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. ■ Decrease in Rainfall and Change in Rainfall Patterns ・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. ■ Increase in Rainfall Amount and Intensity, Increase in Frequency and Intensity of Extreme Events ・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. ■ Increase in Frequency and Duration of Drought ・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. ■ Temperature Rise ・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 mitigating 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 standards that would have been achieved without climate change. ■ Adaptation Measures Rural infrastructure development and support of rural livelihood will improve and maintain primary living standards 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 from meteorological weather stations and regulatory agencies 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. 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 change factors for urban and rural development planning through review of the regional and urban development plans, land use regulations, etc. in order to clarify 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 Clarify 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 Clarify 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) Determine and Project Adaptive Capacity to Climate Change

a) Identification of Adaptive Capacity

・Apply the results of Item 3) b) Present Condition of Facilities and Measures.

・Clarify the present organizational capacity and conditions of residents through meetings with stakeholders such as regional government department concerned and local residents.

・Clarify 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

Clarify 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 standards 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 of extended 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 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 in 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 observed 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>Estimate 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>Clarify 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) Determine and Project 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>Clarify 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>Clarify 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>■ Necessity of Adaptation Options
BAU development project will be implemented for rural development. However, the anticipated climate change will cause difficulty in maintaining the expected livelihood and living standards in the rural areas, which requires considering the adaptation options to climate change impacts.
■ Adaptation Options
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
■ Outcome of Adaptation Options
In case the target areas are exposed to climate change, the rural system will function properly and the area can sustain living standards.</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. Predict 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 of extended 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 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 in 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	Estimate 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 mitigate 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 of 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 use of water resources and impact on 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 ■ Decrease in Rainfall and Change in Rainfall Patterns ・Available amount of portable water will be reduced. ■ Increase in Rainfall Amount and Intensity, Increase in Frequency and Intensity of Extreme Events ・Flood in urban areas including roads, commercial / residential areas will frequently occur due to malfunction of drainage system. ・Flood will indirectly affect economic activities and hygienic environment. ・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. ■ Temperature Rise ・Increased demand for portable water will increase water stress. ・Heat-island phenomenon will increase human health impacts represented by heat stroke. ■ Sea level rise ・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. ■ Others ・Temperature rise and change in rainfall pattern may increase vector for infectious diseases. 2) Other Factors that Influence the Urban Development Sub-sector Associated with Climate Change Impacts ・Changes in population proportion 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 Extension of Urban Drainage Systems ・Rehabilitation and extension of existing drainage channels, pump stations, and flood regulating ponds to increase drainage capacity during intensive rainfall. ■ Rehabilitation and Extension of Water supply and Sewerage Systems ・Rehabilitation and extension of water supply system, and development of alternative water sources to increase supply capacity for urban areas. ・Development, rehabilitation and extension of sewerage system to improve drainage and treatment capacity for urban areas. ■ Development, Rehabilitation and Extension 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 mitigate sediment discharge and landslides in mountainous areas. ・Developing and extending designated evacuation centers. ・Developing and extending 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	■ Necessity of Adaptation Climate change will impact on regular functions of cities / urban areas, and make it difficult to maintain ordinary livelihood. ■ Adaptation Measures The development of urban infrastructure will improve and sustain primary conditions of urban livelihood. ■ Outcome of Adaptation Measures Vulnerability of urban areas will be reduced.
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 referring to rainfall intensity and patterns, seasonal and daily changes of temperature, cycles of extreme events, and conditions of surface and groundwater. 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 change factors for vulnerability of urban areas through review of regional and urban development plans, land use regulations, etc. in order to clarify factors affecting vulnerability. 3) Assess Future Sensitivity to Climate Change a) Study Past Damage Clarify 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 Clarify 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) Determine and Project 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

Clarify 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.

Clarify 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: 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 mitigated. Other urban disaster impacts will be mitigated 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 standards 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 of extended 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")

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. Climate change impacts that are not considered for the project 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 in 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.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorological data	Collect observed data such as meteorological data and river discharge from meteorological stations (and hydrological stations if applicable).
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Estimate 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.
3) Assess Future Sensitivity to Climate Change	Conditions of urban infrastructures and their functional validities	Clarify present conditions of urban infrastructures related to urban livelihood and their functional validities through reconnaissance survey and meetings with the stakeholders.
4) Determine and Project Adaptive Capacity to Climate Change	Conditions of urban infrastructures and their functional validities	Same as above.
	Involvement of the municipal government department and NGOs concerned	Clarify 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.
	Socio-economic conditions of urban residents	It is ideal to focus on the smallest administration unit if possible. While studying secondary sources from statistical offices, it is necessary to conduct investigation and give questionnaire 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 Development (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td>■ Necessity of Adaptation Options
BAU development project will be implemented for urban infrastructure development. However, the anticipated climate change will cause difficulty in maintaining the expected livelihood and living standards in the urban areas, which requires considering the adaptation options to climate change impacts.
■ Adaptation Options
Appropriate measures will be implemented within the project with consideration of the climate change impacts.
■ Outcome of Adaptation Options
In case the target areas are exposed to climate change, the urban system will function properly and the area can sustain living standards.</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 of extended 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")
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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 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 in 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	Estimate 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 mitigate 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).