptions for climate change projection. This results in variance of output even for the same model. Scenarios such as SRESA1B, SRESB1, Plcntrl, 20C3M, and 1PTO2X are used in many models to project future climate change. These results are major outputs of the IPCC AR4 and compiled as CMIP3.
Projections are model-dependent as well as SRES scenario-dependent. Thus, the following considerations are required when such results are applied to the assumed or particular project:
a) Most suitable model for the target country or region
GCM used in IPCC does not always reproduce regional climatic phenomena accurately. If an evaluation model is employed in policy-making on climate change in the target country or region, it is most likely that the model focuses on reproducibility in the specific region. Hence, it will be appropriate to consider using such models in place of GCM.
b) IPCC evaluation model
If a model specific to the target country or region is not available, it is preferable to assess impacts on climate change comprehensively in reference to as many outputs as possible. Ensemble mean is one of the approaches to consider regional uncertainty based on outputs of many models. This approach is intended to evaluate the gaps between mean values obtained from outputs of climate models, and projection results from each model. If the projection result obtained in a model is close to the mean value, the regional climate change is less uncertain. On the contrary, uncertainty is evaluated to be greater for cases with larger gaps.

RCM
<Outline>
RCM is the model used to express climatic elements by computation in finer grids, which cannot be expressed in a coarse grid size of GCM. It is also called dynamical downscaling as climatic phenomena are computed with a physical model in a finer grid size.
RCM enables reproduction of phenomena that are unable to reproduce in GCM due to a coarse computation grid, thus providing more detailed outputs. Although various models provide projection in different resolutions, the area can be projected if it extends approximately 10-30 km in the horizontal direction. If GCM outputs are difficult or not appropriate to be directly applied in the assumed or particular project, it is important to consider using RCM computation results.
Even when detailed computation is performed using RCM, GCM outputs are also needed as external forcing. Thus, it is necessary to prepare GCM outputs for each climatic element as needed in RCM. Computation requires a high-end computer as well as enormous computation costs. It is recommended to use existing results of RCM computation if they are regionally available.
Among the output data, parameters available per project are basically identical to those from GCM outputs.
<RCM project>
In regions such as Europe or Asia, intercomparison experiments are undertaken using various RCMs.

Since IPCC does not disclose individual RCM computation results, it is important to consider obtaining computational results provided by regional RCM projects. Table 4 lists some of the major RCM projects.

Table 4 Major RCM Projects

Name of Project		URL
PRUDENCE	Projection of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects	http://prudence.dmi.dk/
ENSEMBLES		http:/www.ensembles-eu.org/
CORDEX	A COodinated Regional climate Downscaling EXperiment	http://cordex.dmi.dk/joomla/
CECILIA	Central and Eastern Europe Climate Change Impact and VulnerabiLity Assessment	http://www.cecilia-eu.org/WP3.htm
CLARIS LPB	A Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin	http://www.claris-eu.org/
MAIRS	Monsoon Asia Integrated Regional Study	http://www.mairs-essp.org/index.asp
NARCCAP	North American Regional Climate Change Assessment Program	http://www.narccap.ucar.edu/
ARCMIP	Arctic Regional Climate Model Intercomparison Project	http://curry.eas.gatech.edu/ARCMIP/
QUIRCS	Quantification of uncertainties in regional climate and climate change simulations	http://www.tu-cottbus.de/meteo/Quircs/home.html

<Variance and uncertainty inherent to scenarios and models>
As with GCM, reproducibility is also model-dependent in RCM. As RCM outputs inherit uncertainties held in GCM as computational assumption, errors systematically caused by topography should be considered with good understanding of GCM-inherent uncertainties.
When historical observation data in the assumed or particular project area are available for RCM climatic elements, it is possible to correct errors that systematically occurred in the specific region, by comparing historical values with RCM outputs (bias correction). In climate model selection, it will be ideal to select a reproducible model. Moreover, it will be better to use the model that has already been designated in terms of reproducibility in a specific country or region.

<u>Statistical downscaling</u>
<Outline>
If it is difficult or not appropriate to directly apply GCM outputs in the assumed or particular project, and downscaling using RCM is not allowed due to computation costs or other problems, or if climatic data requires a more detailed spatial scale than RCM resolution, statistical downscaling is an alternative approach. While downscaling using RCM is called dynamical downscaling, statistical downscaling refers to the approach to spatially interpolate the data under the assumption of statistical relationship between historical observation data and the climate model projection. Under this assumption, the spatial scale is detailed by setting the regression formula in each climatic element. Statistical downscaling is characterized by lower computational loads compared to dynamical downscaling, and higher applicability especially for cases where climate in the target location is dependent on topography.

3) Projection Term

<Outline>

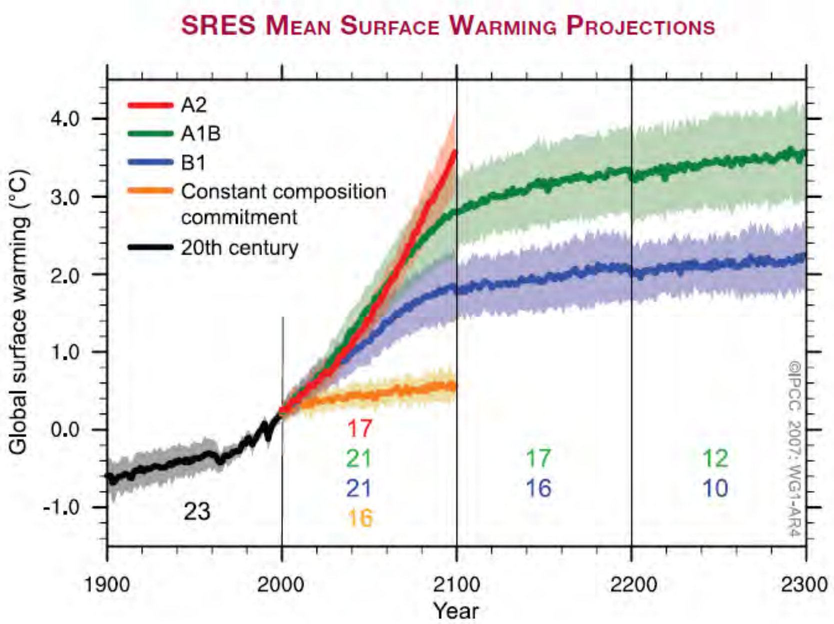
When the projection term is set in the assumed or particular project, appropriate climatic values should be set with consideration on the project amortization period or the service life of major structures and/ or systems to be built in the project. Generally, the mean value in 30 years is employed as the climatic value; however, the mean value in 20 years is sometimes employed. It is appropriate to consider the projection term to set the climatic value in the range of 20-30 years.

<For projection in long-term perspective>

When the projection requires a long-term perspective, it will be necessary to set up the climatic value for longer time-span such as a hundred years, to formulate adaptation measures. The projection accuracy of a climate model tends to be lower as the initiation of projection takes longer period. Thus, uncertainties of the climate model should be taken into account in setting the climatic value for long-term projection.

<For projection in foreseeable term for 20-30 years>

As shown in the figure below, gaps between projected and actual data are comparatively small in a global warming scenario during the term for 20-30 years. More precisely, the mean global temperature rise would be 0.6-0.8 ^{o}C in case GHG emission is successfully controlled. In this regard, the climatic value after 20-30 years should be set in order to consider the detailed adaptation measures against impacts anticipated within a foreseeable term, while envisaging long-term impacts.



Terms to Investigate Adaptation Measures[1]

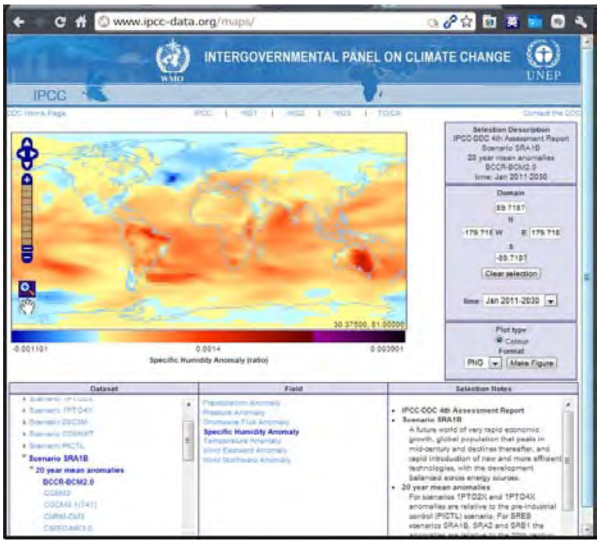
[1] IPCC.(2007). AR4 WG1 Technical Summary

	4) <u>Projection Elements</u> Projections obtained from a climate model include many parameters with those required for computation. Among them, the following items are particularly required in projects: ・Specific humidity ・Precipitation ・Sea level pressure ・Down welling shortwave ・Temperature ・Temperature daily max ・Temperature daily min ・Eastward wind speed ・Northward wind speed These data can be easily viewed using tools described below.

<table>
<tr>
<td>3.
Major Tools and Their Characteristics</td>
<td>
Climate model outputs hold extensive data. To easily view these outputs, various tools are provided to extract data on future climate change for the target region, scenario, or term. The major tools and outlines are as described below.

<u>IPCC DDC Data Visualization Tool[1]</u>
<Outline>
The data display tool provided by Data Distribution Center of IPCC. This is a web-based display system, enabling to extract data from all GCM model outputs.

<Functionality concerning climate change prediction>
The following climatic elements can be displayed as listed earlier in 4) Projection Elements .
・Specific humidity
・Precipitation
・Sea level pressure
・Down welling shortwave
・Temperature
・Temperature daily max
・Temperature daily min
・Eastward wind speed
・Northward wind speed
Any SRES scenarios, GCM types and terms can be specified on the screen.



</td>
</tr>
</table>

[1] http://www.ipcc-data.org/ddc_visualisation.htm

ci:grasp (the Climate Impacts: Global and Regional Adaptation Support Platform)[1]

<Outline>

Climate Impacts: Global and Regional Adaptation Support Platform (ci:grasp) is the web-based information display system for climate change projection developed by German Federal Ministry for Environment (BMU), Potsdam Institute for Climate Impact Research (PIK) and GTZ. This system features a user-friendly display of problems caused by climate change and the adaptation process to overcome such problems.

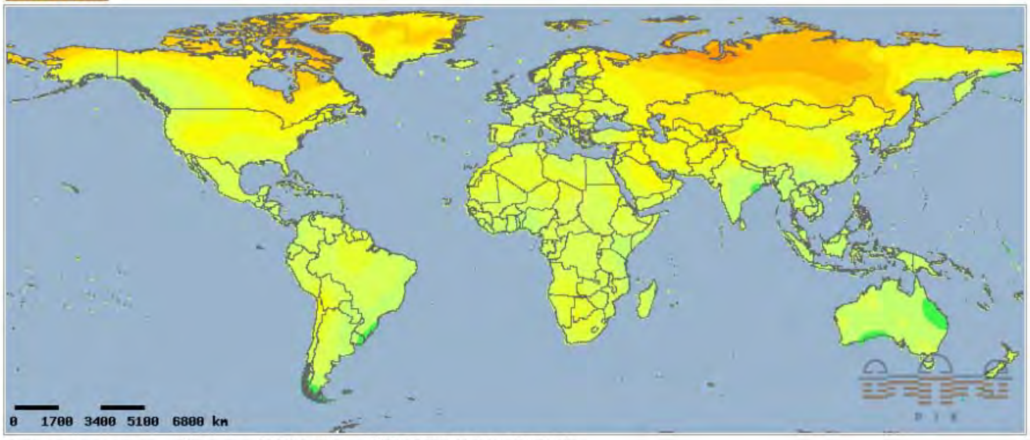
Climate change scenarios provided by ci:grasp include three types of A2, A1B, and B1. Among climate change models, five GCMs, namely CCSM3.0, EM2.1, RCHAM5, ECHO-G, and HadCM3, are referenced.

<Functionality concerning climate projection>

・Simulation results can be displayed on the map by specifying the time scale, term and model used in the simulation.

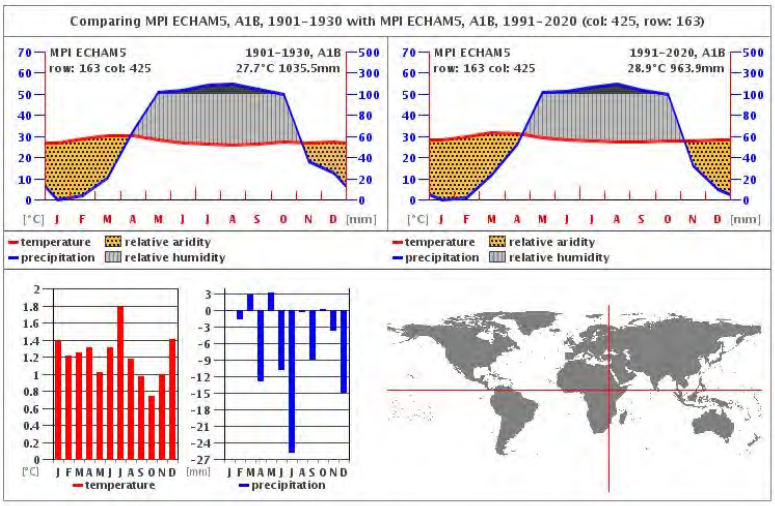
Projected temperature difference, 2031-2060 vs. 1961-1990 (A1B, ECHO-G)

Show Legend

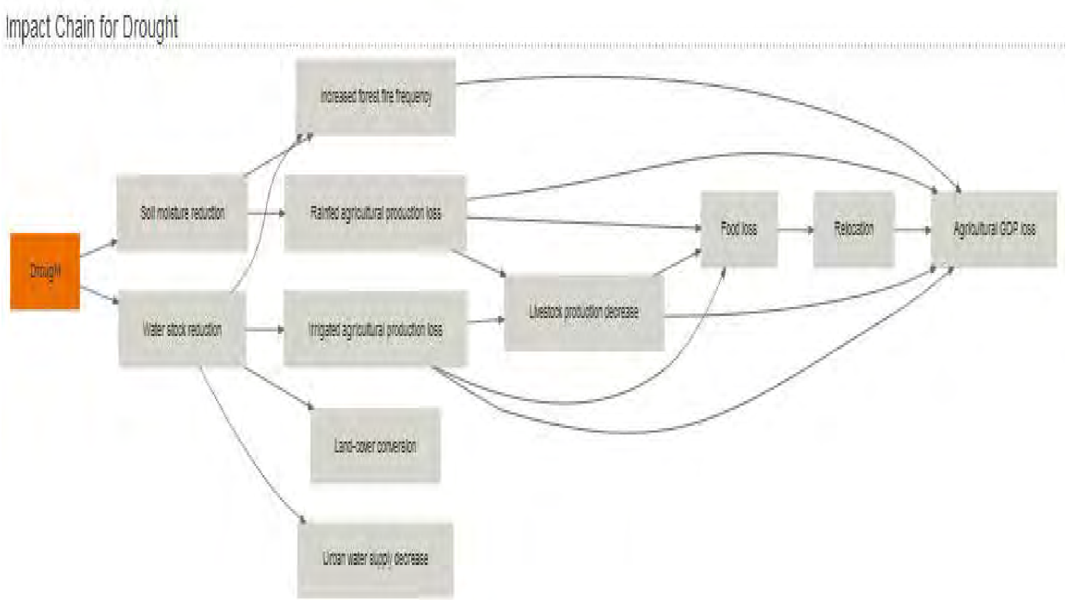


Projected temperature difference, 2031-2060 vs. 1961-1990 (A1B, ECHO-G)

・It enables to graphically display the changes in the specific location for different terms by specifying the coordinates of the particular location, model, scenario and term for comparison.



[1] http://cigrasp.pik-potsdam.de/worldmap

	<Other functionality> ci:grasp is composed of the following three layers. ・ Layer 1: Stimuli: information on climatic elements, sea level rise, precipitation and temperature are displayed. ・ Layer 2: Impacts: Major impacts are displayed for each stimulus in a selected region. ・ Layer 3: Adaptation: Information on adaptation projects are displayed for a specific impact. The search results for layers above can be overlaid on the map. This system allows selection and display of information layers interactively. It is particularly effective for sorting out impact chain triggered by climate change, and for displaying adaptation projects related to the chain. The figure below shows a sample impact chain triggered by drought.  ・By specifying the project type, project status, and spatial scale, the location to implement the adaptation project can be displayed on the map. 

The World Bank (WB) Climate Change Knowledge Portal[1]

<Outline>

The WB Climate Change Knowledge Portal is the portal site visualizing climate-related information using WEB-GIS. On WEB-GIS, the location for implementing the climate change project, climate data, impact map, socio-economic data (population), and location for implementing the mitigation project can be displayed.

<Functionality for climate projection>

Among the 23 GCMs used in the IPCC AR4, information summarizing 14 GCM outputs is provided. Parameters used are surface precipitation and surface temperature only. Data are reorganized in grids with every 2-degree in both latitudinal and longitudinal directions. The climate scenarios used are SRES A1B and B1.

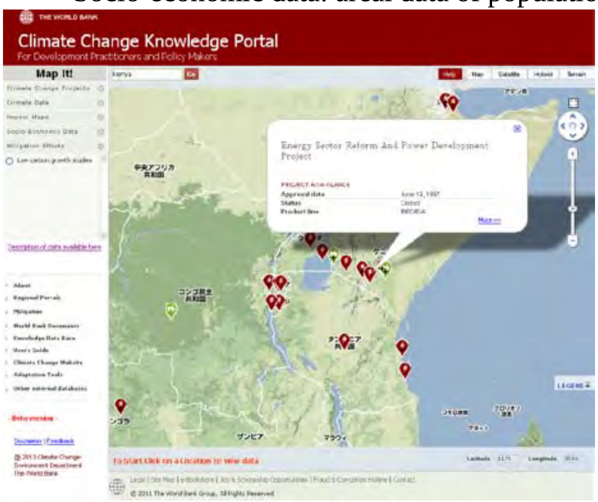
The following climate data can be used in the portal:

- Future climate (14 out of 23 GCM models are implemented (precipitation, temperature). A1 and B1 scenarios are available)
- Historical climate (preset cycle, changes per observatory station, and model compatibility)
- Weather observatory station (Global Historical Climatology Network or GHCN, beta version 2)
- Climate data: areal data such as consecutive dry days, annual mean precipitation, peak rainfall, annual mean temperature, etc.

<Other functionality>

The following data can be displayed using other functionality:

- Agricultural impact data (AEZ programs (termed GAEZ 2007) being published by IIASA and FAO)
- Malaria distribution (Mapping Malaria Risk in Africa or MARA)
- Natural disasters (Natural Disaster Hotspots: A Global Risk Analysis. Disaster Risk Management Series)
- Climate change projects: locations and details of projects relating to agriculture, education, energy, sources of fund
- Impact map: areal data relating to agriculture, public health, water, etc.
- Socio-economic data: areal data of population distribution



1 http://sdwebx.worldbank.org/climateportal/

Climate Wizard[1]

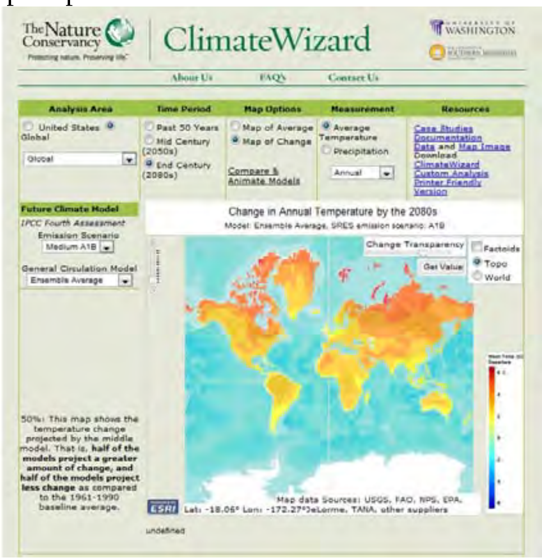
<Outline>

Similar to the aforementioned WB Climate Change Knowledge Portal, this web-based system easily displays climate change statuses. It is particularly effective to display ensemble information for the 23 GCMs. This system was jointly developed by the Nature Conservancy, the University of Washington, and the University of Southern Mississippi.

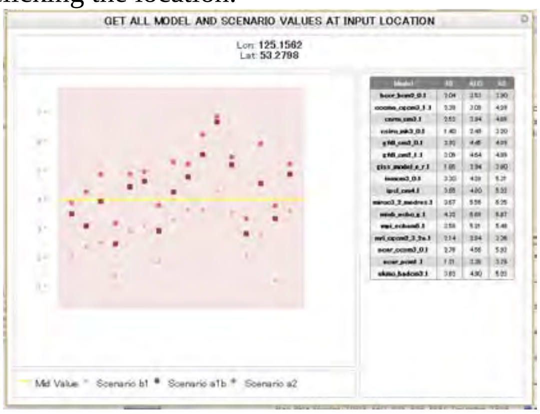
<Functionality>

Various GCM output data on the map display system can be easily displayed, enlarged or moved in the web.

- Term setting: actual data for the past 50 years; projected data around 2050 or 2080
- Map type to display: changes and mean values
- Temperature data to display: annual mean temperature, temperature by month or season
- Precipitation data to display: annual precipitation, monthly precipitation, and seasonal precipitation



Data can be visually shown on the map or GCM computation results can be displayed by clicking the location.

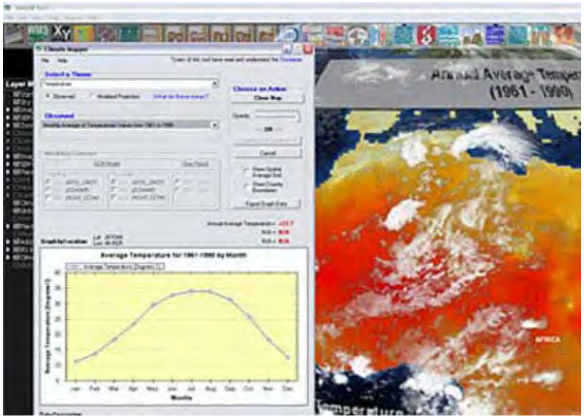


[1] http://www.climatewizard.org/

SERVIR Viz[1]

<Outline>

The climate mapping tool is provided by the USAID, NASA, the Institute for the Application of Geospatial Technology (IAGT), the University of Colorado, and CATHALAC. Datasets of Meso-America and Africa are currently available. By installing Climate Mapper plug-in for SERVIR-Viz additionally, historical climate data and future climate projected data can be handled.



<Functionality>

Data are provided in an approximately 50 km grid size and temperature, and precipitation data for the reference period (1961-1990) are available. Data consist of outputs of three models used in the IPCC AR4, namely NCAR CCSM, ECHAM, and GFDL-CM21, based on A1BSRES scenario.

When data not provided on the platforms above are needed, data open to the public have to be downloaded. Since such data are in NetCDF format, the following tools are required to directly view the data.

・Panoply NetCDF, HDF and GRIB Data Viewer (NASA)

・Integrated Data Viewer (UCAR)

Note: As of May 2011, the tools were able to be downloaded and installed but unable to be run most probably due to program bugs.

1 http://www.servir.net/servir_viz

4.
Sectors and Relevant Items

The projection models provide outputs as various climatic elements such as temperature and precipitation. For formulating adaptation measures in a specific sub-sector, it will be necessary to extract key climatic elements which are highly relevant to the sub-sector or project.
The table below lists sub-sectors and relevant items.

	Specific humidity	Precipitation	Sea level pressure	Down welling shortwave	Temperature	Temperature daily max	Temperature daily min	Wind speed	Sea level rise
1. Water Resources	xx	xx	-	xx	xx	xx	xx	xx	xx
2. Irrigation and Drainage	xx	xx	-	xx	xx	xx	xx	xx	xx
3. Farmland Management Enhancement	x	xx	-	x	xx	x	x	x	-
4. Forest Conservation / Afforestation	x	xx	-	x	xx	x	x	-	xx
5. Ecosystem Integrity	x	xx	-	x	xx	x	x	-	xx
6. Flood Control	-	xx	-	-	-	-	-	-	xx
7. Coastal Protection	-	xx	-	-	-	-	-	xx	xx
8. Sediment-related Disaster Prevention	-	xx	-	-	-	-	-	-	x
9. Disaster Prevention Information System	-	-	-	-	-	-	-	-	-
10. Rural / Urban Development	x	xx	-	x	xx	x	x	xx	xx
11. Bridge, Road and Railway	-	xx	-	-	x	-	-	xx	xx
12. Port and Airport	-	xx	xx	-	xx	xx	x	xx	xx
13. Water Supply	xx	xx	-	x	xx	xx	xx	xx	xx
14. Sewerage / Urban Drainage	x	xx	-	x	x	x	x	-	xx
15. Medical / Health Care	-	x	-	-	x	x	x	-	x

xx: closely related ; need to be considered as reference
x: related or related but not possibly reflected in planning
-: not related

1. Water Resources Sub-sector

Guideline:

(1) Water Resources (Adaptation Project)
(2) Water Resources (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change will affect the water resource sub-sector particularly due to the changing of precipitation and its pattern. Reduction in annual precipitation will lead to water resource scarcity, but on the other hand the increase of precipitation may cause flooding, which does not contribute to increase of water availability. In addition, sea level rise will cause salt water intrusion into rivers and aquifers, while temperature rise will increase the evapotranspiration and water demand in several water uses. The adaptation measures in water resources sub-sector are to maintain and improve the supply and demand of water against climate change impacts; such as the reduction or imbalance of water availability and the increase of water demand through appropriate development, management, and utilization of water resources.
B. Vulnerability	1) Major Climate Change Impacts on the Water Resources Sub-sector ■ Reduction of Precipitation, Change of Precipitation Pattern, Increase/ Intensification/ Prolongation of Drought ・The reduction of precipitation will reduce the surface water. Groundwater also will decrease due to the reduction of groundwater recharge from surface water. ・The change of river discharge or reduction of inflow to dam will cause shortage of water supply, particularly in the case that much of water demand changes by season (e.g. irrigation use). ・The reduction of groundwater recharge to inland freshwater aquifer will invite saline water intrusion to the aquifer from the adjacent saline water aquifer. In addition, temperature rise will also contribute to water salinization by increasing evapotranspiration in semidry and dry areas. ■ Increase / Intensification of Precipitation, Increase/ Intensification of Extreme Events such as Cyclones ・Generally, the increase of precipitation contributes to the increase of water availability and groundwater recharge. However, precipitation increase, which brings about flooding, does not contribute so much, since most of flood water flows out to the sea without utilization. ・The active capacity of dam reservoirs will decrease since soil erosion will increase and become deposited in the reservoir. ・Water resource facilities will be damaged by flood intensification. ■ Temperature Rise ・Temperature rise will increase water use.[1] ・Due to increase in evapotranspiration, water use of irrigation, which is one of the most water consuming activities, will increase. ・Evaporation will increase not only from the water surface of the reservoir, but also from the shallow groundwater table. ・Water availability in the early spring will be influenced due to the change of snow accumulation or thawing time. ・The acceleration of glacier melting will affect water availability both favorably and adversely. The increase of melt-water due to temperature rise will contribute to water availability, but eventually, melt-water will decrease after the shrinkage of glaciers and it will then reduce water availability.

[1] A statistical analysis of water use in New York City showed that temperature above 25°C, the daily per capita water use increases by 11 liters/1°C: roughly 2% of current daily per capita use. (IPCC AR4, 2007)

	■ Sea Level Rise ・Saline water will intrude the aquifer due to sea level rise, and it will cause salinization of groundwater. ・Saline water upward movement of the river will cause salinization of surface water in the lower reaches. ・Seawater intrudes the island freshwater lenses therefore causing salinization. ・Seawater desalination plant constructed in the coast will be damaged due to sea level rise and high tide. 2) Other Factors that Influence the Water Resources Sub-sector Associated with Climate Change Impacts ・Population growth, land use change, and industry activities will change water demand and its allocation among sectors. ・Water saving and improvement of water management at water users might reduce water demand. ・Land use change will influence the groundwater recharge, and excessive intake will lead to drawdown of the groundwater table. ・The suspension of dam development or the removal of the existing dam due to the rising of momentum for dam abolition. 3) Adaptive Capacity to Climate Change ・In case that integrated water resources management; coordination among water suppliers such as surface water and groundwater, coordination among water users, and coordination among water suppliers and users are well-organized and functioning, the adaptive capacity is high. ・If the budget and programs for disaster recovery are well in place, disaster response capability of regulatory agencies is high. ・In case a research institute related to water resources and water use exists and its system is well-organized, the adaptive capacity for climate change is high. 4) Spatial Distribution of Vulnerability a) Climate Change ・In cases that regional water circulation including surface water and groundwater recharge process in and around the catchment area shall be studied, and small basins taking water from glaciers or melting snow are included in the target river basin, it will be necessary to examine the spatial distribution of climate change impacts. Particularly, the study of spatial distribution is important for integrated water resources management since it manages different water sources and water utilization simultaneously. ・Salinization of groundwater and saline water upward movement of the river occurs in the coastal area. ・Salinization of aquifer at inland semidry and dry zones will be influenced by the spatial condition of geology and groundwater distribution. b) Sensitivity in the Water Resources Sub-sector ・Sensitivity varies by the design conditions, development level, time of construction, and maintenance level of water resources facilities. ・Water demand of irrigation and domestic use varies by climate factors such as temperature. The return flow from agriculture use also plays an important role on water

	availability. In this regard, the spatial distribution of the water use sector; such as irrigation, domestic use, etc., are important. c) Adaptive Capacity ・The adaptive capacity of water users may vary especially in water saving capacity among water sectors. The spatial distribution of the water intake point for each sector is important. ・Disaster resilience capacities may vary in case the regulatory agency is different for each facility.
C. Adaptation Measures	Major Adaptation Measures in the Water Resources Sub-sector ■ Development/ Expansion/ Reinforcement of Surface Water Resources Facilities ・Water storage (dam, irrigation pond, lake development, water harvesting, etc.) ・Water intake (diversion weir, etc.) ・Rehabilitation, redevelopment and restructuring of dams ■ Development/ Expansion/ Reinforcement of Groundwater Resource Facilities ・Pumping well, subsurface dam, etc. ■ Development/ Expansion/ Reinforcement of Water Conveyance Facilities ・Water conveyance channel, etc. ■ Development/ Expansion/ Reinforcement of Water Treatment Facilities ・Seawater desalination plant, water recycling plant, etc. ■ Improvement of Water Management, Water Use Coordination ・Integrated water resources management (coordination among water suppliers, among water users, and between water suppliers and users) ・Reallocation of water rights
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Additional water intake would bring about more serious influence to the other water use or area. ■ Maladaptation Common to “Business as Usual” Project ・The change in future river runoff, and the water levels of river and groundwater would exceed the design capacity and affect the safety of facilities.

Guideline: Water Resources (Adaptation Project)

A. General	■ Necessity of Adaptation Climate change will bring imbalance between water supply and demand for existing water resources facilities, due to change in precipitation and its pattern, increase of water demand due to temperature rise, etc. In addition, the intensification of flood would damage the facilities. ■ Adaptation Measures Adaptation measures against water shortage include: to increase the active capacity of reservoir by structural measures such as raising dam height, excavating reservoir, etc.; to increase water resources by reduction of water leakage, new water resources development and water conveyance; and to reallocate and utilize water resources by improvement of dam management or integrated water resources management. Reinforcement of intake facility will be a countermeasure against flood intensification. ■ Outcome of Adaptation Measures The impacts of climate change on the water resources sub-sector will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological and hydrological records in the catchment areas of the target water resources facilities and water supply areas, from meteorological weather stations, hydrological observation stations, and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and the target year for adaptation measures. Estimate hydrological aspects such as precipitation and its pattern, inflow to reservoir, groundwater recharge, evaporation from reservoir, etc., for the target dam or new water resource / water transmission source, for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for water use, such as population change and industrial development, through review of the watershed conservation plan, development plan, land use regulations, etc. Estimate future water demand considering climate change such as temperature rise, or refer to the study results on the change of water demand due to climate change for each sector if available. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage ・Water Shortage in Drought Study the change of water availability by change of precipitation, temperature rise, etc., and water use through hearing among stakeholders such as related agencies, water users, etc., as well as investigation of various records. Attention shall be paid to the tendency that water users (e.g. agriculture, water supply, industry, hydro power, etc.) generally increase their water consumption during high temperature, and agricultural water demand highly depends on the other weather condition (e.g. rainfall and its pattern and evapotranspiration) as well as temperature level.

	Study the drought condition for each water resource facility, and identify the facility vulnerable to drought. Identify past drought damage of water users in the water supplying area, and then clarify the bias among water user sectors and areas. ・Facility Damage by Flood Study the facility damage by climate disaster such as flood in the target area, through hearing among stakeholders such as related agencies, water users, etc., as well as investigation of various records. Identify the areas vulnerable to climate disasters. b) Study Present Condition of Facilities and Measures ・Condition of Facilities: Assess the present condition of facilities such as capability in drought and disasters, and maintenance condition, through field survey and review of documents for facilities and dam operation, etc. ・Operating / Implementing Conditions of Facilities: Assess the implementation status of dam operation in drought through the review of dam operation records. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity of drought condition/ facility damage due to climate change based on the relationship between past drought/ disasters and meteorological conditions, future climate condition, and facilities condition, with consideration of future socio-economical change factors. Step 2 4) Assess Adaptive Capacity to Climate Change a) Identification of Adaptive Capacity ・Flexibility of Water Supplier Side Study flexibility of water supply coordination among water resources including the target water resource facility. ➢ Organization structures of government authorities and institutions supervising each water resource, which are related to the flexibility for coordination of water supply. ➢ Coordination system among water resources such as committees, which is related to the flexibility for coordination of water supply. ・Flexibility of Water User Side Study capacity of water users during drought. ➢ Organizational structures of government authorities and institutions supervising each water user, which are related to the flexibility of water demand coordination. ➢ Coordination system among water users such as committees, which is related to the flexibility of water demand coordination.

・Flexibility of Water Supply and Demand Adjustment

Study the flexibility of adjustment among water suppliers and water users.

- Organizational structures of government authorities and institutions supervising water suppliers and water users, which are related to the flexibility of water supply and demand adjustment.
- Coordination system among water suppliers and water users such as committees, which is related to the flexibility of water supply and demand adjustment.

・Disaster Resilience Capacity of Regulatory Agency

Assess budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development

Assess research and development for water resource and water use.

b) Clarify Exacerbating Factors for Climate Change Impacts

Not assumed.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Flexibility of water supplier side	High	Low
Flexibility of water user side	High	Low
Flexibility of water supply and demand adjustment	High	Low
Disaster resilience capacity of regulatory agency	Excellent	Poor
Existence and ability of research and development	Existing/ Excellent	None/ Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of drought damage	Economic	-
	Reduction of facility damage	Quantitative	-
Flexibility of water supplier side	Coordination among water resources	Qualitative	-
Flexibility of water user side	Coordination among water users	Qualitative	-
Flexibility of water supply and demand adjustment	Coordination among water suppliers and water users	Qualitative	-
Disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period by expanded facilities	Quantitative	・Useable water amount
	Improvement of target return period in the target area by new facility development	Quantitative	・Useable water amount
Non-structural measures	Improvement of target return period in the target area by water management improvement	Quantitative	-
Others	Changes in the number of beneficiaries	Quantitative	-
	Changes in the awareness of stakeholders on water supply and water use	Qualitative	-

D.
Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review
Plan the periodical schedule for monitoring of climate conditions and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Confirm the flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with the counterpart agencies. The items should include the following:
・Countermeasures to the reduction of water availability (necessity of alternative water resources and its existence)
・Countermeasures for the increase of water demand (alternative water resources, rooms for expansion of facilities, etc.)
・Countermeasures to flood damage on facilities (room for expansion of drainage capacity, development of disaster prevention facilities, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

E.
Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect data from meteorological and hydrological stations.
	Operation record of water resource facilities	Collect as much detailed operation records as possible since some of water use, such as irrigation, are seriously affected by the seasonal drought.

2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on meteorological and hydrological data in the target area.
	Climate change impacts on water demand	Study the relationship between meteorological conditions and water use in the past, such as influence of temperature on domestic water use and industrial use, and influence of temperature, precipitation and its pattern on irrigation water use. If the study results on the change of water demand due to climate change for each sector are available, it can be used.
	Socio-economic incidence	Collect higher level plans and development plans, related to water use, all around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Past drought damage	Collect and analyze the drought damage in each water sector or area by each drought event. Secular change shall be also collected in parallel.
	Water use record	Collect records on daily or monthly basis to study the relationship between meteorological factor such as temperature and water use.
	Facility damage	Collect and identify the damage condition of each facility or part by each climate disaster. Secular change shall be also collected in parallel.
	Design capacity of existing facilities	Study the design capacity of each facility based on the existing plan, design standards, design drawings, as-built drawings, etc.
	Condition of existing facilities	Study the operating condition of each facility through field survey.
4) Assess Adaptive Capacity to Climate Change	Flexibility of water supplier side	Study the organization chart of supervising agencies or institutions for water resources which can be interchanged mutually, and regulations and performances of coordination among water resources such as committee.
	Flexibility of water user side	Study the organization chart of supervising agencies or institutions for water users which share the same water resource, and regulations and performances of coordination among water users such as committee.
	Flexibility of water supply and demand adjustment	Study the organizational chart of supervising agencies or institutions for water resources and water users, and regulations and functions of coordination among water resources and water users such as committees.
	Disaster resilience capacity of the regulatory agency	Study and review the budget and programs through interviews with related agencies, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Water Resource (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
It is necessary to develop water resources since future water demand will exceed the existing water supply from water resources, such as dam reservoir, water intake at river, groundwater, etc., in association with economic growth.
Future climate change impacts such as reduction of water availability due to rainfall change, increase of water demand due to temperature rise, and intensification of the flood scale, shall be considered.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
The expected water supply will be maintained in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project the amount and patterns of rainfall and estimate the inflow to and evaporation from the reservoir at the planned base year using the analysis results of climate change projection for the target year.
The increase in water demand due to climate change shall be studied, or refer to the study results on changes in water demand due to climate change for each sector if available.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan the adaptation options that will fill the gap in the supposed shortage of water supply. Possible options should include the following, which could be implemented individually or simultaneously:
・Structural measures to increase water resources, such as new water resources development, development of water conveyance, heightening of dam, excavation of reservoir, and reduction of water leakage.
・Non-structural measures to reallocate or utilize water resources such as improvement of dam operation, and introduction of integrated water resources management.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future Sensitivity to Climate Change</td><td>Reduction of drought damage</td><td>Economic</td><td>-</td></tr>
<tr><td>Reduction of facility damage</td><td>Quantitative</td><td>-</td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Structural measures</td><td>Improvement of target return period of expanded facilities</td><td>Quantitative</td><td>・Useable water amount</td></tr>
<tr><td>Improvement of target return period in the target area by new facility development</td><td>Quantitative</td><td>・Useable water amount</td></tr>
<tr><td>Non-structural measures</td><td>Improvement of target return period in the target area by water management improvement</td><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="2">Others</td><td>Changes in the number of beneficiaries</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in stakeholders' awareness of water supply and water use</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

<table>
<tr>
<td>E.
Necessary Consideration for Planning of Adaptation Options</td>
<td>1) Monitoring and Review
Plan the periodical schedule for monitoring of climate conditions and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure the flexibility to climate change impacts, which are not considered for the project scope but have certain risks. The range of flexibility shall be determined with the counterpart agencies. The items should include the following:
・Countermeasures to the reduction of water availability (necessity of substitute water resources and its existence)
・Countermeasures for the increase of water demand (substitute water resources, rooms for expansion of facilities, etc.)
・Countermeasures to flood damage on facilities (room for expansion of drainage capacity, development of disaster prevention facilities, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td>
</tr>
<tr>
<td>F.
Required Data</td>
<td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td rowspan="2"></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.</td></tr>
<tr><td>Climate change impacts on water demand</td><td>Study the relationship between meteorological conditions and water use in the past, such as influence of temperature on domestic water use and industrial use, and influence of temperature, precipitation and its pattern on irrigation water use.
If the study results on the change of water demand due to climate change for each sector are available, it can be used.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.</td></tr>
</table>
</td>
</tr>
</table>

References and Key Different Features

1) IPCC AR4 Report[1]

According to the report, a statistical analysis of water use in New York City indicates that temperature above 25°C, the daily per capita water use increases by 11 liters/1°C: roughly 2% of current daily per capita use.

2) Handbook on Climate Change Adaptation in the Water Sector[2]

JICA's approach of development assistance to developing countries with regards to climate change adaptation for water sector (mainly focused on flood control, but also includes water resources, water environments, sediment, and coastal protection) is shown in this handbook.

This handbook (HB) is the main reference for this survey of the water resources sub-sector, and the policies and methods are basically the same with each other in this regard. However, there are some differences between this survey and HB. The differences are as follows:

・The target of the HB is mainly a ,master plan; on the other hand, this survey targets the feasibility study directly leading to loan assistance. The HB gives importance on the integrated water resources management as an adaptation measure in the water resources sub-sector.

・OECD-DAC defined climate change adaptation-related aid as activities that aim "to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience". In this regard, vulnerability should be examined, however the definition and assessment procedure of vulnerability are included but not clarified in the HB. This survey clearly specifies the vulnerability assessment and its study procedure.

・The HB defines the target year as 2040-50 in consideration of the availability of calculation results of GCMs used for IPCC AR4. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that IPCC AR5 will be published in 2013, and much of the countries have already involved climate change in their policies.

・The HB recommends the downscaling of AGCM20 results as a general rule. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that AGCM20 has been proved unsuitable to every region of the world through researches and studies, and much of countries have established their own climate change policy using their own selected models which suit to their countries.

Below is a brief summary of the HB.

Conventional planning based on the premise of stationarity which states that past precipitation pattern will not change over time has become invalid due to climate change. The project formulation approach will be fundamentally different from the conventional one in the following aspects:

・It will deal with a changing climate.

・It will involve projecting future impacts for project formulation and implementation.

・Technologies available for projection and adaptation are being developed day to day, and water management systems will change or must be changed accordingly.

The project formulation approach in the water resources sub-sector becomes as follows:

1. Projection concerning normal water levels, groundwater, droughts, and water environments

   The target year will be set to a year during the 2040-50 period.

   Runoff analysis should be done taking into account the effects of solar radiation, temperature, wind and other factors that have traditionally been disregarded, by making heat balance calculations that incorporate climate model outputs. However, the model to be applied will be examined further in light of budgetary and technological limitations. Groundwater flow analysis and environmental analysis will be implemented using existing models.

2. Existing Facilities, Plans, and Management Structure: Identifying Existing Coping Mechanisms

   Identify and inventory existing facilities, plans and institutional frameworks for water management that may be used for adaptation.

(a) Structural measures

(b) Institutional framework

(c) Areas that may not have been identified but need to be identified for implementing community-based measures

(d) City plans and regional development plans

3. Damage Potential and Impact Assessment

4. Adaptation Planning

(1) River Basin Governance

Adaptation planning involves a wide range of stakeholders, as well as various sectors. It also hinges on voluntary activities on the part of communities. It is therefore important to establish a council or forum made up of stakeholder organizations, experts and academics at the early stages of planning.

(2) Meteorological and Hydrological Observation

The improvement and maintenance of meteorological and hydrological observations are considered as cross-cutting adaptation measures in the water sector, aiming at the greater accuracy of climate change impact assessment, a deeper understanding of extreme droughts, and the development of warning system.

(3) Integrated Water Resources Management (IWRM)

・Strengthening water resources management
  − Planning and empowerment regarding IWRM
  − Developing systems for water use coordination and water allocation and coordination mechanisms
  − Monitoring and data collection regarding water resources
  − Making water use more efficient with demand-side management
  − Groundwater resources management
  − Water pollution control
  − Improving existing water use facilities
・Increasing the capacity to store water resources
・Introducing new technologies
・Readjusting the industrial structure

(4) Measures for the poor and the vulnerable

(5) Disaster Insurance

(6) Monitoring (Evaluation and Review) and Maintenance

3) Water and Adaptation to Climate Change[3]

The basic policy of GTZ (recently reorganized as GIZ) for development assistance to developing countries in climate change adaptation for the water sector is shown in this publication. The target of this publication is the upper sector including master plan and sectoral reform, etc., and there are no descriptions about practical procedure or guideline for the study.

Below is a brief summary of this publication.

Adaptation measures with regard to the decrease of water resources, such as water saving and introduction of flexibility into water supply, could be integrated into and further strengthen the water resources planning and operation and maintenance of BAU development.

In this regard, most of the adaptation measures against the reduction of water resources are "no regrets" measures. These adaptation measures are the following:

・Integrate climate change into planning
・Water resources knowledge base
・Water-saving technology
・Management and governance reforms

- Supply augmentation
- Multiple uses of water
- Agricultural research
- Insurance schemes
- Awareness

The areas for development cooperation in order to support adaptive action of developing countries are considered as follows:

- Policy analysis and change
- Infrastructure development and technology
- Changes in management and governance

These areas for development cooperation have been implemented by GTZ before the awareness on climate change was raised, and these will be modified in conformity with priority on adaptation and necessity in the country.

4) Integrated Water Resource Management addressing Climate Change and Other Risks (Interim Report)[4]

This document discusses and explains water management in Japan considering climate change, and recommends the implementation of integrated water resources management. This document is useful and shall be referred in consideration of introducing integrated water resource management in master plan and feasibility study, but the procedure of study or planning is not specified.

A brief summary of the integrated water resource management presented in this material is as follows:

- Building a society to use water effectively and attaining stable water resources
  - Water resource management on both the demand and the supply sides
    (Enhancement of water-saving consciousness, rationalization of water use, rational water supply by active use of existing stocks)
  - Promotion of rational distribution of water resources
    (Review of drought control, promotion of diversion of unused water, promotion of sharing the cost burden for temporary accommodation of water during drought)
- Comprehensive quantity/quality management
  (Promotion of comprehensive water quality improvement, measures for securing safe water, issues to solve when reorganizing the intake/drain system)
- Measures against decline in water supply function in emergency settings of earthquake or accident
  (Basic idea, securing the reliable functions of facilities by asset management, establishment of a system with redundancy, establishment of a mobile water supply system for emergency, promotion of stockpiling, promotion of security measures)
- Promotion of comprehensive surface water/groundwater management
  (Basic idea, proper use of emergency water resources, underground water resource management operation measures, building a social consensus for groundwater resource management)
- Conservation and creation of an abundant water environment
  (Consideration for ecosystems, recovery of the relationship between people and water and conservation and creation of water culture)

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1 IPCC. (2007). AR4 WGII Report

2 JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development

3 GTZ. (2008). Water and Adaptation to Climate Change: Consequences for Developing Countries

4 Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2008). Integrated Water Resource Management addressing Climate Change and Other Risks (Interim Report)

2. Irrigation and Drainage Sub-sector

Guideline:

(1) Irrigation (Adaptation Project)
(2) Irrigation (BAU Development with Adaptation Options)
(3) Drainage (Adaptation Project)
(4) Drainage (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change will intensify extreme events such as drought and flood, and change the precipitation and temperature patterns. These impacts will not only cause adverse effects on rainfed agriculture, but also water shortage and flood damage to agricultural areas that are developed for irrigation and drainage. The adaptation measures in the irrigation and drainage sub-sector are to secure and improve agricultural productivity against climate change impacts through enhancement of water supply and drainage capacity.
B. Vulnerability	1) Major Climate Change Impacts on the Irrigation and Drainage Sub-sector ■ Reduction of Precipitation, Change of Precipitation Pattern ・Water shortage will cause crop damage in rainfed farmlands. ・Water resources such as river and groundwater will decrease, consequently water intake for irrigation will become short. ・Water requirement for irrigation will increase. ■ Increase/ Intensification of Precipitation and Cyclone ・Flood damage on crops will increase. ・Flood will cause structural damage to reservoirs, intakes, and canals. ■ Increase/ Intensification/ Prolongation of Drought ・Rainfed agriculture will severely suffer. ・Irrigated agriculture will suffer shortages in irrigation water even those with reservoirs. ■ Temperature Rise ・Change of snow accumulation volume and thawing season pattern will cause water shortage in the irrigated area dependent on spring runoff. ・Irrigation area with glacial lakes as water source could receive more water in the near future; however, it would decrease from the long-term perspective. ・Water requirement will increase in association with increase in evapotranspiration. ■ Sea Level Rise .・Groundwater would become inappropriate for agricultural use on coastal farmlands due to salinity increase. ・Rivers near estuaries would become inappropriate for agricultural use due to saltwater intrusion. ・Water level in drainage facilities would increase in association with sea level rise, resulting to poor drainage. 2) Other Factors that Influence the Irrigation and Drainage Sub-sector Associated with Climate Change Impacts ・Population growth, land use change, and industry activities will change water demand and alter the allocation among sectors. ・Change in industrial structure, land use, and food demand will change agricultural water demand. ・Change in water management practice would increase water efficiency.

	3) Adaptive Capacity to Climate Change ・If agricultural knowledge and technology are sufficiently disseminated, farmers could cope with the changing weather conditions in farming, and consequently increasing their adaptive capacity. ・If programs of related agencies and NGOs for agricultural extension are active, the adaptive capacity is high. ・If the budget and programs for the rehabilitation of facilities are well in place, disaster response capability of regulatory agencies is high. ・If research institute related to agriculture and irrigation exists and its system is well-organized, the adaptive capacity for climate change is high. ・The existence and enrollment status of climate-related insurance and mutual aid system would affect the damage to farming in the event of crop failure and restoration ability for structures. ・If financial schemes for farmers such as microcredit and rural finance are sufficiently established, farmers could afford to buy agricultural materials even after disaster occurrence; hence the adaptive capacity is high. ・The farmers with good socio-economic conditions, such as sufficient livelihood and educational attainment, could cope with climate change by themselves; consequently their adaptive capacity is higher. 4) Spatial Distribution of Vulnerability a)Climate Change ・With the exception of project areas with huge extent or scattered coverage, climate change impacts on crop growth would be unvaried in the area. ・Flood causing structural damage are brought about by high concentration of rainfall in lower land; hence flood is affected by topography. ・The effect of salinization of groundwater and estuary are dependent on the extent of salt water intrusion. b)Sensitivity in the Irrigation and Drainage Sub-sector ・Sensitivity varies with installation condition, design conditions, development level, and maintenance level of facilities and sections. ・Water shortage tends to occur at the end of the irrigation area. ・In case crops and cropping patterns are different in each area, sensitivity would be different. ・Poor drainage usually occurs at low land areas. c)Adaptive Capacity ・Socio-economic conditions of farmers would vary the adaptive capacity. ・The activities of related agencies and NGOs for agricultural extension affect the adaptive capacity of the area.
C. Adaptation Measures	Major Adaptation Measures in the Irrigation and Drainage Sub-sector ■ Development/ Expansion of Reservoir ・To store irrigation water against reduction of precipitation, change of precipitation pattern, and drought. ・To secure sufficient reservoir capacity considering for future climate change impacts, such as increase in irrigation water demand and evaporation from reservoirs.

	■ Development/ Improvement of Irrigation and Drainage Facilities ・To develop new and improve existing irrigation facilities against the reduction of precipitation and available water. ・To secure sufficient irrigation capacity considering for future climate change impacts. Intake site, increase of irrigation water requirement, etc., shall be carefully examined. ■ Installation of Water Saving Irrigation ・To introduce schemes such as pipeline and drip irrigation systems to improve irrigation efficiency. ・To adopt water saving cultivation methods such as system of rice intensification (SRI) ■ Development of Drainage ・To develop drainage canals or improve natural drainage in order to reduce crop damage due to flooding and poor drainage. ・To secure sufficient drainage capacity considering for future climate change impacts, such as sea level rise that can cause drainage water level to rise, intensification of rainfall. ■ Enhancement of Water Management ・To enhance adaptive capacity to climate change through strengthening of organization capacity for daily operation, maintenance, response to drought, and enhancement of water management system by installation of telemetry system. ■ Participatory Irrigated Agriculture Development ・To enhance farmers' adaptive capacity to climate change by raising their interest, knowledge, and commitment to agriculture and irrigation system.
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Water conflict with other water users would occur at change of water source or water intake position. ■ Maladaptation Common to "Business as Usual" Project ・Future climate change impact would cause shortage of facility capacity, consequently affecting the safety of structure. ・Excessive water withdrawal of groundwater would cause salt water intrusion, and water quality would become inappropriate to agricultural use. ・Drainage to outside area by operation of drainage facilities such as drainage pump in the event of flood, if it is implemented by each area to another area, may offset the drainage capacity of the other.

Guideline: Irrigation (Adaptation Project)

A. General	■ Necessity of Adaptation Climate change impacts, such as decrease in precipitation, change of precipitation patterns, and prolongation of drought, are likely to increase crop damage. ■ Adaptation Measures To reduce drought damage by means of development/ expansion/ improvement of irrigation facilities, installation of water saving irrigation, etc. ■ Outcome of Adaptation Measures Crop damage in the event of drought, which will be exacerbated by climate change, will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect meteorological and hydrological records in the target area, from meteorological weather stations, hydrological observation stations, and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate evapotranspiration, precipitation and its pattern, river discharge, etc., for the target year, and determine irrigation water requirement for the planned base year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for vulnerability to climate change in the target area, through review of the higher level plans of food security and agriculture, development plan, and land use plan, and so on. Items shall include the following: ・Expansion of the target irrigation area ・Water conflict with other users ・Decline of agriculture and water management in association with industrial transformation, development, and urbanization in and around the target area. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage ・Crop Damage at Drought Study the past crop damage at drought through hearing with stakeholders such as related agencies and farmers, then, identify the damages and areas vulnerable to drought. ・Facility Damage by Flood Study facility damages by climate disaster such as flood in the target area, through hearing with stakeholders such as related agencies, water users associations, and farmers, as well as investigation of various relevant records. Identify the areas vulnerable to climate disasters.

b) Study Present Condition of Facilities and Measures

・Condition of Facilities:

Assess the present condition of irrigation facilities based on the design capacity and maintenance condition, through field survey and review of reports and drawings of existing facilities.

・Operating / Functioning Conditions of Facilities:

Assess the operation condition and its difference in causes in the irrigation system, through investigation on operation and management records of water users associations, as well as through interviews with stakeholders.

c) Assess Future Sensitivity to Climate Change

Assess the future sensitivity to drought and facility damage to climate change based on the relationship between past crop damages, structural damages and meteorological conditions, future climate condition, and condition of facilities, with consideration on future socio-economic change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Activity of Agricultural Extension Office and NGOs

Assess the situation and capacity to support farmers and irrigated agriculture. The following factors would be included.

- Budget and programs in related agricultural agencies
- Budget and programs in NGOs

・Disaster Resilience Capacity of Regulatory Agency

Assess budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development

Assess research and development for agriculture and irrigation.

・Compensation for Crop and Structural Damage by Climate Disaster

Assess the disaster restoration capacity and burden alleviation on farmers in the event of climate disaster:

- Available climate insurance and mutual aid system.

・Financial Scheme to Farmers

Assess the ability to maintain livelihood and to purchase agricultural materials after disaster occurrence:

- Scheme and access to microcredit and rural finance.

b) Clarify Exacerbating Factors for Climate Change Impacts

・Socio-economic Condition of Farmers

Assess the adaptive capacity and its disparity in the target area through studying the socio-economic condition of farmers. The items for assessment are assumed as follows:

- Ethnic minority groups and resettlement areas, which are likely to suffer disparity and discrimination from other majorities.

- Crop yield, agricultural income and the share on livelihood, which affect the impact of crop failure on farmers
- Educational level, which is related to the adaptive capacity to climate change
- Health condition of farmers, which would alleviate or exacerbate the adverse effects of climate change on work conditions and labor force
- Subsidy from government, which might discourage the voluntary action of farmers.

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability →	High
Future sensitivity to climate change	Small	Large
Activity of agricultural extension office and NGOs	Sufficient	Poor
Disaster resilience capacity of regulatory agency	Excellent	Poor
Existence and ability of research and development	Existing/Excellent	None/Poor
Compensation for crop and structural damage by climate disaster	Sufficient	Poor
Financial scheme to farmers	Good	Poor
Socio-economic condition of farmers	Good	Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of drought damage	Economic	・Annual income increase of each farmer level
		Quantitative	・Actual irrigated area ・Land usage ratio ・Production volume of major crops ・Productivity of major crops
	Reduction of facility damage	Quantitative	-
Activity of agricultural extension office and NGOs	Improvement of farmers' knowledge on farm management	Qualitative	-
Disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for crop and structural damage by climate disaster	Improvement of disaster restoration capacity and burden alleviation on farmers	Qualitative	-

	(continued)

Financial scheme to farmers	Improvement of ability to maintain livelihood and purchase agricultural materials after disaster occurrence	Qualitative	-
Socio-economic condition of farmers	Improvement of adaptive capacity	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Expansion of irrigated area, improvement of target return period	Quantitative	・Irrigated area ・Amount of water intake
Non-structural measures	Improvement of water management	Quantitative	・Collection ratio of water charge ・Number of water association
Others	Implementation situation of participatory irrigated agriculture development	Quantitative	-
	Changes in the awareness of stakeholders	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

・Countermeasures for reduction of water availability (room for development and expansion of reservoirs and regulating ponds, necessity of alternative water resources and their existence)

・Countermeasures for further increase of irrigation water (room for expansion of irrigation canals and related structures)

・Countermeasures for further increase of flood (room for expansion of drainage canals and related structures)

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

E.
Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect data from meteorological and hydrological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on meteorological and hydrological data in the target area.
	Socio-economic incidence	Collect higher level plans of food security and agriculture, development plans, and land use plan, all around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Historical data on agricultural yield	Collect records on cultivation by each irrigation block. If unavailable, estimate through hearing with stakeholders. Secular change shall be also collected in parallel.
	Facility damage	Collect and identify the damage of each facility by climate disaster. Secular change shall be also collected.
	Design capacity of existing facility	Study the design capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.
	Operation records of water users association	Collect records on gate operation and discharge for each irrigation canal section to assess the relation between crop yield and irrigation for each block. If unavailable, estimate through interview with stakeholders.
4) Assess Adaptive Capacity to Climate Change	Activity of agricultural extension office and NGOs	Study the budget and programs in related agricultural agencies and NGO for each area. Check the imbalance of situations among areas. It is desirable to study by village or whichever is the lowest administrative unit.
	Disaster resilience capacity of regulatory agency	Study and review the budget and programs through interviews with related agencies, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
	Existence and Enrollment of Climate Insurance and Mutual Aid System	Study and review the insurance and mutual aid systems through interview with related agencies and based on related information collected.
	Financial scheme to farmers	Study and review the financial schemes through interview with related agencies and based on related information collected.
	Socio-economic condition of farmers	It is desirable to assess the disparities in area by village or whichever is the lowest administrative unit, through secondary data from the statistics agency, and surveys, if necessary.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Irrigation (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td>■ <u>Necessity of Adaptation Options</u>
New irrigation facilities will be constructed, or existing ones will be rehabilitated or expanded in order to improve agricultural productivity. Potential risks of reduction in irrigation efficiency because of water shortage are likely to increase due to climate change impacts.
■ <u>Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
■ <u>Outcome of Adaptation Options</u>
The expected irrigated farming will be maintained in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological and hydrological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as development, expansion, and improvement of facilities, and non-structural measures such as adoption of water saving irrigation and improvement of water management, which could be implemented individually or simultaneously.</td></tr>
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・Land usage ratio
・Production volume of major crops
・Productivity of major crops</td></tr>
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<tr><td>Structural measures</td><td>Expansion of irrigated area, improvement of target return period</td><td>Quantitative</td><td>・Irrigated area
・Amount of water intake</td></tr>
<tr><td>Non-structural measures</td><td>Improvement of water management</td><td>Quantitative</td><td>・Collection ratio of water charge
・Number of water association</td></tr>
<tr><td rowspan="2">Others</td><td>Implementation situation of participatory irrigated agriculture development</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in the awareness of stakeholders</td><td>Qualitative</td><td>-</td></tr>
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<tr><td>E.
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Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for reduction of water availability (room for development and expansion of reservoirs and regulating ponds, necessity of alternative water resources and their existence)
・Countermeasures for further increase of irrigation water (room for expansion of irrigation canals and related structures)
・Countermeasures for further increase of flood (room for expansion of drainage canals and related structures)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
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<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological and hydrological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.</td></tr>
</table>
</td></tr>
</table>

Guideline: Drainage (Adaptation Project)

A. General	<u>■ Necessity of Adaptation</u> Climate change will increase frequency and intensity of flood, hence the flood damages on crops will increase. <u>■ Adaptation Measures</u> To reduce flood damage on crops by means of development, expansion, and improvement of drainage facilities. <u>■ Outcome of Adaptation Measures</u> Crop damage in the event of flood, which will be exacerbated by climate change, will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological and hydrological records in the target area, from meteorological weather stations, hydrological observation stations, and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate precipitation and its pattern, etc., for the target year, and estimate the required drainage capacity, water discharge and water level of drainage river for the planned base year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for vulnerability to climate change at the target area, through review of higher level plans of food security and agriculture, development plan, and land use plan. Items shall include the followings: ・Policy in using agricultural lands as retarding basins in the event of flood. ・Decline of agriculture and water management in association with industrial transformation, development, and urbanization in and around the target area. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage ・Crop Damage by Flood and Poor Drainage Study the past crop damage by flood condition and poor drainage through hearing with stakeholders such as related agencies and farmers, then, identify the damages and areas vulnerable to flood and poor drainage. ・Facility Damage by Flood Study the facility damage by climate disaster such as flood in the target area, through hearing with stakeholders such as related agencies, water users associations, and farmers, as well as investigation of various relevant records. Identify the areas vulnerable to climate disasters.

b) Study Present Condition of Facilities and Measures

・Condition of Facilities:

Assess the present condition of drainage facilities such as drainage canal, natural drainage, drainage pump, etc., based on the design capacity and maintenance condition, through field survey and review of reports and drawings of existing facilities.

・Operating / Functioning Conditions of Facilities:

Assess the operation condition and its difference with cause, in case there are drainage facilities operated such as pumps, through investigation on operation and management records, as well as through interviews with stakeholders. Also, study and confirm if the operation of drainage facilities in each area resulted in offset of effect of another area, or if they have common understanding on cooperation.

c) Assess Future Sensitivity to Climate Change

Assess the future sensitivity to flood condition and facility damage to climate change based on the relationship between past crop damages/ structural damages and meteorological conditions, future climate condition, and condition of facilities, with consideration on future socio-economic change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

Assess the situation and capacity to support farmers and farming practice. The following factors would be included.

- Budget and programs in related agricultural agencies
- Budget and programs in NGOs

・Disaster Resilience Capacity of Regulatory Agency

Assess budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development

Assess research and development for agriculture and irrigation.

・Compensation for Crop and Structural Damage by Climate Disaster

Assess the disaster restoration capacity and burden alleviation on farmers in the event of climate disaster:

- Available climate insurance and mutual aid system.

・Financial Scheme to Farmers

Assess the ability to maintain livelihood and to purchase agricultural materials after disaster occurrence:

- Scheme and access to microcredit and rural finance.

b) Clarify Exacerbating Factors for Climate Change Impacts

・Socio-economic Condition of Farmers

Assess the adaptive capacity and its disparity in the target area through studying the socio-economic condition of farmers. The items for assessment are assumed as follows:

- Ethnic minority groups and resettlement area, which are likely to suffer disparity and discrimination from other majorities.

- ➢ Crop yield, agricultural income and the share on livelihood, which affect the impact of crop failure on farmers
- ➢ Educational level, which is related to the adaptive capacity to climate change
- ➢ Health condition of farmers, which would alleviate or exacerbate the adverse effects of climate change on work conditions and labor force
- ➢ Subsidy from government, which might discourage the voluntary action of farmers.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Activity of agricultural extension office and NGOs	Sufficient	Poor
Disaster resilience capacity of regulatory agency	Excellent	Poor
Existence and ability of research and development	Existing/Excellent	None/Poor
Compensation for crop and structural damage by climate disaster	Sufficient	Poor
Financial scheme to farmers	Good	Poor
Socio-economic condition of farmers	Good	Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of crop damage by flood and poor drainage	Economic	・Annual income increase of each farmer level
		Quantitative	・Actual irrigated area ・Land usage ratio ・Production volume of major crops ・Productivity of major crops
	Reduction of facility damage	Quantitative	-
Activity of agricultural extension office and NGOs	Improvement of farmers' knowledge on farm management	Qualitative	-
Disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for crop and structural damage by climate disaster	Improvement of disaster restoration capacity and burden alleviation on farmers	Qualitative	-

Financial scheme to farmers	Improvement of ability to maintain livelihood and purchase agricultural materials after disaster occurrence	Qualitative	-
Socio-economic condition of farmers	Improvement of adaptive capacity	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Expansion of area covered by drainage facilities, improvement of target return period for drainage	Quantitative	-
Non-structural measures	Improvement of drainage management	Qualitative	-
Others	Implementation situation of participatory irrigated agriculture development	Quantitative	-
	Changes in the awareness of stakeholders	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

・Countermeasures for reduction of water availability (room for development and expansion of reservoirs and regulating ponds, necessity of alternative water resources and their existence)
・Countermeasures for further increase of irrigation water (room for expansion of irrigation canals and related structures)
・Countermeasures for further increase of flood (room for expansion of drainage canals and related structures)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect data from meteorological and hydrological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Socio-economic incidence	Collect higher level plans of food security and agriculture, development plans, and land use plan, in and around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Historical data on agricultural yield	Collect records on cultivation by each irrigation block. If unavailable, estimate through hearing with stakeholders. Secular change shall be also collected.
	Facility damage	Collect and identify the damage condition of each facility by climate disaster. Secular change shall be also collected in parallel.
	Design capacity of existing facility	Study the design capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.
4) Assess Adaptive Capacity to Climate Change	Activity of agricultural extension office and NGOs	Study the budget and programs in related agricultural agencies and NGO for each area. Check the imbalance of situations among areas. It is desirable to study by village or whichever is the lowest administrative unit.
	Disaster resilience capacity of regulatory agency	Study and review the budget and programs through interviews with related agencies, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
	Existence and enrollment of climate insurance and mutual aid system	Study and review the insurance and mutual aid systems through interview with related agencies and based on related information collected.
	Financial scheme to farmers	Study and review the financial schemes through interview with related agencies and based on related information collected.
	Socio-economic condition of farmers	It is desirable to assess the disparities in area by village or whichever is the lowest administrative unit, through secondary data from the statistics agency, and surveys, if necessary.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Drainage (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
New drainage facilities will be constructed, or existing ones will be rehabilitated or expanded in order to reduce flood damage and insufficient drainage.
Potential risks of reduction of drainage function because of discharge increase in natural drainage, and intensification and increase frequency of flood, are likely to increase due to climate change impacts.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
Crop damages due to flood will be reduced in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological and hydrological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are development, expansion, and improvement of drainage facilities, and improvement of natural drainage, which could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="3">Future sensitivity to climate change</td><td rowspan="2">Reduction of crop damage by flood and poor drainage</td><td>Economic</td><td>・Annual income increase of each farmer level</td></tr>
<tr><td>Quantitative</td><td>・Actual irrigated area
・Land usage ratio
・Production volume of major crops
・Productivity of major crops</td></tr>
<tr><td>Reduction of facility damage</td><td>Quantitative</td><td>-</td></tr>
</table>
[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Expansion of area covered by drainage facilities, improvement of target return period for drainage</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Non-structural measures</td><td>Improvement of drainage management</td><td>Qualitative</td><td>-</td></tr>
<tr><td rowspan="2">Others</td><td>Implementation situation of participatory irrigated agriculture development</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in the awareness of stakeholders</td><td>Qualitative</td><td>-</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for reduction of water availability (room for development and expansion of reservoirs and regulating ponds, necessity of alternative water resources and their existence)
・Countermeasures for further increase of irrigation water (room for expansion of irrigation canals and related structures)
・Countermeasures for further increase of flood (room for expansion of drainage canals and related structures)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>F.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.</td></tr>
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References and Key Different Features

1) Climate Change and Agriculture[1]

This publication contains the basic policy of GTZ (recently reorganized as GIZ) for development assistance to developing countries in climate mitigation and adaptation in agriculture. However, there are no descriptions about practical procedure or guidelines for the study. A brief summary of this publication is as follows:

Adaptation responses can be categorized into two levels: autonomous adaptation and policy-driven adaptation. Autonomous adaptations are initiatives by the private actors, usually triggered by market or welfare changes induced by actual or anticipated climate change. Policy-driven adaptation is the result of a deliberate policy decision on the part of a public agency.

Table Adaptation responses and issues

Type of response	Autonomous	Policy-driven
Short-run	● Crop choice, crop area, planting date ● Risk-pooling insurance	● Improved forecasting ● Research for improved understanding of climate risk
Long-run	● Private investment (on-farm irrigation) ● Private crop research	● Large-scale public investment (water, storage, roads) ● Crop research
Issues	● Costly to poor ● Social safety nets ● Trade-offs with integration	● Uncertain returns on investment ● Costs

Source: Rosegrant et al. (2008), p23, Table 4.

Decisions about what adaptation measures to adopt are taken within the context of a wide society and political economy, thus end choices are shaped by public policy. Adaptation options and their supporting policies should be adopted by the appropriate level of government and implemented by institutions in direct contact with beneficiaries. Possible supporting policies to help promote adaptation measures are shown in the table below:

Table Adaptation options and supporting policies given climate change

<table>
<tr><th></th><th>Adaptation Option</th><th>Supporting Policies</th></tr>
<tr><td rowspan="12">Short-term</td><td>Crop insurance for risk coverage</td><td>Improved access, risk management, revise pricing incentives, etc</td></tr>
<tr><td>Crop/livestock diversification to increase productivity and protect against diseases</td><td>Availability of extension services, financial support, etc.</td></tr>
<tr><td>Adjust timing of farm operations to reduce risks of crop damage</td><td>Extension services, pricing policies, etc</td></tr>
<tr><td>Change cropping intensity</td><td>Improved extension services, pricing policy adjustments</td></tr>
<tr><td>Livestock management to adjust to new climate conditions</td><td>Provision of extension services</td></tr>
<tr><td>Changes in tillage practices</td><td>Extension services to support activities, pricing incentives</td></tr>
<tr><td>Temporary mitigation for risk diversification to withstand climate shocks</td><td>Employment/training opportunities</td></tr>
<tr><td>Food reserves and storage as temporary relief</td><td></td></tr>
<tr><td>Changing crop mix</td><td>Improving access and affordability, revising pricing, etc</td></tr>
<tr><td>Modernization of farm operations</td><td>Promote adoption of technologies</td></tr>
<tr><td>Permanent migration to diversify income opportunities</td><td>Education and training</td></tr>
<tr><td>Defining land-use and tenure rights for investments</td><td>Legal reform and enforcement</td></tr>
</table>

Both short- and long-term	Development of crop and livestock technology adapted to climate change stress: drought and heat tolerance, etc.	Agricultural research (crop and livestock trait development), agricultural extension services
	Develop market efficiency	Invest in rural infrastructure, remove market barriers, property rights, etc
	Irrigation and water storage expansion	Investment by public and private sectors
	Efficient water use	Water pricing reforms, clearly defined property rights, etc
	Promoting international trade	Pricing and exchange rate policies
	Improving forecasting mechanisms	Information needs to be distributed across all sectors, etc
	Institutional strengthening and decision-making structures	Reform existing institutions on agriculture, etc

Source: Kurukulasuriya and Rosenthal (2003) (GTZ. (2008), p24, Table 5.)

In order to make a judicious selection of adaptation measures, multiple criteria from environmental, technical, social, and economic standpoints should be used. Further evaluation criteria need to be developed.

Three actions can be undertaken at national and international levels that would move adaptation forward, which are as follows:

・Promoting adaptation strategies and integration into development planning: Specific adaptation measures could be evaluated and selected within the context of a climate-sensitive strategy and set of policies.

・Ensuring Finance: Donors and investors shall assist in finance of developing country with recognition of adaptation as good investment.

・Promoting insurance: Insurance coverage against extreme weather events are little or not developed in the developing country, and provision of insurance shall be concerned.

Adaptation is imperative; however, adaptation becomes costlier and less effective as the magnitude of climate change increases. Hence mitigation of climate change remains essential.

2) Global Warming Countermeasures Strategies in Agriculture and Rural Development[2]

This document elaborates the measures for climate change in agriculture and rural development including irrigation and drainage in Japan, which mentions adaptation and mitigation, and international contribution. In addition, the document mentions the contribution of agriculture to disaster prevention by multi-functionality of agriculture.

The consideration in this document is for Japan to have well-developed irrigation and drainage, water users association, agricultural research, etc. In this regard, it is difficult to directly apply the mentioned measures in developing countries; nevertheless, the basic concept remains useful.

The followings are brief summary.

Development concept of adaptation can be considered in three categories; (1) development concept of adaptation in farmland and agricultural water, (2) development concept of adaptation in irrigation and drainage facilities, (3) Assessment and management of risk in wide area.

(1) Development Concept of Adaptation in Farmland and Agricultural Water

For the assessment of climate change impacts on agriculture and agricultural water, such as rise in average temperature, change in rainfall patterns, and rise in the average sea level, some models and assessment items are presented in the document.

Flexible implementation based on the prediction evaluation is appropriate for adaptation, as follows: (i) study of risk and monitoring of phenomena, (ii) adaptation by flexible management, (iii) and adaptation by function enhancement. Farming practices occupy the major parts in the flexible implementation; nevertheless infrastructures such as irrigation and drainage facilities are requisites for these practices, so that strategy of infrastructure development shall be contemplated. In addition, the possibility of water use coordination as an adaptation measure also shall be considered.

(2) Development Concept of Adaptation in Irrigation and Drainage Facilities

Adaptation in irrigation and drainage facilities shall also be flexible as well as that in farmlands and agricultural water. The followings are samples of adaptation concept.

Phenomena	Concept of Adaptation
Rise in Average Temperature	● Operation, maintenance and enhancement of water resource facility and water supply facility, for appropriate countermeasures to reduction of reliability of water utilization by water shortage and drought. ● Establishment of water management corresponding to change of water temperature and water quality through utilization of existing water resource and water supply facilities.
Change in Rainfall	● Operation, maintenance and enhancement of water resource and water supply facilities, for appropriate countermeasures to reduction of reliability of water utilization by water shortage and drought. ● Study and coordination of operation rule for water utilization, to maintain reliability of water utilization. ● Review of operation of facilities, strengthening of safety management system, improvement of drainage capacity, in order to maintain the function of irrigation and drainage facilities against changing hydrological aspects.
Rise in Average Sea Level	● Rehabilitation and improvement of coastal protection facilities, and strengthening of disaster prevention management systems for facilities and area, in order to maintain the safety and drainage capacity against changing marine and hydrological aspects. ● Security of function of intake facilities by appropriate operation, in order to maintain reliable water intake on coastal areas against changing marine and hydrological aspects.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan (2008), p.12

Some of the recent rehabilitation and improvement projects for irrigation and drainage adopt the modified value for planning and design, with consideration of historical change in climate. In this regard, the main facilities shall be verified with capacity and structural strength through studying meteorological and hydrological change after the construction as a prioritized measure. In addition, it is important to establish the system for both verification of capacity and regular inspection for existing facilities, with continuous accumulation of meteorological and hydrological data. It is also necessary to consider facility development accounting for climate change impacts in the vulnerable and planned area for urgent development or in the near future

(3) Assessment and Management of Risk in Wide Areas

The existing Japanese GIS database for infrastructure, such as main irrigation and drainage facilities and farm roads, is desirable to be utilized for the assessment and management of risks in wide areas, with integration of climate data such as meteorological and marine data.

The contribution of agriculture will be as follows:
- ・Facilitation for cultivation of energy crops by utilization of farmland.
- ・Flood prevention by utilization of irrigation and drainage facilities.
- ・Maintenance of healthy water circulation as a function of risk hedging.
- ・Security of biodiversity and environmental water.

In addition, the roles of stakeholders in implementing the climate change countermeasures; adaptation, mitigation, and contribution, are described as follows:

(1) Central and Local Government

The central government shall indicate the appropriate climate change countermeasures at agriculture and rural development, and prepare comprehensive policies. The participation of local farmers and inhabitants shall be facilitated into the implementation of measures.

Public research institutes shall improve the certainty of assessment in climate change impacts through accumulation of scientific and objective information and knowledge.

Local governments shall study appropriate measures suitable to local conditions with the central government, and shall lead their respective local inhabitants.

As to regional measures, monitoring, operation and crisis management shall be taken in cooperation with water users associations, farmers, and inhabitants in the target areas.

(2) Assessment and Utilization of Local Knowledge

Peculiar farming practices developed and accumulated in regional agricultural laboratories and agricultural extension center shall be assessed, introduced and promoted. Some irrigation areas utilize information technology on operation and management, and this practice could be applied as adaptation.

With regards to watershed conservation, some areas operate activities for water circulation conservation by utilizing farmland and agricultural water, or establishing a committee mainly led by the irrigation area conducting water quality conservation. These are good model cases to study the cooperation of the whole watershed.

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[1] GTZ. (2008). Climate Change and Agriculture: Threats and Opportunities

[2] Ministry of Agriculture, Forestry and Fisheries, Japan. (2008). Nogyo Noson ni okeru Chikyu Ondanka Taiousaku no Arikata (in Japanese)

3. Farmland Management Enhancement Sub-sector

Guideline:

(1) Farmland Management Enhancement (Adaptation Project)
(2) Farmland Management Enhancement (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Farming is basically related to weather factors, and is much sensitive to climate change impacts such as change of precipitation and temperature, flood and drought. The adaptation measures in the farmland management enhancement sub-sector are to reduce vulnerability of agriculture mainly through non-structural measures such as alternation and development of varieties, improvement of cultivation and post harvesting, and strengthening of farmers' organization.
B. Vulnerability	1) Major Climate Change Impacts on the Farmland Management Enhancement Sub-sector ■ Increase of CO_2 Concentration ・It activates photosynthesis, consequently crop yield will be increased. ■ Reduction of Precipitation, Change of Precipitation Pattern ・Crop failure due to water shortage will occur in association with the reduction of precipitation and irrigation water. ■ Increase/ Intensification of Precipitation and Cyclone ・Water availability will increase, consequently crop yield will increase. ・Crop failure will occur due to poor drainage. ・Heavy rains and strong winds will bring about lodging of crops, and damage to crops and trees. ・Storm surge will cause flooding on farmlands and crop damage due to seawater. Sea breeze will bring salt deposits on crops. ・Farming facilities and equipment will be damaged. ■ Increase/ Intensification/ Prolongation of Drought ・Rainfed agriculture severely suffer . ■ Temperature Rise ・Crop yield will change as suitable areas for crop cultivation are shifted. ・Crop damage would increase with temperature rise. ・In greenhouses, the cost of heating will decrease while that of cooling will increase. ■ Sea Level Rise ・Crop damage by seawater would be caused by salinization of rivers, groundwater and farmlands. ■ Change of Sunshine ・Prolonging of sunlight exposure would increase crop yield. ・Shortage of sunlight exposure would cause crop failure. ■ Others ・Seasonal noxious insect damage on crops would become year round, as temperature rise causes warmer winter temperature, thus, insect can survive during the winter and damages would worsen. ・Increase of other diseases and insect damage, and outbreak of new diseases and alien species.

	2) Other Factors that Influence the Farmland Management Enhancement Sub-sector Associated with Climate Change Impacts ・Changes to the population, industrial structures, policies, market prices, etc., would affect the food crop demand. 3) Adaptive Capacity to Climate Change ・If irrigation and drainage facilities, and water storage facilities are developed, the adaptive capacity on change of precipitation and extreme events such drought and flood will improve. ・If water users associations are well-organized in the irrigation area, adaptive capacity is high because of systematic water management. ・If programs of related agencies and NGOs for agricultural extension are active, the adaptive capacity is high. ・If research institute related to agriculture exists and its system is well-organized, the adaptive capacity for climate change is high. ・The existence and enrollment status of climate insurance and mutual aid system would aide farmers and the respective facilities in the event of crop failure. ・If financial schemes for farmers such as microcredit and rural finance are sufficiently established, farmers could afford to buy agricultural materials even after the disaster strikes, hence, the adaptive capacity is high. ・The farmers with good socio-economic condition, such as livelihood and educational level, could cope with climate change by themselves; consequently their adaptive capacity is higher than those with worse conditions. 4) Spatial Distribution of Vulnerability a) Climate Change ・With the exception of project areas with huge extent or scattered coverage, climate change impacts on crop growth would be unvaried in the area. ・Salinization and other damages by sea water tends to occur in the coastal area. ・Flood damage are brought about by the high concentration of rainfall in lower lands. Hence, flood damages are affected by topography. b) Sensitivity in Farmland Management Enhancement Sub-sector ・Sensitivity varies with dissemination condition of agricultural knowledge and technology, installation condition of greenhouse, post harvest facilities, etc. ・Crop variety and its cultivation period also affects sensitivity. c) Adaptive Capacity ・The development condition of irrigation and drainage facilities would affect the adaptive capacity. ・Socio-economic condition of farmers would vary the adaptive capacity. ・The activities of related agencies and NGOs for agricultural extension affect the adaptive capacity of the area.

C. Adaptation Measures	Major Adaptation Measures in the Farmland Management Enhancement Sub-sector ■ Improvement of Cultivation and Extension of Agricultural Knowledge and Technology ・Review of crop pattern including crop change, improvement of water management, fertilization and prevention, and appropriate use of agricultural equipment and materials. ・Provision of weather information, and guidance for farming and dissemination of agricultural technologies by utilizing the weather information. ・Greenhouse farming. ・Precision agriculture. ■ Development and Introduction of New Crop Variety ・The development, improvement, and introduction of crop varieties that are tolerant or adaptable to climate change and other related phenomena. ■ Strengthening of Post Harvesting ・Installation and operation of post harvest facilities for prevention of quality degradation. ■ Other Agricultural Support Measures mainly to alleviate burden by crop failure on farmers by enhancing farmers' livelihood and financing abilities. ・Strengthening of farmers organization through enhancement of product marketing and agricultural input purchasing. ・Microcredit and rural finance ・Base of pyramid (BOP) business such as agricultural portal
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Increase in disease outbreak, insect damage, and alien species migration in association with crop change and introduction of new crop varieties. ■ Maladaptation Common to "Business as Usual" Project ・Change of agricultural conditions such as temperature, precipitation, water availability, etc.

Guideline: Farmland Management Enhancement (Adaptation Project)

A. General	■ Necessity of Adaptation Climate change impacts, such as conventional farm crops becoming unsuitable to agricultural condition, change of cropping season, exacerbation of quality deterioration after harvesting, are likely to be caused. ■ Adaptation Measures To enhance farmland management through alternation/ development of varieties, improvement of cultivation and post harvesting, strengthening of farmers organization, etc. ■ Outcome of Adaptation Measures Crop damage by climate change will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological records in the target area, from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate agricultural condition for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for vulnerability to climate change in the target area, through review of the higher level plans of food security and agriculture, development plan, and land use plan, and so on. Items shall include the following: ・Policy on using agricultural lands as retarding basins in the event of flood. ・Decline of agriculture and water management in association with industrial transformation, development, and urbanization in and around the target area. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study the past crop damages due to climate condition such as drought, high temperature, sunlight exposure shortage, and floods, through hearing with stakeholders such as related agencies and farmers, and then, identify the damages in the area. b) Study Present Condition of Facilities and Measures ・Condition of Farmers' Agricultural Technology: Assess the present condition of farmers' agricultural technology, through hearing among stakeholders such as related agencies and farmers, and review of related documents. ・Condition of Facilities: Assess the present condition of facilities for farming and post harvesting, through hearing among stakeholders such as the related agency and farmers, and review of related documents.

	c) Assess Future Sensitivity to Climate Change Assess the future sensitivity to climate change based on the relationship between past crop damages and meteorological conditions, future climate condition, and present condition of agricultural technology and facilities, with consideration on future socio-economic change factors. ⇩ Step 2 4) Assess Adaptive Capacity to Climate Change a) Identification of Adaptive Capacity ・Condition of development and operation of irrigation and drainage facilities. ・Activity of Agricultural Extension Office and NGOs Assess the situation and capacity to support farmers and irrigated agriculture. The following shall be included. ➢ Budget and programs in related agricultural agencies ➢ Budget and programs in NGOs ・Existence and Ability of Research and Development Assess research and development for agriculture. ・Compensation for Crop and Facility Damage by Climate Disaster Assess the disaster restoration capacity and burden alleviation on farmers in the event of climate disaster: ➢ Available climate insurance and mutual aid system. ・Financial Scheme to Farmers Assess the ability to maintain livelihood and to purchase agricultural materials after disaster occurrence: ➢ Scheme and access to microcredit and rural finance. b) Clarify Exacerbating Factors for Climate Change Impacts ・Socio-economic Condition of Farmers Assess the adaptive capacity and its disparity in the target area through studying the socio-economic condition of farmers. The items for assessment are assumed as follows: ➢ Ethnic minority groups and resettlement areas, which are likely to suffer disparity and discrimination from other majorities. ➢ Crop yield, agricultural income and the share on livelihood, which affect the impact of crop failure on farmers ➢ Educational level, which is related to the adaptive capacity to climate change ➢ Health condition of farmers, which would alleviate or exacerbate the adverse effects of climate change on work conditions and labor force ➢ Subsidy from government, which might discourage the voluntary action of farmers. ⇩

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability →	High
Future sensitivity to climate change	Small	Large
Condition of development and operation of irrigation and drainage facilities	Existing/Good	None/Poor
Activity of agricultural extension office and NGOs	Sufficient	Poor
Existence and ability of research and development	Existing/Excellent	None/Poor
Compensation for crop and structural damage by climate disaster	Sufficient	Poor
Financial scheme to farmers	Good	Poor
Socio-economic condition of farmers	Good	Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of crop damage	Economic	・Gross farming earnings ・Gross farming earnings per house
		Quantitative	・Planted Area of each crop ・Cultivated Area of each crop ・Production of each crop ・Selling amount and price of each crop
Condition of development and operation of irrigation and drainage facilities	Reduction of damages on crops due to drought and flood	Quantitative	・Irrigated area ・Actual irrigated area ・Collection ratio of water charge ・Number of water association ・Production volume of major crops ・Land usage ratio ・Productivity of major crops
Activity of agricultural extension office and NGOs	Improvement of farmers' knowledge and technology on farm management	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for crop and structural damage by climate disaster	Improvement of restoration capacity and burden alleviation on farmers in the event of climate disaster	Qualitative	-

Financial scheme to farmers	Improvement of ability to maintain livelihood and to purchase agricultural materials after disaster occurrence	Qualitative	-
Socio-economic condition of farmers	Improvement of adaptive capacity	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Non-structural measures	Improvement of cultivation (review of cropping pattern, condition of farming guidance and dissemination of agricultural knowledge and technology)	Qualitative	-
	Improvement of cultivation (installation of greenhouse and precision agriculture, agricultural input)	Quantitative	-
	Condition of development and introduction of new crop varieties	Quantitative	-
	Strengthening post harvesting (condition of facility installation and operation)	Quantitative	-
	Condition of other agricultural support (farmers organization, financial scheme)	Qualitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures	1) Monitoring and Review Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items. 2) Flexibility to Climate Change Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined and confirmed with counterpart agencies. 3) Consideration to Maladaptation Check maladaptation caused by the project, and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology	Collect data from meteorological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on meteorological data in the target area.
	Socio-economic incidence	Collect higher level plans of food security and agriculture, development plans, and land use plan, all around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Historical data of agricultural yield	Collect records on cultivation by each irrigation block. If unavailable, estimate through hearing with stakeholders. Secular change shall be also collected.
	Condition of farmers' knowledge and technology on farm management	Study and review the condition through interviews with related agencies and farmers. It is desirable to conduct the study by village, or whichever is the lowest administrative unit.
	Condition of existing facility	Study the operating condition of each facility through field survey.
4) Assess Adaptive Capacity to Climate Change	Condition of development and operation of irrigation and drainage facilities	Study and review the condition through interviews with related agencies and farmers.
	Activity of agricultural extension office and NGOs	Study the budget and programs in related agricultural agencies and NGO for each area. Check the imbalance of situations among areas. It is desirable to study by village or whichever is the lowest administrative unit.
	Existence and ability of research and development	Study and review the research activity through interviews with related agencies, and based on related information collected.
	Existence and enrollment of climate insurance and mutual aid system	Study and review the insurance and mutual aid systems through interview with related agencies and based on related information collected.
	Financial scheme to farmers	Study and review the financial schemes through interview with related agencies and based on related information collected.
	Socio-economic condition of farmers	It is desirable to assess the disparities in area by village or whichever is the lowest administrative unit, through secondary data from the statistics agency, and surveys, if necessary.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Farmland Management Enhancement (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td>■ Necessity of Adaptation Options
Projects for farmland management enhancement will be implemented.
Climate change impacts, such as conventional farm crops becoming unsuitable to change in agricultural condition, change of cropping season, and exacerbation of quality deterioration after harvesting, are necessary to be considered.
■ Adaptation Options
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
■ Outcome of Adaptation Options
Farming practice will be maintained in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are development and introduction of new crop variety, improvement of cultivation and post harvesting, strengthening of farmers organization, etc., which could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future sensitivity to climate change</td><td rowspan="2">Reduction of crop damage</td><td>Economic</td><td>・Gross farming earnings
・Gross farming earnings per house</td></tr>
<tr><td>Quantitative</td><td>・Planted Area of each crop
・Cultivated Area of each crop
・Production of each crop
・Selling amount and price of each crop</td></tr>
</table>
[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="3">Non-structural measures</td><td>Improvement of cultivation (review of cropping pattern, condition of farming guidance and dissemination of agricultural knowledge and technology)</td><td>Qualitative</td><td>-</td></tr>
<tr><td>Improvement of cultivation (Installation of greenhouse and precision agriculture, agricultural input)</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Condition of development and introduction of new crop varieties</td><td>Quantitative</td><td>-</td></tr>
</table></td></tr>
</table>

	Strengthening post harvesting (condition of facility installation and operation)	Quantitative	-
	Condition of other agricultural support (farmers organization, financial scheme)	Qualitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined and confirmed with counterpart agencies.

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Climate Change and Agriculture[1]

This publication contains the basic policy of GTZ (recently reorganized as GIZ) for development assistance to developing countries in climate mitigation and adaptation in agriculture. However, there are no descriptions about practical procedure or guidelines for the study. A brief summary of this publication is as follows:

Adaptation responses can be categorized into two levels: autonomous adaptation and policy-driven adaptation. Autonomous adaptations are initiatives by the private actors, usually triggered by market or welfare changes induced by actual or anticipated climate change. Policy-driven adaptation is the result of a deliberate policy decision on the part of a public agency.

Table Adaptation responses and issues

Type of response	Autonomous	Policy-driven
Short-run	● Crop choice, crop area, planting date ● Risk-pooling insurance	● Improved forecasting ● Research for improved understanding of climate risk
Long-run	● Private investment (on-farm irrigation) ● Private crop research	● Large-scale public investment (water, storage, roads) ● Crop research
Issues	● Costly to poor ● Social safety nets ● Trade-offs with integration	● Uncertain returns on investment ● Costs

Source: GTZ. (2008), p23, Table 4.

Decisions about what adaptation measures to adopt are taken within the context of a wide society and political economy, thus end choices are shaped by public policy. Adaptation options and their supporting policies should be adopted by the appropriate level of government and implemented by institutions in direct contact with beneficiaries. Possible supporting policies to help promote adaptation measures are shown in the table below:

Table Adaptation options and supporting policies given climate change

	Adaptation Option	Supporting Policies
Short-term	Crop insurance for risk coverage	Improved access, risk management, revise pricing incentives, etc
	Crop/livestock diversification to increase productivity and protect against diseases	Availability of extension services, financial support, etc.
	Adjust timing of farm operations to reduce risks of crop damage	Extension services, pricing policies, etc
	Change cropping intensity	Improved extension services, pricing policy adjustments
	Livestock management to adjust to new climate conditions	Provision of extension services
	Changes in tillage practices	Extension services to support activities, pricing incentives
	Temporary mitigation for risk diversification to withstand climate shocks	Employment/training opportunities
	Food reserves and storage as temporary relief	
	Changing crop mix	Improving access and affordability, revising pricing, etc
	Modernization of farm operations	Promote adoption of technologies
	Permanent migration to diversify income opportunities	Education and training
	Defining land-use and tenure rights for investments	Legal reform and enforcement

Both short- and long-term	Development of crop and livestock technology adapted to climate change stress: drought and heat tolerance, etc.	Agricultural research (crop and livestock trait development), agricultural extension services
	Develop market efficiency	Invest in rural infrastructure, remove market barriers, property rights, etc
	Irrigation and water storage expansion	Investment by public and private sectors
	Efficient water use	Water pricing reforms, clearly defined property rights, etc
	Promoting international trade	Pricing and exchange rate policies
	Improving forecasting mechanisms	Information needs to be distributed across all sectors, etc
	Institutional strengthening and decision-making structures	Reform existing institutions on agriculture, etc

Source: Kurukulasuriya and Rosenthal (2003) (GTZ. (2008), p24, Table 5.)

In order to make a judicious selection of adaptation measures, multiple criteria from environmental, technical, social, and economic standpoints should be used. Further evaluation criteria need to be developed.

Three actions can be undertaken at national and international levels that would move adaptation forward, which are as follows:
・Promoting adaptation strategies and integration into development planning: Specific adaptation measures could be evaluated and selected within the context of a climate-sensitive strategy and set of policies.
・Ensuring Finance: Donors and investors shall assist in finance of developing country with recognition of adaptation as good investment.
・Promoting insurance: Insurance coverage against extreme weather events are little or not developed in the developing country, and provision of insurance shall be concerned.

Adaptation is imperative; however, adaptation becomes costlier and less effective as the magnitude of climate change increases. Hence mitigation of climate change remains essential.

2) Comprehensive Strategy for Global Warming[2]
This document discusses adaptation and mitigation as climate change measures in Japan and overseas. It covers not only farming, but also structural and non-structural measures on forestry, livestock, and fishery.

The contents of farming include recent climate damage especially by high temperature and its countermeasure policy on each major crop in Japan, as well as basic strategy for research and development.

The following summarizes of efforts on farming:

(1) Implementation of Global Warming Adaptation with Consideration of Climate Damage on Agriculture, Forestry and Fishery

"Report on Countermeasures for High Temperature Damage, 2006" has been prepared by gathering and organizing the situation of research institutes and condition of countermeasures for crop fields including paddy. In addition, "Report and Implementation Schedule on Adaptation Measures for Major Crops, 2007", which shows adaptation in near future and basic strategy, has been prepared with consideration of past efforts.

(In 2010, "Report on adaptive technology for high temperature, 2010" were published.)

(2) Technical Development for Global Warming Adaptation

・Research for assessment of climate change impacts:

It aims to develop prediction models for yield, natural resources, quality, disease and insect damage on agriculture, forestry and fishery, with comprehensive consideration of factors for global warming, and to assess the impacts.

・Technical development of adaptation measures:

It aims to disseminate the developed varieties tolerable and adaptable to high temperature and disease and pest damage, and farmland management technologies for agricultural fields. In addition, to develop new crop varieties and production stabilization technology based on research plan, which will be prepared with consideration of assessment on climate change impacts.

To investigate the relationship between physiological mechanism and hereditary factor of crops with climate change impacts, and to develop new varieties by utilizing production stabilization and genome information. Furthermore, to develop assessment system for crop change with comprehensive consideration of climate change impacts, crop demand and supply prospects, adaptation measure cost, etc.

3) Nogyo-ondanka Net[3]

The website was established in 2010 supported by the Ministry of Agriculture, Forestry and Fisheries, Japan. The website provides information exchange about climate change impacts to agriculture in Japan, and introduces the corresponding countermeasures.

Knowledge from experts on paddy, barley, soybean, vegetable, forestry, flowers, and livestock are presented. Also, the answers of experts on questions asked by guests are shown in the website.

This serves as a good tool in investigating the damages on agricultural fields due to climate change, and identifying the necessary countermeasures.

1 GTZ. (2008). Climate Change and Agriculture: Threats and Opportunities.

2 Ministry of Agriculture, Forestry and Fisheries, Japan. (2008). Nourinsuisan-sho Chikyu Ondanka Taisaku Sogo Senryaku (in Japanese)

3 Japan Agricultural Development and Extension Association. (2010): https://www.ondanka-net.jp/index.php

4. Forest Conservation / Afforestation Sub-sector

Guideline:

(1) Forest Conservation / Afforestation (BAU Development with Adaptation Options)
(2) Mangrove Reforestation (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change impacts assumed in the forest conservation / afforestation sub-sector include changes in elements such as CO_2 concentration, temperature, precipitation, or rainfall patterns that may affect vegetation growth. These elements may affect forestry productivity both positively and negatively. However, in many cases the phenomena as the results of interaction among these elements which may offset are unknown. Temperature rise may cause shifts in vegetation spatial distribution in the poleward direction or to a higher elevation. In addition to the abovementioned impacts, climate change may increase frequencies of forest fire and/or pest damages in an unprecedentedly extensive area. Furthermore, coastal and mangrove forests may be affected by sea level rise. Climate change adaptation measures in the forest conservation / afforestation sub-sector shall reduce forest vulnerability to climate change by strengthening forestry management, improving management facilities, and promoting systematic reforestation efforts, among others. It is also important to reduce human-induced impacts on forests, which helps lessen forests' vulnerability to climate change.
B. Vulnerability	1) Major Climate Change Impacts on the Forest Conservation / Afforestation Sub-sector <u>■ Increase in CO_2 Concentration</u> ・This may positively affect vegetation growth with fertilizing effects in general. <u>■ Temperature Rise</u> ・Vegetation may grow better as the growth period is extended. ・Spatial distribution of vegetation may shift in the poleward direction or to a higher elevation. ・Usable water volume may be reduced as evapotranspiration increases due to temperature rise. ・Frequency and severity of forest fires may be aggravated. ・New pest damages may emerge or frequency and severity may be aggravated. <u>■ Decrease in Precipitation, Change in Rainfall Patterns, Aggravated Drought Frequency and Severity and Extended Drought Period</u> ・Forest productivity may be decreased due to reduction in usable water volume. ・Forest component species may decrease, vegetation may be destroyed or potential resilience may be lowered due to reduction in usable water volume. ・Frequency and severity of forest fires may be aggravated. ・New pest damages may emerge or frequency and severity may be aggravated. <u>■ Increase in Precipitation and Rainfall Intensity</u> ・Increase in precipitation generally brings more usable water. However, most of the precipitation, if the rainfall pattern is intensified or changed along with the increase in precipitation, may run off, thus, adding little usable water volume. ・Soil erosion may be aggravated, decreasing forest floor stability. ・Forest accessibility may be worsened, which will make forestry maintenance and forest product transport difficult, resulting in increased maintenance costs of facility such as forest roads.

	<u>■ Aggravated Frequency and Severity of Extreme Event such as Cyclones</u> ・As a result of the extreme phenomena, trees may fall due to wind or destroyed in inundation, and forest floor may be washed away due to slope failure, etc. <u>■ Sea Level Rise</u> ・Brine inflow may destroy forests along the waterside if they are not resistant to saline water. ・Spatial distribution of coastal and mangrove forests may be changed. <u>■ Notes</u> Direct climate change impacts on forests have not been fully elucidated because interactions, synergies or offset among elements may bear unknown impacts or possibilities. Climate change may affect change in vegetation spatial distribution in the poleward direction, or to the higher elevation, aggravate frequency and severity of forest fires and pest damages. Moreover, it may change spatial distribution of coastal and mangrove forests due to sea level rise. 2) Other Factors that Influence the Forest Conservation/ Afforestation Sub-sector associated with Climate Change Impacts ・Progress of deforestation associated with farmland development ・Increase of unsustainable development of forest resources such as fuel woods or raw materials due to population growth 3) Adaptive Capacity to Climate Change ・Adaptive capacity to forest fire and pest damages is increased in an environment where forest management facilities including forest roads and fireproof belts are well maintained. ・Adaptive capacity is increased in an environment where residents organize forest management unions to collectively address pest control, fire prevention and other problems. ・Adaptive capacity is increased in a community where people acquire good technologies in forestry management to cope with future climate changes. ・In communities under good living and socio-economic conditions including residents' educational level, people are able to address forestry aggravating elements other than climate change, thus increasing their adaptive capacity. 4) Spatial Distribution of Vulnerability a) Climate Change ・If the project area extends in a wide area or is scattered in many locations, various local meteorological conditions should be taken into account. ・If the project area is located in a high elevation or at the border of different vegetation zones, different local meteorological conditions should be considered. b) Sensitivity in the Forest Conservation / Afforestation Sub-sector ・Sensitivity may be dependent on different local vegetation. c) Adaptive Capacity ・Adaptive capacity may be dependent on levels of income, education or acquired technology of residents.

C. Adaptation Measures	Major adaptation measures assumed in the Forest Conservation / Afforestation sub-sector are as follows; ■ Gene and Seedling Management ・Study responses to meteorological elements among forest component species. ・Breed varieties with higher resistance to stress caused by pests and climate change. ・Place seed and seedling production facilities at appropriate locations. ・Mix seed and seedling producers. ■ Forest Fire Countermeasures ・Convert to fire-resistant breeds; change harvest/ reforestation cycle; control burning. ・Establish management facilities including fireproof belts and forest roads. ・Intensify fire prevention management in forests in terms of economic or social values. ・Introduce forest fire monitoring and early warning system by means of satellites, etc. ・Expedite post-fire recovery. ■ Pest Control ・Reduce infection by clearing trees with low activity ・Clear and eliminate infected trees as early as possible. ・Establish pest control belts. ・Shorten forest rotation. ・Use pesticides and antibacterial agents. ・Introduce breeds with genetically acquired disease resistance. ■ Afforestation Management ・Clear unnecessary tree species to supply sufficient water to necessary species. ・Manage tree species/ density/ community structure. ・Plant seedlings adaptive to future meteorological conditions. ・Prepare supplementary seedlings to cope with lower survival rate due to drought or damages due to cyclones. ・Plant trees (mangroves) in consideration of vertical and horizontal changes as well as tidal current changes in intertidal zones. ■ Promotion of Forest Succession ・Select tree species with drought resistance. ・Promote introduction of tree species adaptive to future meteorological conditions. ・Control inadequate species. ■ Forestry Product Management ・Harvest forest products before being damaged by fire. ・Construct management roads. ■ Non-timber Forest Resource ・Prevent forestry discretization and secure continuity. ・Preserve forest by its seral stage.

D. Maladaptation	■ Maladaptation in Adaptation Measures ・Climate change may affect forests both positively and negatively depending on climatic elements. However, since such impacts are not fully elucidated, vulnerability may increase depending on the natures of climate change or forest responses. ■ Maladaptation Common to “Business as Usual” Project ・Afforestation and/or forestry management may increase forest vulnerability to climate change (temperature, precipitation, extreme phenomena) if such occurrence as well as associated forest fire and pest damages are not considered. ・Sea level rise due to climate change may destroy coastal forests, causing the area to be unsuitable.

Guideline: Forest Conservation/ Afforestation (BAU Development with Adaptation Options)

A. General	■ <u>Necessity of Adaptation Options</u> In regions where forests are devastated due to human activities such as grazing and fuel woods collection, efforts including reforestation, restoration, and forestry management should be intensified. Such efforts should also include construction of seedling production facilities, distribution of seedlings, and improvement of infrastructure for forestry activities. Changes in temperature and precipitation need to be considered as elements causing impacts on vegetation. Aggravated frequency and severity of forest fire and pest damages may be associated with future climate change. ■ <u>Adaptation Options</u> Appropriate measures will be implemented within the project with consideration of the climate change impacts. ■ <u>Outcome of Adaptation Options</u> Even under climate change impacts, forest areas can still be expanded and forest quality may be increased as expected.
B. Vulnerability Assessment (Risk and Change)	Review the national policies related to climate change, and discuss and confirm with the counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Based on results of the climate change analysis in the target year, further analyze the results in terms of climatic elements such as temperature, precipitation, and rainfall patters, drought frequency and past and/or surrounding meteorological conditions. This is intended to crosscheck them with forest survival conditions under the current climatic conditions. In addition, analysis should be performed in terms of forest fire and pest damages against past meteorological conditions in the target and surrounding areas. If conditions for survival and/or constraint factors cannot be set, or statistical analysis cannot be performed, investigate matters through interviews with stakeholders (organizations concerned, residents, research institutes, etc.).
C. Planning Adaptation Options	Investigate several adaptation options for various assumed impacts in consideration of impacts associated with future climate change. ■ Change in vegetation associated with climate change ・Strengthen forest resistance to climate changes by introducing tree species with higher resistance to climate change stresses and procuring seedlings from different production areas. ・Set up the specially important seedling production facilities at locations with less impacts due to climate change. ・Set up the supplementary planting rate under the assumption of that vegetation declines. ・By shortening the forest re-generation cycle, secure flexibility to deal with climate change. ■ Forest fire countermeasures ・Plant tree species which are fire resistant especially in the areas vulnerable to forest fire. ・Establish fire control facilities including control burning, fireproof belts, forest roads, and fire extinguishing tools. ・Organize fire prevention patrol/ fire fighting units. ・Establish early warning system using satellites and other means. ・Formulate the seedling production plan assuming early post-fire recovery.

■ Pest control

・Plant breeds that are pest resistant and establish pest control belts especially in the areas highly vulnerable to pest damages and/or the front line of pest invasion.

・Reduce infection by selective clearing of lower-activity trees and strengthen the forestry management system to clear and eliminate infected trees at the earliest opportunity.

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Sensitivity to climate change	Reduction of affected areas due to forest fire or pest damages	Qualitative	-
Adaptive capacity to climate change	Expansion of coverage area / production volume with trees which is resistant to climate change stress/ seedling	Quantitative	・ Tree coverage area ・ Seedling production volume
	Expansion of coverage area/ production volume with trees which is resistant to fire/ pests/ seedling	Quantitative	・ Tree coverage area ・ Seedling production volume

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Forest road length, progress in the introduction of fire extinguishing equipments	Quantitative	・ Constructed or improved forest road length
	Length of fireproof belts and pest control belts	Quantitative	-
Non-structural measures	Frequency of fire prevention patrol	Quantitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies.

Since climate change impacts on forests are not fully understood and explicit adaptation measures are hardly formulated, it is crucial to discuss potential impacts with stakeholders including the counterpart organization and share related information with them.

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Forest fire histories	Such data may not be maintained in many countries. Thus, study the forest fire summaries through interviews.
	Pest damage histories	Such data may not be maintained in many countries. Thus study the pest damage summaries through interviews.
	Threshold of pest distribution	If the threshold such as temperature or humidity is known for pest distribution, understand the threshold for potential pest damages. If the threshold is not clearly set or unknown, complement information on past pest damages through interviews with specialists.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

Guideline: Mangrove Reforestation (BAU Development with Adaptation Options)

A. General	■ <u>Necessity of Adaptation Options</u> Mangrove forests have been significantly deforested for fuel woods production, or paddy field and aquafarm development. In order to restore and conserve the mangrove forests, replanting, construction of seedling production facilities of mangroves, and assistance to sustainable fishery, agriculture and eco tourism for livelihood will be implemented. As future climate change impacts, changes in inundation areas due to sea level rise as well as in tidal current and water temperature should be considered. If sediment inflow from upstream greatly affects mangrove growth, sediment supply volumes need to be considered in association with changes in precipitation or rainfall patterns. ■ <u>Adaptation Options</u> Appropriate measures will be implemented within the project with consideration of the climate change impacts. ■ <u>Outcome of Adaptation Options</u> Even under climate change impacts, planted mangroves can take roots and grow as expected.
B. Vulnerability Assessment (Risk and Change)	Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, as well as the target year for adaptation measures. Based on the climate change analysis results in the target year, understand the tidal level, water temperature, and salinity as in the assumed target year. If flow conditions constrain mangrove forest survival, investigate changes in tidal current or velocity associated with the sea level rise both qualitatively and quantitatively. If sediment inflow affects mangrove forests, investigate changes in sediment supply volumes associated with changes in precipitation or rainfall patterns.
C. Planning Adaptation Options	In consideration of future climate change impacts, several adaptation options should be investigated for different assumed impacts. ■ Tidal Level, Water Temperature, Salinity ・Select locations and species to plant mangroves, and determine locations of nursery beds in consideration of changes in inundation frequency, water temperature rise, salinity change, and changes in tidal current and velocity. ・Formulate a monitoring plan and upgrade organizational capability to continuously monitor the tidal level, water temperature, and salinity so that reforestation areas are appropriately determined based on the monitoring results. ■ Sediment Inflow ・Select locations and species to plant mangroves in consideration of topographical changes due to sediment inflow. ・Take the watershed management measures (forest conservation, sediment control dams, river bed/ bank erosion control, etc.) to address the increased sediment inflow volumes.

D.
Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Sensitivity to climate change	Afforested mangrove will be preserved.	Quantitative	・Afforested area

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Maintenance of planted mangrove area	Quantitative	・Constructed or improved forest road length
Non-structural measures	Capacity building of the bureau responsible for reforestation	Qualitative	-

E.
Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies.

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

F.
Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate in the target area using the data from the analysis models and climate change scenarios adopted in the country.
	Inundation frequency, tidal current / velocity	Project the parameters based on future tidal level, topographical data and river regime.
	Survival conditions by tree type	If survival conditions are unknown, statistically project them based on the current growth environment for each tree type.

References and Key Different Features

1) Wise Adaptation to Climate Change[1]

This presents currently understood impacts, future impacts, vulnerability assessment, and adaptations in the field of foods, water environment/resources, natural ecosystem and health under assumed climate change adaptations to be taken in Japan. Forestry-relevant descriptions include forestry ecosystem, high mountain ecosystem, and coastal ecosystem (mangroves), among others.
Since this document focuses on Japan, there would be gaps in formulating projects to assist developing countries. The following is the comparison of the MoE document with this survey.

・Vulnerability assessment: In the MoE document, vulnerability of forest ecosystem is assessed based on species distribution projected in the spatial distribution project model. Methods to specify vulnerable areas where distribution probability is significantly decreased or to set the vulnerability indicator based on annual average evapotranspiration of cedars. However, these will not be useful for development assistance, and thus only general information is given here.

・Adaptation measures: In the MoE document, the focus is placed on ecosystem integrity. In this regard, adaptation measures include acceptance of natural changes or conversion of plantation into natural forest. Since maintenance and strengthening of forest production is one of the major objectives in development assistance, acceptance approaches are not employed as adaptation in this study.

2) IPCC AR4[2]

The description in "1) Major Impacts to the Forest Conservation/ Afforestation Sub-sector" in this survey is mainly derived from the Report of Working Group II of IPCC AR4. The following impacts on forests and forest products are also extracted here.

- "Terrestrial biological systems" and "1.3.6 Agriculture and forestry" in the "Assessment of observed changes and responses in natural and managed systems"
- "4.4.5 Forests and woodlands" in "Ecosystems, their properties, goods and services"
- "Chapter 5 Food, Fiber and Forest Products" and descriptions related to forests in Chapter 9 and the following

3) Adaptation to Climate Change in Forest Management[3]

This is the paper posted in a journal, compiling adaptations in forest sector systematically. Some adaptations described in this survey are based on this paper.

4) Adaptation of Forest Ecosystems and the Forest Sector to Climate Change[4]

The literature is prepared by FAO and Intercooperation in Switzerland for policy-makers and experts in focusing on climate change adaptations with emphasis on forest social groups. It covers wider topics such as climate change overview, vulnerability assessment, adaptation project, and financial measures.

・Vulnerability assessment method: Methods and steps for vulnerability assessment are not explicitly presented. As an example of vulnerability assessment, investigation steps taken in the Adaptation Policy Framework (APF) of UNDP are shown in the document. This is similar to the process in the "Mapping Climate Change Vulnerability and Impact Scenarios"[5] introduced in this survey.

・Targets of vulnerability assessment: Vulnerability assessment should include both direct (temperature, precipitation, drought, etc.) and indirect (livelihood maintenance associated with forestry impacts, food and other security) impacts. However, this survey does not formulate guideline for Adaptation Projects in the Forest Conservation/ Afforestation Sub-sector. Thus, vulnerability assessment in this survey is limited to direct impacts.

・Adaptation: This encompasses the forestry sector including relevant social systems, and adaptations are for wider fields including organization, economy/ treasury, forestry management, relevant social system and research and study. Since many of these fields are out of the scope of this survey, adaptations described in the reference document are not mentioned in this survey.

[1] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou (in Japanese), Chapter 4 Natural Ecosystem

[2] IPCC. (2007).AR4 WGII Report

[3] David L. Spittlehouse, Robert B. Stewart. (2003). Adaptation to Climate Change in Forest Management. BC Journal of Ecosystems and Management. Vol. 4. No.1

[4] FAO / Intercooperation (Swiss). (2005).Adaptation of Forest Ecosystems and the Forest Sector to Climate Change

[5] UNDP. (2010). Mapping Climate Change Vulnerability and Impact Scenarios – A Guidebook for Sub-National Planners

5. Ecosystem Integrity Sub-sector

Guideline:

(1) Wetland Conservation (Adaptation Project)
(2) Wetland Conservation (BAU Development with Adaptation Options)

General Concept

A. General Concept	Local ecosystem is sustained under local geographical and meteorological conditions, which may be affected by various climate change impacts such as precipitation and temperature change. However, the mechanism sustaining the ecosystem is very complex, and thus hardly adaptive to climate change or reducing sensitivity of ecosystem. On the other hand, human-induced factors such as land development or artificial disruption play a primary role in the deterioration of the ecosystem in many countries and regions. Ecosystem vulnerability to climate change may be reduced by improving and mitigating existing human-induced impacts. Thus, it is particularly important in the Ecosystem Integrity Sub-sector to reduce human-induced impacts that negatively affect the ecosystem. This will represent an effective adaptation measure against ecosystem deterioration even if the other threats or vulnerability to climate change remains. In addition, recovery from disasters such as cyclones can be an adaptation option.
B. Vulnerability	1) Major Climate Change Impacts on the Ecosystem Integrity Sub-sector <u>■ Desert</u> ・Aridification and temperature rise may affect flora and fauna in deserts in the winter-rainfall zone. ・Increase of CO2 concentration may increase vegetation productivity; however, the extent and impact remain uncertain. ・Net effect of interaction among the climate change impacts described above is very likely to be region-specific. <u>■ Grassland / Savanna</u> ・Increase of CO_2 concentration and temperature rise may impact quite differently on trees and C3 grass plants, and on C4 grass plants. This may cause drastic changes in the ecosystem structure. ・Disruption factors, particularly fire, may affect vegetation coverage, reducing vegetation volumes. However, from the regional perspective, such factors may increase tree coverage with fertilizing effects. ・Mammals' habitats will be shifted but limited by habitat fragmentation and human pressure, likely causing aggravated diversity in species. <u>■ Mediterranean Ecosystem</u> ・Even mild warming and/or drying may cause desertification due to expansion of surrounding semi-arid and arid areas. ・Habitats of species may shift due to warming and desertification. However, many indigenous species may acquire insufficient migration speed to reach their adequate habitat. ・Fire triggered by desertification and temperature rise may affect specific species and vegetation. <u>■ Tundra and the Arctic / Antarctic</u> ・Tundra may shift in the poleward direction due to warming. ・Vegetation in the polar desert may change to tundra vegetation. ・Species may move (intrude) from southern to northern areas.

	■ Mountain Region ・Warming may cause earlier onset of the snowmelt season, shorter snowing period, or shrinking of glacier areas, resulting in water shortage in downstream areas during summer growth season. ・Spatial distribution of ecosystem may shift to a higher elevation; however, mountain ridges limit the shifting of distribution areas, resulting in the shrinkage of spatial distribution. ■ Freshwater Wetland, Lakes, and Rivers ・Temperature rise may induce decrease in oxygen concentration in deep water layer, releasing phosphorus from deposits and increase thermal stability, consequently deteriorating freshwater quality. ・Slight change in rainfall patterns may affect various flora and fauna in wetlands at different levels of the life cycle. ・Changes in freshwater flow rate may cause changes in salinity, sediment load inflow and nutrient loads, affecting the coastal wetlands. ■ Ocean and Shallow Sea Area ・Decrease in pH associated with CO_2 absorption in the ocean may reduce carbonate ion concentration, and thus decrease saturation of coral reef, cold-water coral and aragonite. Alternatively this may affect unsaturated ecosystem (particularly cold water regions). ・Rise in sea water temperature and decrease in carbonate ions may bear synergetic effects. ・Warm-water coral reef may be affected by sea level rise or decrease in aragonite saturation. ・Sea water temperature rise may induce frequent coral reef bleaching. ・Decreased upwelling of deep layer water, and stratification may decrease nutrients supply to photobathic areas, thus decreasing productivity. ・In coastal and shelf sea areas, stratification may cause oxygen deficiency, thus inducing decrease in habitats, biodiversity and spatial distribution of species. ・Low oxygen phenomena may further deteriorate due to water quality deterioration associated with changes in precipitation and/or nutrients supply from lands. ■ Impacts across Multiple Biomes ・Extensive vegetation change may occur in tundra due to shift of boreal woody vegetation among others. However, vegetation changes in zones in low- to mid-latitude or tropical zones will hold great uncertainties. 2) Other Factors that Influence the Ecosystem Integrity Sub-sector Associated with Climate Change Impacts ■ Desert ・Abuse of ecosystem and land quality may further deteriorate due to overall infrastructure insufficiency and shortage in investment. ■ Grassland and Savanna ・Human pressure may increase fragmentation and limitation of wild animal habitats. ■ Mediterranean Ecosystem ・Land use and human pressure may increase to limit the adaptive capability of moving species and habitats are fragmented.

	■ Mountain Region ・Land use may change due to expanded human utilization associated with warming. Excessive grazing in addition to land use change may cause instability of vegetation and soil erosion. 3) Adaptive Capacity to Climate Change ・As a habitat be in a component of the ecosystem which is greater in size and interconnected, capability to recover from temporary disruption and adaptive capability tend to be higher. ・In a community with better socio-economic conditions including living status and educational level, residents are ready to cope with ecosystem deterioration factors other than climate change and are highly adaptive to changes. 4) Spatial Distribution of Vulnerability a) Climate Change ・If the project area extends in a wider area or disperses in many regions, different regional meteorological conditions should be taken into account. b)Sensitivity in the Ecosystem Integrity Sub-sector ・If multiple ecosystem sub-classes (vegetation, etc.) are included in the target ecosystem, different sensitivity by sub-class should be considered. c) Adaptive capacity ・Depending on the setting of conservation zones and/or management statuses, human-induced impacts may affect the ecosystem in various ways. ・Depending on residents' income and educational levels, human-induced impacts may affect the ecosystem in various ways.
C. Adaptation Measures	Major adaptation measures in the Ecosystem Integrity Sub-sector are as follows. ■ Direct Adaptation Measures ・Improve infrastructure to counter floods (levees, breakwater, embankment, etc.) ・Secure water (water use right) to maintain water level and volume during drought period ・Establish corridors (green corridor) and backland to extend wildlife mobility and reduce extinction risks ・Breed and migrate vulnerable species under protection ・Restore habitats exposed to serious threats ・Create new habitats in regions with less possibility to naturally form settlements ■ Indirect Adaptation Measures ・Reduce and control stresses to species and ecosystem triggered by "factors other than climate change" including habitat fragmentation/ destruction, overexploitation, eutrophication, desertification, and acidification ・Reduce pressures to natural ecosystem by improving agricultural productivity ・Promote adaptive management under an enhanced study, monitoring and assessment system.

D. Maladaptation	■ Maladaptation in Adaptation Measures ・Migration or movement of wildlife individuals may cause unintended impacts on the ecosystem. ・Infrastructure for conservation of coastal area ecosystem (embankment, levees, etc.) may adversely affect ecosystem process. ■ Maladaptation Common to “Business as Usual” Project ・Infrastructure for conservation of coastal area ecosystem may adversely affect the ecosystem process. ・Development for eco-tourism may increase human-induced disruption.

Guideline: Wetland Conservation (Adaptation Project)

A. General	<u>■ Necessity of Adaptation</u> Ecosystem in lakes and wetlands may be affected by changes in precipitation, rainfall patterns and others resulted in future climate change, which might cause water quality deterioration and physical water area shrinkage associated with change in freshwater inflow, increase in sediment and nutrients inflow, increased secondary products and stratification due to temperature rise. Ecosystem in coastal wetlands may be further affected by sea level rise and associated changes in water depth, tidal level, salinity and tidal current conditions. <u>■ Adaptation Measures</u> In order to reduce nutrients inflow, introduce waste water treatment facilities, plant trees and manage farmlands in the whole catchment area. Also in order to reduce loads such as sediment inflow in the catchment area, plant trees, construct sediment control facilities such as hillside works and sediment dams, and control soil erosion in farmlands. In addition to the above efforts, establish the conservation zones as well as buffer zones to alleviate stresses to ecosystem. <u>■ Outcome of Adaptation Measures</u> Climate change impacts to ecosystem will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks ・Collect annual data in the target lakes and wetlands from the competent authorities for as much as possible. Required information includes physical data of the target lake or wetland such as topography, water level, water quality, and water temperature; past meteorological and hydrological data in the catchment area; ecosystem sub-classes; spatial distribution of vegetation; the list of species inhibiting in the target area; habitats of important and noteworthy species; and historical changes in the ecosystem. ・For coastal wetlands, study tidal level, tidal current and salinity. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, review climate change policy of the country, and confirm the climate change scenarios, analysis models, and the targeted year for adaptation measures suitable in such country. Based on the outputs of the climate change analysis for the target year, figure out precipitation and rainfall patterns in the catchment area. For coastal wetlands, study sea level rise. b) Study Other Factors related to Socio-economic Changes Review the development plans and related documents for the target country and catchment area in order to investigate factors that might be attributable for the changes in inflow of freshwater, nutrients, and sediments associated with changes in land use, population, urbanization, industrialization, water use, and others. c) Catchment Load Analysis Based on a) and b) above, analyze loads (freshwater volume, nutrients, and sediments) in the catchment area. 3) Assess Future Sensitivity to Climate Change a) Past and Current Impacts

Based on documents, interviews with residents and field studies, study past and current changes in the ecosystem, important and noteworthy species, and habitats, and temporary or permanent changes in external factors.

b) Ecosystem Sensitivity

Based on general survival conditions, interviews with research institutes and field surveys, collect information on physical conditions (water temperature/ quality/ depth, tidal level, salinity, tidal current, interactions among species, etc.) required for survival.

c) Study of Control Facilities

Check facilities controlling nutrients and sediment inflows such as waste water treatment facilities, dams, and sediment control facilities, and understand their conditions.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Adaptive capacity relevant to watershed management

Obtain the following information to understand activities and capacity relevant to watershed management;

・Past and current watershed management
・Organizations, budgets and activities relevant to watershed management
・Monitoring capacity of indicators for water quality, sediment inflow, etc.

b) Adaptive capacity relevant to ecosystem management

Obtain the following information to understand activities relevant to ecosystem management;

・Restoration and maintenance of ecosystem, and conservation activities
・Statuses of conservation zones and their management
・Research on ecosystem

c) Clarify Exacerbating Factors for Climate Change Impacts

・Confirm factors that might directly affect ecosystem. Such factors include fishery, land filling and reclamation of lakes and wetlands, construction of coastal facilities such as breakwater.

Step 3

5) Assess Vulnerability

Based on factors in Steps 1 and 2, compute physical and chemical conditions in the target catchment area including future topography, water temperature, water quality, water depth, salinity, tidal current, and others. Such analysis should preferably be based on physical simulation. However, in case that simulation could not be performed due to insufficient information or resources required in the analysis, or that future uncertainties may be significantly great, assume future conditions based on balance analysis, statistical analysis, or opinions of experts.

Based on investigation results, ecosystem integrity conditions, and survival conditions of important and noteworthy species, assess vulnerability of each ecosystem location, species, important species, and habitat.

<table>
<tr><td>C.
Project Evaluation of Adaptation Measures</td><td>

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Sensitivity to future climate change	Area expansion per habitat unit	Quantitative	-
	Habitat expansion for important or noteworthy species	Quantitative	-
Risks associated with climate change	Decrease in load inflow volume (nutrients, sediments)	Quantitative	-
Ecosystem conservation activities	Expansion of conservation zones	Quantitative	-
	Expansion of buffer zones	Quantitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Risks associated with climate change	Water quality, sediment load volume	Quantitative	-
	Installation of watershed management facility	Quantitative	-
Ecosystem conservation activities	Changes in the awareness of stakeholders related to ecosystem	Qualitative	-

</td></tr>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasure for unexpected responses of ecosystem (research promotion)
・Countermeasure for extreme phenomena such as flood and cyclones that will directly affect ecosystem (construction of sediment control facilities, decentration of habitats)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

</td></tr>
</table>

E. Required Data			
		Data	Remarks
	B. Vulnerability Assessment		
	1) Assess Past and Present Climate Trends and Risks	Past meteorological, hydrological, and water quality data	Collect meteorological and hydrological records on the target lake/wetland and the catchment area. For coastal wetlands, collect data on tidal level/ current and salinity.
		Ecosystem statuses	Study the current information of the target ecosystem based on documents, interviews with stakeholders and field studies.
	2) Risks and changes associate with climate change	Future climate	Use data from the climate change scenarios and analysis models employed in the target country to project future climate based on past meteorological and hydrological observation data in the target region.
		Catchment loads	Assess the catchment load volume based on land use in the catchment area, past water quality data, general or regional unit of nutrients or sediment yield volume.
	3) Evaluation of sensitivity to climate change	Past and current impacts to ecosystem	Preferably understand impacts associated with physical conditions for each habitat unit or species.
		Statuses of existing facilities	Perform field survey to understand operational statuses of existing facilities.
	4) Evaluation of adaptive capacity to climate change	Adaptive capacity relevant to watershed management	Study the organizations of authorities that are competent on watershed management (land use, water management, disaster prevention, agriculture, forestry, etc.), coordinating agencies, and activities related to both hardware and software approaches.
		Adaptive capacity relevant to ecosystem management	Study the organizations of authorities that are competent on ecosystem management (environment, forestry, costal management, etc.), coordinating agencies, and activities related to both hardware and software approaches, and statuses of research activities.
	Other		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Wetland Conservation (BAU Development with Adaptation Options)

A. General	■ Necessity of Adaptation Options The target wetland faces impacts to ecosystem due to water quality deterioration, and shrinkage in wetland area, which resulted from land development in the catchment area, nutrients inflow due to urbanization, increase in sediment inflow, unsustainable fishery, and coastal development. In order to conserve wetland ecosystem, requirements include reduction of inflowing load volume by proper management of the catchment area, introduction of sustainable use, and protection of important zones. Among future climate change impacts, change in precipitation, increase in inflowing load volume due to changed rainfall patterns, and water quality deterioration due to temperature rise need to be considered. For coastal wetlands, changes in water depth, tidal level, and salinity associated with sea level rise, and physical damages due to increased disasters such as cyclones should also be considered. ■ Adaptation Options Appropriate measures will be implemented within the project with consideration of the climate change impacts. ■ Outcome of Adaptation Options Even under climate change impacts, wetlands can still be conserved as expected.
B. Vulnerability Assessment (Risk and Change)	Review national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, as well as the targeted year for adaptation measures. Obtain the results from climate change analysis in the target year, and precipitation and rainfall patterns in the catchment area to compute inflow volume of nutrients, sediment loads, and freshwater from the catchment area. In addition, based on said results including temperature and radiant heat budget from climate change analysis, compute the future topography, water quality, and water temperature among others in the target wetland. For coastal wetlands, water depth, tidal level, and salinity should also be projected in relation to sea level rise.
C. Planning Adaptation Options	In consideration of future climate change impacts, multiple adaptation options should be investigated for each assumed impact. The assumed options are as follows; ■ Watershed Management ・Afforestation, strengthen nutrients reduction measures such as farmland management, introduction of waste water treatment facilities. ・Strengthen sediment load control measures such as afforestation, construction of sediment control facilities, hillside works, sediment dams, as well as soil erosion control in farmlands. ■ Ecosystem Conservation ・Establish conservation zones and buffer zones. ・Restore and remediate the ecosystem. ・Promote ecosystem research activities.

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Sensitivity to future climate change	Area expansion of each ecosystem sub-class	Quantitative	-
	Habitat expansion of important or noteworthy species	Quantitative	-
Risks associated with climate change	Reduction of sediment and nitrogen load from catchment	Quantitative	-
Ecosystem conservation activities	Expansion of conservation zones	Quantitative	-
	Expansion of buffer zones	Quantitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Risks associated with climate change	Water quality, sediment load volume	Quantitative	-
	Installation of watershed management facility	Quantitative	-
Ecosystem conservation activities	Changes in the awareness of stakeholders related to ecosystem	Qualitative	-

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies.

Since climate change impacts on ecosystem are not fully elucidated and explicit adaptation measures are hardly formulated, it is crucial to discuss potential impacts with stakeholders including the counterpart organization and share information with them.

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
Risks and changes associated with climate change	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
Other		
	Plans and documents relevant to adaptation measures	Investigate adaptation measures in reference to study reports and documents if available for the target and surrounding regions in relation to climate change adaptation.

References and Key Different Features

1) Wise Adaptation to Climate Change[1]

This presents currently understood impacts, future impacts, vulnerability assessment, and adaptations in the field of foods, water environment / resources, natural ecosystem and health under assumed climate change adaptations to be taken in Japan. Forestry-relevant descriptions include forestry ecosystem, high mountain ecosystem, and coastal ecosystem (mangroves) among others.
Since this document focuses on Japan, there would be gaps in formulating projects to assist developing countries. The following is the comparison of the MoE document with this survey.

・ Vulnerability assessment: MoE introduces four approaches below. Approaches 1 and 3 may be infeasible aids for developing countries in terms of project periods, technical aspects and accumulated data resources. Thus, they are not employed in this survey. Approach 4 assumes modeling of ecosystem and biological groups, requiring vast knowledge and advanced modeling technique. This study incorporates methods handling physical phenomena through lower trophic level ecosystem model. If this approach is not applicable, statistical approaches based on the current ecosystem survival conditions which is quite similar to Approach 2, may be feasible.

1. Assessment through long-term monitoring
2. Assessment based on the wide-area study along latitude and elevation
3. Global warming experiment
4. Simulation model based on physiological and ecological assumptions

・Adaptation measures: MoE describes anthropogenic biological relocation; however, this requires further consideration. Moreover, MoE fundamentally recommends elimination of human-induced factors that promote impacts from global warming. This study takes the same position as that of MoE.

2) IPCC AR4[2]

The description in “1) Major Impacts to the Ecosystem Integrity Sub-sector” in this survey is mainly derived from the impacts for each ecosystem sub-class in “Ecosystems, their Properties, Goods and Services”, in the Report of Working Group II of IPCC AR4.

3) Climate Change and Wetlands: Impacts, Adaptation, and Mitigation[3]

This is one of the resolutions of the said conference, which mentions that wetlands play pivotal roles in the adaptation and mitigation of climate change as well as ongoing climate change impacts on many wetlands in the world.
As wetland adaptation measures, it requires members to “manage wetlands in a way to enhance recovery capacity against climate change and abnormal meteorology, and to reduce flood and drought risks to expedite wetland and catchment protection and restoration”.
This study does not refer to this survey directly.

4) Connecting Biodiversity and Climate Change –Mitigation and Adaptation-[4]

The second meeting report prepared by an ad-hoc expert group on biodiversity and climate change. This aims at providing scientific and technological advices and evaluation to incorporate biodiversity integrity and sustainable utilization in climate change mitigation and adaptation measures. This study does not reference these descriptions directly; however, the following descriptions may provide insights on assisted relocation and migration or ex-situ conservation of species.

・Providing beneficial conditions for natural adaptation of species and ecosystem

The most fundamental biodiversity conservation strategy will continue to be promoting the conservation of intact and functioning ecosystems wherever possible.

・Adapting restoration practices to respond to climate change

Ecosystem restoration involves activities that transform a degraded ecosystem into an ecosystem that is more natural and better condition able to provide ecosystem services.

Ecosystem restoration strategies will need to consider a wider set of issues to address the additional stress from climate change in the future.

・Assisted relocation of species affected by climate change

In case where there are existing barriers to migration such as landscape fragmentation, or limits to dispersal capacity, assisted relocation, or migration, of species may be the only approach to ensure their persistence.

Although in some instance they may be the only viable option, there are limitations, risks, uncertainties, and often high costs associated with assisted relocation techniques.

・Ex-situ conservation

Given the links between climate change and extinction risks, it may be desirable to store species or genotypes that are likely unable to survive under new conditions.

The practice of conservation includes a long history of maintaining species and genetic stock in zoos, aquaria and gene banks.

Costs and currently available space are key limitations to captive breeding of threatened animal species, although the ex-situ conservation of plants is relatively less expensive.

5) Climate Change, and Adaptation – Nature-Based Solutions from the World Bank Portfolio[5]

This is a case study on biodiversity and climate change (mitigation and adaptation) prepared by the World Bank. Adaptations here mainly focus on roles of biodiversity for adaptation measures rather than adaptations to protect biodiversity. Descriptions of this document are not referenced in this study.

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[1] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou (in Japanese), Chapter 4 Natural Ecosystem

[2] IPCC. (2007).AR4 WGII Report

[3] The Ramsar Convention on Wetland. (2002). Climate Change and Wetlands: Impacts, Adaptation, and Mitigation (Resolution VIII.3)

[4] Secretariat of Convention of Biological Diversity. (2009). Connecting Biodiversity and Climate Change –Mitigation and Adaptation-. CBD Technical Series No.41

[5] IBRD / WB. (2008). Climate Change, and Adaptation – Nature-Based Solutions from the World Bank Portfolio

6. Flood Control Sub-sector

Guideline:

(1) Flood Control (Adaptation Project)
(2) Flood Control (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	The flood control sub-sector would be influenced by climate change. The intensity and occurrence of cyclone will be exacerbated and consequently, flood will intensify and increase. Sea level rise will result to capacity reduction of drainage systems thus prolonging inundation on coastal areas. Application of appropriate measures against flood damage is necessary to reduce flood risk due to climate change. Measures include structural infrastructure means such as development of facilities, non-structural means include evacuation drills, and cross-sectoral programs such as community development. The flood control sub-sector will contribute to reduction of flood damage induced by climate change, through structural and non-structural measures.
B. Vulnerability	1) Major Climate Change Impacts on Flood Control Sub-sector <u>■ Temperature Rise</u> ・Glacier melting will increase the base flow of river, and raise risk of flood. ・Outbreaks of glacial lakes by temperature rise would bring extensive damage in downstream areas. <u>■ Increase/ Intensification of Precipitation and Extreme Events such as Cyclones</u> ・The base flow of river will increase, then flood risk is heightened. ・Flood discharge will increase, which would bring damage even in protected areas by overflowing and destroying river bank. ・There will be some concerns on damage and collapse of dam by overtopping due to increase of inflow to reservoir. ・There will be flash floods, which can cause extensive damage. ・Flood control function of facility will be curtailed by increased sedimentation in reservoir and river channels, induced by increase of soil erosion. <u>■ Sea Level Rise</u> ・The reduction of drainage capacity due to sea level rise will expand inundation area and prolong the inundation duration. 2) Other Factors that Influence Flood Control Sub-sector Associated with Climate Change Impacts ・Population growth, economic development, and intensification of land use lead to development and settlement in flood prone area. ・Deforestation in the river upstream area will change the runoff characteristics of the river. ・Urbanization reduces rainwater infiltration into the ground. ・Increasing opposition against construction of dams leads to suspension of dam development and removal of the existing dams. 3) Adaptive Capacity to Climate Change ・Implementing non-structural measures such as operation of flood forecasting and warning system, preparation of hazard maps, and development of evacuation and precaution, improves adaptive capacity of related government agencies and communities. ・Development of legal systems such as development regulation for the flood prone areas, development regulation of upstream forest to retain water and farmlands to store flooded water, improve adaptive capacity.

	・If adequate public information is implemented, and inhabitants are educated and responsive on disaster and risk management issues, they would implement appropriate precautionary measures and actions in times of disaster, hence, improving their adaptive capacity. ・If the budget and programs for disaster recovery are well in place, disaster response capability of regulatory agencies is high. ・If research institute related to flood control exists and its system is well-organized, the adaptive capacity for climate change is high. ・The existence and enrollment status of insurance and mutual aid systems for flood damage would affect disaster recovery capability. 4) Spatial Distribution of Vulnerability a) Climate Change ・For a watershed branch that can have glacier or snow melt, spatial distribution shall be studied. ・Influence of backwater due to sea level rise shall be studied at downstream or estuarine areas. b) Sensitivity in Flood Control Sub-sector ・Sensitivity varies with installation condition, design conditions, development level, and maintenance level of flood control facilities such as dams, and river dikes. ・Occurrence of river flooding is affected not only by river discharge, but also its cross section, river bed gradient, roughness coefficient, and backwater effect at that point. ・Intrusion of flood flow into the protected areas is influenced by topography. c) Adaptive Capacity ・Each branch watershed differs in runoff characteristics, sedimentation and water retention conditions, and so on, depending on its land use, development regulations, and condition of flood control basin. Hence, adaptive capacity also varies in each branch watershed. ・Disaster resilience capacities vary with the policies of different regulatory agencies. ・Adaptive capacity depends on coping capability and current state of affairs of related local government agencies and communities.
C. Adaptation Measures	Major Adaptation Measures in the Flood Control Sub-sector ■ Development/Improvement of Flood Control Facility ・River improvement (excavation of river channel, levee setting back and embankment, discharge channels and cut-off channels, floodgate, inland water drainage, etc.) ・Control of runoff into river, focusing on rivers (dam, flood control basin, etc.) ・Control of runoff into river, focusing on basins (storage and infiltration facility, etc.) ・Control of flooding flow (secondary levee, open levee, ring levee, flood barrier forest, etc.) ■ Evacuation and Guidance on Evacuation Measures ・Flood forecast, equipment for forecasting and warning systems ・Preparation of hazard maps ・Community organization and training on safety, evacuation and its guidance

	■ Cross-sectoral Measures ・Urban and watershed conservation plans ・Securing facilities and roads for evacuation. ・Elevating building floors, installing electrical and mechanical equipment at higher places
D. Maladaptation	■ Maladaptation in Adaptation Measures ・The areas protected by river dikes seem to be safe. If more inhabitants are convinced that such areas are safe and decide to resettle on dike-protected lands, risk of damage to persons and/or property due to dike failure would increase. ・The awareness of inhabitants on disaster prevention, might be reduced due to the development of flood control facilities, and their responsiveness to possible future changes would weaken. ■ Maladaptation Common to “Business as Usual” Project ・Future change of river discharge, river and sea water level would create shortage of facility capacity, which consequently might cause flood damage.

Guideline: Flood Control (Adaptation Project)

A. General	■ <u>Necessity of Adaptation</u> The target river had been developed with flood control facilities. However, climate change would change precipitation patterns, increase extreme events, and cause backwater effect by sea level rise. Hence, flood frequency will increase and intensify in the target river basin. ■ <u>Adaptation Measures</u> The flood control capacity in the target area shall be strengthened by structural measures such as development of flood control facilities, and non-structural measures such as evacuation. ■ <u>Outcome of Adaptation Measures</u> Flood damage increased by climate change will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological and hydrological records in the target river basin, from meteorological weather stations, hydrological observation stations, and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate hydrological aspects for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for land use, such as population change and industrial development, through review of watershed conservation plan, development plan, and land use regulations. Water retention function of the river basin shall be studied in parallel. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study the damage of past flood and heavy rains through hearing among stakeholders such as related agencies and inhabitants, and through field survey in tracing past flood, and then identify flood vulnerable areas. b) Study Present Condition of Facilities and Measures ・Condition of Facilities: Assess the present condition of facilities based on the design capacity and maintenance condition, through field survey and review of the reports and drawings for facilities in the target river basin. ・Operating / Functioning Conditions of Facilities: Assess the operation conditions of flood gate and other river structures, through investigation of operation and management records of the facilities, as well as through interviews with stakeholders.

c) Assess Future Sensitivity to Climate Change

Assess future sensitivity to flood damage based on the relationship between past flood damage and meteorological conditions, future climate condition, and condition of facilities, with consideration on future socio-economical change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Risk on Priority Protection Area (Topography and Flood Control Facilities)

Identify the priority areas to be protected such as densely populated urban areas and important facilities, and study the condition of flood control.

- Topography of priority areas, and flood control facilities, which are related to the capability against flood.

・Community Based Disaster Management and Crisis Management

Assess responsiveness against flood occurrence:

- Situations of non-structural measures such as hazard maps, flood forecasting and warning systems, and evacuation drills, which are related to the responsiveness of the local government and inhabitants.
- Maintenance conditions of roads and shelters, which can facilitate evacuation during disaster.

・Disaster Resilience Capacity of Regulatory Agency

Assess budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development

Assess research and development for flood control.

・Compensation for Flood Damage

Assess the capability to recover damages caused by floods:

- Available insurance or mutual aid system for flood disaster

b) Clarify Exacerbating Factors for Climate Change Impacts

・Land Use and Land Use Regulations

Clarify the land use and related regulatory policies which affect flood damage.

- Land development at flood prone area, which is related to risk of damage from floods.
- Distribution of forest land, which is related to rainwater infiltration and storage.
- Land-use change of farmlands, flood control basins, etc., which is related to the retarding function of the river basin.
- Management of slopes in the upstream areas, with its mismanagement leading to flash floods, due maybe to underdevelopment of retaining and slope protection structures, and vandalism of observation and warning equipment.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low	← Vulnerability →	High
Future sensitivity to climate change	Small		Large
Risk of priority protection area	Low		High
Community based disaster management and crisis management	Excellent		Poor
Disaster resilience capacity of regulatory agency	Excellent		Poor
Existence and ability of research and development	Exist/ Excellent		None/Poor
Compensation for flood damage	Sufficient		Poor
Land use and land use regulation	Planned		Unplanned

C.
Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of flood damage	Economic	・Amount of damage
		Quantitative	・Flooded area ・Flooded houses ・Victim ・Maximum water depth ・Inundation duration
Risk of priority protection area	Reduction of flood damage	Economic	・Amount of damage
		Quantitative	・Flooded area ・Flooded houses ・Victim ・Maximum water depth ・Inundation duration
Community- based disaster management and crisis management	Improvement of responsive ability on flood disaster	Qualitative	-
Disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for flood damage	Improvement of restoration capability after disaster occurrence	Qualitative	-
Land use and land use regulation	Reduction of damage in flood prone area	Economic	・Amount of damage
		Quantitative	・Flooded houses ・Victim

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period in the whole river basin or the target area	Quantitative	・Total reservoir capacity ・Water level ・Flood level ・Discharge ・Maximum flood ・Maximum high water level ・Use frequency of facility ・Flood controllable capacity
	Improvement of target return period in priority protection area	Quantitative	・Flood controllable capacity
Non-structural measures	Quantity and quality of land area for storage, infiltration and retarding	Quantitative Qualitative	・Afforestation area
Others	Changes in the number of inhabitants and economical activities in the whole river basin, priority protection area, and flood prone area	Quantitative	-
	Changes in the awareness of stakeholders on flood disaster	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which is not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

・Countermeasures for flood damage to facilities (room for expansion of flood control capacity)

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect data from meteorological and hydrological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Socio-economic incidence	Collect watershed conservation plans, development plans, and land use regulations, related to flood control, in and around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Past flood damage	Collect and identify the damage condition of each area by flood event. Secular change shall be also collected.
	Design capacity of existing facility	Study the design capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.
	Operation and maintenance record of flood control facilities	Collect detailed operation and maintenance record to study the situation during flood disaster occurrence.
4) Assess Adaptive Capacity to Climate Change	Risk of priority protection area	Study the vulnerability of priority protection area to flood disaster based on topographical conditions; and study the design capacity and condition of sediment-related disaster prevention facilities.
	State of non-structural measures	Study and review the current state of non-structural measures through interviews with related agencies, and based on related information collected.
	Conditions of evacuation road and shelters	Study and review the condition through interview with related agencies, and based on related information collected.
	Disaster resilience capacity of regulatory agency	Study and review the budget and programs through interviews with related agencies, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
	Existence and enrollment of damage insurance and mutual aid system for flood disaster	Study and review the status through interview with related agencies and based on related information collected.
	Land use and land use regulation	Study present status of land use including differences in land use regulations, and investigate actual condition by site reconnaissance, by using land use maps and satellite images. Study land use regulation by reviewing related information and conducting interviews with related agencies.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Flood Control (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
It is necessary to increase flood control capacity of the target river, in association with economic growth and land development.
Potential risks of flood disasters in larger areas, or in greater magnitudes, are likely to occur in the target river basin and areas. The climate change impacts are expected to increase the amount of precipitation, change rainfall patterns, increase frequency and scale of extreme events, and increase backwater effects due to sea level rise.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the increased flood damage associated with climate change.
<u>■ Outcome of Adaptation Options</u>
The expected damages from the flood disaster will be reduced in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project hydrological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as developing or improving flood control facilities, and non-structural measures such as evacuation drills, which could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future sensitivity to climate change</td><td rowspan="2">Reduction of flood damage</td><td>Economic</td><td>・Amount of damage</td></tr>
<tr><td>Quantitative</td><td>・Flooded area
・Flooded houses
・Victim
・Maximum water depth
・Inundation duration</td></tr>
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・Flooded houses
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・Maximum water depth
・Inundation duration</td></tr>
</table></td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period in the whole river basin or the target area	Quantitative	・Total reservoir capacity ・Water level ・Flood level ・Discharge ・Maximum flood ・Maximum high water level ・Use frequency of facility ・Flood controllable capacity
	Improvement of target return period in priority protection area	Quantitative	・Flood controllable capacity
Non-structural measures	Quantity and quality of land area for storage, infiltration and retarding	Quantitative Qualitative	・Afforestation area
Others	Changes in the number of inhabitants and economical activities in the whole river basin, priority protection area, and flood prone area	Quantitative	
	Changes in the awareness of stakeholders on flood disaster	Qualitative	

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which is not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

・Countermeasures for flood damage to facilities (room for expansion of flood control capacity)

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate conditions	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Handbook on Climate Change Adaptation in the Water Sector[1]

JICA's approach of development assistance to developing countries with regards to climate change adaptation for water sector (mainly focused on flood control, but also includes water resources, water environments, sediment, and coastal protection) is shown in this handbook.

This handbook (HB) is the main reference for this survey of the flood control sub-sector, and the policies and methods are basically the same with each other in this regard. However, there are some differences between this survey and HB. The differences are as follows:

・The target of the HB is mainly a ,master plan; on the other hand, this survey targets the feasibility study directly leading to loan assistance. The HB gives importance on the flood damage reduction by regional/urban planning and land use control as an adaptation measure in the flood control sub-sector.

・OECD-DAC defined climate change adaptation-related aid as activities that aim "to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience". In this regard, vulnerability should be examined, however the definition and assessment procedure of vulnerability are included but not clarified in the HB. This survey clearly specifies the vulnerability assessment and its study procedure.

・The HB defines the target year as 2040-50 in consideration of the availability of calculation results of GCMs used for IPCC AR4. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that IPCC AR5 will be published in 2013, and much of the countries have already involved climate change in their policies.

・The HB recommends the downscaling of AGCM20 results as a general rule. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that AGCM20 has been proved unsuitable to every region of the world through researches and studies, and much of countries have established their own climate change policy using their own selected models which suit to their countries.

Below is a brief summary of the HB.

Conventional planning based on the premise of stationarity which states that past precipitation pattern will not change over time has become invalid due to climate change. The project formulation approach will be fundamentally different from the conventional one in the following aspects:

・It will deal with a changing climate.

・It will involve projecting future impacts for project formulation and implementation.

・Technologies available for projection and adaptation are being developed day to day, and water management systems will change or must be changed accordingly.

The project formulation approach in flood control sub-sector becomes as follows:

1. Flood Projection

The target year will be set to a year during the 2040-50 period.

The current practice of determining the target return period will be applied.

More than one design rainfall level should be used to allow for flexibility to cope with uncertainties. Such design rainfall levels may include, for example, the current value without taking climate change into consideration; the value calculated using the downscaling models or the average value from the ensemble model.

Runoff analysis will be implemented by following the existing methods.

2. Existing Facilities, Plans, and Management Structure: Identifying Existing Coping Mechanisms

Identify and inventory existing facilities, plans and institutional frameworks for disaster prevention that may be used for adaptation.

(a) Structural measures
(b) Institutional framework
(c) Areas that may not have been identified but need to be identified for implementing community-based measures
(d) City plans and regional development plans

3. Damage Potential and Impact Assessment
Since inundation occurs and is managed in floodplains, it is essential to simulate and analyze the inundation. If data for simulation is insufficient, conduct interviews on the largest flood and yearly floods to date to estimate the inundation depths.
Damage and vulnerability will be assessed through an inundation analysis. In addition to the conventional assessment, the following items shall be examined from the perspective of human security:
・Damage to specific vulnerable groups, including the poor
・Damage to the livelihoods and property of individuals
The detailed mechanisms of glacial lakes outburst are unknown. Priority should be given to identifying dangerous glacier lakes through continuous surveys and analyses and to developing methods and improving their accuracy, with the focus on the following:
・Analyses of glacier lake dynamics and collapse risks using satellite data
・Analyses of the structure, thermal environment, and collapse mechanisms of glacier lakes based on field surveys
・Development of a monitoring system using remote sensing and other technologies

4. Adaptation Planning
(1) River Basin Governance
Adaptation planning involves a wide range of stakeholders and various sectors. It also hinges on voluntary activities on the part of communities. It is therefore important to establish a council or forum made up of stakeholder organizations, experts and academics at the early stages of planning.
(2) Meteorological and Hydrological Observation
Improving and maintaining meteorological and hydrological observations are considered as cross-cutting adaptation measures in the water sector, aiming at the greater accuracy of climate change impact assessment, a deeper understanding of extreme floods, and the development of warning.
(3) Flood Disasters
(a) Target Setting
Target setting is primarily aimed at protection of human lives and minimization of losses. The following steps are adopted as the strategy:
Step 1: Protection of strategic facilities
Step 2: No settlement
Step 3: Community-based disaster management and crisis management
(b) Facilities Planning
Flexible and resilient responses are necessary since the magnitude of disasters will be increasing.
(c) Economic Assessment
Usually, the benefits of intervention will most likely be affected by the impacts of climate change. Yet assessing climate change impacts for each year may be too complicated and impractical. A viable alternative option is be to use the projected benefits at a year halfway between the current year and the target year as the benefits for each year on the assumption that the benefits will change at a fixed rate until the target year.
There are no established methods for quantitatively assessing the improvement of disaster management capacity through non-structural measures such as capacity building for communities

on evacuation. Such assessments have to be made on a case-by-case basis.

(d) Regional/Urban Planning, Land Use Control

i) Risk Zoning and Development Control

・Limit the use by prohibiting settlement in a damage risk zone, or settle after implementing the countermeasures through flood-proof structures such as reinforced concrete or elevating floors.

・Control the development in flood-prone regions

ii) Obligatory Development of Rain-water Penetration Facilities and Flood Control Ponds

iii) Green Belt (Surrounding Open/Green Spaces)

iv) Establishment of a Legal Framework and Its Proper Implementation

v) Organizations, Process and Capacity Development

(e) Community-based Disaster Management and Crisis Management

i) Assessing the Strengths and Weaknesses of a Community (risk and capacity assessment)

ii) Project Planning

(infrastructure development, environmental conservation, establishment of a forecast/warning system, human resources development, development of voluntary organizations for disaster preparedness, dwellings, safety nets, budget)

iii) Project Appraisal

iv) Project Formulation

v) Establishment of a Risk Communication Framework through a Series of Efforts

(4) Measures for the Poor and the Vulnerable

(5) Disaster Insurance

(6) Monitoring (Evaluation and Review) and Maintenance

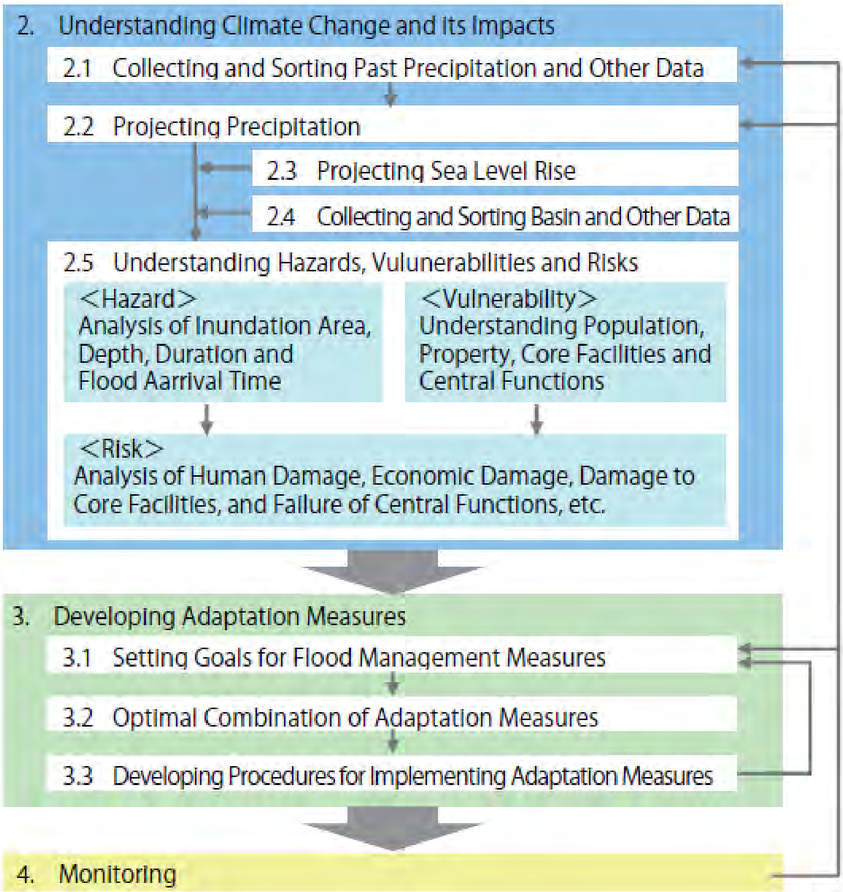
2) Practical Guidelines on Strategic Climate Change Adaptation Planning - Flood Disasters -[2]

These guidelines (GLs) describe a framework in developing adaptation measures against the increase in the intensity and frequency of floods (excluding storm surges) caused by climate change. The guidelines are intended mainly for countries in Asia-Oceania and elsewhere where urbanization and land use are expected to intensify because of social and economic progress and population growth; production facilities and people are concentrated in alluvial plains; and effective flood control measures are yet to be developed.

The GLs are highly developed to be practical for master plan and feasibility study of flood control sub-sector in the development assistance. This survey refers much to the GLs and most parts are basically same. The distinctive difference between this survey and GLs are as follows:

・“Vulnerability Assessment” in this survey corresponds to “Understanding Hazards, Vulnerabilities and Risks” in GLs. The definition of vulnerability has been established globally, where the vulnerability shall be assessed by “hazard of climate change”, “sensitivity”, and “adaptive capacity” that includes non-structural measures and land use regulations. GLs have no clear description about adaptive capacity and its assessment, even though GLs may involve the basic concept of the adaptive capacity. This survey specifies the vulnerability assessment.

The process in developing adaptation measures are shown in the chart below.



Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan (2010), p.1

The following describes the summary of each step.

2.1 Collecting and Sorting Past Precipitation and Other Data

It is necessary to collect and sort long-term precipitation data with consistent quality. These data are also needed to review and verify calculation results replicating the present status with GCM, downscaling, and bias correction methods.

2.2 Projecting Precipitation

Near-future projection results (after 20-30 years) may not vary greatly according to the scenario, so it is possible to reduce the number of scenarios to be considered. However, it is desirable to consider as many scenarios as possible, because long-term projection results will differ according to different scenarios.

The three scenarios in IPCC AR4 scenarios, i.e., A1B, A2, and B2 have been used predominantly for developing global warming projection. Furthermore, A1B is widely used in projecting global warming impacts and developing adaptation measures.

It is important to use projection calculation results obtained from multiple GCMs capable of accurately reproducing region-specific precipitation phenomena. Statistical downscaling and dynamic downscaling have respective advantages and disadvantages.

2.3 Projecting Sea Level Rise

Projections of sea level rise may include uncertainties in developing scenarios and calculation models. This should be recognized and projection results should be appropriately selected so that they can be used for assessment and examination.

2.4 Collecting and Sorting Basin and Other Data

Catchment data for runoff analysis, river data for calculation of flood propagation in river channels, and floodplain data for inundation analysis are collected. In addition, hydrological and hydraulic values relating to river flow and flooding such as discharge, water level, and flooding depth, are collected and sorted to compensate for the insufficiency of information about rivers and basins.

2.5 Understanding Hazards, Vulnerabilities and Risks

Flood damage is assessed through a series of runoff analysis, calculations of flood propagation in river channels, and inundation analysis.

3.1 Setting Goals for Flood Management Measures

It is a good practice to estimate changes over a period of about 20 to 30 years. General goals are set such as to “minimize victims” and “avoid paralysis of capital city functions”. Based on these goals, after developing and setting adaptation measures, it is important to clearly present and specify goals in terms of time, cost, etc.

3.2 Optimal Combination of Adaptation Measures

It is necessary to carefully evaluate the effectiveness of adaptation measures, taking into consideration the climate characteristics and socio-economic situation of the basin; and financial and legal systems, administrative organizations, and infrastructure conditions of the country.

The optimal measure shall be selected from the formulation and assessment of specific measures, and likewise assessed, based on opinions of the local residents. The major adaptation measures are listed as follows:

A. Measures for reducing risks of inundation (e.g,. excavation of river channels, levee setting back, embankment, dam, and flood control facilities)

B. Measures for controlling flooding flow (e.g., secondary levees, open levees, ring levees)

C. Measures for reducing damage in floodplain (e.g., regulation of land-use, raising floors of buildings, installing electric and machinery equipment at higher places)

D. Evacuation and evacuation guidance measures (e.g., evacuation and evacuation guidance, forecast and warning, evacuation facilities)

E. Emergency measures (e.g., flood fighting, cofferdams, drainage measures, training, and education)

F. Measures for expediting rehabilitation and reconstruction (e.g., disaster prevention facilities, transportation network, disaster prevention operation plan, business continuity plan, and disposal of flood-generated waste)

3.3 Developing Procedures for Implementing Adaptation Measures

It is important to develop and assess multiple procedure options to clearly show the implementation procedure of the adaptation measures.

4. Monitoring

It is important to carry out monitoring to understand climate changes and to conform to the PDCA cycle considering the uncertainties of climate change impacts.

[1] JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development

[2] Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2010). Practical Guidelines on Strategic Climate Change Adaptation Planning -Flood Disasters-

7. Coastal Protection Sub-sector

Guideline:

(1) Coastal Protection (Adaptation Project)
(2) Coastal Protection (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change will raise the sea water level and increase frequency and intensify magnitude of storm surge and high wave, and wave force will be increased. It will lead to coastal erosion and damage on coastal protection structures. Adaptation measures in coastal area have been discussed in IPCC in terms of retreat, accommodation, and protection. Retreat and accommodation are mainly political action initiatives, as land use regulation and resettlement, and protection is technical measures. Coastal protection sub-sector will contribute to reduction of vulnerability against coastal damage intensified by climate change, mainly by technical measures.
B. Vulnerability	1) Major Climate Change Impacts on the Coastal Protection Sub-sector <u>■ Sea Level Rise</u> ・Coastlines will recede due to rising sea levels, and as a result, some land would be lost. ・Some areas will become flooded during high tide, and inundation on coastal areas will be prolonged. ・Incidence of wave overtopping breakwaters and sea walls will increase. ・Wave force will intensify in association with increase in water depth, even in the same sea wave condition. This may lead to exceedance of the design capacities of structures, and will cause displacement and damage to revetments, wave dissipating blocks, parapets, etc. The effects on coastal erosion would also intensify. ・Sea level rise will increase buoyancy of buried pipes and manholes, and cause ground uplift. Risk of soil liquefaction will also increase. <u>■ Increase/ Intensification of Cyclones</u> ・Damage from storm surge and high wave will increase and intensify, and it will worsen coastal erosion in association with sea level rise. ・Inundation in the coastal land area will increase. ・Sea waves larger than design conditions might hit the coastal area, and consequently, hasten deterioration of coastal protection structures. <u>■ Sea Temperature Rise</u> ・Sea temperature rise would cause widespread coral bleaching and fish kills, which lead to reduction of its preventive functional capacity against coastal erosion and environmental deterioration in coastal areas <u>■ Increase/ Intensification of Precipitation</u> ・Sediment loads will increase in association with increased river discharge. However, sediment supply to sandy shore will not increase, since sedimentation in the river will be deposited and dredged before reaching sandy shore. <u>■ Change of Ocean Currents</u> ・Characteristics of littoral drift will be changed, and sandy beaches will be affected. 2) Other Factors that Influence the Coastal Protection Sub-sector Associated with Climate Change Impacts ・Population growth, economic development, intensification of land use lead to development and settlement in coastal areas. ・Excessive groundwater intake leads to subsidence in coastal areas.

・River development and port construction can change the characteristics of sediment load and littoral drift.
・Dredging around the coastal areas will influence the shoreline conditions.
・Land use change influences coastal environment; e.g., environmental problems in urban areas such as water quality and other environmental problems on natural habitats such as corals and mangroves.

3) Adaptive Capacity to Climate Change
・If the legal framework for coastal management is strengthened, this can lead to enhancement of its adaptive capacities.
・If non-structural measures such as operation of equipment for flood forecasting and warning system, and development of evacuation and precautionary measures are implemented in the related government and communities, adaptive capacities are improved.
・If adequate public information is implemented, and inhabitants are educated and responsive on disaster and risk management issues, they would implement appropriate precautionary measures and actions in times of disaster, hence, improving their adaptive capacity.
・If the budget and programs for disaster recovery are well in place, disaster response capability of regulatory agencies is high.
・If research institute related to coastal protection exists and its system is well-organized, the adaptive capacity for climate change is high.
・The existence and enrollment status of insurance and mutual aid systems for damage from storm surge and high wave would affect disaster recovery capability.

4) Spatial Distribution of Vulnerability
a) Climate Change
・Storm surges and tidal waves are influenced by submarine and coastal topography. Hence, this results to variations in coastal characteristics such as wave, flow, longshore sediment transport, and the wave forces on coastal structures.

b) Sensitivity in the Coastal Protection Sub-sector
・Sensitivity varies by installation condition, design conditions, development level, and maintenance level of coastal protection facilities.
・Influences from sea level rise, storm surge, and high wave vary by topography and elevation.

c) Adaptive Capacity
・If utilities on reclaimed lands, such as buried pipes and manholes, are installed with fully compacted ground conditions, adaptive capacity due to the increase of groundwater level is high.
・If land use regulations include implementation of restrictions in development and resettlement in coastal areas, adaptive capacity remains high.
・Disaster resilience capacity would vary if the regulatory agency is different for each facility.
・Adaptive capacity depends on coping capability and the current state of affairs of related local government agencies and communities.

C. Adaptation Measures	Major Adaptation Measures in the Coastal Protection Sub-sector ■ Development/ Improvement of Coastal Structure ・Construction, raising, stabilization of base and levee of coastal structures ・Component upgrade/alteration of wave dissipating blocks, gabions, rubbles, and revetments, etc. ■ Other Structural Measures ・Floating prevention through replacement of or improved ground compaction for buried pipes and manholes, which are affected by buoyancy in the event of increase in groundwater level. ■ Non-structural Engineering (including Environmental Engineering) ・Sandy shore restoration and/or conservation by beach nourishment method and sand bypass method. ・Reduction of high wave damages by afforestation of mangroves. ・Conservation and restoration of coral reefs by transplanting or breeding through asexual and sexual reproduction. ■ Non-structural Measures for Evacuation ・Development of warning system ・Preparation of hazard map ・Community organization and training on safety, evacuation and its guidance ■ Cross-sectoral Measures ・Urban plan, and land use plan ・Securing of facilities and roads for evacuation and guidance.
D. Maladaptation	■ Maladaptation in Adaptation Measures ・The areas protected by coastal structures seem to be safe. If more inhabitants are convinced that such areas are safe and decide to resettle into the coastal areas, risk of damage to persons and/or property due to dike failure would increase. ・The awareness of inhabitants on disaster prevention might be reduced due to the development of coastal protection structures, and their responsiveness to possible future changes would weaken. ■ Maladaptation Common to “Business as Usual” Project ・Future changes in sea water level, wind force, etc., would require design changes, otherwise this will result to inadequate height of structure or resisting bearing force, which consequently will affect the safety of the structure. ・Changes in coastal management will affect the different stakeholders, such as dredging companies, marine product processing companies, warehousing companies, transport companies, etc. Coordination among the stakeholders is very important.

Guideline: Coastal Protection (Adaptation Project)

A. General	■ <u>Necessity of Adaptation</u> Climate change will raise the sea water level and increase frequency and intensity of cyclones, which translates to inundation, coastal erosion, storm surge-related damage, and tidal waves at coastal areas. Groundwater level increase associated with sea level rise will exacerbate the risk of ground uplift, buoyancy increase of buried pipes and manholes, and soil liquefaction in coastal areas. Other concerns are coral bleaching and fish death due to sea temperature rise, and decline of preventive measures for coastal areas against coastal erosion and environmental deterioration. ■ <u>Adaptation Measures</u> To take countermeasures for inundation, coastal erosion and groundwater level rise; strengthen disaster management; and promote conservation of coastal environment by means of structural and non-structural measures. ■ <u>Outcome of Adaptation Measures</u> Damages due to inundation, coastal erosion, groundwater level increase, storm surges, and tidal waves, induced by climate change will be reduced. Coastal environment will be conserved and coral reefs will be protected against wave forces.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks ・Collect past marine weather records such as tide level, wave, storm surge and high wave, in and around the target coastal area, from marine weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate marine and meteorological weather aspects for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for land use in the target area, which affect the inundation, coastal erosion, storm surge and high wave damage, sediment load and littoral drift, such as population change and industrial development, through review of the national and regional development plan and land use regulations. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study the records on inundation, coastal erosion, storm surge and high wave damage such as observed record, aerial photo, and topographic surveys, through collection and hearing among stakeholders such as the related agency and inhabitants, as well as through websites on meteorology. Identify the areas vulnerable to inundation, coastal erosion, storm surge, and high wave damage in the target coastal area. b) Study Present Condition of Facilities and Measures ・Condition of Facilities: Assess the present condition of facilities based on the design condition, bearing capacity, and maintenance condition, through field survey and review of reports and drawings for coastal structures in the target coastal area.

・Operating / Functioning Conditions of Facilities:
Assess the operational condition of the facilities such as flood gate and drainage pumping station, through investigation on operation and management records of facilities, as well as through interviews among stakeholders.

c) Assess Future Sensitivity to Climate Change
Study the seabed and coastal topographical features, coastal characteristics such as wave, flow, and longshore sediment transport, and coastal vegetation of the target coastal areas. Then, assess the future sensitivity of coastal area to inundation, coastal erosion, and storm surge and high wave damage, based on the relationship between past disasters and oceanographic and meteorological conditions, future climate and marine condition, and condition of facilities, with consideration on future socio-economical change factors.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
・Community Based Disaster Management and Crisis Management
Assess the responsiveness against storm surge and high wave occurrence:

- Situations of non-structural measures such as hazard maps, warning system, and evacuation drills, which are related to the responsiveness of the local government and inhabitants.
- Maintenance conditions of roads and shelters, which can facilitate evacuation during disaster.

・Disaster Resilience Capacity of Regulatory Agency
Assess budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development
Assess research and development for coastal protection.

・Compensation for Storm Surge and High Wave Damage
Assess the disaster restoration capability:

- Available insurance or mutual aid system for storm surge and high wave damage.

b) Clarify Exacerbating Factors for Climate Change Impacts
・Land Use and Land Use Regulations
Clarify the land use and related regulatory policies which affect the inundation, coastal erosion, and storm surge and high wave damages.

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Community based disaster management and crisis management	Excellent	Poor
Disaster resilience capacity of regulatory agency	Excellent	Poor
Existence and ability of research and development	Exist/ Excellent	None/Poor
Compensation for storm surge and high wave damage	Sufficient	Poor
Land use and land use regulation	Planned	Unplanned

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of inundation, coastal erosion, and storm surge and high wave damages	Economic	・Amount of damage
		Quantitative	・Flooded area ・Flooded houses ・Victim ・Maximum water depth ・Inundation duration
Community-based disaster management and crisis management	Improvement of responsive ability on occurrence of storm surge and high wave	Qualitative	-
Disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for storm surge and high wave damage	Improvement of restoration capability after disaster occurrence	Qualitative	-
Land use and land use regulation	Reduction of calamity or property damage in coastal area	Economic	・Amount of damage
		Quantitative	・Flooded houses ・Victim

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period/ safety factor of facilities	Quantitative	-
Non-structural measures	Implementation record of projects, such as beach nourishment, mangrove afforestation, transplanting of coral reef.	Quantitative	・Afforestation area ・Survival rate of forested tree
Others	Changes in the awareness of stakeholders on coastal protection	Qualitative	-

<table>
<tr>
<td>D.
Necessary Consideration for Planning of Adaptation Measures</td>
<td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impact, which is not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Countermeasures for further sea level rise, storm surge and high wave (room for enhancement of bearing capacity, raising of structure, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td>
</tr>
<tr>
<td>E.
Required Data</td>
<td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present marine weather and meteorology</td><td>Collect data from marine weather and meteorological stations.</td></tr>
<tr><td rowspan="2">2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.</td></tr>
<tr><td>Socio-economic incidence</td><td>Collect development plans and land use regulations, in and around the target coastal areas and country from relevant organizations and other agencies.</td></tr>
<tr><td rowspan="4">3) Assess Future Sensitivity to Climate Change</td><td>Information about inundation, coastal erosion, storm surge and high wave damage</td><td>Collect and identify damages of inundation, coastal erosion, storm surge and high wave, of each area by each event. Secular change shall be also collected in parallel.</td></tr>
<tr><td>Design condition and design bearing capacity of existing structure</td><td>Study the design capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.</td></tr>
<tr><td>Condition of existing facility</td><td>Study the operating condition of each facility through field survey.</td></tr>
<tr><td>Operation and maintenance record of disaster prevention facilities</td><td>Collect detailed operation and maintenance record to study the situation during disaster occurrence.</td></tr>
<tr><td rowspan="2">4) Assess Adaptive Capacity to Climate Change</td><td>State of non-structural measures</td><td>Study and review the situation of non-structural measures through interviews with related agencies, and based on related information collected.</td></tr>
<tr><td>Conditions of evacuation road and shelters</td><td>Study and review the condition through interview with related agencies, and based on related information collected.</td></tr>
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</table>

		Disaster resilience capacity of regulatory agency	Study and review the budget and program of activity through interviews with related agencies, and based on related information collected.
		Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
		Existence and enrollment of damage insurance and mutual aid system	Study and review the status through interview with related agencies and based on related information collected.
		Land use and land use regulation	Study present status of land use including differences in land use regulations, and investigate actual condition by site reconnaissance, by using land use maps and satellite images. Study land use regulation by reviewing related information and conducting interviews with related agencies.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Coastal Protection (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
It is necessary to increase coastal protection capacity, in association with land development in the coastal area due to economic growth.
Potential risks of flood inundation, coastal erosion, storm surge and high wave damage are likely to increase in the target coastal areas due to climate change impacts, such as sea level rise and increase of frequency and intensification of cyclones.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
The expected coastal protection function will be maintained in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Identify marine weather and meteorological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as developing or improving coastal protection structures, non-structural measures for coastal erosion such as beach nourishment, afforestation, and transplant of coral reefs, and non-structural measures for evacuation and guidance, which could be implemented individually or simultaneously.</td></tr>
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Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
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・ Victim
・ Maximum water depth
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[Alternative Items for Assessment in Monitoring and Review]
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<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
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<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Countermeasures for further sea level rise, storm surge and high wave (room for enhancement of bearing capacity, raising of structure, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
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<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.</td></tr>
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</td></tr>
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References and Key Different Features

1) Handbook on Climate Change Adaptation in the Water Sector[1]
JICA's approach of development assistance to developing countries with regards to climate change adaptation for water sector (mainly focused on flood control, but also includes water resources, water environments, sediment, and coastal protection) is shown in this handbook.

The differences between the handbook (HB) and this survey are as follows:
・The target of the HB is mainly a master plan; on the other hand, this survey targets the feasibility study directly leading to loan assistance.
・OECD-DAC defined climate change adaptation-related aid as activities that aim "to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience". In this regard, vulnerability should be examined, however the definition and assessment procedure of vulnerability are included but not clarified in the HB. This survey clearly specifies the vulnerability assessment and its study procedure.
・The HB defines the target year as 2040-50 in consideration of the availability of calculation results of GCMs used for IPCC AR4. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that IPCC AR5 will be published in 2013, and much of the countries have already involved climate change in their policies.
・The HB recommends the downscaling of AGCM20 results as a general rule. On the contrary, this survey proposes to conform to the policies of the recipient country, considering that AGCM20 has been proved unsuitable to every region of the world through researches and studies, and much of countries have established their own climate change policy using their own selected models which suit to their countries.

Below is a brief summary of the HB.

Conventional planning based on the premise of stationarity which states that past precipitation pattern will not change over time has become invalid due to climate change. The project formulation approach will be fundamentally different from the conventional one in the following aspects:
・It will deal with a changing climate.
・It will involve projecting future impacts for project formulation and implementation.
・Technologies available for projection and adaptation are being developed day to day, and water management systems will change or must be changed accordingly.

The project formulation approach in the coastal protection sub-sector becomes as follows:

1.Projection
The rise in sea levels will occur over decades to centuries, while extreme weather conditions last for days to weeks. This difference in time scale should be taken into account. Prediction models have not been sufficiently developed to be put to practical use. The near-term target will be to improve assessment accuracy by analyzing trends in changes based on observed data on tidal levels and wave conditions and keeping track of the development of relevant technologies.

2. Existing Facilities, Plans, and Management Structure: Identifying Existing Coping Mechanisms
Identify and inventory existing facilities, plans and institutional frameworks for disaster prevention that may be used for adaptation.
(a) Structural measures
(b) Institutional framework
(c) Areas that may not have been identified but need to be identified for implementing community-based measures
(d) City plans and regional development plans

3. Damage Potential and Impact Assessment
The following items are assessed:
・Inundation risk (normal, temporary)
・Coastal erosion and the stability of structures
・Groundwater level rise
・Salt intrusion into the ground and river water
・Impacts of rises in water temperature and erosion on coastal ecosystems (vegetation change, coral bleaching, etc.)

4. Adaptation Planning
(1) River Basin Governance
Adaptation planning involves a wide range of stakeholders, as well as various sectors. It also hinges on voluntary activities on the part of communities. It is therefore important to establish a council or forum made up of stakeholder organizations, experts and academics at the early stages of planning.
(2) Meteorological and Hydrological Observation
Improving and maintaining meteorological and hydrological observations are considered as cross-cutting adaptation measures in the water sector, aiming at the greater accuracy of climate change impact assessment, a deeper understanding of extreme floods, and the development of warning.
(3) Coastal protection
・Structural measures
・Non-structural measures
・Coastal erosion control
(4) Measures for the poor and the vulnerable
(5) Disaster Insurance
(6) Monitoring (Evaluation and Review) and Maintenance

2) Adapting to Coastal Climate Change[2]
This guidebook discusses adaptation of coastal areas, covering the whole project formulation process from vulnerability assessment to implementation of adaptation measures.

There are no significant differences in vulnerability assessment and other considerations between the guidebook and this survey. The guidebook recommends the following adaptation measures for coastal areas:

・Functioning and Healthy Coastal Ecosystems
1. Coastal Wetland Protection and Restoration
2. Marine Conservation Agreements
3. Marine Protected Areas
4. Payment for Environmental Services
・Built Environment is Less Exposed
1. Beach and Dune Nourishment
2. Building Standards
3. Coastal Development Setbacks
4. Living Shorelines.
5.Structural Shoreline Stabilization
・Diversified Livelihoods
1. Fisheries Sector Good Practices

2. Mariculture Best Management Practices
3. Tourism Best Management Practices

・Human Health and Safety Enhanced
1. Community-based Disaster Risk Reduction
2. Flood Hazard Mapping

・Overarching Planning and Governance
1. Coastal Watershed Management
2. Integrated Coastal Management
3. Special Area Management Plan

[1] JICA. (2010). Handbook on Climate Change Adaptation in the Water Sector: A Resilient Approach that Integrates Water Management and Community Development

[2] USAID. (2009). Adapting to Coastal Climate Change: A Guidebook for Development Planners

8. Sediment-related Disaster Prevention Sub-sector

Guideline:

(1) Sediment-related Disaster Prevention (Adaptation Project)
(2) Sediment-related Disaster Prevention (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change would intensify heavy rainfall events and increase frequency. This would increase sediment-related disasters, including increases in frequency and scale, change in timing of occurrence as well as expansion of sediment-related disaster areas. With the increase of total precipitation and rise of temperature, risk of landslides would increase even in low risk areas. It would also affect dams, downstream river channels and estuaries with the increase of sediment yield and discharge. Against the increase of these sediment-related disaster risks, appropriate measures, both structural and non-structural are necessary. Structural measures consist of facility construction while non-structural measures include prediction of frequency, area, scale and timing of disaster occurrences, designation of sediment-related hazard areas, evacuation planning, and cross-sectoral measures of regional development. The sediment-related disaster prevention sub-sector will contribute to the reduction of vulnerability against climate change described above through structural and non-structural measures.
B. Vulnerability	1) Major Climate Change Impacts on the Sediment-related Disaster Prevention Sub-sector ■ Increase of Precipitation, Increase in Intensity and Frequency of Heavy Rain, and Increase in Intensity and Frequency of Extreme Events (Cyclones) ・Increases in intensity, frequency and total precipitation of heavy rainfall events will raise the groundwater level in landslide slopes, thereby disturbing their stability, which then lead to an increase in frequency and scale, and change in timing of sediment-related disaster occurrences. ・In case of increased flood flow, the frequency and scale of debris flow followed by landslide will both increase. These sediment-related disasters will not only increase direct damage, but also cause long-term impact on downstream facilities such as dams, flood control facilities, river channels and estuaries. ・The increase of melting snow and precipitation will cause overflow of water at glacier lakes or landslide dams. This will consequently lead to their collapse. ・The increase of occurrences of landslides and slope collapses is expected to exacerbate soil erosion within basin areas, consequently, degrading water quality in the watershed due to the increase of sediment yield and discharge. ・The increase of river discharge will reduce frictional force at the end portion of the landslide which faces the river especially, and the instability of slopes will increase consequently. ■ Temperature Rise ・Temperature rise will melt snow and consequently raise the groundwater level in slopes, and it would cause slope collapse and landslides. ・Outbreaks of glacial lakes by temperature rise would cause debris flow and landslides, which extensively damage the downstream area. ■ Sea Level Rise ・The reduction of drainage capacity due to the rise of sea level would exacerbate the debris flow and sediment deposition brought by increased soil erosion in the upstream area, which would then bring about land desolation.

	2) Other Factors that Influence the Sediment-related Disaster Prevention Sub-sector Associated with Climate Change Impacts ・Population growth, urbanization, resource exploitation, and intensification of land use will extend development in landslide-prone areas and landslide hazard zones. ・Land use change at the upstream forest and hilly lands as well as deforestation will change slope topography and vegetation. 3) Adaptive Capacity to Climate Change ・If non-structural measures are carried out such as preparation of hazard maps or identification of critical locations; designation of sediment-related disaster risk areas; forecasting and warning systems regarding the scale and timing of disaster occurrence; development of evacuation and precaution, in the related government and communities, adaptive capacity are improved. ・Development of legal systems such as development regulation for the sediment-related disaster prone areas, and development of regulation for upstream forest to retain water and farmlands to store flooded water, improve adaptive capacity. ・If adequate public information is implemented, and inhabitants are educated and responsive on disaster and risk management issues, they would implement appropriate precautionary measures and actions in times of disaster, hence, improving their adaptive capacity. ・If the regulatory agency for sediment-related disaster is organized, and budget and programs for disaster recovery are well in place, their disaster resilience response capability is high. ・If research institute related to sediment-related disaster prevention exists and its system is well-organized, the adaptive capacity for climate change is high. ・The existence and enrollment status of insurance and mutual aid systems for sediment-related damage would affect disaster recovery capability. 4) Spatial Distribution of Vulnerability a) Climate Change ・If the catchment area is extensive, or steep mountainous terrain or alluvial plain exists, spatial distribution shall be studied. ・For a watershed branch that can have glacier or snow melt, spatial distribution shall be studied. b) Sensitivity in the Sediment-related Disaster Prevention Sub-sector ・Sensitivity varies with installation condition, design conditions, development level, and maintenance level of disaster prevention facilities such as slope protection, sabo dam, and river dike. ・The types of sediment-related disaster differ based on the zone of a basin area. The upper and middle basin areas suffer from direct damage due to landslide and slope collapse, and accompanied debris flow. The middle and lower basin areas suffer also from consequential damage such as increase and expansion of debris flow due to riverbed rise by sedimentation deposition. ・The risk of occurrence and exacerbation of sediment-related disaster would increase especially in steep mountainous terrain and weathered geological zone with geological structures.

	c) Adaptive Capacity ・Land use control, development regulation, watershed management, and river management in each river basin influence slope stability condition, and the quantity and quality of sediment runoff. ・Adaptive capacity for damage alleviation depends on the coping ability and situation of related local government and communities.
C. Adaptation Measures	Major Adaptation Measures in the Sediment-related Disaster Prevention Sub-sector ■ Development/Improvement of Sediment-related Disaster Prevention Facilities ・Slope stabilization measures, control measures against sediment production and discharge (slope protection, drainage, soil conservation, sediment control, etc.) ・Regulation and control measures against sediment discharge to the midstream and downstream area (sabo dam, bank protection, etc.) ・Control of debris flow in the downstream area (river dike, dredging of riverbed, etc.) ・Direct protection measures for conservation target (greenbelt, protection wall, retaining wall, etc.) ■ Forecasting, Early Warning, and Evacuation ・Preparation of hazard maps for sediment-related disaster areas ・Identification of critical locations and designation of sediment-related disaster risk areas ・Prediction of landslide, debris flow, and damage area of debris flow; and establishment of forecasting and warning system ・Organization and training in the community on precaution, evacuation and guidance ・Establishment of organization for disaster restoration ■ Cross-sectoral Measures ・Urban plan, land-use plan, and watershed conservation plan ・Securing of facilities and roads for evacuation and its guidance ・Design criteria ・Crisis management plan including that for earthquake disaster
D. Maladaptation	■ Maladaptation in Adaptation Measures ・The areas protected by river dikes seem to be safe. If more inhabitants are convinced that such areas are safe and decide to resettle on dike-protected lands, risk of damage to persons and/or property due to dike failure would increase. ・The awareness of inhabitants on disaster prevention, might be reduced due to the development of sediment-related disaster prevention facilities, and their responsiveness to possible future changes would weaken. ■ Maladaptation Common to "Business as Usual" Project ・Intensification and increase of precipitation would exceed the design capacity of facilities, consequently causing collapse even in low risk areas. ・Farm land development and settlement tend to proceed at the slope collapsed area, where land clearing can be readily conducted for agricultural activities regardless of formal or informal ones. Consequently, such lands are usually vulnerable against massive water flow, which would potentially increase a risk of large-scale sediment-related disaster, thereby damages by collapsed land and debris flow.

Guideline: Sediment-related Disaster Prevention (Adaptation Project)

A. General	■ <u>Necessity of Adaptation</u> Climate change will increase short-term rainfall and continuous precipitation. The change of temporal and spatial distribution in rainfall will change the frequency, scale, and timing of sediment-related disaster, expand the collapse area, and increase the probability for multiple disasters occurring. Direct damage from a sediment-related disaster will increase mainly in the upstream area, while consequential damage due to debris flow will increase in the downstream area. Hence, there are anxieties on land degradation and desertification in the upstream area, and adverse effects to the downstream dams, river channels and estuaries. ■ <u>Adaptation Measures</u> In order to strengthen the responsiveness of the target area on sediment-related disaster, appropriate measures shall be implemented. The measures include structure construction, and non-structural approaches such as forecasting, warning, and evacuation, etc. ■ <u>Outcome of Adaptation Measures</u> Sediment-related disaster by climate change will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological records in the target river basin or area and surrounding sediment-related disaster risk areas, from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate precipitation aspects such as intensity, frequency, and volume, for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for land use, which is critical to the damage extent of disaster in and around the target area, such as population change and industrial development, through review of the watershed conservation plan, development plan, and land use regulations, related to flood control, sediment-related disaster, etc. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study the relationship among aspects of past sediment-related disasters such as scale, spatial distribution, and timing of occurrence; and meteorological conditions, through investigation of disaster history, disaster report of government, newspapers, and weather statistics, and through hearing with stakeholders (e.g. related agencies, persons in charge of disaster, and inhabitants). Identify the areas exposed to sediment-related disasters based on past sediment-related disasters in the target watershed and area. b) Study Present Condition of Facilities and Measures ・Condition of Facilities: Assess the present condition of facilities based on the design capacity and maintenance

condition, through field survey and review of reports and drawings for facilities in the target watershed and area.

・Operating / Functioning Conditions of Facilities:
Assess the operation condition of facilities in the target watershed, through investigation of operation and management records of the facilities such as slope protection, afforestation, sabo dam, and river dike, and through interviews with stakeholders.

c) Assess Future Sensitivity to Climate Change
Assess geology, topography, and land use data for the target watershed. Then, assess future sensitivity of sediment-related disaster to climate change based on the relationship between past disasters and meteorological conditions, future climate condition, and condition of facilities, with consideration on future socio-economic change factors.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
・Risk on Priority Protection Area (Geology, Topography, and Sediment-related Disaster Prevention Facilities)
Identify the priority areas to be protected such as urban areas, densely populated areas, and important facilities, and study the condition of sediment-related disaster prevention.

- Geology and topography of priority areas, and sediment-related disaster prevention facilities. These conditions are related to the responsive ability on sediment-related disaster.

・Community Based Disaster Management and Crisis Management
Assess the responsiveness against sediment-related disaster occurrence:

- Situations of non-structural measures such as hazard maps, forecasting and warning system, and evacuation drills, which are related to the responsiveness of the local government and inhabitants.
- Maintenance conditions of roads and shelters, which can facilitate evacuation during disaster.

・Organizational Structure and Disaster Resilience Capacity of Regulatory Agency
Assess organizational structure, budget and programs for disaster recovery in regulatory agencies.

・Existence and Ability of Research and Development
Assess research and development for sediment-related disaster.

・Compensation for Sediment-related Disaster
Assess the disaster restoration capability:

- Available insurance and mutual aid system for sediment-related disaster.

b) Clarify Exacerbating Factors for Climate Change Impacts
・Land Use and Land Use Regulations
Clarify the land use and related regulation that affect sediment-related disaster damage.

- Land development at collapse-prone areas and sediment-related disaster hazard areas, which are related to risk of damage from a sediment-related disaster.

- ➢ Distribution of forest land, farmland, and crop species, which are related to the condition of sediment runoff.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Risk of priority protection area	Low	High
Community-based disaster management and crisis management	Excellent	Poor
Organizational structure and disaster resilience capacity of regulatory agency	Excellent	Poor
Existence and ability of research and development	Existing/ Excellent	None/Poor
Compensation for flood damage	Sufficient	Poor
Land use and land use regulation	Planned	Unplanned

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of damage due to sediment-related disaster	Economic	・Amount of damage
		Quantitative	-
Risk of priority protection area	Reduction of damage due to sediment-related disaster	Economic	・Amount of damage
		Quantitative	-
Community-based disaster management and crisis management	Improvement of responsive ability on sediment-related disaster	Qualitative	-
Organizational structure and disaster resilience capacity of regulatory agency	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for sediment-related disaster	Improvement of restoration capability after disaster occurrence	Qualitative	-
Land use and land use regulation	Reduction of damage in sediment-related disaster hazard areas	Economic	・Amount of damage

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target safety factor of the target section and facilities	Quantitative	-
Others	Changes in the awareness of stakeholders on sediment-related disaster	Qualitative	-

<table>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Countermeasures for direct damage of slope collapse and debris flow, and consequential damage of excessive sediment supply in the downstream area (priorities for the development of sediment-related disaster prevention facilities)
- Countermeasures for combined impacts of heavy rains and earthquakes (increases in frequencies and scales of slope collapse)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>E.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present meteorology and hydrology</td><td>Collect data such as meteorological data, river discharge, sediment yield, and riverbed elevation from meteorological and hydrological stations.</td></tr>
<tr><td rowspan="2">2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on observed meteorological and hydrological data in the target area.</td></tr>
<tr><td>Socio-economic incidence</td><td>Collect watershed conservation plans, development plans, and land use regulations, related to flood control and sediment-related disaster prevention, in and around the target areas and country from relevant organizations and other agencies.</td></tr>
<tr><td rowspan="4">3) Assess Future Sensitivity to Climate Change</td><td>Past sediment-related disaster damage</td><td>Collect and identify the damage situation by area, spatial distribution of disaster, recurrence cycle of wide-area disaster, etc.</td></tr>
<tr><td>Design capacity of existing facility</td><td>Study the design capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.</td></tr>
<tr><td>Condition of existing facility</td><td>Study the operating condition of each facility through field survey.</td></tr>
<tr><td>Operation and maintenance record of sediment-related disaster prevention facilities</td><td>Collect detailed operation and maintenance record to study the situation during sediment-related disaster occurrence.</td></tr>
<tr><td>4) Assess Adaptive Capacity to Climate Change</td><td>Risk of priority protection area</td><td>Study the vulnerability of priority protection areas to sediment-related disaster based on geological and topographical conditions. Also study the design capacity and condition of sediment-related disaster prevention facilities.</td></tr>
</table>
</td></tr>
</table>

		State of non-structural measures	Study and review the current state of non-structural measures through interviews with related agencies, and based on related information collected.
		Conditions of evacuation road and shelters	Study and review the condition through interview with related agencies, and based on related information collected.
		Organizational structure and disaster resilience capacity of regulatory agency	Study and review the organizational structure, and budget and programs through interviews with related agencies, and based on related information collected.
		Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
		Existence and enrollment of damage insurance and mutual aid system	Study and review the status through interview with related agencies and based on related information collected.
		Land use and land use regulation	Study present status of land use including differences in land use regulations, and investigate actual condition by site reconnaissance, by using land use maps and satellite images. Study land use regulation by reviewing related information and conducting interviews with related agencies.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Sediment-related Disaster Prevention (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
It is necessary to plan or reconsider sediment-related disaster prevention works, in association with economic growth and land development.
Potential risks of sediment-related disasters in larger areas, and in greater magnitudes, are likely arising in the target river basin and areas due to climate change. The anticipated climate change impacts are considered to increase the amount of precipitation, change rainfall patterns, and increase the frequency and scale of extreme events such as torrential rainfall and tropical cyclones.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the increased sediment-related disaster damage associated with climate change.
<u>■ Outcome of Adaptation Options</u>
The expected damages from the sediment-related disaster will be controlled or reduced in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project amount and patterns of rainfall at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as developing sediment-related disaster prevention facilities, and non-structural measures such as evacuation and guidance, which could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future sensitivity to climate change</td><td rowspan="2">Reduction of damage due to sediment-related disaster</td><td>Economic</td><td>・ Amount of damage</td></tr>
<tr><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="2">Risk of priority protection area</td><td rowspan="2">Reduction of damage due to sediment-related disaster</td><td>Economic</td><td>・ Amount of damage</td></tr>
<tr><td>Quantitative</td><td>-</td></tr>
</table>
[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of target safety factor of the target section and facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Others</td><td>Changes in the awareness of stakeholders on sediment-related disaster</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Countermeasures for direct damage of slope collapse and debris flow, and consequential damage of excessive sediment supply in the downstream area (priorities for the development of sediment-related disaster prevention facilities)
- Countermeasures for combined impacts of heavy rains and earthquakes (increases in frequencies and scales of slope collapse)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>F.
Required Data</td><td><table>
<tr><td></td><td>Data</td><td>Remarks</td></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate conditions</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on observed meteorological and hydrological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.</td></tr>
</table></td></tr>
</table>

References and Key Different Features

1) Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming (Policy Report)[1]

This document discusses and explains the impacts of climate change and adaptation measures on water-related disaster sectors, such as water resources, flood control, sediment-related disaster, and coastal protection. The study procedures are not specified.

Adaptation strategies are proposed and elaborated in four different themes. "Adaptation strategies using structures" describes how to reduce damage from flood, sediment-related, storm-surge, and other disasters using structural protection. "Adaptation strategies in relation to community development" introduces a perspective of community development. "Adaptation strategies based on crisis management" discusses how to minimize damage in case of flooding, inundation and sediment-related disasters. There is also a section about "adaptation strategies to avoid drought risk." In addition, "adaptation strategies for river environment changes" centers on the understanding of the impacts of climate change on river environment.

The policy is described against intensified sediment-related disaster as follows:

・It is important to design appropriate response measures depending on the risk level since it is not practical to take every possible preventive measure.

・When implementing preventive structures, the priority should be set upon places with the highest risk of sediment-related disasters, where such structures can protect human lives. Construction costs should be reduced as much as possible so that structures can be built in as many places as possible.

・Non-structural measures are also important. It is necessary to promote land use regulation, such as designation of sediment-related disaster danger zones. Warning and evacuation systems should also be strengthened to accurately monitor and collect information about the precursors and initial status of disasters. Information technology should be utilized to share information between disaster management organizations and residents.

・Comprehensive sediment control measures for mountain to coastal areas should be enhanced in order to cope with the increase of sediment runoff while balancing flood control, water use and environment in basins.

[1] Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2008). Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming (Policy Report)

9. Disaster Prevention Information System Sub-Sector

Guideline:

(1) Development of Disaster Prevention Information System (Adaptation Project)

Basic Concept

A. General Concept	Climate change impact is likely to cause more frequent or intense tropical cyclones, which will increase the risk of flood, storm surge, storm wind, and landslides. This sub-sector is expected to develop observation system for natural phenomenon as well as to develop early warning system in order to prevent human damage from increasing natural disaster risk. In this sub-sector, appropriate operation and maintenance of such systems will reduce vulnerability against extreme events arisen from climate change.
B. Vulnerability	1) Major Climate Change Impacts on the Disaster Prevention Information System Sub-sector The disaster prevention information system primarily requires observation infrastructures of meteorology, hydrology, tide, inclination, etc., which imply that climate change itself could be the observation object for the sub-sector. Thus, the impact on the sub-sector due to climate change is not the case to consider. 2) Other Factors that Influence the Disaster Prevention Information System Sub-sector Associated with Climate Change Impacts The patterns and scale of natural disasters or extreme weather events as well as disaster prone areas may change according to the degree of climate change impacts. Therefore in this regard, there are possibilities to increase the vulnerability of the information system. 3) Adaptive Capacity to Climate Change Generally in developing countries, the lack of observation infrastructures and data accumulation has been a typical issue. Such condition tends to make it difficult to observe and analyze real time weather conditions and to disseminate early warning information to the public. Considering that many countries experience such difficulty, the adaptive capacity to climate change for this sub-sector must be considerably low. 4) Spatial Distribution of Vulnerability a) Climate Change An existing or newly installed observation system may possess uneven spatial distribution of vulnerability accorded by geological and disaster occurrence conditions. b) Sensitivity in the Disaster Prevention Information System Sub-sector As mentioned above, geological and disaster occurrence conditions will change the sensitivity of the climate observation system regardless of existing or newly developed ones. c) Adaptive Capacity ・The development level of the observation system differs according to the target countries, their natural attributes (climatic zones, geology, water resources, coastal and non-coastal areas) and population distributions. Thus, the adaptive capacity for the sub-sector is subject to these attributes. ・In addition, functional validity depends on the organizational capacity of the agencies in charge of operation and maintenance (O&M) of the system, and accessibility to the stations and other observation points.

C. Adaptation Measures	■ Development of Meteorological Observation Systems ・Development and improvement of meteorological observation systems covering the entire country and priority areas ・Development and improvement of a centralized telemetry monitoring system ■ Development of Hydrological Observation Systems ・Development and improvement of hydrological observation systems in major rivers and dams ・Development and improvement of a centralized telemetry monitoring system ■ Development of Tide Level Observation Systems ・Development and improvement of tidal level observation systems in coastal areas ・Development and improvement of a centralized telemetry monitoring system ■ Development of Clinometric Observation Systems ・Development and improvement of clinometric observation systems in mountainous and sloping terrain ・Development and improvement of a centralized telemetry monitoring system ■ Development of Dissemination System for Early Warning and Evacuation ・Installation of warning sirens in disaster-prone areas that are linked with observation systems ・Establishment of an early warning dissemination system which utilize Short Message Service (SMS) of mobile networks as means of transmission ■ Capacity Building of O&M for Observation Systems and Early Warning Systems ・Strengthening the capacity of O&M staff ・Regular evacuation drills for regional residents which are organized by agencies and organizations connected with O&M
D. Maladaptation	■ Maladaptation in Adaptation Measures Although various observation systems, monitoring frameworks, and early warning systems are established, extreme events due to climate change may damage the installed measurement instruments and the overall system, leading them to malfunction. ■ Maladaptation Common to "Business as Usual" Projects The established systems may not be fully utilized because of lack of operational and institutional capacities of the organization in charge. This will potentially result in malfunction of the system particularly in emergency cases. Catastrophic disaster may strike an area where the developed system does not cover for observation and monitoring.

Guideline: Development of Disaster Prevention Information System (Adaptation Project)

A. General	■ Necessity of Adaptation It is highly possible that the frequency and intensity of natural disasters associated with climate change will increase. The target area is very vulnerable since reliable or properly functioning observation systems for natural phenomenon are not available. The adaptation project for the sub-sector will need to establish observation systems for natural phenomenon which disseminate early warning for evacuation, thereby, minimizing human casualties caused by disasters and reducing overall vulnerability to natural disasters. ■ Adaptation Measures Enabling the dissemination of early warning through development and proper operation of observation and monitoring systems for natural phenomenon. ■ Outcome of Adaptation Measures Human casualties due to natural disasters that are associated with climate change will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Referring to existing references (National Communication (NC) and National Adaptation Program of Action (NAPA)), study and assess the climate trends from past to present (rainfall intensity and pattern, daily and seasonal temperature changes, frequency, intensity, and cycle of extreme events). 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions In addition to the above review of references, review national policies related to climate change, and discuss and confirm with counterpart organizations the applied climate change scenarios and analysis models, and target year for the implementation of adaptation measures. Qualitatively assess precipitation aspects such as intensity, frequency, and volume for the target year based on the analysis results on climate change. It will be useful to verify existing disaster-prone areas so that the information can be referred to in determining the locations of installing measurement instruments and facilities. b) Study Other Factors related to Socio-economic Changes No specific items considered here. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Identify past records whether observation facilities or measurement instruments have been damaged by natural disasters. b) Study Present Condition of Facilities and Measures No specific items considered here. c) Assess Future Sensitivity to Climate Change No specific items considered here.

	Step 2 4) Assess Adaptive Capacity to Climate Change a) Identification of Adaptive Capacity Assess existing conditions and functional validity of meteorological and hydrological observation facilities through field survey. Assess the present condition of early warning systems through meetings with the agencies and organizations concerned. Assess the present capacity of human resources of the organization in charge of O&M of the observation system and equipment through the meetings. b) Clarify Exacerbating Factors for Climate Change Impacts No specific items considered here. ↓ Step 3 5) Assess Vulnerability Assess vulnerability to climate change in the targeted area by overlapping the factors assessed in Steps 1 and 2.

Items	Low ← Vulnerability → High	
The past damages on observation and measurement facilities	Small	Large
Development level of observation and measurement facilities	High	Low
Development level of early warning system	High	Low
Present budget level related to observation system for natural phenomenon	High	Low
Present conditions of human resource and organizational capacities	High	Low

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
The past damages on observation and measurement facilities	Resilience against natural phenomenon will be strengthened	Qualitative	-
Development level of observation and measurement facilities	Observation and measurement facilities will be developed and utilized.	Quantitative	-
Development level of early warning system	Early warning system will be introduced and utilized.	Quantitative	-
Present budget level related to observation system for natural phenomenon	Sufficient budget for O&M will be allocated.	Quantitative	-
Present conditions of human resources and organizational capacity	Appropriate human resources will be recruited and individual capabilities will be improved to properly operate the developed system.	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Items	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Conditions of O&M (number of measurement instruments properly functioning, and number of locations for those installed)	Quantitative	-
Others	Number of early warnings performed in fact	Quantitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review
Continuous observation and data accumulation are the keys in establishing a disaster prevention information system. Therefore, it will be necessary to continuously monitor and review whether proper O&M for the facilities are undertaken.

2) Flexibility to Climate Change
No specific items considered here.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorological data	Identify the past and present meteorological conditions and trends through the review of NC, NAPA and other available relevant documents.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	In addition to the review of NC, NAPA, etc., qualitatively estimate the future climate including trends in temperature, rainfall pattern and intensity, and extreme weather using the available data from the analysis models and climate change scenarios adopted in the country.
3) Assess Future Sensitivity to Climate Change	Past damages on observation and measurement facilities	Identify the past records whether observation facilities or measurement instruments have been damaged by natural disasters, and assess the causes of damages and damage conditions, if available.
4) Assess Adaptive Capacity to Climate Change	Development level of observation and measurement facilities	Identify present conditions, functional validity and type of measurement for existing observation facilities through field survey
	Development level of early warning system	Identify the present conditions of the early warning system through meetings with the agencies and organizations concerned. If there is an existing system, identify the type of system, methods used, and actual operation conditions.
	Present budget level related to observation system for natural phenomenon	Identify the present budget levels allocated by the central or local government regarding disaster prevention and climate observation activities.

		Present conditions of human resources and organizational capacity	Identify and assess present capacity of human resources of the organization in charge of O&M of the observation system and equipment through the meetings.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

References and Key Different Features

1) Weather Info for All Initiative 2008-2012[1]
This document examines the issues of the weather observation network in Africa, proposing to utilize existing mobile network sites to install automatic weather stations for data collection and information dissemination. In line with the proposal, this guideline mentions the utilization of SMS for information dissemination since the penetration rates of mobile phones in developing countries are relatively high.

[1] WMO, the Earth Institute, Global Humanitarian Forum, Zain, and Ericsson. (2008). Weather Info for All Initiative 2008-2012.

10. Rural / Urban Development Sub-Sector

Guideline:

(1) Rural Development (Adaptation Project)
(2) Rural Development (BAU Development with Adaptation Options)
(3) Urban Development (Adaptation Project)
(4) Urban Development (BAU Development with Adaptation Options)

Basic Concept (Rural Development)

A. General Concept	In rural areas where income levels are relatively low in general, overall vulnerability to climate change is considered high, while adaptive capacity is low. Adaptation to climate change in this sub-sector will require a cross-cutting or multi-sectoral approach aiming at rural development based on structural and non-structural measures. The former is represented by development of small / medium-scale infrastructures, while the latter could be by poverty alleviation. Adaptation measures should be conducted in combination of both measures and several sectors in order to reduce overall vulnerability of rural areas.
B. Vulnerability	1) Major Climate Change Impacts on the Rural Development Sub-sector In rural areas where the primary industry represented by agriculture is the main productive activity, the increased uncertainty of future climate conditions will affect cropping patterns and decisions. Flooding and sediment-related disasters due to the increased frequency and intensity of extreme events will potentially damage basic infrastructure in rural areas. <u>■ Decrease in Rainfall and Change in Rainfall Patterns</u> ・Available amount of portable water will be reduced. ・Reduced rainfall and irrigation water will impact on agricultural productivity ・Lack of water resources will cause difficulty to secure livestock water. <u>■ Increase in Rainfall Amount and Intensity, Increase in Frequency and Intensity of Extreme Events</u> ・The available amount of water demand of rainfed and irrigated agricultural lands will increase, resulting in increased crop yields. ・Heavy storm and wind will damage crops and perennial trees. ・Storm surge will cause salt-water intrusion into soil and potentially lead to chronic salt erosion in the coastal rural areas. Salt breeze will cause saline stress on the plants. ・Facilities for agriculture and livestock will be physically damaged due to extreme events. ・Heavy storm and winds will erode unpaved rural roads surface and potentially make them impassable. ・In mountainous and sloping areas, sediment-related disasters such as landslides will isolate an area from another, as well as cause physical damages and casualties. ・Flood and sediment-related disasters will reduce arable land areas through direct damages on agricultural land. <u>■ Increase in Frequency and Duration of Drought</u> ・It will cause disastrous crop failure for rainfed agriculture. ・It will cause regional famine due to food shortage and difficulty in transportation. ・It will cause difficulty to secure potable water for rural residents. <u>■ Temperature Rise</u> ・Some types of crops will achieve higher yields, while higher temperature will damage some other crops. ・Demand for potable water will increase.

	■ Sea Level Rise ・Coastal and plain areas will be affected by saltwater intrusion and then cause groundwater salinization, inundate residential areas, and possibly cause salt damage on agricultural soil. ■Others ・Crop disease and pest damage will increase, and alien species may arise. ・Temperature rise and change in rainfall pattern may increase the vector for infectious diseases. 2) Other Factors that Influence the Rural Development Sub-sector Associated with Climate Change Impacts ・Changes in the proportion of population between urban and rural areas, industrial structures and rural development policy will affect development issues in rural areas. 3) Adaptive Capacity to Climate Change ・The adaptive capacity is high if the development level of socio-economic infrastructure is high. Such infrastructures are for schools, clinics, small-scale irrigation, agricultural extensions, water supply and sanitation, access roads, electricity, flood and sediment control. ・Intensive organizational programs at community level suggest strength of self-help capability, thereby indicating a high adaptive capacity. ・The adaptive capacity is likely higher if socio-economic conditions such as income and education levels are better. ・The adaptive capacity is likely higher if development activities of the local government and NGOs are active. 4) Spatial Distribution of Vulnerability a)Climate Change ・When the target areas are extended to wider areas or dispersed by spots, vulnerability may differ in these locations. Otherwise, it is considered unique. ・Saltwater intrusion and damages will be significant in coastal areas. ・Flood damage will likely affect low-lying terrain. ・Sediment-related disasters will be concentrated on sloping and mountainous areas. b)Sensitivity in the Rural Development Sub-sector ・Sensitivity may differ by regional development levels of socio-economic infrastructure. c)Adaptive Capacity ・Adaptive capacity may differ by regional development levels of socio-economic infrastructure. ・Adaptive capacity may differ by socio-economic conditions of local residents.
C. Adaptation Measures	Major Adaptation Measures in the Rural Development Sub-sector ■ Introduction of Irrigation and Drainage Facilities ・Development of small to medium-scale irrigation and drainage facilities

	■ Enhancement of Farm Management ・Reform of cropping patterns including choice of crops, improvement of watering, soil fertilization, pest and weed control, and proper application of agricultural input materials ■ Development of Hygiene Management Facilities ・Development of shallow wells, water supply, sewerage systems, and public toilets ・Development and upgrading of healthcare centers and clinics ■ Development of Rural Road and Bridge ・Development of inter-village roads ・Development and rehabilitation of access roads connecting to trunk roads. ■ Rural Electrification ・Introduction of small-scale hydropower generation ・Connecting to the national grid ■ Structural Measures of Rural Disaster Prevention Facilities ・Development of dikes, gates, and other river structures as flood damage prevention measures ・Development of slope protection and sabo dams as sediment-related disaster prevention. ■ Non-structural Measures for Rural Disaster Prevention ・Development and installation of simple early warning systems ・Development of hazard maps ・Promotion of community disaster management and implementation of evacuation drills ■ Others As other supporting measures for the improvement of living conditions, income levels, and reducing impacts from climate change, the following are considered: ・Strengthening community organizations aimed at regional development, operation and maintenance of rural infrastructure ・Providing microcredit or microfinance *(Refer to the related adaptation measures examined in other sub-sectors for more details.)*
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Project benefits may be unevenly distributed within the target areas. This will create regional gaps in beneficiaries resulting in the increase of vulnerability to climate change of some residents. ■ Maladaptation Common to “Business as Usual” Project ・Project benefits may be distributed only to some portion of the beneficiaries. This creates a regional gap within the target areas.

Guideline: Rural Development (Adaptation Project)

A. General	■ Necessity of Adaptation Maintaining basic human needs (BHN) in rural areas are exposed to the risk of climate change impacts, which can potentially worsen living environment that would have been achieved without climate change. ■ Adaptation Measures Rural infrastructure development and support of rural livelihood will improve and maintain primary living environment in rural areas. ■ Outcome of Adaptation Measures Climate change vulnerability of rural areas will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect the available past meteorological records referring to rainfall intensity and patterns, seasonal or daily changes of temperatures, cycles of extreme events, and surface and groundwater conditions from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, review the climate change policy of the country, and confirm the climate change scenarios, analysis models, and the target year for the implementing of adaptation measures suitable in the country. Estimate rural environmental aspects related to climate for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for urban and rural development planning through review of the regional and urban development plans, land use regulations, etc. in order to identify factors affecting vulnerability. For instance, the following are considered as the factors: ・Changes in policy for urban and regional development plans in and around the target areas. ・Mass population migration from rural areas associated with rapid growth of the closest urban areas. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Identify the past damages in rural areas brought about by extreme weather events such as drought, heat wave, heavy rain and flood, through hearing from the stakeholders (regional government department concerned and local residents). b) Study Present Condition of Facilities and Measures Assess the present conditions of rural infrastructure and their functional validities through reconnaissance survey and meetings with the stakeholders such as regional government department concerned and local residents. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity to climate change of rural livelihood based on the relationship between past problems related to rural infrastructure and meteorological

conditions, and future climate conditions with consideration on future socio-economic change factors.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
・Apply the results of Item 3) b) Present Condition of Facilities and Measures.
・Assess the present organizational capacity and conditions of residents through meetings with stakeholders such as regional government department concerned and local residents.
・Assess the involvement of the regional or local government department concerned and NGOs for rural development. This is to identify the present situation of BHN support in rural areas. The following are the indicators:

- Budget level and supporting programs of the regional or local government regarding rural infrastructure development
- Present activities of NGOs.

b) Clarify Exacerbating Factors for Climate Change Impacts
・Socio-economic conditions of rural residents
Assess the socio-economic conditions of rural residents in order to verify the overall adaptive capacity as well as the gaps within the target areas. The following are the indicators:

- Ethnic minorities and resettlement areas: socio-economic gaps with other areas and potential discrimination issues
- Farm income shares to overall income: potential impacts on farmers by crop failure due to extreme events
- Education level: adaptive capacity to climate change
- Health conditions of residents: climate change impacts on rural labor supply due to exacerbated hygienic environment in rural areas
- Level of government subsidies: residents' motivation toward voluntary actions

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Step 1 and 2 as follows:

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Conditions of rural infrastructures and their functional validities	Good	Poor
Organizational capacity and conditions of residents	High	Low
Involvement of the regional / local government department and NGOs concerned	Good	Poor
Socio-economic conditions of rural residents	Good	Poor

C.
Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change (conditions of rural infrastructures and their functional validities)	Damages to crops will be reduced. Farm income level will be stable. Income sources will be diversified.	Quantitative	・Area cultivated by crop ・Area harvested by crop ・Agricultural gross income ・Production volume by crop ・Crop yield ・Sales volume and price by crop ・Production cost by crop ・Agricultural gross income per household ・Irrigated area ・Actual irrigated area ・Collection Ratio of Water Charge ・Number of Water Association ・Production Volume of Major Crops ・Annual Income Increase of Each Farmer Level ・Productivity of Major Crops
	Water served population will increase. Hygienic environment will be improved. Medical / healthcare facilities will be sufficiently available.	Quantitative	・Percentage of Served Population ・Sewerage Served Ratio ・Birthrate / Mortality Rate ・Infant Mortality Rate ・Mortality Rate by Incidence ・Morbidity Rate
	Number of electrified households will increase.	Quantitative	・Electrification Rate
	Education level will be improved.	Quantitative	・Increase in School Enrollment Ratio ・Increase in the Number of Students Proceeding to a Higher School
	Rural road network and total road length will be improved.	Quantitative	-
Conditions of rural infrastructures and their functional validities	Same as above*	Quantitative or Qualitative	・Same as above*
Organizational capacity and conditions of residents	Community organizations will be formed and strengthened.	Qualitative	-

Involvement of the regional / local government department and NGOs concerned	Living environment in rural areas will be improved.	Qualitative	-
Socio-economic conditions of rural residents	Community adaptive capacity to climate change will be improved.	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	・ Relative Operation and Effect Indicators
Structural measures	Improvement of the target return period by expanded and newly developed facilities	Quantitative	-
Non-structural measures	Improvement of the target return period of target areas by O&M improvement	Quantitative	-
Others	Changes in the number of beneficiaries	Quantitative	-
	Changes in stakeholders' awareness on climate change	Qualitative	-

*Note: For this sub-sector, the prospective target infrastructure for the project cannot be determined until actual field survey and study on climate change impacts are implemented. Furthermore, expected adaptation measures will comprise of multi-sectoral or crosscutting measures. Therefore, prior to formulating the preparatory survey, it is difficult to distinguish the facilities in order to assess the sensitivity from other facilities and to assess the adaptive capacity. In this regard, assessment items are identical for both categories. Each adaptation measure for respective infrastructure and facilities can be found in the other individual sub-sectors as presented below for more detailed references.

Measures	Referable Sub-Sector
Small to Medium-scale Irrigation and Drainage	Irrigation and Drainage ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Supporting Agriculture and Farm Management	Farmland Management Enhancement ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Sanitary Improvement for Water Supply and Rural Water Development	Water Supply ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Sanitary Improvement for Sewerage, and Drainage	Sewerage / Urban Drainage ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Medical / Healthcare Facilities	Medical/Health Care ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Rural Roads and Bridges	Bridge/Road/Railway ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Disaster Management in Rural Areas	Flood Control ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures") Sediment-related Disaster Prevention ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")

<table>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>1) Monitoring and Review
Plan the periodical schedule for monitoring of climate condition, and review after project implementation. Climate change impacts that are not considered for the project scope but have certain risks shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts that are not considered for the project scope but has certain risks. The range of flexibility shall be determined with counterpart agencies.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.</td></tr>
<tr><td>E.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present meteorological data</td><td>Collect data such as meteorological data and river discharge from meteorological stations and hydrological stations, if available.</td></tr>
<tr><td>2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological (and hydrological) data in the target area.</td></tr>
<tr><td>3) Assess Future Sensitivity to Climate Change</td><td>Conditions of rural infrastructures and their functional validities</td><td>Identify present conditions of rural infrastructure related to rural livelihood and their functional validities through reconnaissance survey and meetings with the stakeholders.</td></tr>
<tr><td rowspan="4">4) Assess Adaptive Capacity to Climate Change</td><td>Conditions of rural infrastructures and their functional validities</td><td>Same as above.</td></tr>
<tr><td>Organizational capacity and conditions of residents</td><td>Identify present community organizations, their capacity and performances through meetings with stakeholders, assessing regional gaps within the target areas as well as focus areas on agriculture, commercial, gender, youth, and elderly.</td></tr>
<tr><td>Involvement of the regional / local government department and NGOs concerned</td><td>Identify budget level of regional/local government department concerned for rural development, and involvement of NGO activities for rural development to assess regional gaps within the target areas. It is ideal to focus on the smallest administration unit (village or district) if possible.</td></tr>
<tr><td>Socio-economic conditions of rural residents</td><td>It is ideal to focus by village, district, or whichever is lowest administration unit, if possible. While studying secondary sources from statistical offices, it is necessary to conduct interview and provide questionnaire surveys.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.</td></tr>
</table>
</td></tr>
</table>

Guideline: Rural Development (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td>■ <u>Necessity of Adaptation Options</u>
BAU infrastructure project will be implemented for rural development. However, the anticipated climate change will cause difficulty in maintaining the expected livelihood and living environment in the rural areas, which requires considering the adaptation options to climate change impacts.
■ <u>Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
■ <u>Outcome of Adaptation Options</u>
In case the target areas are exposed to climate change, the rural system will function properly and the area can sustain living environment.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organizations the applied climate change scenarios and analysis models, and the target year for the implementation of adaptation measures. Project the climate conditions at the planned base year using the analysis results of climate change projection for the target year. Accordingly, it is necessary to identify the major problems and risks brought by climate change. This will aid in planning the necessary adaptation options.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Various adaptation options will be considered according to the nature of climate change impact. Generally, the following options will be adopted: irrigation and drainage, flood control, sediment-disaster prevention, farm management support, sanitary improvement for water supply and sewerage and community water supply), regional healthcare services and facilities, rural road network, community organizational strengthening, and microfinance.

(For more details on the adaptation options, refer to “Basic Concept (Rural Development)” and other guidelines of relevant sub-sectors.)</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Future sensitivity to climate change</td><td>Reduced sensitivity to climate change will decrease vulnerability. (The outcome will depend on projected climate change impacts and components of the project.)</td><td>Quantitative or Qualitative (depending on the project components)</td><td>・Depending on the project components to be undertaken</td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of the target return period by expanded and/or newly developed facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Non-structural measures</td><td>Improvement of the target return period in target area by O&M improvement</td><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="2">Others</td><td>Changes in the number of beneficiaries</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in stakeholders’ awareness on climate change</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

Each adaptation measure for respective infrastructure and facilities can be found in other individual sub-sectors as presented below for more detailed references.

Measures	Referable Sub-Sector
Small to Medium-scale Irrigation and Drainage	Irrigation and Drainage (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Supporting Agriculture and Farm Management	Farmland Management Enhancement (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Sanitary Improvement for water supply and rural water development	Water Supply (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Sanitary Improvement for sewerage and Urban Drainage	Sewerage / Urban Drainage (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Medical/Healthcare Facilities	Medical/Health Care (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Rural Roads and Bridges	Bridge, Road, and Railway (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)
Disaster Management in Rural Areas	Flood Control (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”) Sediment-related Disaster Prevention (“Planning Adaptation Option”, “Project Evaluation of Adaptation Options”)

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review
Plan the periodical schedule for monitoring of climate conditions, and review after project implementation. Climate change impacts that are not considered for the project scope but have certain risks shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts that are not considered for the project scope but have certain risks. The range of flexibility shall be determined with counterpart agencies.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and other observation data in the target area. Since the estimated result will determine the type of adaptation options, it requires careful clarification.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Civil Engineering in Global Warming[1]

This document discusses adaptation measures for coastal protection, water and sewage systems for urban and rural areas in the civil engineering perspective. As climate change affects urban life in Japan, the document suggests the effectiveness to adapt recycled water from sewerage systems, introduction of water conservation facilities and equipment, and development of new dams in order to reduce the impacts of drought. For flood mitigation, the following measures were proposed: development of flood regulating storage, rainwater absorbent facility, regulation of low-lying land use, mobile levee, drainage pump, preparation of hazard map, and hazard information dissemination system.

2) Wise Adaptation to Climate Change[2]

This document assesses the climate change impacts and adaptation measures from five aspects, namely, “safe livelihood”, “healthy livelihood”, “wealthy livelihood”, “comfortable livelihood”, and “culture and history-sentient livelihood” with respect to rural and urban development, which requires multi-sectoral approach. It also argues the impacts and measures for each specific sector comprised of disaster prevention, water supply and sanitation, human health, food, and ecosystem.

[1] Japan Society of Civil Engineers. (2009). Chikyu Ondanka ni Idomu Doboku Kougaku – Dai 4 pen: Chikyu Ondanka ni taisuru Tekiousaku. (in Japanese).

[2] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 7 Kokumin Seikatsu / Toshi Seikatsu Bunya. (in Japanese).

Basic Concept (Urban Development)

A. General Concept	Increase in intensity and frequency of rainfall and temperature rise due to the anticipated climate change will negatively affect on hygienic environment of urban areas. In the areas where drainage system and network are under malfunction or insufficient capacity, human settlement in urban areas is exposed to higher risks of inundation by flood water, which contains both contaminated water and rainwater. Such inundation in urban areas will potentially cause outbreak of infectious diseases and stagnate economic activities. Decrease in rainfall amount and sea level rise will reduce the available water resources and reduce capability of urban water supply. In coastal cities, storm surge will inundate the settlement areas and cause coastal / beach erosion. In this sub-sector, it is important to incorporate components of urban disaster prevention into the usual urban development scenario. Thus, the key feature of this sector is to increase resilience to climate change impacts and to reduce vulnerability of human settlement in urban areas.
B. Vulnerability	1) Major Climate Change Impacts on the Urban Development Sub-sector <u>■ Decrease in Rainfall and Change in Rainfall Patterns</u> ・Available amount of portable water will be reduced. <u>■ Increase in Rainfall Amount and Intensity, Increase in Frequency and Intensity of Extreme Events</u> ・Flood in urban areas including roads, commercial / residential areas will frequently occur due to malfunction of drainage system. ・Due to the increased frequency and intensity of floods, economic activities will stagnate and deteriorated hygienic environment will potentially increase the epidemics in urban areas. ・Risk of river flood will increase. ・Coastal areas will be affected by storm surge, coastal erosion, stressing available land use ・In mountainous and sloping areas, sediment-related disaster such as landslides may frequently occur. <u>■ Temperature Rise</u> ・Increased demand for portable water will increase water stress. ・Heat-island phenomenon will increase human health impacts represented by heat stroke. <u>■ Sea level rise</u> ・Coastal and plain areas will be affected by saltwater intrusion which will cause groundwater salination, inundation in residential area, and limit land use availability. ・It will impact on logistics facilities such as coastal roads, ports and airports. <u>■ Others</u> ・Temperature rise and change in rainfall pattern may increase or decrease harmful vector species for human health.

	2) Other Factors that Influence the Urban Development Sub-sector Associated with Climate Change Impacts ・Changes in population composition between urban and rural areas, industrial structures and urban development policy will affect development issues in urban areas. 3) Adaptive Capacity to Climate Change ・If development level of socio-economic infrastructures (water supply, sewerage and drainage systems, overpass roads, dykes, breakwater, hospital, greening facilities and so forth) is high, adaptive capacity is high. ・If development level of emergency facilities (early warning system, designated evacuation centers, storage facilities for emergency foods and goods and so on) and hazard maps is high, adaptive capacity is high. ・If the municipal budget for urban development is high, and activities for disaster management are proactive, adaptive capacity is high. 4) Spatial Distribution of Vulnerability a) Climate Change ・Since possible target areas will be limited to a city and its suburban areas, there may be no regional difference of climate change impacts. ・Saltwater intrusion or damages by saltwater will be significant in the coastal areas. ・Flood damage will likely affect low-lying terrain. ・Sediment-related disaster will concentrate on sloping mountainous areas. b) Sensitivity in the Urban Development Sub-sector ・ Sensitivity may differ by regional development levels of socio-economic infrastructures. ・Sensitivity may differ if the target areas include slum / poverty areas. c) Adaptive Capacity ・Adaptive capacity may differ by regional development levels of socio-economic infrastructures. ・Adaptive capacity may differ by socio-economic conditions of local residents.
C. Adaptation Measures	Major Adaptation Measures in the Urban Development Sub-sector ■ Rehabilitation and Expansion of Urban Drainage Systems ・Rehabilitation and expansion of existing drainage channels, pump stations, and flood regulating ponds to increase drainage capacity during intensive rainfall. ■ Rehabilitation and Expansion of Water supply and Sewerage Systems ・Rehabilitation and expansion of water supply system, and development of alternative water sources to increase supply capacity for urban areas. ・Development, rehabilitation and expansion of sewerage system to improve drainage and treatment capacity for urban areas. ■ Development, Rehabilitation and Expansion of Roads and Bridges ・Raising existing road, building overpass, conducting slope protection works, installing windbreak walls, developing road drainage networks.

	■ Development of Urban Disaster Management Facilities (Structural Measures) ・Strengthening and rehabilitating riverbank protection works such as dyke and gate for flood control. ・Developing breakwater and coastal protection works against sea level rise and storm surge in coastal cities. ・Developing slope protection and drainage works, forestation to reduce sediment discharge and landslides in mountainous areas. ・Developing and expanding designated evacuation centers. ・Developing and expanding emergency storage for relief goods. ■ Non-structural Measures for Urban Disaster Management ・Developing disaster forecasting and early-warning system. ・Developing hazard maps. ・Promoting community disaster management, conducting evacuation drill. ■ Others ・Developing and expanding medical / healthcare facilities. ・Facilitating schools as evacuation centers, introducing disaster management education ・Development of green areas and parks. *(Refer to the related adaptation measures examined in other specific sub-sectors for more details.)*
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Improved function and increased resilience of city / urban areas may attract population inflow, resulting in increase of vulnerability to climate change. ■ Maladaptation Common to "Business as Usual" Project ・Project benefits may be distributed only to some portion of the beneficiaries. This creates a regional gap within the target areas. ・Climate change impacts may become greater than estimated and design capacities adopted for the project may be insufficient as a result.

Guideline: Urban Development (Adaptation Project)

A. General	<u>■ Necessity of Adaptation</u> Climate change will affect on regular functions of cities / urban areas, and make it difficult to maintain ordinary livelihood. <u>■ Adaptation Measures</u> The development of urban infrastructure will improve and sustain primary conditions of urban livelihood. <u>■ Outcome of Adaptation Measures</u> Vulnerability of urban areas will be reduced.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect the available past meteorological records referring to rainfall intensity and patterns, seasonal and daily changes of temperature, cycles of extreme events, and conditions of surface and groundwater from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, review the climate change policy of the country, and confirm the climate change scenarios and analysis models, and the target year for the implementation of adaptation measures suitable in the country. Estimate urban environmental aspects related to climate for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for vulnerability of urban areas through review of regional and urban development plans, land use regulations, etc. in order to identify factors affecting vulnerability. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Identify past damages in urban areas brought about by extreme weather events such as drought, heat waves, heavy rains, floods, storm surges, and sediment erosion through meetings with the stakeholders (municipal government department concerned and local residents). b) Study Present Condition of Facilities and Measures Assess the present conditions of urban infrastructure and their functional validities through reconnaissance survey and meetings with the stakeholders (municipal government department concerned and local residents). c) Assess Future Sensitivity to Climate Change Assess the future sensitivity of urban livelihood to climate change based on the relationship between past problems related to urban infrastructure, meteorological conditions, and future climate condition, with consideration on future socio-economic change factors.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
・Apply the results of Item 3) b) Present Condition of Facilities and Measures.
・Involvement of the municipal government and NGOs concerned
Assess the involvement of the municipal government department and NGOs concerned in order to assess past and present programs for adaptation measures in urban development. The following are the indicators:

- Budget level and supporting activities of the municipal government regarding urban infrastructure development.
- Present activities of NGOs.

b) Clarify Exacerbating Factors for Climate Change Impacts
・Socio-economic conditions of urban residents.
Assess the socio-economic conditions of urban residents in order to verify the overall adaptive capacity as well as the gaps within the target areas. The following are the indicators:

- Existence of slum and poverty-stricken areas: socio-economic gaps with other areas and potential discrimination issues
- Sectoral employment rates and income level: adaptive capacity to climate change
- Education level and health care system level: adaptive capacity to climate change
- Level of government subsidies: residents' motivation toward voluntary actions

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2 as follows:

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Conditions of urban infrastructures and their functional validities	Good	Poor
Involvement of the municipal government department and NGOs concerned	Good	Poor
Socio-economic conditions of urban residents	Good	Poor

C. Project Evaluation of Adaptation Measures	[Items for Assessment in Project Formulation]			
	Items	**Outcome**	**Method**	**Relative Operation and Effect Indicators**
	Future sensitivity to climate change (conditions of urban infrastructures and their functional validities)	Flood damages will be reduced. Other urban disaster impacts will be reduced or prevented.	Quantitative	・Flooded Area ・Flooded Houses ・Economic Value of Damage ・Affected population ・Maximum Inundation Depth ・Inundation Time
		Water supply volume and served population will increase. Hygienic environment will be improved.	Quantitative	・Water Supply ・Unaccounted-for water (UFW) ・Percentage of Water Loss ・Raw Water Intake ・Accounted for Water Rate ・Water Quality ・Percentage of Served Population ・Income ・Land Subsidence ・Sewerage Treatment Amount ・Population Served by Sewerage ・Sewerage Service Fee ・Area Served ・Total Length of Sewerage Pipe ・BOD of Inlet Waste Water ・BOD of Outlet Treated Water ・Collection Efficiency ・Treated Sludge Amount ・Sewerage Served Ratio ・River Polluted Condition
		Medical / healthcare facilities and services will be improved.	Quantitative	・Birthrate / Mortality Rate ・Infant Mortality Rate ・Mortality Rate by Incidence ・Morbidity Rate
		Education level will be improved.	Quantitative	・Increase in School Enrollment Ratio ・Increase in the Number of Students Proceeding to a Higher School
		Urban transportation capacity and road network will be improved	Qualitative	-
		Disaster management capacity will be improved.	Qualitative / Quantitative	-

Conditions of urban infrastructures and their functional validities	Same as above*	Qualitative / Quantitative	・Same as above*
Involvement of the municipal government department and NGOs concerned	Living environment in urban areas will be improved.	Qualitative	-
Socio-economic conditions of urban residents	Urban community adaptive capacity to climate change will be improved.	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of the target return period by expanded and/or newly developed facilities	Quantitative	-
Non-structural measures	Improvement of the target return period in target area by O&M improvement	Quantitative	-
Others	Changes in the number of beneficiaries	Quantitative	-
	Changes in stakeholders' awareness on climate change	Qualitative	-

*Note: For this sub-sector, the prospective target infrastructure for the project can not be determined until actual field survey and study on climate change impact are implemented. Furthermore, expected adaptation measures will comprise of multi-sectoral or crosscutting measures. Therefore, prior to formulating the preparatory survey, it is difficult to distinguish the facilities in order to assess sensitivity from other facilities and to assess the adaptive capacity. In this regard, assessment items are identical for both categories. Each adaptation measure for respective infrastructure and facilities can be found in the other individual sub-sectors as presented below for more detailed references.

Measures	Referable Sub-Sector
Water Supply and Sewerage Systems	Water Supply and Sewerage ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Urban Drainage System	Urban Drainage ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Roads and Bridges	Bridge / Road / Railway ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Disaster Management in Urban Areas	Flood Control ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures") Coastal Protection ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures") Sediment-related Disaster Prevention ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")
Medical / Healthcare Facilities	Medical / Health Care ("Vulnerability Assessment", "Project Evaluation of Adaptation Measures")

<table>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>1) Monitoring and Review
Plan the periodical schedule for monitoring of climate conditions, and review after project implementation. Climate change impacts that are not considered for the project scope but have certain risks shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts that are not considered for the project scope but have certain risks. The range of flexibility shall be determined with counterpart agencies.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.</td></tr>
<tr><td>E.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present meteorological data</td><td>Collect data such as meteorological data and river discharge from meteorological stations (and hydrological stations if applicable).</td></tr>
<tr><td>2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>Project future climate using data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological (and hydrological) data in the target area.</td></tr>
<tr><td>3) Assess Future Sensitivity to Climate Change</td><td>Conditions of urban infrastructures and their functional validities</td><td>Identify present conditions of urban infrastructures related to urban livelihood and their functional validities through reconnaissance survey and meetings with the stakeholders.</td></tr>
<tr><td rowspan="3">4) Assess Adaptive Capacity to Climate Change</td><td>Conditions of urban infrastructures and their functional validities</td><td>Same as above.</td></tr>
<tr><td>Involvement of the municipal government department and NGOs concerned</td><td>Identify budget level of municipal government department concerned for rural development, and involvement of NGO activities for rural development to assess regional gaps within the target areas.</td></tr>
<tr><td>Socio-economic conditions of urban residents</td><td>It is ideal to focus on the smaller administration unit if possible. While studying secondary sources from statistical offices, it is necessary to conduct investigation and give questionnaire surveys.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.</td></tr>
</table>
</td></tr>
</table>

Guideline: Urban Development (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
BAU infrastructure project will be implemented for urban infrastructure development. However, the anticipated climate change will cause difficulty in maintaining the expected living environment in the urban areas, which requires considering the adaptation options to climate change impacts.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
In case the target areas are exposed to climate change, the urban system will function properly and the area can sustain living environment.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organizations the applied climate change scenarios and analysis models, and the target year for the implementation of adaptation measures. Project the climate conditions at the planned base year using the analysis results of climate change projection for the target year. Accordingly, it is necessary to identify the major problems/risks brought by climate change. This will aid in planning the necessary adaptation options.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Various adaptation options will be considered according to the nature of climate change impact. Generally, the following options will be adopted:

Urban drainage system, sanitary improvement (water supply and sewerage), urban disaster management (structural and non-structural measures), regional healthcare services and facilities, trunk roads, highway network.

(For more details on the adaptation options, refer to “Basic Concept (Urban Development)” and other guidelines of relevant sub-sectors.)</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Future sensitivity to climate change</td><td>Reduced sensitivity to climate change will decrease vulnerability. (The outcome will depend on projected climate change impacts and components of the project)</td><td>Quantitative or Qualitative (depending on the project components)</td><td>・ Depending on the project components to be undertaken</td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of the target return period by expanded and newly developed facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Non-structural measures</td><td>Improvement of the target return period of target areas by O&M improvement</td><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="2">Others</td><td>Changes in the number of beneficiaries</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in stakeholders’ awareness on climate change</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

Each adaptation measure for respective infrastructure and facilities can be found in other individual sub-sectors as presented below for more detailed references.

Measures	Referable Sub-Sector
Water Supply and Sewerage Systems	Water Supply and Sewerage (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”)
Urban Drainage System	Urban Drainage (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”)
Roads and Bridges	Bridge / Road / Railway (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”)
Disaster Management in Urban Areas	Flood Control (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”) Coastal Protection (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”) Sediment-related Disaster Prevention (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”)
Medical / Healthcare facilities	Medical / Health Care (“Vulnerability Assessment”, “Project Evaluation of Adaptation Options”)

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review
Plan the periodical schedule for monitoring of climate conditions, and review after project implementation. Climate change impacts that are not considered for the project scope but have certain risks shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts that are not considered for the project scope but have certain risks. The range of flexibility shall be determined with counterpart agencies.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate using data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and other observation data in the target area. Since the estimated result will determine the type of adaptation options, it requires careful clarification.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Civil Engineering in Global Warming[1]

This document discusses the adaptation measures for coastal protection, water and sewage systems, urban life and rural life in the eyes of civil engineering.

As climate change affects urban life in Japan, the document suggests the effectiveness to adapt recycled water from sewerage systems, introduction of water conservation facilities and equipment, and development of new dams in order to reduce the impacts of drought. For flood mitigation, the following measures were proposed: development of flood regulating storage, rainwater absorbent facility, regulation of low-lying land use, mobile levee, drainage pump, preparation of hazard map, and hazard information dissemination system.

2) Wise Adaptation to Climate Change[2]

This document assesses the climate change impacts and adaptation measures from five aspects, namely, “safe livelihood”, “healthy livelihood”, “wealthy livelihood”, “comfortable livelihood”, “culture and history-sentient livelihood” with respect to rural and urban development, which requires multi-sectoral approach. It also argues the impacts and measures for each specific sector comprising of disaster prevention, water supply and sanitation, human health, food, and ecosystem.

[1] Japan Society of Civil Engineers. (2009). Chikyu Ondanka ni Idomu Doboku Kougaku – Dai 4 pen: Chikyu Ondanka ni taisuru Tekiousaku. (in Japanese).

[2] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 7 Kokumin Seikatsu / Toshi Seikatsu Bunya. (in Japanese).

11. Bridge, Road and Railway Sub-sector

Guideline:

(1) Bridge, Road and Railway (Adaptation Project)
(2) Bridge, Road and Railway (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Climate change will increase rainfall intensity, exceeding the drainage capacity of roads and railways, and cause slope failures and landslides resulting in traffic disturbance. The occurrence of traffic accidents and traffic restrictions will increase, and it will stagnate economic activities, damage traffic structures, and trigger other accidents. In another case, some structures will require reinforcement or rehabilitation in association with the rise of sea water and river water levels, and the increase of wind loads due to the increase and intensification of cyclones. The adaptation measures in the bridge, road and railway sub-sector are to secure the safety of traffic as a requisite for roads and railways, and to reduce the damages on related structures and users. *(The vulnerability, adaptation measures and maladaptation for bridge, road and railway structures in coastal areas are also to be referred in the coastal protection sub-sector.)*
B. Vulnerability	1) Major Climate Change Impacts on the Bridge, Road and Railway Sub-sector <u>■ Increase/ Intensification of Precipitation</u> ・Increase in the base flow and flood discharge of a river will reduce the clearance of existing bridges, consequently increasing the risk of overtopping and washing out of these bridges. ・Heavy rainfall beyond the drainage capacity will cause flood damages. ・Increased sediment discharge into drainage facilities will decrease drainage capacity. ・The risk of flood damage in underground spaces, such as subways, is likely to increase. ・The occurrence of slope failures and landslides would cause traffic restrictions or disruptions. <u>■ Increase/ Intensification of Cyclone</u> ・Increase of wind speed will affect the static and dynamic behavior of bridges to a certain scale, in which their safety would be reduced. ・The risks for the washing away of tracks and roadbeds and falling of roadside trees will increase, as well as damage to facilities for generation, transmission, distribution and transformation of electricity for railway. ・Storm surges in association with sea level rise will bring larger damage to bridges, roads and railways along the coastal area, and consequently increasing the risks of bridge washout and embankment failure. ・The increase of precipitation and wind speeds will cause traffic restrictions and speed limitations more frequently. ・Damages on buildings, such as stations and bus stops, will increase. 2) Other Factors that Influence the Bridge, Road and Railway Sub-sector Associated with Climate Change Impacts ・Deforestation in the upstream area will change the runoff characteristics of river. ・Policy changes on river development will change the flood characteristics of river. ・Vegetation changes due to activities such as tree cutting will reduce slope stability. 3) Adaptive Capacity to Climate Change ・If alternative traffic schemes or detours are available, traffic interruption would be avoided even at traffic restriction.

	・If non-structural measures which, for example, can communicate and indicate information and suspend traffic with automatic detection of slope and embankment failures and occurrence of debris flow are implemented, human casualties due to structural damage would be reduced. ・If hazard maps, and evacuation guides from underground spaces and leading to detour or alternative traffic are sufficiently prepared and implemented by regulatory agencies, human casualties and traffic interruptions would be reduced. ・If the budget and programs for disaster recovery are well in place, disaster response capability of regulatory agencies is high. ・If research institute related to bridge, road and railway, or disaster prevention exists and are well-organized, the adaptive capacity for climate change is high. 4) Spatial Distribution of Vulnerability a) Climate Change ・If the target area is extensive, the spatial difference of climate change impact shall be studied. b) Sensitivity in the Bridge, Road and Railway Sub-sector ・Sensitivity varies based on installation condition, design conditions, development level, and maintenance level of facilities and sections. ・Bridges with certain scales and shapes are affected by the increase of wind speed. ・Sensitivity to slope failure, landslide, and flood damage varies based on topography and geology. ・Human casualties and property damage tend to be larger underground. c) Adaptive Capacity ・Ability for evacuation guidance, leading to detour and alternative traffic schemes, and disaster resilience would vary if management is different for each facility or section.
C. Adaptation Measures	Major Adaptation Measures in the Bridge, Road and Railway Sub-sector ■ Bridge ・Raising ・Replacement in association with river improvement ・Wind resistance measures ■ Road and Railway ・Slope stabilization ・Realignment or change of route (including tunnel route) ・Raising of roadbed ・Installation and enhancement of drainage facilities ・Construction of underground tunnels for urban roads with drainage pipes at the bottom (as a part of urban flood mitigation) ・Flood prevention measures at subway entrances ・Road related facilities which can be used as evacuation areas during disasters such as bus stops and rendezvous

	■ Non-structural Measures ・Preparation of hazard map, and informing regulatory agencies and users. ・Installation and operation of equipment which can detect slope failure and debris flow, and systems which can communicate and disseminate information and suspend traffic. ・Installation and operation of evacuation guidance systems at underground areas. ・Installation and operation of guidance systems leading to detour and alternative schemes.
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Power loss would cause malfunction to system operations that are used for evacuation and guidance, consequently exacerbating damages. Power loss in tunnels could trigger traffic accidents. ■ Maladaptation Common to “Business as Usual” Project ・Road development will cause resettlement of inhabitants along roads. In case the site is sensitive to climate change impacts, damages will exacerbate. ・Future climate change impacts will affect the safety of bridges, roads and railways.

Guideline: Bridge, Road and Railway (Adaptation Project)

A. General	■ Necessity of Adaptation Climate change would intensify flood, which can cause inundation, slope failures and landslides, affecting roads, railways, and subways. There are certain risks in road and railway functions that are adversely affected or lost due to climate change impacts. ■ Adaptation Measures In order to enhance the disaster prevention capacity of bridges, roads and railways, countermeasures such as realignment of route, slope stabilization, enhancement of drainage capacity and flood prevention, and raising, reinforcement or replacement of bridges are required. ■ Outcome of Adaptation Measures The impacts of climate change related to structural damage, traffic restriction and interruption, as well as damage on related facilities and users will be reduced. *(Adaptation measures for bridge, road and railway structures in coastal areas are also to be referred in the coastal protection sub-sector.)*
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological and hydrological records in and around the target bridge or route, from meteorological weather stations, hydrological observation stations, and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate hydrological aspects for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for traffic in the target bridge or route, through review of the development plan and hearing with the related agencies. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage ・Study past structural damage, and traffic restriction and interruption due to flood, heavy rain, storm surge, storm wind, etc., through hearing with stakeholders such as the regulatory agencies and inhabitants. Identify the areas and sections vulnerable to climate disasters. b) Study Present Condition of Facilities and Measures Assess the present condition of facilities based on the design condition, bearing capacity, and maintenance condition, through field survey and review of reports and drawings of bridge, road and railway structures. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity based on the relationship between past structural damage, traffic restriction and interruption, and meteorological conditions, future climate condition, and condition of facilities, with consideration on future socio-economic change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Alternative Traffic Means and Detour

Assess the situation of alternative traffic schemes and detour for the section with risk of traffic restriction and interruption.

・Crisis Management of Regulatory Agency and Management Body

Assess the responsiveness against climate disaster:

- Systems for damage detection, communication, indication, and suspension of traffic.
- Situations of hazard map preparation, evacuation guidance, measures for leading to detour or alternative traffic, etc.

・Disaster Resilience Capacity of Regulatory Agency and Management Body

Assess budget and programs for disaster recovery in regulatory agency for each facility and section.

・Existence and Ability of Research and Development

Assess research and development for bridge, road and railway, and sediment-related disaster.

b) Clarify Exacerbating Factors for Climate Change Impacts

・Land Use and Land Use Regulations

Assess the land use and related regulatory policies which affect sediment-related disaster damage.

- Land development at areas prone to slope failure and sediment-related disaster hazard areas, which are related to risk of damages to sediment-related disaster.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Alternative traffic means and detour	Existing/Sufficient	None/Poor
Crisis management of regulatory agency and management body	Excellent	Poor
Disaster resilience capacity of regulatory agency and management body	Excellent	Poor
Existence and ability of research and development	Existing/Excellent	None/Poor

<table>
<tr><td>C.
Project Evaluation of Adaptation Measures</td><td>

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Reduction of inundation, structural damage, and traffic restriction	Quantitative	・Traffic volume ・Number of running train
Alternative transportation means and detour	Reduction of traffic interruption	Qualitative	-
Crisis management of regulatory agency and management body	Improvement of responsive ability against climate disaster occurrence	Qualitative	-
Disaster resilience capacity of regulatory agency and management body	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period and safety factor of facilities	Quantitative	-
Non-structural measures	Situation of preparation and recognition of hazard map	Quantitative	-
	Reduction of time for damage detection and suspension of traffic	Quantitative	-
	Reduction of time for evacuation guidance	Quantitative	-
	Reduction of time for leading to detour or alternative traffic	Quantitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

</td></tr>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for further increase of precipitation (room for enhancement or expansion of drainage facilities)

Since impact of both longitudinal and cross-sectional realignment of railway route to the surrounding environment tends to be larger than that of road, it shall be studied carefully.

</td></tr>
</table>

	3) Consideration to Maladaptation Check maladaptation caused by the project, and plan the corresponding countermeasures.
E. Required Data	(see table below)

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect data from meteorological and hydrological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.
	Socio-economic incidence	Collect development plans and land use regulations, in and around the target port and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Information about inundation, structural damage, and traffic restriction	Collect and identify damages of each section and facility by event. Secular change shall be also collected.
	Design condition and design bearing capacity of existing structure	Study the design condition and design bearing capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.
4) Assess Adaptive Capacity to Climate Change	Alternative traffic schemes and detour	Study and review the detour and alternative traffic means including sea lane through interviews with related agencies, and based on related information collected.
	Crisis management of regulatory agency and management body	Study and review the situation of installation and operation of systems for crisis management through interviews with related agencies and management, and based on related information collected.
	Disaster resilience capacity of regulatory agency and management body	Study and review the budget and programs through interviews with related agencies and management body, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies, and based on related information collected.
	Land use and land use regulation	Study present status of land use including differences in land use regulations, and investigate actual condition by site reconnaissance, by using land use maps and satellite images. Study land use regulation by reviewing related information and conducting interviews with related agencies.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Bridge, Road and Railway (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
New bridges, roads and railways will be constructed, or existing facilities will be replaced or extended.
Potential risks such as the reduction of safety of bridges, inundation damage on roads and railways, slope failure and landslides, and flooding in underground space such as subway are likely to increase due to climate change impacts.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
The safety of facilities and traffic will be maintained in the event of climate change.

(Adaptation measures for bridge, road and railway structures in coastal areas are also to be referred in the coastal protection sub-sector.)</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological and hydrological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as new infrastructure considering for climate change impact, realignment of road and railway, reinforcement and replacement of bridges, slope stabilization, enhancement of drainage facilities and flood control, and non-structural measures which enhance the crisis management capability such as hazard map preparation, and installation of hazard detection facilities. These could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Future sensitivity to climate change</td><td>Reduction of inundation, structural damage, and traffic restriction</td><td>Quantitative</td><td>・Traffic volume
・Number of running train</td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of target return period and safety factor of facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="4">Non-structural measures</td><td>Situation of preparation and recognition of hazard map</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Reduction of time for damage detection and suspension of traffic</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Reduction of time for evacuation guidance</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Reduction of time for leading to detour or alternative traffic</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Others</td><td>Changes in the awareness of stakeholders</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for further increase of precipitation (room for enhancement or expansion of drainage facilities)

Since impact of both longitudinal and cross-sectional realignment of railway to the surrounding environment tends to be larger than that of road, it shall be studied carefully.

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>F.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.</td></tr>
</table>
</td></tr>
</table>

References and Key Different Features

1) The action of companies operating public infrastructure in line with the Climate Change Act in the United Kingdom (UK) : Highway Agency[1] and Network Rail[2]
Department for Environment, Food and Rural Affairs, UK, obligates companies owning and operating public infrastructure to prepare and submit reports about climate change impacts and its countermeasures on their respective infrastructure based on the Climate Change Act enacted in 2008. Responding to the said obligation, the Highways Agency which operates large-scale road networks, and Network Rail which operates railway networks, prepared and submitted their respective interim reports in 2010.

Since both agencies have been controlling large-scale operations, the reports are mainly focused on management such as discomfort of passengers and burden of field workers, and maintenance such as deterioration of physical assets.

2) Assessing the Impact of Climate Change on Transport Infrastructure[3]
This document assesses the storm surge and tidal wave damages, associated with sea level rise, to railways on the coastal area of Dawlish in Devon, UK.

[1] Highway Agency. (2010). The Highway Agency’s Interim Climate Change Risk Assessment
[2] Network Rail. (2010). Network Rail Interim Climate Change Adaptation Report
[3] Rail Safety & Standards Board. (2008). Assessing the Impact of Climate Change on Transport Infrastructure

12. Port and Airport Sub-sector

Guideline:

(1) Port (Adaptation Project)
(2) Port (BAU Development with Adaptation Options)
(3) Airport (Adaptation Project)
(4) Airport (BAU Development with Adaptation Options)

Basic Concept (Port)

A. General Concept	Climate change will raise the sea water level and increase the frequency and intensity of storm surges and high waves, which will adversely affect the safety of port structures. The adaptation measures in the port sub-sector are aimed to maintain its function by reducing vulnerability to climate change mainly through development and improvement of structures.
B. Vulnerability	1) Major Climate Change Impacts on the Port Sub-sector ■ <u>Sea Level Rise</u> ・Wave overtopping prevention function of breakwater and sea wall will decrease. ・Wave forces will intensify and exceed the design loads of structures in association with the increase of water depth, even in the same sea wave condition, causing damage and displacement of revetments, wave dissipating block, parapets, etc. ・Sea level rise will increase buoyancy of buried pipes and manholes, and cause ground uplift of the reclaimed land area. Risk of ground liquefaction will also increase. ・Berthing facilities and cargo-handling yards on low elevation will be submerged and inundated, which will adversely affect the port function. ■ <u>Increase of Wave Height</u> ・Wave forces against structures such as quays and sea walls will intensify due to increase of wave height, which will cause damage to structures. ・Aprons will be affected by inundation due to wave overtopping. ■ <u>Increase/ Intensification of Cyclones</u> ・Damage due to storm surges and high waves will increase and intensify in association with sea level rise, which will damage buildings, containers, and apron machinery and materials. ・Wind speed will hamper operating efficiency of cargo handling more frequently. ■ <u>Increase/ Intensification of Precipitation</u> ・Heavy rains beyond the drainage capacity of aprons will cause inundation. ■ <u>Sea Temperature Rise</u> ・Water quality will be degraded in enclosed water area such as the inside of port breakwaters. ■ <u>Change of Ocean Current</u> ・Characteristics of littoral drift will change, which affects the waterways. 2) Other Factors that Influence the Port Sub-sector Associated with Climate Change Impacts ・Development at hinterland of the port. ・Change in the characteristics of sediment load and littoral drift by river development and coastal development. 3) Adaptive Capacity to Climate Change ・If alternative transport routes or logistics means are available, logistics function are maintained even when the port malfunctions.

	・If the budget and programs for disaster recovery are well in place, disaster response capability of the port management body and regulatory agencies is high. ・If research institute related to port exists and its system is well-organized, the adaptive capacity for climate change is high. ・The existence and enrollment status of insurance and mutual aid systems for damage from storm surge and high wave would affect disaster recovery capability. 4) Spatial Distribution of Vulnerability a) Climate Change ・Storm surge and high waves are affected by submarine and coastal topography, hence wave force for port structures varies. b) Sensitivity in the Port Sub-sector ・Sensitivity varies based on installation condition, design conditions, development level, and maintenance level of port facilities. ・The affecting climate change factor is different for each structure as mentioned in “Major Climate Change Impacts on the Port Sub-sector (Item 1)”. c) Adaptive Capacity ・Disaster resilience capacities will vary in case that the management body is different for each facility.
C. Adaptation Measures	Major Adaptation Measures in the Port Sub-sector ■ Development/ Improvement of Port Structure ・Strengthening of existing quays with design conditions corresponding to the climate change impacts. ・Change or reinforcement of structures such as revetments, wave dissipating block, and parapets, with consideration of climate change impacts. ・Reinforcement of facilities and equipment affected by wind pressure, such as tower cranes. ・Replacement or compaction of buried pipes and manholes to prevent uplift due to increase in buoyancy caused by groundwater level rise, and installation of pumps to drain groundwater. ■ Raising of Facilities ・Raising of aprons and breakwaters against inundation and wave overtopping. ・Steepening of apron gradients in order to improve drainage capacity. ■ Non-structural Measures ・Improvement of cargo handling to reduce materials and equipment loss due to storm surges and high waves. ・Facilitation of water circulation of inside of breakwaters from and to outside to reduce water quality degradation. ・Dredging of ports and waterways. ・Secure and coordinate with related organizations, alternative transport routes and logistics schemes.

D. Maladaptation	■ Maladaptation in Adaptation Measures ・Not assumed. ■ Maladaptation Common to “Business as Usual” Project ・Future rise of the sea water level, increase in wind forces, etc., would cause shortages in the height of structures and its bearing, consequently affecting the safety of structures.

Basic Concept (Airport)

A. General Concept	Climate change will increase precipitation, cloud amount and wind speed. These conditions will adversely affect the safety of flight operations especially during take-off and landing. The airport constructed along coastal areas and on reclaimed lands will be affected by sea level rise and wind pressure increase, as described in the port sub-sector. The adaptation measures in the airport sub-sector are to maintain the safety of flight operation and airport facilities against climate change impacts. *(The vulnerability, adaptation measures and maladaptation for airport structures on coastal areas and reclaimed lands are to be referred in the port sub-sector.)*
B. Vulnerability	1) Major Climate Change Impacts on the Airport Sub-sector <u>■ Increase of Precipitation and Cloud Amount</u> ・Lowering of cloud ceiling and increase of cloud amount will cause poor visibility, consequently adversely affecting the visual take-off and landing. Flight operation might be suspended depending on cloud ceiling and cloud amount. ・Inundation at runway due to rainfall increase would cause hydroplaning during take-off and landing. ・Rainfall increase will raise the risk of inundation at facilities such as runways, aprons, terminal buildings, access roads, and tunnel, in lowland airports. <u>■ Change of Wind Direction and Speed</u> ・Change of prevailing wind will greatly affect flight operation. Take-off and landing will be disrupted by increase in wind speed. ・Change of runway direction and its length would become necessary, in case the change in wind direction and speed becomes permanent. <u>■ Temperature Rise</u> ・Temperature rise will reduce air density. This leads to reduction of lift, consequently the runway length would become short for take-off and landing. <u>■ Change of Ecosystem</u> ・Change of ecosystem in association with climate change might raise the risk of bird strikes and avian ingestion. 2) Other Factors that Influence the Airport Sub-sector Associated with Climate Change Impacts ・Changes in the avian ecosystem due to land development. ・Development tendency of aircraft, such as increasing large body, and improvement of performance. 3) Adaptive Capacity to Climate Change ・If alternative transport routes and logistics are available, traffic disruption would be avoided when airport use is restricted. ・If budget and programs for disaster recovery are well in place, disaster response capability of management body and regulatory agency is high. ・If research institute related to airport exists and its system is well-organized, the adaptive capacity for climate change is high.

	4) Spatial Distribution of Vulnerability a) Climate Change ・Not assumed b) Sensitivity in the Airport Sub-sector ・Sensitivity varies among runway, apron, terminal building, access road, tunnels, etc. Development level and construction era would affect the sensitivity of facilities. ・The affecting climate change factor is different to each function as mentioned in "Major Climate Change Impacts on the Airport Sub-sector (Item 1)". c) Adaptive Capacity ・Disaster resilience capacity would vary if the management body is different for each facility.
C. Adaptation Measures	Major Adaptation Measures in the Airport Sub-sector ■ Development of Facilities ・Installation and operation of the instrument landing system. ・Construction of crosswind runway. ■ Improvement of Facilities ・Grooving on runway. ・Expansion of runway length. ・Improvement of drainage capacity and prevention of inundation for airport facilities such as landing area, apron, terminal building, access road, and tunnels. ■ Non-structural Measures ・Countermeasures against bird strikes and avian ingestion. ・Security and coordination with alternative transport routes and logistics means.
D. Maladaptation	■Maladaptation in Adaptation Measures ・Not assumed. ■Maladaptation Common to "Business as Usual" Project ・Direction of runway and its length might become inadequate for future change of wind direction, temperature, etc.

Guideline: Port (Adaptation Project)

A. General	■ Necessity of Adaptation Climate change will raise sea water level and increase and intensify cyclones, which increase the damage to revetments and port structures, inundation at apron, and damage to buildings, containers, machinery and materials on the apron. Sea level rise will increase buoyancy of buried pipes and manholes, and cause ground uplift of the reclaimed land area. The risk of ground liquefaction will increase. ■ Adaptation Measures To strengthen the disaster mitigation capacity of port facilities by development, reinforcement, and raising of revetments and port structures, etc. ■ Outcome of Adaptation Measures The impacts of climate change such as damage to structures, equipment and materials, and inundation, will be reduced, and port function will also be maintained.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks ・Collect past marine weather records such as tide level, wave, storm surge and high wave, in and around the target port, from marine weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Estimate marine and meteorological weather aspects for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for land use in the hinterland of the target port and characteristics of littoral drift, through review of the national and regional development plan and land use regulations around the port. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study past inundation damage on apron, damage on revetments and other port structures, coastal erosion, storm surge and high wave damage on equipment and materials, based on data collected and through hearing with stakeholders such as the port management body and port users, as well as through websites for meteorology. Identify the areas and places vulnerable to damage due to tidal change, storm surges and high wave damage in the target port. b) Study Present Condition of Facilities and Measures Assess the present condition of facilities based on design conditions, bearing capacity, and maintenance conditions, through field survey and review of reports and design drawings of revetments and port structures. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity of the target port based on the relationship between past damage and oceanographic and meteorological conditions; future climate and marine condition; and condition of facilities, with consideration on future socio-economic change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Alternative Transportation Means

Assess alternative transport routes and logistics means.

・Disaster Resilience Capacity of Regulatory Agency and Management Body

Assess budget and activity for disaster recovery of regulatory agencies and management bodies.

・Existence and Ability of Research and Development

Assess research and development for port.

・Compensation for Storm Surge and High Wave Damage

Assess the disaster restoration capability:

- Available damage insurance and mutual aid system for storm surge and high wave damages.

b) Clarify Exacerbating Factors for Climate Change Impacts

・Not assumed.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Alternative transportation means	Existing/ Sufficient	None/Poor
Disaster resilience capacity of regulatory agency and management body	Excellent	Poor
Existence and ability of research and development	Existing/ Excellent	None/Poor
Compensation for storm surge and high wave damage	Sufficient	Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Maintenance of port function (for logistics and transportation)	Quantitative	・Freight ・Tonnage of vessel entered ・Berth occupation ration ・Weekly working hours ration ・Weekly crane operation ration

	Reduction of inundation and facility damage	Quantitative	・Flooded area ・Maximum water depth ・Inundation duration
Alternative transportation means	Reduction of transportation and logistics interruption	Qualitative	-
Disaster resilience capacity of regulatory agency and management body	Improvement of restoration capability after disaster occurrence	Qualitative	-
Existence and ability of research and development	Improvement of adaptive capacity	Qualitative	-
Compensation for storm surge and high wave damage	Improvement of restoration capability after disaster occurrence	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period and safety factor of facilities	Quantitative	-
Non-structural measures	Implementation records of projects, such as dredging.	Quantitative	・Dredged amount
Others	Changes in the awareness of stakeholders	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for further sea level rise, storm surge and high wave (room for enhancement of bearing capacity, raising of structure, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

E.
Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present marine weather and meteorology	Collect data from marine weather and meteorological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.
	Socio-economic incidence	Collect development plans and land use regulations, in and around the target port and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Information about structural damage by tide change, storm surge and high wave damage	Collect and identify damages of each place by event. Secular change shall be also collected.
	Design condition and design bearing capacity of existing structure	Study the design condition and bearing capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.
4) Assess Adaptive Capacity to Climate Change	Alternative transportation means	Study and review the alternative transport schemes including land and air routes through interviews with related agencies, and based on related information collected.
	Disaster resilience capacity of regulatory agency and management body	Study and review the budget and programs through interviews with related agencies and management bodies, and based on related information collected.
	Existence and ability of research and development	Study and review the research activity programs through interviews with related agencies and based on related information collected.
	Existence and enrollment of damage insurance and mutual aid system	Study and review the status through interview with related agencies and based on related information collected.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Port (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
New ports will be constructed, or existing ports will be expanded for the development in maritime trade.
Potential risks of damages on revetments and port structures by sea level rise and extreme events, damages by storm surge and high waves, and ground uplift and buoyancy increase of buried pipes and manholes by sea level rise, are likely to increase in the target port due to climate change impacts.
<u>■ Adaptation Options</u>
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
<u>■ Outcome of Adaptation Options</u>
Port functions will be maintained in the event of climate change.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project marine weather and meteorological aspects at the planned base year using the analysis results of climate change projection for the target year.</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>Plan adaptation options considering future climate change.
Possible options are structural measures such as new development, improvement and raising of port structures accounting for marine weather and meteorological aspects after climate change, and non-structural measures for improvement of cargo-handling in reducing materials and equipment loss, and security of alternative transportation means, which could be implemented individually or simultaneously.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future sensitivity to climate change</td><td>Maintenance of port function (for logistics and transportation)</td><td>Quantitative</td><td>・Freight
・Tonnage of vessel entered
・Berth occupation ration
・Weekly working hours ration
・Weekly crane operation ration</td></tr>
<tr><td>Reduction of inundation and facility damage</td><td>Quantitative</td><td>・Flooded area
・Maximum water depth
・Inundation duration</td></tr>
<tr><td>Alternative transportation means</td><td>Reduction of transportation and logistics interruption</td><td>Qualitative</td><td>-</td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of target return period and safety factor of facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Non-structural measures</td><td>Implementation records of projects, such as dredging.</td><td>Quantitative</td><td>・Dredged amount</td></tr>
<tr><td>Others</td><td>Changes in the awareness of stakeholders</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for further sea level rise, storm surge and high wave (room for enhancement of bearing capacity, raising of structure, etc.)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>F.
Required Data</td><td>
<table>
<tr><td></td><td>Data</td><td>Remarks</td></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed marine weather and meteorological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.</td></tr>
</table>
</td></tr>
</table>

Guideline: Airport (Adaptation Project)

A. General	<u>■ Necessity of Adaptation</u> Climate change will increase precipitation, cloud amount and wind speed, and change the bird ecosystem. These conditions are likely to adversely affect the safety of flight operation especially during take-off and landing and cause damage to the airport. <u>■ Adaptation Measures</u> To secure safety during take-off and landing of planes, and structure safety of the airport by mainly development and improvement of airport facilities. <u>■ Outcome of Adaptation Measures</u> The impacts of climate change on flight operations and structure safety will be reduced. *(Adaptation measures for airport structures on coastal areas and reclaimed land are to be referred in the port sub-sector.)*
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect past meteorological records in and around the target airport, from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological aspects for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for the design conditions of airports, such as change in the bird ecosystem and tendency of development of aircrafts, through review of development plan and hearing with the related agencies. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Study past inundation conditions, structural damage, and limitation of take-off and landing through hearing with stakeholders such as regulatory agencies, management bodies for airport structures, terminal buildings and access roads, and users. Identify the areas and functions vulnerable to climate disasters. b) Study Present Condition of Facilities and Measures Assess the present condition of facilities based on design conditions, bearing capacity, and maintenance conditions, through field survey and review of reports and drawings of airport structures. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity of the airport based on the relationship between past inundation condition, structural damage, limitation of take-off and landing and meteorological conditions, future climate conditions, and condition of facilities, with consideration on future socio-economic change factors.

<table>
<tr>
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Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
・Alternative Transportation Means
Assess alternative transport routes and logistics in case of limitation in take-off and landing.

・Disaster Resilience Capacity of Regulatory Agency and Management Body
Assess budget and programs for disaster recovery in regulatory agencies and management bodies of each facility.

・Existence and Ability of Research and Development
Assess research and development for airport and aviation.

b) Clarify Exacerbating Factors for Climate Change Impacts
・Not assumed.

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

<table>
<tr><th>Items</th><th>Low ← Vulnerability → High</th><th></th></tr>
<tr><td>Future sensitivity to climate change</td><td>Small</td><td>Large</td></tr>
<tr><td>Alternative transportation means</td><td>Existing/Sufficient</td><td>None/Poor</td></tr>
<tr><td>Disaster resilience capacity of regulatory agency and management body</td><td>Excellent</td><td>Poor</td></tr>
<tr><td>Existence and ability of research and development</td><td>Existing/Excellent</td><td>None/Poor</td></tr>
</table>

</td>
</tr>
<tr>
<td>C.
Project Evaluation of Adaptation Measures</td>
<td>

[Items for Assessment in Project Formulation]

<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td rowspan="2">Future sensitivity to climate change</td><td>Maintenance of airport function</td><td>Quantitative</td><td>・Number of passenger
・Volume of freight
・Number of takeoffs and landings by origin and destination</td></tr>
<tr><td>Reduction of inundation and facility damage</td><td>Quantitative</td><td>・Flooded area
・Maximum water depth
・Inundation duration</td></tr>
<tr><td>Alternative transportation means</td><td>Reduction of transportation and logistics disruption</td><td>Qualitative</td><td>-</td></tr>
<tr><td>Disaster resilience capacity of regulatory agency and management body</td><td>Improvement of restoration capability after disaster occurrence</td><td>Qualitative</td><td>-</td></tr>
<tr><td>Existence and ability of research and development</td><td>Improvement of adaptive capacity</td><td>Qualitative</td><td>-</td></tr>
</table>

</td>
</tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period and safety factor of facilities	Quantitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review

Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

・Countermeasures for further increase of precipitation (room for installation of new drainage facilities or enhancement)

・Countermeasures for further temperature rise (room for expansion of runway)

3) Consideration to Maladaptation

Check maladaptation caused by the project, and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology	Collect data from meteorological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological data in the target area.
	Socio-economic incidence	Collect development plans in and around the target airport and country, and development tendency of aircraft, from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Information about inundation and structural damage, limitation of take-off and landing	Collect and identify damages of each location by event. Secular change shall be also collected.
	Design condition and design bearing capacity of existing structure	Study the design condition and bearing capacity of each facility based on the existing plan, design standard, design drawings, as-built drawings, etc.
	Condition of existing facility	Study the operating condition of each facility through field survey.

	4) Assess Adaptive Capacity to Climate Change	Alternative transportation means	Study and review the alternative transport means including land and sea routes through interviews with related agencies, and based on related information collected.
		Disaster resilience capacity of regulatory agency and management body	Study and review the budget and programs through interviews with related agencies and management bodies, and based on related information collected.
		Existence and ability of research and development	Study and review the research activity through interviews with related agencies, and based on related information collected.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Airport (BAU Development with Adaptation Options)

A. General

■ <u>Necessity of Adaptation Options</u>

New airports will be constructed, or existing ones will be expanded or improved.

Potential risks of structural damages and decline of safety in take-off and landing by increase of rainfall, cloud amount and wind speed, and change of avian ecosystem, are likely to increase in the target airport by climate change impacts.

■ <u>Adaptation Options</u>

Appropriate measures will be implemented within the project with consideration of the climate change impacts.

■ <u>Outcome of Adaptation Options</u>

The safety of flight operation and airport function will be maintained in the event of climate change.

(Adaptation measures for airport structures on coastal area and reclaimed land are to be referred in the port sub-sector.)

B. Vulnerability Assessment (Risk and Change)

Review the national policies related to climate change, and discuss and confirm with counterpart organization the applied climate change scenarios and analysis models, and target year for adaptation measures. Project meteorological aspects at the planned base year using the analysis results of climate change projection for the target year.

C. Planning Adaptation Options

Plan adaptation options considering future climate change.

Possible options are structural measures such as new development and improvement of facilities, and non-structural measures such as security and coordination with alternative transport routes and logistics, which could be implemented individually or simultaneously.

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Maintenance of airport function	Quantitative	・ Number of passenger ・ Volume of freight ・ Number of takeoffs and landings by origin and destination
	Reduction of inundation and facility damage	Quantitative	・ Flooded area ・ Maximum water depth ・ Inundation duration
Alternative transportation means	Reduction of transportation and logistics disruption	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period and safety factor of facilities	Quantitative	-
Others	Changes in the awareness of stakeholders	Qualitative	-

<table>
<tr>
<td>E.
Necessary Consideration for Planning of Adaptation Options</td>
<td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
・Countermeasures for further increase of precipitation (room for installation of new drainage facilities or enhancement)
・Countermeasures for further temperature rise (room for expansion of runway)

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td>
</tr>
<tr>
<td>F.
Required Data</td>
<td>
<table>
<tr><td></td><td>Data</td><td>Remarks</td></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td></td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological data in the target area.</td></tr>
<tr><td colspan="3">Others</td></tr>
<tr><td></td><td>Information related to adaptation</td><td>Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.</td></tr>
</table>
</td>
</tr>
</table>

References and Key Different Features

1) Concept of Port Policy on Climate Change Resulting from Global Warming (Policy Report)[1]

This document discusses the impacts of climate change and measures for adaptation and mitigation on port facilities in Japan.

The assumed climate change impacts on ports and hinterlands are listed in the document as follows:

・Increase of inundation in the hinterland by storm surge
・Increase of coastal erosion
・Adverse affect on port function

Against these impacts, basic concept is set for alleviation of storm surge damage at hinterlands where population and properties are accumulated, and sustenance of port activities that support international and domestic transportation. The three polices drawn up in the document are as follows:

・Improvement of resilience to sea level rise and related effects.
・Precautions for reduction of disaster risks at the occurrence of storm surge.
・Capacity improvement for disaster management

This survey for the port sub-sector refers to this document for climate change impacts, and concepts and measures for adaptation.

[1] Ministry of Land, Infrastructure, Transport and Tourism, Japan. (2009). Chikyu-Ondanka ni Kiinsuru Kiko-Hendo ni Taisuru Kowan-Seisaku no Arikata: Toshin (in Japanese).

13. Water Supply Sub-sector

Guideline:

(1) Water Supply (Adaptation Project)
(2) Water Supply (BAU Development with Adaptation Option)

Basic Concept

A. General Concept	Due to the climate change, a water supply system is exposed to the following potential risks: long-term changes in rainfall amount and patterns, increased frequency of extreme events such as droughts and floods, and increased water demand arising from increased average temperature, changes in water qualities of both surface and groundwater water sources. Adaptation measures in the water supply sub-sector are expected to stabilize supply of safe water by increasing water supply capacity and improving the water and sanitation environment, which could be exposed to climate change impacts.
B. Vulnerability	1) Major Climate Change Impacts on the Water Supply Sub-sector The climate change impacts on water supply sub-sector can be divided into direct and indirect effects: the direct effects are on the quantity and quality of water sources, and the indirect effects are on the sanitation conditions due to water shortage. The details of both effects are listed below. a） Direct Effects ・In case of river as water source, changes in the period and cycle of low flow and high flow will affect the adjustment of water intake, and changes in water temperature will influence the water source's own purification capacity. ・Sea level rise will cause an extended salinization at estuarine areas. ・Enclosed water bodies such as lakes and ponds that serve as water sources, have their water quality vulnerable to changes in solar irradiation and temperature, while the water levels are dependent on precipitation amount. ・In case of groundwater as water source, climate change may influence on groundwater recharges in the long term and sea level rise may affect groundwater quality. b） Indirect Effects ・Malfunctioning of the water intake and change in water quality will affect water supply capacity and indirectly worsen sanitation conditions around human settlements. ・Increase in water temperature may cause an epidemic of water-borne diseases. 2) Other Factors that Influence the Water Supply Sub-sector Associated with Climate Change Impacts ・Changes in people's lifestyle, increased number of industrial structures due mainly on rapid population growth, urbanization and economic growth may influence the balance between potable water supply and sectoral water demand. ・Particularly in urban areas, population is on increasing trend globally, which will translate to increases in the demand for potable water. 3) Adaptive Capacity to Climate Change ・Urban areas located in humid climate regions, where surface water resources are sufficiently available but exposed to water shortages, are readily adaptive to extreme and long-term climate change impacts. ・Arid and semi-arid areas, where water sources are heavily dependent on groundwater resources, are exposed to uncertainties in the future water supply, thereby exhibiting likely low adaptive capacities. ・In case of high operational capacities of water service providers that also exhibit low rates of unaccounted-for-water (UFW) as well as high users' awareness on water conservation initiatives, the adaptive capacity seems to be higher.

	4) Spatial Distribution of Vulnerability a) Climate Change ・Water supply system, considered as one consolidated system from water sources to end users, generally has its catchment for water source located within or adjacent to the beneficiary areas. Therefore, for this case, it is assumed that there is no spatial difference in vulnerability distribution. b) Sensitivity in the Water Supply Sub-sector ・Although sensitivity to climate change may differ by catchment areas, it is assumed that there are no spatial differences between different water supply systems located within the same catchment area. c) Adaptive Capacity ・Adaptive capacities may differ depending on population distribution and beneficiaries socio-economic conditions (i.e. water supply to poverty / slum areas and non-slum areas).
C. Adaptation Measures	■ Development and Rehabilitation of Water Supply System ・Relocation of water intake ・Diversification of water sources (combined utilization of surface and groundwater resources). ・Structural designs of facilities (water intake, water treatment plant, distribution pipes, tanks) based on river discharge that account for climate change impacts, water demand projection based on increased per capita water consumption. ■ Water Conservation Measures ・Strengthening of organizational capacity of water service providers to reduce UFW. ・Raising awareness on water conservation initiatives for water users / beneficiaries. ■ Strengthening Water Quality Management ・Improve management of chlorination during water treatment process. ・Improve management of odor induced by water quality change, through the introduction of charcoal absorption treatment.
D. Maladaptation	■ Maladaptation in Adaptation Measures ・As a result of an adaptation project that has developed a water supply system considering future climate change impacts, mass-migration from regions affected by water shortage would occur and cause excessive demand for water due to unexpected increase of population inflow. ■ Maladaptation Common to "Business as Usual" Project ・Difficulty in securing water supply that meets additional water demand due to climate change. ・Water sources may become unsuitable as potable water source due to considerable change in water quality.

Guideline: Water Supply (Adaptation Project)

A. General	■ <u>Necessity of Adaptation</u> In an existing watery supply system, its stable operation in the future will be at risk due to anticipated changes in rainfall intensity and patterns brought by climate change. This will reduce the available amount of water from the sources, and the rising temperature will affect the water quality at the source as well as increase per capita water consumption. ■ <u>Adaptation Measures</u> It will be necessary to increase water supply capacity through the development / expansion of alternative water sources, reduction of water leakages and the rate of unaccounted-for-water (UFW), and improvement of water treatment capability. ■ <u>Outcome of Adaptation Measures</u> The adaptation measures will be able to prevent or reduce climate change impacts on water supply quantity and quality.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect the available past meteorological records referring to rainfall intensity / pattern, seasonal / daily changes of temperatures, cycles of extreme events, river discharges for surface water sources, and groundwater levels for groundwater sources, from meteorological weather stations and regulatory agencies. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, review climate change policies of the country, and confirm the climate change scenarios, analysis models, and target year for suitable adaptation measures for the country. Estimate precipitation aspects such as intensity, frequency, and volume as well as temperature changes, available river discharges and groundwater resources for the target year based on the analysis results on climate change. Take into account the expected change in per capita water demand (consumption) due to temperature rise. b) Study Other Factors related to Socio-economic Changes Study factors that influence conditions of water resources use such as population change and industrial development through review of the regional / urban development plans, land use regulations, and so on. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Assess the past water supply conditions whether there are significant variations on water balances during wet and drought years. To undertake such clarification, it will be worth collecting and inspecting the past records of water supply volume, disruptions in water supply, changing trends of per capita water consumptions, and percentage of served population. Assess past and present conditions regarding morbidity and mortality rates due to water and vector-borne diseases while paying attention to significant relationships during drought period.

b) Study Present Condition of Facilities and Measures

Assess the past and present conditions of river discharges during low and high flows at the water intake site in case the river is the water source.

Assess the past and present conditions of groundwater level and results of pump tests as well as groundwater qualities as water source.

c) Assess Future Sensitivity to Climate Change

Assess future sensitivity of the water supply sub-sector to climate change based on the relationship between past problems related to water supply, water quality, health and meteorological conditions, future climate conditions, and condition of facilities, with consideration on future socio-economic change factors.

Step 2

4) Assess Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Identify the following records of water service providers in charge of water supply in the target areas:

- Past trends of UFW
- Past trends of water leakages / losses
- Past trends of water quality at the taps.

・ Identify alternative water sources that can substitute existing water supply system.

・ Identify beneficiaries' awareness on conservation initiatives of water resources through questionnaire or interview surveys.

・Identify the socio-economic conditions such as population, number of households, water supply condition if there are slum or poverty areas within the target areas.

・Identify other stakeholders' interest on water supply in the assessment of other activities associated with water and sanitation. The following indicators are potentially applied:

- National or regional budgets on climate change adaptation for water supply facilities
- Activities of NGOs regarding climate change focusing on water supply issues

b) Clarify Exacerbating Factors for Climate Change Impacts

Identify exacerbating factors on climate change impacts through the review of water and sanitation-related national / regional development plans of the country / regions. The factors are considered as follows:

- Contamination of existing water sources by other water users such as industrial consumers.
- Inappropriate river management which results to excessive sediment deposits and riverbank erosion.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. If vulnerability differs within the target area, its spatial distribution shall be studied.

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Organizational capacity and operation conditions of water service providers	Excellent	Poor
Available water volume and quality at alternative water sources	Excellent	Poor
Awareness of water conservation initiatives	High	Low
Socio-economic conditions of the target areas	Excellent	Poor
Budget related to climate change impacts on Water Supply Sub-sector	Large	Small
Climate change-related activities of NGOs for Water Supply Sub-sector	Active	Inactive

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Stable and safe water supply is provided and improved sanitation conditions.	Quantitative	・Water Supply ・Percentage of Served Population ・Raw Water Intake
Organizational capacity and operation conditions of water service providers	Reduction of UFW and water loss, and stable or improved water quality at the tap.	Quantitative	・UFW ・Percentage of Water Loss ・Water Quality
Available water volume and quality at alternative water sources	The future risk of water shortage is reduced by development of alternative water sources	Qualitative	-
Awareness of water conservation	Beneficiaries' awareness on water conservation initiatives is improved.	Qualitative	-
Socio-economic conditions of the target areas	If a residential district of the poor like a slum is included, its living and sanitation conditions are improved	Qualitative	-
Budget related to climate change impacts on the Water Supply Sub-sector	The budget amount is kept stable or increased.	Quantitative	-
Climate change-related activities of NGO for the Water Supply Sub-sector	The activities of NGOs become more active and focused on climate change impact alleviation.	Qualitative	-

<table>
<tr><td></td><td>
[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of target return period by expanded and/or newly developed facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Non-structural measures</td><td>Changes in beneficiaries' awareness on water conservation</td><td>Qualitative</td><td>-</td></tr>
<tr><td>Others</td><td>Changes in the number of beneficiaries</td><td>Quantitative</td><td>-</td></tr>
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<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>
1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Countermeasures against reduced volume of available water (further securing alternative water sources)
- Countermeasures against increased water demand (securing complemental water sources, improving capacity of water treatment).
- Countermeasures against water quality changes at water sources (increasing / expanding capacity of water treatment).

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures
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</td></tr>
<tr><td>E.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present meteorological and hydrological data</td><td>Collect data such as meteorological data, river discharge from meteorological stations and hydrological stations.</td></tr>
<tr><td rowspan="2">2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.</td></tr>
<tr><td>Socio-economic incidences</td><td>Collect development plans in and around the target areas and country from relevant organizations and other agencies.</td></tr>
<tr><td>3) Assess Future Sensitivity to Climate Change</td><td>Past and present water balance (demand and supply) conditions</td><td>Collect the past and present (5-10 years) data and records from water service providers regarding water supply volume, disruptions in water supply, trends of per capita water consumption, percentage of served population, and assess significant relationship with the past and present climate trends.</td></tr>
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		Conditions of the present water sources	Regarding the existing water sources (surface and groundwater), collect the past and present (5-10 years) data on river discharge, water level, available water volume and quality at intake site, and assess their chronological changes and significant relationship with the past and present climate trends.
		Conditions related to water and vector-borne diseases	Identify the past and present morbidity and mortality rates of infectious diseases, and assess potential disease-causing impacts of water and sanitation conditions.
	4) Assess Adaptive Capacity to Climate Change	Organizational capacity and operational conditions of water service providers	Collect and assess data or records from the existing water service providers regarding UFW, percentage of water loss, quality of distributed water, and identify performance of water service providers.
		Available water volume and quality at alternative water sources	Identify availability of additional alternative water sources (both surface and groundwater), and assess possibility to utilize them in the future.
		Awareness of water conservation	Identify past and present campaigns or awareness programs for water conservation and assess the effectiveness of the activities, if possible.
		Socio-economic conditions of the target areas	Identify existence of slum or poverty areas within the target areas, and collect socio-economic information such as population distribution, number of households, income levels, and sanitation conditions, through reconnaissance survey and interview with the relevant personnel.
		Budget related to climate change impacts on the Water Supply Sub-sector	Identify the budget amount and activity records of agencies in charge of water supply, and assess regional imbalances if any within the target areas.
		Climate change-related activities of NGO for the Water Supply Sub-sector	Identify water- and sanitation-related activities and records by NGO.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Water Supply (BAU Development with Adaptation Options)

A. General	■ Necessity of Adaptation Options Due to the anticipated climate change impacts, there will be increased possibility of reduced water supply volume at intake site, poor water quality, and increased water demand caused by the rise of average temperatures. ■ Adaptation Options Appropriate measures will be implemented within the project with consideration of the climate change impacts. ■ Outcome of Adaptation Options This will enable supply of safe and sufficient water to the population in the event of climate change.
B. Vulnerability Assessment (Risk and Change)	Review the national policies related to climate change, and discuss and confirm with counterpart organization regarding the applied climate change scenarios and analysis models, and target year for implementation of adaptation measures. Project amount and patterns of rainfall, and river discharge / level and groundwater level from the planned base year using the analysis results of climate change projection for the target year. Based on this, study the future water balance considering increased per capita water demand as result of temperature rise.
C. Planning Adaptation Options	Plan adaptation options considering future climate change and thus results to supply of stable and safe water. Possible options are as follows: - Structural measures such as development / expansion / rehabilitation / upgrade of water supply facilities. - Non-structural measures represented by strengthening the O&M system and water quality management. - Raising awareness on water conservation initiatives. - Combined implementation of various options
D. Project Evaluation of Adaptation Options	(see tables below)

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Conditions of water balance	Increased volume of supplied water and served population	Quantitative	・Water Supply ・Percentage of Served Population
Conditions of water sources	Monitoring of volume and level of available water at intake source	Quantitative	・Raw Water Intake
O&M system and capacity of water service providers	Reduction of UFW and water loss, and stabilization of water quality	Quantitative	・UFW ・Percentage of Water Loss ・Water Quality

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of target return period by expanded and/or newly developed facilities	Quantitative	-

	Non-structural measures	Changes in beneficiaries' awareness on water conservation	Qualitative	-
	Others	Changes in the number of beneficiaries	Quantitative	-

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review

Plan periodic schedule for monitoring of climate condition, and conduct reviews after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change

Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

- Countermeasures against reduction in available water supply (further securing alternative water sources).
- Countermeasures against increased water demand (securing complemental water sources, improving capacity of water treatment).
- Countermeasures against water quality changes at water sources (increasing / expanding capacity of water treatment).

3) Consideration to Maladaptation

Check maladaptation caused by the project and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate conditions	Project future climate using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Past and present water balance (demand and supply) conditions	Collect the past and present (5-10 years) data and records from water service providers regarding water supply volume, disruptions in water supply, trends of per capita water consumption, percentage of served population, and assess significant relationship with the past and present climate trends.
	Present conditions of the water sources	Regarding the existing water sources (surface and groundwater), collect the past and present (5-10 years) data on river discharges, water levels, available water volume and water quality at intake points, and assess their chronological changes and significant relationship with the past and present climate trends.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Wise Adaptation to Climate Change[1]
According to this document, there will be strain in water supply due to localized increases in water demand caused by heterogeneous population distribution, while other research results demonstrate that drought occurrence would drive downwards water demand, which suggests that water demand and supply will be balanced flexibly and vulnerability to high water demand will be lower than expected.

2) Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies[2]
This document describes adaptation measures for water supply system, as part of water resources issues. It includes proposals such as changing location or height of water intakes, using closed conduits, leak repairs, promoting water efficient appliances and rainwater harvesting, which are comparable measures discussed under this guideline. Presented also in this document are the adaptation measures in the areas of coastal zones, agriculture, human health, forest, and biodiversity.

[1] Ministry of the Environment, Japan. (2008). Kikouhendo heno Kashikoi Tekiou: Chapter 3 Mizu Kankyo / Mizu Shigen Bunya (in Japanese).
[2] UNEP. (1998). Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies; Chapter 6.

14. Sewerage / Urban Drainage Sub-sector

Guideline:

(1) Sewerage (Adaptation Project)
(2) Sewerage (BAU Development with Adaptation Options)
(3) Urban Drainage (Adaptation Project)
(4) Urban Drainage (BAU Development with Adaptation Options)

Basic Concept (Sewerage)

A. General Description	Increase in intensity and frequency of rainfall, and temperature rise due to climate change will negatively affect the hygienic environment of urban areas. In areas where sewerage system malfunctions or has insufficient capacity, human settlement is exposed to higher risks of inundation by floodwater, which contains both contaminated water and storm water. Such inundation in urban areas will potentially cause outbreak of infectious diseases such as cholera, typhoid, and diarrhea. Furthermore, contaminated floodwater will worsen the environment in and around rivers and coastal areas. In areas where no sewerage system is available, such situation will be exacerbated with climate change impacts. In the sewerage sub-sector, the development, expansion and upgrading of sewerage systems themselves are considered as an adaptation project, while improving living conditions, the social environment, and hygiene, which would worsen due to climate change.
B. Vulnerability	1) Major Climate Change Impacts on the Sewerage Sub-sector Possible impacts on the sub-sector by extreme events and climate change are considered as follows. A) In Case of Existed Sewerage Treatment System ・Degradation of organic materials is likely to be accelerated by bacteria and microscopic organisms due to temperature rise and changes in solar irradiation condition. ・In case of a combined sewerage system, the increased intensity of rainfall may cause flooding of contaminated water that will eventually flow into rivers and coastal areas without any treatment. B) In Case of No Sewerage Treatment System and Commonly Expected Impacts ・Retention and inundation by sewerage and contaminated water will considerably exacerbate the hygienic environment in urban areas. ・Climate change will amplify the conditions of a worsened hygienic environment, and potentially cause outbreak of water and vector borne diseases such as diarrhea, cholera, and typhoid therefore increasing the morbidity and mortality rates of such diseases. 2) Other Factors that Influence the Sewerage Sub-sector Associated with Climate Change Impacts ・Changes in lifestyle and industry structures together with the growth of the population and the economy will increase water demand and thereby demand for sewerage treatment. ・The recycling of greywater, which is yet to be utilized in developing countries in general, can complement shortage in water resources and will require drastic changes to the sewerage treatment process. 3) Adaptive Capacity to Climate Change ・The adaptive capacity is higher in areas where water supply and sewerage systems are available. ・Slums or poverty-stricken areas possess lower adaptive capacity, regardless of existence of sewerage systems.

	・Areas with urban drainage networks possess higher adaptive capacity. ・Areas with healthcare or medical facilities which can respond to infectious diseases possess higher adaptive capacity. ・Areas where informative and preventive activities regarding infectious diseases are active possess higher adaptive capacity. 4) Spatial Distribution of Vulnerability a)Climate Change Sewerage systems are considered as consolidated system from end users (sewerage connectors) through sewerage pipes and treatment plants to drainage areas and usually developed within a city or township as a unit of system. Therefore, it is considered that there is no spatial difference for climate change impacts within the system. b)Sensitivity in the Sewerage Sub-sector Sensitivity is likely higher for densely populated areas within the target areas for sewerage development. Sensitivity may differ according to the existing coverage of the sewerage system as well as the existing level of effective functions. c)Adaptive Capacity Adaptive capacity may differ according to population distribution and socio-economic conditions (inclusion of slums) within the target areas.
C. Adaptation Measures	■ Rehabilitation and Expansion of the Sewerage System (also applicable in the case of new development) ・Replacement and dredging of the sewerage pipes ・Upgrading and improvement of the sewerage system ・Strengthening O&M system and capacity ・Adapting and renewing design capacity (diameters of sewerage pipes, storage and osmosis plant and treatment method) accounting for the future climate change impacts ・Strengthening of water quality management at drainage areas ■ Informative and Preventive Activities to Raise the Awareness of Beneficiaries ・Disseminating information on contaminated water ・Raising the awareness of beneficiaries regarding hygienic conditions
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Climate change may not be realized as projected, which will result in the excess or lack of facilities' capacity. ■ Maladaptation Common to "Business as Usual" Project ・Established sewerage systems may not be fully utilized if many households can not connect to the system due to financial reasons.

Guideline: Sewerage (Adaptation Project)

A. General	<u>■ Necessity of Adaptation</u> Increase in intensity and frequency of rainfall, and temperature rise due to climate change will cause inundation and exacerbated hygienic conditions in urban areas. If areas possess ineffective or insufficient sewerage and urban drainage systems, it will potentially cause outbreaks of infectious diseases such as cholera, typhoid, and diarrhea due to the exacerbated hygienic conditions. <u>■ Adaptation Measures</u> The development of sewerage systems (sewerage treatment plant, installation of sewerage network and pump stations, etc.) will improve the hygiene and living conditions of the environment in the target areas. <u>■ Outcome of Adaptation Measures</u> Risks of which will worsen the hygiene and living conditions of the environment due to climate change will be reduced, and the morbidity rate of infectious diseases will improve.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect from meteorological weather stations and regulatory agencies the available past meteorological records on maximum hourly rainfall, rainfall intensity and patterns, annual and monthly average temperatures. Identify past inundation conditions of commercial and residential areas during heavy rainfall if any, through hearing from local residents and relevant organizations concerned. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, the review climate change policy of the country, and confirm the climate change scenarios, analysis models, and the target year for the implementation of adaptation measures suitable in the country. Estimate precipitation aspects such as intensity, frequency, and volume as well as temperature changes for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for hygienic conditions such as population growth and industrial development through review of the regional and urban development plans, land use regulations, etc. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Data and information on infectious diseases that are highly associated with exacerbated hygienic conditions in the target areas should be collected and examined for the past 5-10 years based on morbidity and mortality rates. Such information could be available from statistical documents, local healthcare centers, and regional administration offices. Reconnaissance surveys and meetings with the stakeholders will be required in order to assess the existing conditions of sewerage water discharged into the surrounding bodies of water as well as to identify the source of odor, and distributions and deposit of sewerage pollution materials. It is also necessary to survey flood conditions due to the overflowing of storm water and sewerage draining.

Water quality surveys will be required in the surrounding body of water where storm water and sewerage are discharged, which may cover the past 5-10 years data in order to assess the medium-term changes in water quality.

b) Study Present Condition of Facilities and Measures
Assess the present conditions and functional validity of the existing sewerage system.

c) Assess Future Sensitivity to Climate Change
Assess the future sensitivity to climate change of the sewerage sub-sector based on the relationship between past discharge conditions of sewerage water, health impacts, existing conditions of facilities, and expected future climate conditions with consideration on future socioeconomic change factors.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
In case of absence of existing sewerage networks or system, adaptive capacity against sewerage water, sewerage pollution materials, and odor is significantly low. Thus, adaptive capacity should be assessed by the following indicators:

・Preventive activities against infectious diseases by residents in the target areas
・Knowledge level of residents regarding sewerage water or contaminated water
・Geographical distribution of existing medical institutions, healthcare centers, which can treat infectious diseases

In case that existing sewerage network or system is available and functioning as designed, adaptive capacity is considered relatively high. However, if the existing facilities are in a condition that requires rehabilitation or expansion, the same indicators listed above will be applicable.

b) Clarify Exacerbating Factors for Climate Change Impacts
Since the indicators mentioned above in a), are indirectly related to the sewerage development project, it is considered that changes in values of these indicators are correlated with a degree of vulnerability. Yet, these indicators will be replaced with changes in number of infectious disease patients after the project.

Step 3
5) Assess Vulnerability
Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2 as follows:

Items	Low ← Vulnerability → High
Future sensitivity to climate change	Small Large
Condition of preventive activities against infectious diseases by residents in the target areas	Good Poor
Geographical distribution of existing medical institutions, healthcare centers,	Sufficient Insufficient
Present conditions and functional validity of existing sewerage system	Good Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Regional hygienic conditions will be improved and climate change impacts on health will be reduced.	Quantitative	・BOD of Outlet Treated Water ・River Polluted Condition
Condition of preventive activities against infectious diseases by residents in the target areas	Preventive knowledge against infectious diseases will be disseminated and the number of the patients will be reduced.	Qualitative	-
Geographical distribution of existing medical institutions and healthcare centers	Medical institutions / healthcare centers will be evenly located in and around the target areas.	Qualitative	-
Present conditions and functional validity of the existing sewerage system	Present conditions and functional validity of the existing sewerage system will be improved	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of the target return period by expanded and/or newly developed facilities	Quantitative	-
Others	Changes in the number of the patients of infectious diseases	Quantitative	-
	Changes in number of beneficiaries	Quantitative	-
	Changes in beneficiaries' awareness on hygiene	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures

1) Monitoring and Review

In this sub-sector, the sewerage development project itself will contribute to the improvement of hygienic conditions which are potentially exacerbated by climate change (reduced vulnerability = strengthened adaptive capacity). Therefore, it is difficult to distinguish the effects of an ordinary project with that of an adaptation project for sewerage development. Thus, while requiring periodical monitoring of climate conditions, project monitoring will also be required based on the assessment items set in "C. Project Evaluation of Adaptation Measures" mentioned above.

2) Flexibility to Climate Change

Principally, the project components for adaptation measures are the same as for ordinary sewerage development. However, specific attentions will be required for the discharge capacity of sewerage pipes and storage facilities considering the increased storm water inflow due to changes in rainfall patterns.

3) Consideration to Maladaptation

Check maladaptation caused by the project and plan the corresponding countermeasures.

E.
Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorological data	Collect data such as meteorological data, from meteorological stations and other relevant agencies.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate conditions using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Socio-economic incidence	Collect development plans in and around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Number of the patients of infectious diseases	Referring to national or regional statistics, collect data and information on the number of patients from relevant agencies or organizations (Ministry / Department of Health, healthcare centers and clinics), in order to assess infectious diseases due to poor hygienic conditions.
	Present conditions of sewerage water discharge and flood	It is necessary to conduct reconnaissance survey for existing sewerage and drainage networks, while identifying conditions of sewerage flow, areas of inundation, and distribution of sewerage polluted materials by review of literatures and cadastral maps if available.
	Present conditions of water quality in surrounding water bodies	Collect water quality data in the surrounding bodies of water where storm water and sewerage are discharged. Identify the availability of past data at relevant organizations such as water resources management, and collect as much data as possible. Consider subcontracting the survey on water quality in and around the target areas.
4) Assess Adaptive Capacity to Climate Change	Condition of preventive activities against infectious diseases by residents in the target areas	Identify present activities on preventive measures against infectious diseases from the Ministry/Department of Health, healthcare centers, and other relevant agencies, while identifying the programs of the government and NGOs that are associated with information dissemination on sewerage and contaminated water to the residents of the target areas.
	Geographical distribution of existing medical institutions and healthcare centers	Identify present geographical distribution of health related facilities, which can treat infectious diseases in order to assess the present capacity of treatment.
Others		
	Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target areas, if available.

Guideline: Sewerage (BAU Development with Adaptation Options)

A. General

■ Necessity of Adaptation Options

In order to improve the hygiene and living conditions in the environment of the target areas or city, the project for development, expansion, and rehabilitation of sewerage and drainage systems will be implemented. Due to the anticipated climate change impacts, increased rainfall intensity is likely to cause inundation damages coupled with increased storm water in drainage systems, and it is highly concerned that hygienic conditions will deteriorate.

■ Adaptation Options

Appropriate measures will be implemented within the project with consideration of the climate change impacts.

■ Outcome of Adaptation Options

In the event of climate change, the developed sewerage system will function properly.

B. Vulnerability Assessment (Risk and Change)

Review the national policies related to climate change, and discuss and confirm with counterpart organization regarding applied climate change scenarios and analysis models, and target year for the implementation of adaptation measures. Project amount and patterns of rainfall, and relative temperatures at the planned base year using the analysis results of climate change projection for the target year, and assess the possible flood and inundation by sewerage and storm water. Based on past water quality data, identify the changes to water quality in the surrounding bodies of water where sewerage and storm water are discharged.

C. Planning Adaptation Options

Plan adaptation options considering future climate change and prevent hygienic conditions from deteriorating. Possible options are as follows:

- Structural measures such as development / expansion / rehabilitation / upgrading of sewerage facilities.
- Non-structural measures represented by strengthening O&M system and water quality management.
- Awareness programs for preventive measures against infectious diseases.
- Combined implementation of various options

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Morbidity and mortality rates of infectious diseases	Morbidity and mortality rates of infectious diseases, which are associated with poor hygienic conditions, will be reduced.	Quantitative	-
Present conditions of sewerage and rainwater discharge	Flow volume of sewerage polluted materials into drainage will be reduced by development of sewerage networks.	Qualitative	-
Water quality	Water quality in surrounding bodies of water where treated water is discharged, will be improved by sewerage treatment.	Quantitative	・BOD of Outlet Treated Water ・River Polluted Condition

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of the target return period by expanded and/or newly developed facilities	Quantitative	-

Others	Changes in the number of the patients with infectious diseases	Quantitative	-
	Changes in the number of beneficiaries	Quantitative	-
	Changes in beneficiaries' awareness on hygiene	Qualitative	-

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review
In this sub-sector, the sewerage development project itself will contribute to the improvement of hygienic conditions which are potentially exacerbated by climate change (reduced vulnerability = strengthened adaptive capacity). Therefore, it is difficult to distinguish the effects of an ordinary project with that of an adaptation project for sewerage development. Thus, while requiring periodical monitoring of climate conditions, project monitoring will be required based on the assessment items set in "D. Project Evaluation of Adaptation Options" mentioned above.

2) Flexibility to Climate Change
Principally, the project components for adaptation options are the same as for ordinary sewerage development. However, specific attentions will be required for the discharge capacity of sewerage pipes and storage facilities considering the increased storm water inflow due to climate change.

3) Consideration to Maladaptation
Check maladaptation caused by the project and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Future climate	Project future climate conditions using data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Number of the patients with infectious diseases	Referring to national or regional statistics, collect data and information on number of the patients from relevant agencies or organizations (Ministry / Department of Health, healthcare centers and clinics), assessing infectious diseases due to poor hygienic conditions.
	Present conditions of sewerage water discharge and flood	It is necessary to conduct reconnaissance survey for existing sewerage and drainage networks, while identifying conditions of sewerage flow, areas of inundation, and distribution of sewerage polluted materials by review of literatures and cadastral maps if available.
	Present conditions of water quality in the surrounding water bodies	Collect water quality data in the surrounding bodies of water body where storm water and sewerage are discharged. Identify the availability of past data at relevant organizations such as water resources management, and collect as much data as possible. Consider an option to survey on water quality in and around the target areas by subcontract.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Wise Adaptation to Climate Change[1]

According to this document, recycling sewerage water is effective in reducing drought impacts. In developing countries, the development level of sewerage networks and systems is generally low, therefore the improvement of hygienic conditions tends to be more prioritized rather than recycling in the context of sewerage development. Thus, this guideline emphasizes more on the aspect of hygienic condition.

2) Handbook for Climate Change Adaptation in Water Sector[2].

This handbook warns that temperature rise and decrease of river discharge due to reduced rainfall will result to the deterioration of water quality and water resource exploitation. Also, sewerage development will be important to prevent water contamination and runoff of surface water, and to maintain capacity of natural depuration through flora and wetland conservation. In this regard, water quality management of the surrounding bodies of water proposed in this guideline is in line with the contents of the handbook.

3) Three Unexpected Impacts by Global Warming – Contamination of Portable Water by Sewerage (Chikyu Ondanka ga Umidasu Mittsu no Igaina Heigai - Gesui niyoru Inryousui no Osen)[3]

The numerical model projected an impact of increased rainfall due to climate change on sewerage networks in Wisconsin, United States. The results indicated that untreated water will potentially flood into the lakes in case of large-scale hurricane attacks. This implies that source of drinking water will be contaminated by pathogenic bacteria and viruses, which will urge to take necessary measures such as improving flow capacity of sewerage pipes for the possible increase of rainfall intensity.

[1] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 3 Mizu Kankyo / Mizu Shigen Bunya. (in Japanese).

[2] JICA. (2010). Handbook for Climate Change Adaptation in Water Sector.

[3] National Geographic official website (Japanese). (2011). Chikyu Ondanka ga Umidasu Mittsu no Igaina Heigai - Gesui niyoru Inryousui no Osen (in Japanese): http://www.nationalgeographic.co.jp/news/news_article.php?file_id=20110302002

Basic Concept (Urban Drainage)

A. General Concept	Increase in intensity and frequency of rainfall, and temperature rise due to climate change will negatively affect the hygienic environment of urban areas. In areas where drainage systems or networks malfunction or have insufficient capacity, human settlement is exposed to higher risks of inundation by floodwater, which contains both contaminated water and storm water. Such inundation in urban areas will potentially cause outbreak of infectious diseases such as cholera, typhoid, and diarrhea. Furthermore, contaminated flood will likely include toxic chemicals and deteriorate the water environment in and around rivers and coastal areas. In areas without urban drainage systems, networks and stations, such situation will exacerbate due to the anticipated impacts of climate change. In the urban drainage sub-sector, the development, expansion and upgrading of drainage systems themselves are considered as an adaptation project, while improving the living conditions, social environment, and hygiene, which would worsen due to climate change.
B. Vulnerability	1) Major Climate Change Impacts on the Urban Drainage Sub-sector Possible impacts on the sub-sector by extreme events and climate change are considered as follows. A) In Case of Existing Drainage System ・Depending on the flow capacity of the existing drainage network, the increased hourly rainfall due to heavy rains will cause flooding and result in inundation in some locations of urban areas. ・In case of a combined sewerage system, the increased amount and intensity of rainfall will cause contaminated floods, which will be discharged without treatment into the surrounding bodies of water, such as rivers, lake, and coastal areas. B) In Case of No Existing Urban Drainage System and Commonly Expected Impacts ・Retention and inundation by contaminated water and materials will considerably exacerbate the hygiene of the environment in urban areas. ・Climate change will amplify the conditions of a worsened hygienic environment, and potentially cause outbreak of water and vector borne diseases such as diarrhea, cholera, and typhoid, thus, increasing the morbidity and mortality rates of such diseases. 2) Other Factors that Influence the Urban Drainage Sub-sector Associated with Climate Change Impacts ・Changes in lifestyle and industry structures together with the growth of the population and the economy will increase solid wastes, which will be dispersed in urban areas, and then potentially reduce the capacity of the drainage system due to congestion or clogging. 3) Adaptive Capacity to Climate Change ・The adaptive capacity is higher in areas where sewerage systems are available. ・Slum or poverty-stricken areas tend to have a lower adaptive capacity, regardless of existence of drainage systems. ・Areas with healthcare or medical facilities that can respond to infectious diseases possess higher adaptive capacity. ・Areas where informative and preventive activities regarding infectious diseases are active possess higher adaptive capacity.

	4) Spatial Distribution of Vulnerability a) Climate Change Urban drainage systems are considered as consolidated systems including drainage channels, networks, and pump stations within drainage basins. Therefore, it is considered that there is no spatial difference for climate change impacts within the system. b) Sensitivity in the Urban Drainage Sub-sector Sensitivity is likely higher for densely populated areas within the target areas for drainage development. Sensitivity may differ according to the existing coverage of the drainage system and landscape as well as the existing level of effective functions. c) Adaptive Capacity Adaptive capacity may differ according to population distribution and socio-economic conditions within the target areas.
C. Adaptation Measures	■ Rehabilitation and Expansion of the Urban Drainage System (also applicable to the case of new development) ・Replacement and dredging of drainage pipes and channels ・Upgrading and improvement of drainage systems and drainage pump stations ・Development of flood control basins and regulating ponds ・Strengthening the O&M system and capacity ・Adapting and renewing design capacity (flow capacity of drainage channels, capacity of regulating pond or flood control basins, and capacity of pumps) accounting for the future climate change impacts ・Strengthening water quality management at drainage areas ■ Informative Activities to Raise Awareness of the Beneficiaries ・Disseminating information on contaminated drainage water ・Raising the awareness of beneficiaries regarding hygienic conditions
D. Maladaptation	■ Maladaptation in Adaptation Measures ・Climate change may not be realized as projected, which will result in the excess or lack of facilities' capacity. ■ Maladaptation Common to "Business as Usual" Project ・Drastic population growth and insufficient O&M activities may cause early clogging of drainage channels and result to the malfunctioning of the drainage network.

Guideline: Urban Drainage (Adaptation Project)

A. General	■ Necessity of Adaptation Increase in intensity and frequency of rainfall, and temperature rise due to climate change will cause inundation and exacerbated hygienic conditions in urban areas. If areas possess drainage systems that are malfunctioning or have insufficient capacity, it will potentially cause outbreaks of infectious diseases such as cholera, typhoid, and diarrhea. Storm water contaminated with solid waste and chemical materials will flow into the surrounding bodies of water, therefore seriously affecting water quality. ■ Adaptation Measures The development of urban drainage systems (open and closed drainage channels, pump stations, etc.) will improve drainage capacity and hygienic conditions, reduce the risk of floods, and enhance socio-economic activities in the target areas. ■ Outcome of Adaptation Measures Risks of flooding and inundation due to malfunctioning drainage systems will be reduced, and socio-economic activities and the morbidity rate of infectious diseases will be improved.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks Collect the available past meteorological records referring to maximum hourly rainfall, rainfall intensity / pattern, annual and monthly average temperatures, and cycles of extreme events, from meteorological weather stations and regulatory agencies. Identify past inundation conditions of commercial and residential areas during heavy rainfall if any, through meetings with local residents and relevant organizations concerned. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions Together with counterpart agencies, review the climate change policy of the country, and confirm the climate change scenarios, analysis models, and the target year for the implementation of adaptation measures suitable in the country. Estimate precipitation aspects such as intensity, frequency, and volume as well as temperature changes for the target year based on the analysis results on climate change. b) Study Other Factors related to Socio-economic Changes Study factors for hygienic conditions such as population growth and industrial development through review of the regional and urban development plans, land use regulations, etc. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Data and information on the infectious diseases cases that are highly associated with exacerbated hygienic conditions in the target areas should be collected and examined for the past 5-10 years based on morbidity and mortality rates. Such information could be available from statistical documents, local healthcare centers, and regional administration offices. Reconnaissance surveys and hearing with the stakeholders will be required in order to assess the present conditions of flood and inundation in residential and commercial areas during past heavy rainfall, and assess the flood-prone areas in the target areas.

	In case there are existing drainage network, it is necessary to assess the functional conditions through reconnaissance and hearing survey at agencies or organizations concerned. Water quality surveys will be required in the surrounding bodies of water where storm water and sewerage are discharged, which may cover the past 5-10 years data in order to assess the medium-term changes in water quality. b) Study Present Condition of Facilities and Measures Assess the present conditions of the drainage system if available in terms of its coverage areas and functional validity. c) Assess Future Sensitivity to Climate Change Assess the future sensitivity of the urban drainage sub-sector to climate change based on the relationship between the past discharge conditions of drainage water, health impacts, existing conditions of facilities, and expected future climate condition, with consideration on future socio-economic change factors. Step 2 4) Assess Adaptive Capacity to Climate Change a) Identification of Adaptive Capacity In case of absence of existing drainage networks or systems, the adaptive capacity against flood is significantly low. Thus, the adaptive capacity should be assessed by the following indicators: ・Preventive activities against infectious diseases by residents in the target areas ・Geographical distribution of existing medical institutions and healthcare centers, which can treat infectious diseases In case that existing drainage networks or systems are available and functioning as designed, the adaptive capacity is considered relatively high. In addition to the above indicators, in this case, it will be necessary to identify the design and effective capacities of discharge, and conditions of O&M through field survey. b) Clarify Exacerbating Factors for Climate Change Impacts Since the indicators mentioned above in the previous item a), are indirectly related to the drainage development project, it is considered that changes in values of these indicators are correlated with a degree of vulnerability. Yet, these indicators will be replaced with changes in the number of patients with infectious disease after the project. Furthermore, in case there are existing drainage networks, vulnerability to climate change is also accorded by the level of sewerage system development. Step 3 5) Assess Vulnerability Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2.

Items	Low← Vulnerability →High
Future sensitivity to climate change	Small Large
Condition of preventive activities against infectious diseases by residents in the target areas	Good Poor
Geographical distribution of existing medical institutions and healthcare centers,	Sufficient Insufficient
Present conditions and functional validity of the existing drainage system	Good Poor

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Regional hygienic conditions will be improved and urban flood damage and climate change impacts on health will be reduced.	Quantitative	・Flooded Area ・Flooded Houses ・Economic Value of Damage ・Affected population ・Maximum Inundation Depth ・Inundation Time ・BOD of Outlet Treated Water ・River Polluted Condition
Condition of preventive activities against infectious diseases by residents in the target areas	Preventive knowledge against infectious diseases will be disseminated and the number of patients will be reduced.	Qualitative	-
Geographical distribution of existing medical institutions and healthcare centers	Medical institutions and healthcare centers, which can treat infectious diseases, will be evenly located in and around the target areas.	Qualitative	-
Present conditions and functional validity of existing drainage system	Present conditions and functional validity of existing drainage system will be improved	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Structural measures	Improvement of the target return period by expanded and/or newly developed facilities	Quantitative	-
Others	Changes in number of the patients with infectious diseases	Quantitative	-
	Changes in the number of beneficiaries	Quantitative	-
	Changes in beneficiaries' awareness on hygiene	Qualitative	-

D. Necessary Consideration for Planning of Adaptation Measures	1) Monitoring and Review In this sub-sector, urban drainage development project itself will contribute to the improvement of hygienic conditions which are potentially exacerbated by climate change (reduced vulnerability = strengthened adaptive capacity). Therefore, it is difficult to distinguish the effects of an ordinary project with that of an adaptation project for drainage development. Thus, while requiring periodical monitoring of climate conditions, project monitoring will also be required based on the assessment items set in “C. Project Evaluation of Adaptation Measures” mentioned above. 2) Flexibility to Climate Change Principally, the project components for adaptation measures are the same as for ordinary drainage development. However, specific attentions will be required for the capacities of drainage channels, pump station, flood control basins and regulating ponds considering the increased storm water inflow due to changes in rainfall patterns. 3) Consideration to Maladaptation Check maladaptation caused by the project and plan the corresponding countermeasures.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorological data	Collect data such as meteorological data, from meteorological stations or other relevant agencies.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Project future climate conditions using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.
	Socio-economic incidence	Collect development plans in and around the target areas and country from relevant organizations and other agencies.
3) Assess Future Sensitivity to Climate Change	Number of the patients with infectious diseases	Referring to national or regional statistics, collect data and information on the number of the patients from relevant agencies or organizations (Ministry / Department of Health, healthcare centers and clinics) in order to assess infectious diseases due to poor hygienic conditions.
	Conditions of flood damages	It is necessary to conduct reconnaissance survey for existing drainage networks, while identifying conditions of flood hazard areas by review of literature, meeting with residents or others and referring to cadastral maps, if available.
	Present conditions of water quality in the surrounding water bodies	Collect water quality data in the surrounding bodies of water where storm water and sewerage are discharged. Identify the availability of past data at relevant organizations such as water resources management, and collect as much data as possible. Consider an option to subcontract the survey on water quality in and around the target areas.
4) Assess Adaptive Capacity to Climate Change	Condition of preventive activities against infectious diseases by residents in the target areas	Identify present activities for preventive measures against infectious diseases from the Ministry / Department of Health, healthcare centers, and other relevant agencies,

		Geographical distribution of existing medical institutions and healthcare centers	Identify present geographical distribution of health related facilities, which can treat infectious diseases in order to assess the present capacity of treatment.
		Functional validity of the existing drainage system	In case there are existing drainage networks or systems, identify the design and effective capacities of discharge, and the conditions of O&M through reconnaissance and field surveys.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Urban Drainage (BAU Development with Adaptation Options)

A. General

■ Necessity of Adaptation Options

In order to improve the hygiene and living conditions in the environment of the target areas or city, the project for development/expansion/rehabilitation of urban drainage systems will be implemented. Due to the anticipated climate change impacts, increased rainfall intensity is likely to cause inundation damages coupled with increased storm water drainage, and it is highly concerned that hygienic conditions will deteriorate.

■ Adaptation Options

Appropriate measures will be implemented within the project with consideration of the climate change impacts.

■ Outcome of Adaptation Options

In the event of climate change, the developed drainage system in urban areas will function properly.

B. Vulnerability Assessment (Risk and Change)

Review the national policies related to climate change, and discuss and confirm with counterpart organizations the applied climate change scenarios and analysis models, and target year for adaptation measures. Project the amount and patterns of rainfall, and relative temperatures at the planned base year using the analysis results of climate change projection for the target year, and assess possible flood and inundation by sewerage and storm water. Based on past water quality data, assess the changes to water quality in the surrounding bodies of water where sewerage and storm water are discharged.

C. Planning Adaptation Options

Plan adaptation options considering future climate change impacts and prevent hygienic conditions from deteriorating. Possible options are as follows:

- Structural measures such as development / expansion / rehabilitation / upgrading of drainage facilities.
- Non-structural measures represented by strengthening O&M system and water quality management.
- Awareness raising activities for preventive measures against infectious diseases.
- Combined implementation of various options

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Morbidity and mortality rates of infectious diseases	Morbidity and mortality rates of infectious diseases, which are associated with poor hygienic conditions, will be reduced.	Quantitative	–
Conditions of flood and inundation damages	Improved overall capacity of the drainage system will reduce the risk of flood damages.	Quantitative	・Flooded Area ・Flooded Houses ・Economic Value of Damage ・Affected population ・Maximum Inundation Depth ・Inundation Time
Water quality	Water quality in surrounding bodies of water where drainage water is discharged, will be improved by designated drainage networks.	Quantitative	・BOD of Outlet Treated Water ・River Polluted Condition

<table>
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[Alternative Items for Assessment in Monitoring and Review]
<table>
<tr><th>Type of Measures</th><th>Alternative Indicators</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Structural measures</td><td>Improvement of the target return period by expanded and/or newly developed facilities</td><td>Quantitative</td><td>-</td></tr>
<tr><td rowspan="3">Others</td><td>Changes in the number of the patients with infectious diseases</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in the number of beneficiaries</td><td>Quantitative</td><td>-</td></tr>
<tr><td>Changes in beneficiaries' awareness on hygiene</td><td>Qualitative</td><td>-</td></tr>
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<tr><td>E.
Necessary Consideration for Planning of Adaptation Options</td><td>
1) Monitoring and Review
In this sub-sector, the urban drainage development project itself will contribute to the improvement of hygienic conditions which are potentially exacerbated by climate change (reduced vulnerability = strengthened adaptive capacity). Therefore, it is difficult to distinguish the effects of an ordinary project with that of an adaptation project for drainage development. Thus, while requiring periodical monitoring of climate conditions, project monitoring will be required based on the assessment items set in "D. Project Evaluation of Adaptation Options" mentioned above.
2) Flexibility to Climate Change
Principally, the project components for adaptation options are the same for ordinary drainage development. However, specific attentions will be required for flow capacity of drainage channels, and the capacities of flood control basins and regulating ponds, considering the increased storm water inflow due to climate change.
3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.
</td></tr>
<tr><td>F.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td rowspan="3"></td><td>Future climate conditions</td><td>Project future climate conditions using the data from the analysis models and climate change scenarios adopted in the country, based on the observed meteorological and hydrological data in the target area.</td></tr>
<tr><td>Number of the patients with infectious diseases</td><td>Referring to national or regional statistics, collect data and information on the number of the patients from relevant agencies or organizations (Ministry / Department of Health, healthcare centers and clinics) in order to assess infectious diseases due to poor hygienic conditions.</td></tr>
<tr><td>Conditions of flood damages</td><td>It is necessary to conduct reconnaissance survey for existing drainage networks, while identifying conditions of flood hazard areas by review of literature, meeting with residents or others and referring to cadastral maps, if available.</td></tr>
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		Present conditions of water quality in the surrounding water bodies	Collect water quality data in the surrounding bodies of water where storm water and sewerage are discharged. Identify the availability of past data at relevant organizations such as water resources management, and collect as much data as possible. Consider an option to subcontract the survey on water quality in and around the target areas.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

References and Key Different Features

1) Wise Adaptation to Climate Change[1]

According to this document, the introduction of drainage management systems is effective to alleviate drought impacts. In developing countries, the development level of drainage networks or systems is generally low, there the improvement of hygienic conditions tend to be prioritized rather than drought alleviation in the context of drainage development. Thus, this guideline emphasizes more on the aspect of hygienic condition.

[1] Ministry of the Environment, Japan. (2008). Kikouhendou heno Kashikoi Tekiou - Chapter 3 Mizu Kankyo / Mizu Shigen Bunya. (in Japanese).

15. Medical / Health Care Sub-sector

Guideline:

(1) Medical / Health Care (Adaptation Project)
(2) Medical / Health Care (BAU Development with Adaptation Options)

Basic Concept

A. General Concept	Temperature rise due to climate change is likely to shift or expand habitat areas of disease-carrying vectors. Climate-induced changes in locations and seasons may potentially trigger an epidemic of mosquito-borne diseases such as malaria and dengue fever. Water temperature fluctuations will likely increase water-borne diseases such as diarrhea and cholera, while flood, drought, and crop failure associated with change in rainfall intensities and patterns will potentially increase risks of water- and food-borne diseases. Particularly in the areas with poor healthcare services and facilities as well as poor hygienic conditions, risks of exposure to these infectious diseases are considerably high, which may be exacerbated by climate change impacts. Adaptation measures for this sub-sector includes strengthening of preventive and responsive actions against outbreaks of infectious diseases, as reducing mechanism of significant risks arising from climate change.
B. Vulnerability	1) Major Climate Change Impacts on the Medical / Health Care Sub-sector According to WHO (2003)[1], there are epidemiologically significant associations between temperature rise and mortality rates. WHO suggests the following as key points of view regarding health and climate change. a) Air Pollution Air pollutant emissions such as carbon monoxide, ozone, nitrogen oxides, and sulfuroxides) vary by anthropogenic emissions such as those caused by increased consumption of energy and economic activities. Control of air pollutant emissions, which is expected to increase in urban centers in developing countries, will necessitate imposition of rigorous environmental air quality standards. b) Disasters Increased intensity and frequency of extreme events such as floods and heavy storms, may potentially lead to increase in incidences of injury and malnutrition, increased morbidities due to water/vector-borne diseases, intensified contamination of flood water by toxic chemicals, and more mental disorders. More frequent occurrences of drought will likely exacerbate hygienic environment due to non-availability of fresh water, and also increase the risk of diarrhea, trachoma and scabies. c) Vector-Borne Diseases Temperature rise and change in rainfall amount due to climate change will alter or expand distribution disease-carrying vectors, and will potentially increase the risk of malaria, filariasis, dengue fever, West Nile fever, tick-borne diseases and schistosomiasis. d) Water-borne and Food-borne Diarrheal Diseases Temperature rise and change in rainfall and humidity will likely promote proliferation of pathogens, while heavy rains and floods will increase chances of transmission through water, food, insects, and eventually to humans, potentially causing diarrhea, shigella, and salmonellosis. There are some studies that came up with estimates of potential impacts of climate change on the incidence of water-borne and food-borne diseases. In developing countries, reduction in the occurrence of these diseases is expected with the economic development and improved sanitation, apart from the climate change (WHO 2003).

	e) Stratospheric Ozone Depletion Stratospheric ozone has been substantially depleted from the polar regions to middle latitudes, increasing concerns for impact of incoming UV radiation. Particularly, it is known that there is significant association with UV radiation which causes nonmelanocytic skin cancer. 2) Other Factors that Influence the Medical / Health Care Sub-sector Associated with Climate Change Impacts ・Changes in lifestyle and industrial structure associated with population and economic growth will impact the socially vulnerable group of the population such as elderly, infants, poor and physically weak people. 3) Adaptive Capacity to Climate Change ・Adaptive capacity is likely higher in areas with high infrastructure development levels of sanitation-related facilities (sewerage and drainage system, waste disposal system). ・Adaptive capacity is likely higher in areas with high infrastructure development levels of hospitals, clinics, healthcare centers that can respond to infectious diseases. ・Adaptive capacity is likely higher in the areas where residents' awareness of sanitation is relatively high. 4) Spatial Distribution of Vulnerability a) Climate Change ・According to WHO (2003), meteorological conditions should be considered as follows. If daily data are used, temperatures are homogeneous within about a 300-km radius if no local landscape features such as mountains, watercourses and coastal regions affect climate. For monthly data, temperatures are considered similar up to 1,200 km in radius. Precipitation is more localized in area and time, but should not be used beyond a 50-km radius for daily recorded values or 400-km radius for monthly recorded values. b) Sensitivity in Medical / Health Care Sub-sector ・There is an uneven spatial distribution of sensitivity according to distribution of the existing healthcare-related facilities as well as the geographical distribution of population in the target areas. c) Adaptive Capacity ・Adaptive capacities may differ depending on the demographic conditions (age and income level structures) of the target areas.
C. Adaptation Measures	■ Development of Hospital / Medical Facilities and Capacity Strengthening of Medical Personnel ・Development of new hospital / clinic / healthcare facilities ・Improvement / expansion of healthcare equipment for existing facilities ・Training healthcare related personnel and strengthening their capacity for prevention and treatment of infectious diseases ■ Countermeasures for Beneficiaries ・Raising awareness of the beneficiaries on sanitation management and preventive measures against infectious diseases

	■ Other Measures to Improve Hygienic Conditions (Refer to Water Supply, Sewerage, and Urban Drainage Sub-sectors for more details) ・Development / Improvement / Expansion of Water Supply System ・Development / Improvement / Expansion of Sewerage System ・Development / Improvement / Expansion of Urban Drainage System
D. Maladaptation	■ Maladaptation in Adaptation Measures ・It will be necessary to pay attention not to neglect treatment frameworks for other diseases or injuries while further strengthening those for infectious diseases. ■ Maladaptation Common to “Business as Usual” Project ・There is nothing particular under this condition.

Guideline: Medical / Health Care (Adaptation Project)

A. General	■ <u>Necessity of Adaptation</u> Temperature rise due to climate change is likely to shift or expand habitat areas of disease-carrying vectors for infectious diseases. Climate-induced changes in locations and seasons will likely trigger an epidemic of infectious diseases such as malaria and dengue fever. Flood, drought, and crop failure associated with change in rainfall intensities and patterns will increase risks of water- and food-borne diseases. Particularly in the areas with poor healthcare services and facilities as well as poor hygienic conditions, risks of exposure to these infectious diseases are considerably high, which will be exacerbated by climate change impacts. ■ <u>Adaptation Measures</u> The adaptation measures will strengthen preventive and responsive actions against infectious diseases and improve health conditions of people in the target areas by developing clinics or general hospitals, upgrading equipment, and strengthening capacity of healthcare personnel. ■ <u>Outcome of Adaptation Measures</u> The framework for treatment will be strengthened for patients whose numbers are increasing due to climate change impacts, and corresponding preventive measures will be undertaken.
B. Vulnerability Assessment	Step 1 1) Assess Past and Present Climate Trends and Risks a) Study Past and Present Climate Conditions Based on existing reference materials [National Communication (NC) and National Adaptation Program of Action (NAPA)], study and assess the past to present climate trends (rainfall intensity / pattern, daily / seasonal temperature changes, frequency / intensity / cycle of floods and droughts). b) Study Future Climate Conditions In addition to the above review of references, review the national policies related to climate change, and discuss and confirm with counterpart organization regarding applied climate change scenarios and analysis models, and target year for adaptation measures. Qualitatively assess precipitation parameters such as intensity, frequency, and volume, for the target year based on the analysis results on climate change. 2) Assess Future Exposure to Climate Hazards and Perturbations a) Study Future Weather Conditions For this sub-sector, readily and qualitatively assess future weather conditions through review of references as mentioned in the above item 1). b) Study Other Factors related to Socio-economic Changes Study factors for healthcare regulations and development plans, while examining insurance and subsidy policies associated with infectious diseases. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Since affected areas and vectors' habitat will likely shift to extended areas, the trend of the different diseases based on morbidity and mortality rates should be investigated for the past 5-10 years. This should include statistics from the target countries, neighboring countries, and other site-specific areas. The following diseases are epidemiologically

associated with the impacts of climate change in tropical and sub-tropical regions.

・Vector-borne diseases (malaria, dengue fever, B-encephalitis, filariasis, West Nile fever, tick-borne diseases and schistosomiasis)
・Water- and food-borne diseases (diarrhea, shigella, and salmonella)
・Other locally specific diseases

Furthermore, this will be important in collecting primary information on the above cases from existing public health facilities, medical/clinical institutions, and public agencies (Ministry and / or Department of Health, and healthcare centers) as well as from available secondary statistics data.

b) Study Present Condition of Facilities and Measures
Assess the present infrastructure development level of health-related facilities such as water supply, sewerage, drainage and public toilet. And assess the conditions of these infrastructures during rainfall through interviews with the relevant organizations and agencies, qualitatively evaluating potential influences on infectious disease incidences.

c) Assess Future Sensitivity to Climate Change
Assess the future sensitivity of the sub-sector to climate change based on the correlation between the past and present records of infectious disease cases, meteorological conditions, future climate condition, and the development level of public health infrastructures with consideration of predicted socio-economic parameters.

Step 2
4) Assess Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
Identifying demographics of the target areas, investigate regional dispersal distribution of infectious diseases cases, and assessment of the locality's overall adaptive capacities and regional capacity gaps of the whole area. In the assessment, identify the following:
・Population at risk structured by age groups and income levels
・Potential risk of diseases on socially-vulnerable groups, including infant, elderly, poor households, identifying the population shares and structures.
・Identify the following in relation to adaptive capacities of patients
  - Number of doctors per population
  - Geographic distribution of healthcare facilities that specialize in the treatment of infectious diseases
  - Current preventive activities against infectious diseases

・Other stakeholders' involvement
In order to assess the levels of public sanitation improvement and disease prevention, different stakeholders' involvement on the following indicators are investigated:
  - Medical or infectious disease-related budgets of central or regional governments
  - Preventive action initiatives by NGOs regarding infectious diseases

b) Clarify Exacerbating Factors for Climate Change Impacts
As exacerbating factors, the following is considered:
・Lack of medical personnel specializing in treatment of infectious diseases, such as doctors, nurses, health workers.

Step 3

5) Assess Vulnerability

Assess vulnerability to climate change in the target area by overlapping the factors assessed in Steps 1 and 2. Vulnerability Assessment should adopt as below:

Items	Low ← Vulnerability → High	
Future sensitivity to climate change	Small	Large
Population shares of socially-vulnerable groups	Low	High
Number of doctors per population	Large	Small
Number of existing medical institutions / healthcare centers	Large	Small
Conditions of preventive activities against infectious diseases	Active	Inactive
National / regional budgets for medical care and infectious diseases	Sufficient	Insufficient
Activities by NGOs	Active	Inactive

C. Project Evaluation of Adaptation Measures

[Items for Assessment in Project Formulation]

Items	Outcome	Method	Relative Operation and Effect Indicators
Future sensitivity to climate change	Support framework for medical treatment will be improved, and infection periods and mortality rate will be reduced.	Quantitative	・Disease incidence per population and mortality rate
Population shares of socially-vulnerable groups	Monitoring of population shares of infant, elderly, and poor households	Quantitative	-
Number of doctors per population	Proportion of doctors to population will be improved.	Qualitative	-
Number of existing medical institutions / healthcare centers	Distribution density will increase	Quantitative	-
Conditions of preventive activities against infectious diseases	Preventive activities will become proactive.	Qualitative	-
National / regional budgets for medical care and infectious diseases	The budgets will be stabilized or increased.	Quantitative	-
Activities by NGOs	Preventive activities will become proactive.	Qualitative	-

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Non-structural measures	Trend of the budgets for disease prevention	Quantitative	-
Others	Number of patients	Quantitative	・Disease incidence per population and mortality rate

<table>
<tr><td>D.
Necessary Consideration for Planning of Adaptation Measures</td><td>1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:
- Consider the option of allocating treatment service of climate-sensitive diseases into other departments within hospitals or medical facilities, in case prevalence of these types of diseases exceeds the medical facilities' normal capacity
- Consider not only strengthening capacities of facilities, equipment and personnel, but also promotion of preventive measures (promoting hand-wash, distribution of mosquito nets) as part of project scope.

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
<tr><td>E.
Required Data</td><td>
<table>
<tr><th></th><th>Data</th><th>Remarks</th></tr>
<tr><td colspan="3">B. Vulnerability Assessment</td></tr>
<tr><td>1) Assess Past and Present Climate Trends and Risks</td><td>Past and present meteorological data</td><td>Identify the past and present meteorological conditions and trends through review of NC, NAPA and other relevant / available documents.</td></tr>
<tr><td>2) Assess Future Exposure to Climate Hazards and Perturbations</td><td>Future climate</td><td>In addition to the review of NC, NAPA and other reference materials, qualitative estimate of future climate conditions including trends in temperature, rainfall pattern / intensity, and extreme weather, using the data if any, from the analysis models and climate change scenarios adopted in the country.</td></tr>
<tr><td rowspan="2">3) Assess Future Sensitivity to Climate Change</td><td>Incidence levels of infectious disease cases (morbidity and mortality rates)</td><td>Study infectious disease cases in the target country and other potentially affected areas in neighboring countries.
For the specific disease types observed, collect data and information on morbidity and mortality rates of the infectious diseases for the past 5-10 years. Using national and regional statistics as basic secondary data, then, collect the primary data from public health organizations, health-related government institutions, and other regional health centers.</td></tr>
<tr><td>Conditions of existing public health-related infrastructures</td><td>Identify the level of infrastructure development of public health-related facilities such as water supply, sewerage, drainage and public toilet interviews with the relevant agencies, while examining potential health risks that may arise from the use of these facilities (i.e., flood of contaminated and/or rain water, incidence of stagnant water areas).</td></tr>
</table>
</td></tr>
</table>

	4) Assess Adaptive Capacity to Climate Change	Population shares of socially-vulnerable groups	Collect demographic profiles of infant, elderly, poor households from national or regional census. Substitute with the morbidity and mortality rates and other population data obtained in “3) Assess Future Sensitivity to Climate Change”.
		Number of doctors per population	Identify number of doctors and other healthcare-related workers and obtain their proportions to the population of the target areas or the entire administration unit.
		Number of existing medical institutions / healthcare centers	Identify the number and geographic distribution of existing medical and healthcare centers that can treat infectious diseases in the target areas or the entire administration unit.
		Conditions of preventive action initiatives against infectious diseases	Identify current preventive action programs and performances against infectious diseases.
		Other stakeholders’ involvement	Identify and assess budget levels of national or regional government for infectious disease prevention and treatment. Identify NGOs’ involvement in preventive or treatment activities. Identify imbalances on these aspects in the target areas.
	Others		
		Information related to adaptation	Review and study the adaptation policy by reviewing past studies and other information about adaptability to climate change in and around the target area, if available.

Guideline: Medical / Health Care (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td><u>■ Necessity of Adaptation Options</u>
It is necessary to upgrade and expand medical / healthcare facilities and equipment in order to provide better healthcare services in the target areas. Climate change impacts are expected to increase infectious disease cases which would have been a minor issue in the target areas.
<u>■ Adaptation Options</u>
In the development under the business-as-usual condition, the project may focus on capacity-building for the areas of cardiac and brain surgeries, other internal medicine, trauma care, adult disease, and HIV. In addition to these, adaptation measures to climate change will require preparation for the increasing concern on water and vector-borne diseases.
<u>■ Outcome of Adaptation Options</u>
In case there are serious climate change impacts, sufficient medical or healthcare services will be provided.</td></tr>
<tr><td>B.
Vulnerability Assessment (Risk and Change)</td><td>Referring to existing references (National Communication and National Adaptation Program of Action), study and assess the past and present climate trends (rainfall intensity / pattern, daily / seasonal temperature changes, frequency / intensity / cycle of floods and droughts).</td></tr>
<tr><td>C.
Planning Adaptation Options</td><td>The planning of adaptation options must take into consideration the primary objectives of prevention and treatment of infectious diseases associated with climate change. Adaptation options is comprised of the following several measures:
- Development of departments or facilities specifically designated for prevention and treatment of infectious diseases.
- Strengthening capacity of personnel involved in prevention and treatment of infectious diseases.
- Conducting awareness campaigns or activities to promote preventive measures against infectious diseases.
- Combinations of the above options.</td></tr>
<tr><td>D.
Project Evaluation of Adaptation Options</td><td>[Items for Assessment in Project Formulation]
<table>
<tr><th>Items</th><th>Outcome</th><th>Method</th><th>Relative Operation and Effect Indicators</th></tr>
<tr><td>Morbidity rates for infectious diseases</td><td>Monitoring number of patients, infection periods will be reduced.</td><td>Quantitative</td><td>・Disease incidence per 100 persons by type of disease</td></tr>
<tr><td>Mortality rates for infectious diseases</td><td>Treatment environment will be improved and mortality rates will be reduced.</td><td>Quantitative</td><td>・Disease mortality rate per 1000 persons</td></tr>
<tr><td>Conditions of preventive activities against infectious diseases</td><td>Preventive activities will become proactive.</td><td>Qualitative</td><td>-</td></tr>
</table></td></tr>
</table>

[Alternative Items for Assessment in Monitoring and Review]

Type of Measures	Alternative Indicators	Method	Relative Operation and Effect Indicators
Non-structural measures	Trend of the budgets size for disease prevention	Quantitative	-
Others	Number of patients	Quantitative	・Disease incidence per population and mortality rate

E. Necessary Consideration for Planning of Adaptation Options

1) Monitoring and Review
Plan periodical schedule for monitoring of climate condition and review after project implementation. The climate change impacts, which are not considered for the project scope but have certain risks, shall be included among the monitoring items.

2) Flexibility to Climate Change
Secure flexibility to climate change impacts, which are not considered for the project scope but to address certain risks. The range of flexibility shall be determined with counterpart agencies. The items should include the following:

- Consider the option of allocating treatment service of climate-sensitive diseases into other departments within hospitals or medical facilities, in case prevalence of these types of diseases exceeds the medical facilities' normal capacity
- Consider not only strengthening capacities of facilities, equipment and personnel, but also promotion of preventive measures (promoting hand-wash, distribution of mosquito nets) as part of project scope.

3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.

F. Required Data

	Data	Remarks
B. Vulnerability Assessment		
	Past and present meteorological data	Identify the past and present meteorological conditions and trends through review of NC, NAPA and other relevant / available documents.
	Incidence levels of infectious disease cases (morbidity and mortality rates)	Study infectious disease cases in the target country and other potentially affected areas in neighboring countries. For the specific disease types observed, collect data and information on morbidity and mortality rates of the infectious diseases for the past 5-10 years. Using national and regional statistics as basic secondary data, then, collect the primary data from public health organizations, health-related government institutions, and other regional health centers.
	Conditions of preventive action initiatives against infectious diseases	Identify current preventive action programs and performances against infectious diseases.
Others		
	Information related to adaptation	Review and study the adaptation policy as well as the past studies and other information about adaptation to climate change in and around the target area, if available.

References and Key Different Features

1) Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change[1]
WHO proposes the following steps to assess vulnerability and adaptation in the area of public health:

a) Determine the scope of assessment
b) Describe the current distribution and burden of climate-sensitive diseases
c) Identify and describe current strategies, policies and measures that reduce the burden of climate-sensitive diseases
d) Review the health implications of the potential impact of climate variability and change on other sectors
e) Estimate the future potential health impact using scenarios of future climate change, population growth and other factors and describe the uncertainty
f) Synthesize the results and draft a scientific assessment report
g) Identify additional adaptation policies and measures to reduce potential negative health effects, including procedures for evaluation after implementation

This document highlights the procedures in developing adaptation measures from the assessment of human health vulnerability affected by climate change. Assessment methods for general infectious diseases (vector, water and food-borne diseases and health impacts by flood, heat wave, air pollution and ozone depletion) will be useful in formulating yen loan adaptation projects for the healthcare sub-sector. Since the document is designed for developed countries as well as developing countries, it considers heat wave impacts and risk of skin cancer due to increasing level of incoming UV radiation.

2) Wise Adaptation to Climate Change[2]
The document contains discussion on human health impacts by climate change in Japan and points out potential risks of increase in heat stroke cases and its mortality rate. While alerting outbreak of infectious diseases in Japan, it concerns possibility of indirect import of pathogen and vectors from developing countries through trade of goods and materials as well as intercommunication of travelers. Thus, it recognizes that risk of disease outbreak in developing countries as own risk in Japan, which supports the importance of reduction measures against infectious disease risk in developing countries.

[1] WHO. (2003). Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change.
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