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)
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

- **Sea Level Rise**
  - 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.

- **Increase of Wave Height**
  - 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.

- **Increase/ Intensification of Cyclones**
  - Damage due to storm surges and high waves will become increase and intensify in association with sea level rise, which will damage buildings, containers, and apron machinery and materials.
  - Wind speed in the operation of cargo-handling equipment will be exceeded more frequently, and operating efficiency will fail.

- **Increase/ Intensification of Precipitation**
  - Heavy rains beyond the drainage capacity of aprons will cause inundation.

- **Sea Temperature Rise**
  - Water quality will be degraded in enclosed water such as the inside of port breakwaters.

- **Change of Ocean Current**
  - 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 become 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.

<table>
<thead>
<tr>
<th>C. Adaptation Measures</th>
<th>Major Adaptation Measures in the Port Sub-sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Development/ Improvement of Port Structure</td>
<td></td>
</tr>
<tr>
<td>- Strengthening of existing quays with design conditions conforming to the climate change impacts.</td>
<td></td>
</tr>
<tr>
<td>- Change or reinforcement of structures such as revetments, wave dissipating block, and parapets, with consideration of climate change impacts.</td>
<td></td>
</tr>
<tr>
<td>- Reinforcement of facilities and equipment affected by wind pressure, such as tower cranes.</td>
<td></td>
</tr>
<tr>
<td>- 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.</td>
<td></td>
</tr>
<tr>
<td>■ Raising of Facilities</td>
<td></td>
</tr>
<tr>
<td>- Raising of aprons and breakwaters against inundation and wave overtopping.</td>
<td></td>
</tr>
<tr>
<td>- Steepening of apron gradients in order to improve drainage capacity.</td>
<td></td>
</tr>
<tr>
<td>■ Non-structural Measures</td>
<td></td>
</tr>
<tr>
<td>- Improvement of cargo handling to mitigate materials and equipment loss due to storm surges and high waves.</td>
<td></td>
</tr>
<tr>
<td>- Facilitation of water circulation of inside breakwaters from and to outside to mitigate water quality degradation.</td>
<td></td>
</tr>
<tr>
<td>- Dredging of ports and waterways.</td>
<td></td>
</tr>
<tr>
<td>- Security and coordination with alternative transport routes and logistics schemes.</td>
<td></td>
</tr>
</tbody>
</table>
| 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

- **Increase of Precipitation and Cloud Amount**
  - 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.

- **Change of Wind Direction and Speed**
  - Change of prevailing wind will greatly affect flight operation. Take-off and landing will be affected 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.

- **Temperature Rise**
  - Temperature rise will reduce air density. This leads to reduction of lift, consequently the runway length would become short for take-off and landing.

- **Change of Ecosystem**
  - 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 bird 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 interruption would be avoided when air transportation is restricted.
- If budget and programs for disaster recovery are well in place, disaster response capability of management body and regulatory agency become 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.
  - Extension 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.

### 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.
### 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 mitigated, 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 change 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 investigation with stakeholders such as the port management body and port users, as well as through websites for meteorology. Organize 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 inventory survey and review of documents such as 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) Determine and Project Adaptive Capacity to Climate Change
a) Identification of Adaptive Capacity
   • Alternative Transportation Means
     Assess the situation of alternative transport routes and logistics means.
   • Disaster Resilience Capability of Regulatory Agency and Management Body
     Assess condition of budget and activity for disaster recovery of regulatory agencies and management bodies.
   • Existence and Ability of Research and Development
     Assess condition of research and development for port.
   • Compensation for Storm Surge and High Wave Damage
     Assess the post-disaster restoration capability:
     - Situations of 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.

<table>
<thead>
<tr>
<th>Items</th>
<th>Low</th>
<th>← Vulnerability →</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future sensitivity to climate change</td>
<td>Small</td>
<td></td>
<td>Large</td>
</tr>
<tr>
<td>Alternative transportation means</td>
<td>Existing/ Sufficient</td>
<td>None/Poor</td>
<td></td>
</tr>
<tr>
<td>Disaster resilience capability of regulatory agency and management body</td>
<td>Excellent</td>
<td></td>
<td>Poor</td>
</tr>
<tr>
<td>Existence and ability of research and development</td>
<td>Existing/ Excellent</td>
<td>None/Poor</td>
<td></td>
</tr>
<tr>
<td>Compensation for storm surge and high wave damage</td>
<td>Sufficient</td>
<td></td>
<td>Poor</td>
</tr>
</tbody>
</table>

C. Project Evaluation of Adaptation Measures

<table>
<thead>
<tr>
<th>Items for Assessment in Project Formulation</th>
<th>Items</th>
<th>Outcome</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future sensitivity to climate change</td>
<td>Maintenance of port function (for logistics and transportation)</td>
<td>Quantitative</td>
<td>• Freight</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Tonnage of vessel entered</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Berth occupation ration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Weekly working hours ration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Weekly crane operation ration</td>
</tr>
</tbody>
</table>
12. Port and Airport

| Alternative transportation means | Mitigation of transportation and logistics interruption | Quantitative | ・ Flooded area  
| ・ Maximum water depth  
| ・ Inundation duration |
| Disaster resilience capability 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]

<table>
<thead>
<tr>
<th>Type of Measures</th>
<th>Alternative Indicators</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

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 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

#### B. Vulnerability Assessment

<table>
<thead>
<tr>
<th>Data</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1) Assess Past and Present Climate Trends and Risks</strong></td>
<td>Past and present marine weather and meteorology.</td>
</tr>
<tr>
<td><strong>2) Assess Future Exposure to Climate Hazards and Perturbations</strong></td>
<td>Future climate estimate 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 information about development plans and land use regulations, in and around the target port and country from relevant organizations and other agencies.</td>
</tr>
<tr>
<td><strong>3) Assess Future Sensitivity to Climate Change</strong></td>
<td>Information about structural damage by tide change, storm surge and high wave damage.</td>
</tr>
<tr>
<td></td>
<td>Collective damages of each place by event. Secular change shall be also collected.</td>
</tr>
<tr>
<td>Design condition and design bearing capacity of existing structure</td>
<td>Study the design condition and bearing 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 inventory survey.</td>
</tr>
<tr>
<td><strong>4) Determine and Project Adaptive Capacity to Climate Change</strong></td>
<td>Alternative transportation means.</td>
</tr>
<tr>
<td></td>
<td>Study and review the situation of alternative transport schemes including land and air routes through interviews with related agencies, and based on related information collected.</td>
</tr>
<tr>
<td>Disaster resilience capability of regulatory agency and management body</td>
<td>Study and review budget and programs of activity through interviews with related agencies and management bodies, and based on related information collected.</td>
</tr>
<tr>
<td>Existence and ability of research and development</td>
<td>Study and review the research activity programs through interviews with related agencies and based on related information collected.</td>
</tr>
<tr>
<td>Existence and enrollment of damage insurance and mutual aid system</td>
<td>Study and review the status through interview with related agencies and based on related information collected.</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>Information related to adaptation.</td>
</tr>
<tr>
<td></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>
</tbody>
</table>
A. General

■ Necessity of Adaptation Options
New ports will be constructed, or existing ports will be extended 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.

■ Adaptation Options
Appropriate measures will be implemented within the project with consideration of the climate change impacts.

■ Outcome of Adaptation Options
Port functions will be maintained 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 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.

C. Planning Adaptation Options
Plan adaptation options that account for 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 mitigating materials and equipment loss, and security of alternative transportation means, which could be implemented individually or simultaneously.

D. Project Evaluation of Adaptation Options

[Items for Assessment in Project Formulation]

<table>
<thead>
<tr>
<th>Items</th>
<th>Outcome</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
</tr>
</thead>
</table>
| 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 |
| Mitigation of inundation and facility damage | Quantitative | • Flooded area  
• Maximum water depth  
• Inundation duration |
| Alternative transportation means | Mitigation of transportation and logistics interruption | Qualitative | - |

[Alternative Items for Assessment in Monitoring and Review]

<table>
<thead>
<tr>
<th>Type of Measures</th>
<th>Alternative Indicators</th>
<th>Method</th>
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</thead>
<tbody>
<tr>
<td>Structural measures</td>
<td>Improvement of target return period and safety factor of facilities</td>
<td>Quantitative</td>
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</tr>
<tr>
<td>Others</td>
<td>Changes in the awareness of</td>
<td>Qualitative</td>
<td>-</td>
</tr>
</tbody>
</table>
12. Port and Airport

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 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 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.

F. Required Data

<table>
<thead>
<tr>
<th>B. Vulnerability Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
</tr>
<tr>
<td>Future climate</td>
</tr>
</tbody>
</table>

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. |
### A. General

<table>
<thead>
<tr>
<th>Necessity of Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>To secure safety during take-off and landing of planes, and structure safety of the airport by mainly development and improvement of airport facilities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome of Adaptation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The impacts of climate change on flight operations and structure safety will be mitigated.</td>
</tr>
</tbody>
</table>

*(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. Estimate meteorological aspects 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 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 investigation 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 investigation with stakeholders such as regulatory agencies, management bodies for airport structures, terminal buildings and access roads, and users. Organize 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 inventory survey and review of documents such as 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.
Step 2
4) Determine and Project Adaptive Capacity to Climate Change
   a) Identification of Adaptive Capacity
      • Alternative Transportation Means
        Assess the situation of alternative transport routes and logistics in case of limitation in take-off and landing.
      • Disaster Resilience Capability of Regulatory Agency and Management Body
        Assess condition of budget and programs for disaster recovery of regulatory agencies and management bodies of each facility.
      • Existence and Ability of Research and Development
        Assess condition of 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.

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<thead>
<tr>
<th>Items</th>
<th>Outcome</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
</tr>
</thead>
</table>
| 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  |
| Alternative transportation means                   | Mitigation of inundation and facility damage | Quantitative     | • Flooded area  
|                                                    |                                               |                  | • Maximum water depth  
|                                                    |                                               |                  | • Inundation duration  |
| Disaster resilience capability of regulatory agency and management body | Mitigation of transportation and logistics interruption | Qualitative | |
| Existence and ability of research and development | Improvement of adaptive capacity             | Qualitative      | - |

C. Project Evaluation of Adaptation Measures

<table>
<thead>
<tr>
<th>Items</th>
<th>Outcome</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
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|                                                    |                                               |                  | • Volume of freight  
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| Alternative transportation means                   | Mitigation of inundation and facility damage | Quantitative     | • Flooded area  
|                                                    |                                               |                  | • Maximum water depth  
|                                                    |                                               |                  | • Inundation duration  |
| Disaster resilience capability of regulatory agency and management body | Mitigation of transportation and logistics interruption | Qualitative | |
| Existence and ability of research and development | Improvement of adaptive capacity             | Qualitative      | - |
### 12. Port and Airport

#### [Alternative Items for Assessment in Monitoring and Review]

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<tr>
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<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>Changes in the awareness of stakeholders</td>
<td>Qualitative</td>
<td>-</td>
</tr>
</tbody>
</table>

#### 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 further increase of precipitation (room for installation of new drainage facilities or enhancement)
- Countermeasures for further temperature rise (room for extension of runway)

3) **Consideration to Maladaptation**

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

#### E. Required Data

<table>
<thead>
<tr>
<th>Data</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B. Vulnerability Assessment</strong></td>
<td></td>
</tr>
<tr>
<td>1) Assess Past and Present Climate Trends and Risks</td>
<td>Collect observed data from meteorological stations.</td>
</tr>
<tr>
<td>Past and present meteorology</td>
<td></td>
</tr>
<tr>
<td>2) Assess Future Exposure to Climate Hazards and Perturbations</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 data in the target area.</td>
</tr>
<tr>
<td>Future climate</td>
<td></td>
</tr>
<tr>
<td>Socio-economic incidence</td>
<td>Collect information about development plans in and around the target airport and country, and development tendency of aircraft, from relevant organizations and other agencies.</td>
</tr>
<tr>
<td>Information about inundation and structural damage, limitation of take-off and landing</td>
<td>Collect and organize damages of each location by event. Secular change shall be also collected.</td>
</tr>
<tr>
<td>Design condition and design bearing capacity of existing structure</td>
<td>Study the design condition and bearing 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 inventory survey.</td>
</tr>
<tr>
<td>4) Determine and Project Adaptive Capacity to Climate Change</td>
<td>Alternative transportation means</td>
</tr>
<tr>
<td>Disaster resilience capability of regulatory agency and management body</td>
<td>Study and review budget and programs of activity through interviews with related agencies and management bodies, and based on related information collected.</td>
</tr>
<tr>
<td>Existence and ability of research and development</td>
<td>Study and review the situation of research activity through interviews with related agencies, and based on related information collected.</td>
</tr>
<tr>
<td>Others</td>
<td>Information related to adaptation</td>
</tr>
</tbody>
</table>
A. General

- **Necessity of Adaptation Options**
  New airports will be constructed, or existing ones will be extended 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 bird ecosystem, are likely to increase in the target airport by climate change impacts.

- **Adaptation Options**
  Appropriate measures will be implemented within the project with consideration of the climate change impacts.

- **Outcome of Adaptation Options**
  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 that account for 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

<table>
<thead>
<tr>
<th>Items for Assessment in Project Formulation</th>
<th>Outcome</th>
<th>Method</th>
<th>Relative Operation and Effect Indicators</th>
</tr>
</thead>
</table>
| 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 |
|                                            | Mitigation of inundation and facility damage | Quantitative | • Flooded area  
  • Maximum water depth  
  • Inundation duration |

<table>
<thead>
<tr>
<th>Alternative Items for Assessment in Monitoring and Review</th>
</tr>
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<tbody>
<tr>
<td>Type of Measures</td>
</tr>
<tr>
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</tr>
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<td>Structural measures</td>
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</table>

**B. Vulnerability Assessment**

- 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) Concept of Port Policy on Climate Change Resulting from Global Warming (Policy Report)

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 mitigation 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.

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