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 its occurrence. This would in turn lead to an increase in 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 <u>■ Increase of Precipitation, Increase in Intensity and Frequency of Heavy Rain, and Increase in Intensity and Frequency of Extreme Events (Cyclones)</u> ・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. <u>■ Temperature Rise</u> ・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. <u>■ Sea Level Rise</u> ・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 becomes 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 mitigation 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 post-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	■ Necessity of Adaptation Climate change will bring about precipitation increase during short-term and continuous rainfall. 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 desolation in the upstream area, and adverse effects to the downstream dams, river channels and estuaries. ■ Adaptation Measures 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. ■ Outcome of Adaptation Measures Sediment-related disaster by climate change will be mitigated.
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 change 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 investigations with stakeholders (e.g. related agencies, persons in charge of disaster, and inhabitants). Organize 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 inventory survey and review of documents such as 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
Organize 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) Determine and Project 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.

- Conditions of 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 Capability of Regulatory Agency
Assess organizational structure, condition of budget and program of activity for disaster recovery of regulatory agencies.

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

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

- Situations of 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 capability 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	Mitigation of damage due to sediment-related disaster	Economic	・Amount of damage
		Quantitative	-
Risk of priority protection area	Mitigation 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 capability 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	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 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 in 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.

E. Required Data

	Data	Remarks
B. Vulnerability Assessment		
1) Assess Past and Present Climate Trends and Risks	Past and present meteorology and hydrology	Collect observed data such as meteorological data, river discharge, sediment yield, and riverbed elevation from meteorological and hydrological stations.
2) Assess Future Exposure to Climate Hazards and Perturbations	Future climate	Estimate 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.
	Socio-economic incidence	Collect information about 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.
3) Assess Future Sensitivity to Climate Change	Past sediment-related disaster damage	Collect and organize the damage situation by area, spatial distribution of disaster, recurrence cycle of wide-area disaster, etc.
	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 inventory survey.
	Operation and maintenance record of sediment-related disaster prevention facilities	Collect detailed operation and maintenance record to study the situation during sediment-related disaster occurrence.
4) Determine and Project Adaptive Capacity to Climate Change	Risk of priority protection area	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.

	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 capability of regulatory agency	Study and review the organizational structure, and 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: Sediment-related Disaster Prevention (BAU Development with Adaptation Options)

<table>
<tr><td>A.
General</td><td>■ Necessity of Adaptation Options
It is necessary to plan or reconsider sediment-related disaster prevention works, as demanded, in association with economic growth and land development.
Potential risks of sediment-related disasters in more extended 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.
■ Adaptation Options
Appropriate measures will be implemented within the project with consideration of the increased sediment-related disaster damage associated with climate change.
■ Outcome of Adaptation Options
The expected damages from the sediment-related disaster will be mitigated or reduced in the event of climate change.</td></tr>
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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>
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Planning Adaptation Options</td><td>Plan adaptation options that account for 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>
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3) Consideration to Maladaptation
Check maladaptation caused by the project, and plan the corresponding countermeasures.</td></tr>
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References and Key Different Features

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

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 mitigate 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.

[i] 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)