Approaches to Climate Change Adaptation

November , 2010

The Committee on Approaches to Climate Change Adaptation

List of Members

The Committee on Approaches to Climate Change Adaptation

（Titles omitted）

Chairperson

Nobuo Mimura	Professor and Special Assistant to the President, Center for Water Environment Studies, Ibaraki University
Hiroshi Ando	Manager, Global Warming Countermeasures Section , Department of Environment, Saitama Prefecture
Seita Emori	Chief of Center for Global Environmental Research (CGER)(Climate Risk Assessment Research Section), National Institute for Environmental Studies
Takahiro Ochiai	Director of Conservation of Water and Soil Division, Forestry and Forest Products Research Institute
Kuga Hitoshi	Group Leader of Global Warming Countermeasures and Senior Researcher of Recycling Society Division, Nagano Ｅnvironmental Conservation Research Institute
Mitsuru Tanaka	Professor, Hosei School of Policy Sciences
Kaoru Nakata	General Manager of Marine Productivity Department, National Research Institute of Fisheries Science, Fisheries Research Agency
Toshihiro Hasegawa	Senior Researcher of Agro-Meteorology Division, National Institute for Agro-Environmental Sciences
Yasuaki Hijioka	Senior Researcher of Social and Environmental Systems Division (Integrated Assessment Section), National Institute for Environmental Studies

Koh-ichi Fujita Research Coordinator for Watershed Management, River Department, National Institute for Land and Infrastructure Management

Takao Masumoto Team Leader, Research Team for Global Warming and Environment & Head, Lab. of Hydrology and Water Resources, National Institute for Rural Engineering, National Agriculture and Food Research Organization

Approaches to Climate Change Adaptation

CONTENTS

Summary i

1. Background and objectives
1.1 Background and the need for adaptation 1
1.2 Objectives, audience, scope of this report 2

2. Approaches and concepts of adaptation
2.1 Framework for adaptation 3
2.2 Approaches to adaptation based on current scientific knowledge
(1) Types of adaptation 5
(2) Fundamentals needed to implement adaptation measures 10

3. Basic factors of adaptation common to all sectors
3.1 Factors in considering adaptation
(1) Latest knowledge on climate change 14
(2) Short-, medium- and long-term risk management in the face of uncertainty 17
(3) Consideration of regional characteristics 19

3.2 Specific procedures for adaptation planning and implementation 20

A Track. Detailed planning and implementation steps
Step (1) Analyze past observation data, review responses (including existing measures) to climate change and extreme weather events 22
Step (2) Plan and Implement monitoring of climate change and its impacts 22
Step (3) Project future climate change and its impacts 26
Step (4) Assess impacts, vulnerability, resilience, and risk 30
Step (5) Determine need for adaptation measures, determine priority 40
Step (6) Design and implement adaptation measures 45
Step (7) Track and assess progress and effects of adaptation policies measures, revise regularly 55
Step (8) Conduct integrated adaptation, basic capacity enhancement 57
Step (9) Communicate and share information with the public 58
Step (10) Review and implement based on feedback and re-assessment 58

B Track. Simplified first five steps for adaptation planning and implementation 59
Step 1 Share knowledge and approaches to adaptation, and examine existing measures 61
Step 2 Assess risks associated with climate change impacts 61
Step 3 Promote communication and decide adaptation plans, programs, and measures 62
Step 4 Start with the most feasible initiatives 62
Step 5 Consolidate risk assessments and adaptation measures based on monitoring and the latest knowledge 62

3.3 Approaches to incorporate adaptation into plans, programs and policies
(1) Use diverse options, including “soft” and “hard” measures 64
(2) Create synergies and prevent adverse socioeconomic and other impacts 68
(3) Integrate adaptation measures 70

Summary

Audience and objectives of this report

This report is mainly for national and local government departments responsible for adaptation to climate change. It summarizes basic approaches common to multiple sectors, with the following three objectives:

(1) to indicate various approaches to adaptation, based on the latest scientific knowledge and consideration of uncertainty;
(2) to indicate the basic factors of adaptation common to all sectors, relating to the consideration, planning, and implementation of adaptation measures; and
(3) to raise awareness about adaptation and its necessity.

Approaches to adaptation based on latest scientific knowledge

- Short-term adaptation: It is essential to initiate and encourage urgent response measures to prevent or mitigate short-term impacts that are already occurring and likely to arise from climate change.

- Medium- and long-term adaptation: Response measures are necessary to enhance adaptive capacity to prevent and mitigate possible impacts, by assessing the risks of impacts that may occur in the medium and long term, and by controlling the impacts, reducing vulnerability, and strengthening resilience.

    - Adaptation measures in individual sectors: These are measures implemented with the intention of adapting to estimated impacts in specific sectors. Even in sectoral adaptation, it is essential to evaluate the risk-reduction effects, costs, and other relevant factors comprehensively. (E.g., new construction and functional improvements of embankments to cope with sea level rise and storm surges, “soft” (non-structural) measures such as improvements in tsunami and storm surge hazard maps, and strengthening of measures to prevent outbreaks of infectious diseases such as dengue fever.)

    - Integrated adaptation and basic capacity enhancement: These approaches include integration of measures planned on a sectoral basis to a unified and effective adaptation plan, and enhancement of basic capacities of localities and sectors such as technologies and human resources. These should be implemented with a systematic and long-term perspective. (E.g., the identification of issues that require cross-sectoral approaches.)

- Awareness-raising (improvement of enabling conditions): It is of fundamental importance to raise the awareness and understanding of the people and government agencies responsible for adaptation. It is also important to identify the responsibilities, roles and collaborations among organizations both at national and local levels. These efforts should be initiated and promoted as quickly as possible.

- Information consolidation (improvement of enabling conditions): Institutional arrangements and methodology development for gathering, managing, and utilizing basic information on the target areas and sectors are the basis for planning and implementation of adaptation measures. These efforts should be initiated and promoted as quickly as possible.

- Research and technology development: Research and technology development should be promoted in such areas as monitoring and projections of climate change, measures for the short-term, and the medium- and long-term adaptation effective to improve the resilience of local societies.

Basic Factors of Adaptation Common to All Sectors

At the initial stage of adaptation planning and implementation, the following points deserve special attention.

- As the impacts of climate change are already occurring, it is urgent to strengthen existing response measures in individual sectors and take short-term adaptation measures. In parallel with this, it is essential to start planning the medium- and long-term adaptation measures, while assessing the future risks of climate change based on the latest scientific research.
- Effectively utilize existing information at the initial stage of assessing the risk of climate change impacts.
- Publish the results of risk assessments at an early stage, and broadly share awareness of those risks.
- Within government agencies, establish structures to promote adaptation, and give adequate priority to adaptation within policies, plans and programs.
- It is essential to initiate urgent efforts to prevent and/or mitigate short-term impacts, and also to give higher consideration to measures where socioeconomic benefits are clearly superior in terms of cost (e.g., no-regrets and win-win adaptation measures).

Steps for Adaptation Planning and Implementation

This report presents two “tracks” of steps for the planning and implementation of adaptation measures.

The first is a set of standard steps that should be conducted in any case. These are steps that can be implemented if a certain amount of information has already been compiled on climate change and its local impacts (“A-track” steps for planning and implementation of adaptation measures). Many local governments, however, are not ready to apply those steps directly. Therefore, it provides a second set of steps easy for those who consider adaptation measures for the first time. These consist of steps simplified from the “A-track”, to facilitate initial efforts for adaptation measures utilizing currently available information (“B-track” of the first five steps). It is envisioned that local governments intending to launch adaptation initiatives will first implement the initial B-track steps and then shift to the A-track steps later. It is also expected that the more detailed climate projection information at the local level required for these actions will become available as the research progresses. Below only “B-track” steps are shown, while ” A-track” steps are described in detail in the main text of the report.

The simplified first five steps for adaptation planning and implementation

Step 1: Share knowledge and approaches to adaptation, and examine existing measures

- Share knowledge and approaches about the need for, the importance of, and concepts relating to adaptation.
- Compile information about adaptation-related aspects of existing policies and measures, and identify areas where gaps exist.

Step 2: Assess the risks associated with climate change impacts

- Collect and analyze existing, readily available monitoring results information, etc.
- Assess risks of climate change impacts using existing information (identify high-risk events and areas).

Step 3: Promote communication, and decide adaptation plans, programs, and measures

- Share risk assessment results with the public and stakeholders.
- Determine the necessity of adaptation measures, consider their levels of importance, and prioritize adaptation planning and implementation in the policies.

Step 4：Start with the most feasible initiatives

- First, initiate urgent response measures to prevent and/or mitigate short-term impacts.
- Next, consider adaptation measures where socioeconomic benefits are clearly higher than costs.
- Track and assess progress and effectiveness of adaptation measures (overall assessment of progress).

Step 5: Consolidate risk assessments and adaptation measures based on monitoring and the latest knowledge

- Identify areas and items requiring priority monitoring and consider and improve methodologies and arrangements for them.
- Improve future projections using the latest research results and local monitoring data.
- Reassess risks, review and integrate adaptation measures.

Develop from "B-track" steps to the full-scale "A-track" steps

1. Background and objectives

1.1 Background and the need for adaptation

- The impacts of climate change are already evident in Japan and around the world. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) pointed out that even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades. To ensure the safety, security, and sustainable development of the society, it is therefore essential to implement not only initiatives for the long-term mitigation of climate change, but also policies to adapt to climate change.
- Across many of the relevant sectors as well as government departments and ministries, there has been much discussion and reporting on the impacts of and adaptation to global warming.
- Adaptation to the impacts of climate change will be essential in all countries, developing and developed. This report gives examples from England, the Netherlands, and Finland, which are already undertaking specific adaptation measures based on the results of national impact assessments.
- In Japan the socioeconomic impacts of climate change differ from those of other developed countries—from the perspective of terrain, topography, land use, and climate (being in the Asian monsoon region). It important for Japan to prepare for adaptation in ways that apply specifically to its own circumstances.
- Meanwhile, in Japan as in other countries, some initiatives are already underway that include a variety of adaptation benefits—in sectors where climate change's possible impacts are being felt. The importance of adaptation has yet to be adequately recognized, however, and in fact, adaptation efforts have really just begun. In the future, it will be essential to accelerate broad-based and integrated initiatives at the national and local levels, based on the latest scientific knowledge.

1.2 Objectives, audience, scope of this report

(1) Objectives

Below are the three objectives of this report.

1) To indicate basic approaches to adaptation, based on the current state of discussions about adaptation measures and the latest scientific knowledge, so that the national and local government departments responsible for adaptation can consider, plan, and implement adaptation measures in a coherent way.

2) To indicate the basic factors common to all sectors when developing specific adaptation measures, with the objective of supporting the national and local governments to consider, plan, and implement specific adaptation measures.

3) To overcome the current gap of awareness on the significance and necessity of adaptation, and raise awareness and motivation to undertake adaptation nationally, including at the local government level by presenting basic approaches to adaptation and basic factors.

(2) Audience

- Adaptation is not only a responsibility of national and local governments, but also directly related to the general public, corporations, and other actors in society. This report, however, is prepared especially for national and local government departments responsible for adaptation to climate change.

(3) Scope

- The scope of this report examines basic approaches that should be shared across multiple sectors, with the aim of achieving coherence among sectors, and basic factors relating to the planning and implementation of adaptation measures. Based on these approaches and basic factors, it is expected that the bodies responsible in each sector (e.g., water resources; disaster prevention; agriculture, forestry and fisheries; health; specific industries) will consider specific measures (i.e., assessment of individual adaptation measures, specific details of adaptation measures, etc.).

2. Approaches and concepts of adaptation

2.1 Framework for adaptation

- Adaptation prevents or moderates harm or exploits beneficial opportunities, by making changes in natural or human systems in the context of climate change impacts. The impacts of climate change are already occurring, and because they are projected to become even more severe in the future, it is essential to undertake short-, medium- and long-term adaptation measures. Short-term adaptation measures are required immediately in order to prevent and moderate impacts that are already experienced, while medium- and long-term adaptation measures are to prevent and mitigate projected future impacts.
- Adaptation measures are designed based on the following concepts.[1]

  1) Risk avoidance: Preventive measures against the occurrence of estimated impacts. (E.g., disaster prevention facilities, and regulation of development in vulnerable areas.

  2) Reduction of negative impacts: Measures to reduce the damage caused by impacts that occur. In the area of disaster prevention, examples include measures to reduce the damage from disasters, recovery assistance, etc.

  3) Risk sharing: Measures to suppress the concentration of impacts by spreading their burden across a wider population and over time.

  4) Risk acceptance: Accepting the potential for adverse impacts that have a low likelihood of occurrence, by not taking any specific measures today, or by delaying the implementation of measures while monitoring the situation.

  5) Exploitation of opportunities: Among the impacts of climate change, new business and other opportunities may appear from positive impacts, depending on the sector and region. The key here is to proactively utilize those opportunities.

- Such concepts are widely applied today in a variety of sectors. The key feature of climate change adaptation is in its proactive nature, including responses to the occurring impacts. These efforts thus should be based on projections of future climate, impacts, and societal trends. Because these projections involve uncertainty, the challenge is how to formulate adaptation planning under such uncertainties.
- It is essential to prepare the basic conditions for adaptation planning and

[1] Source: Partially adapted from Nobuo Mimura (2006) Perspectives and issues of adaptation as responses to global warming, *Global Environmental Research*, Vol. 11, No.1, 103-110 (in Japanese).

implementation. These efforts include accumulating information, raising public awareness, and arranging institutional frameworks for organized initiatives. In particular, as medium- and long-term adaptation is a proactive response, it requires development of institutional arrangements and methodologies for gathering, storing, managing, and utilizing basic information on the target regions and sectors. Discussions about global warming tend to focus on mitigation strategies such as the reduction of greenhouse gas emissions like carbon dioxide, and interest in adaptation measures is typically not very high. Nevertheless, to control the adverse impacts until climate change mitigation actually becomes effective, it is essential to promote both mitigation and adaptation measures in an integrated way. It is also important to view these measures in the context of future regional and community development. To promote these types of measures, it is important to aim for greater awareness about adaptation measures—among not only government departments (including local governments), but also at every level of society.

- The time scales for considering these types of adaptation measures, as stated above, include the short term, and the medium and long term. This report generally takes the following approach to distinguish between them.
    - Short term: Less than 10 years
    - Medium and long term: 10 to 100 years
        - Medium term: 10 to 30 years (inclusive)
        - Long term: More than 30 years to 100 years

2.2 Approaches to adaptation based on current scientific knowledge

- Regarding the topics discussed above in section 2.1, Figure 1 below shows Japan's integrated approach to adaptation at this point in time.
- Adaptation covers an extremely broad range, but the scope of concepts covered by this report can be summarized as shown below. Note that some adaptation policies, plans, and measures may overlap across more than one concept.

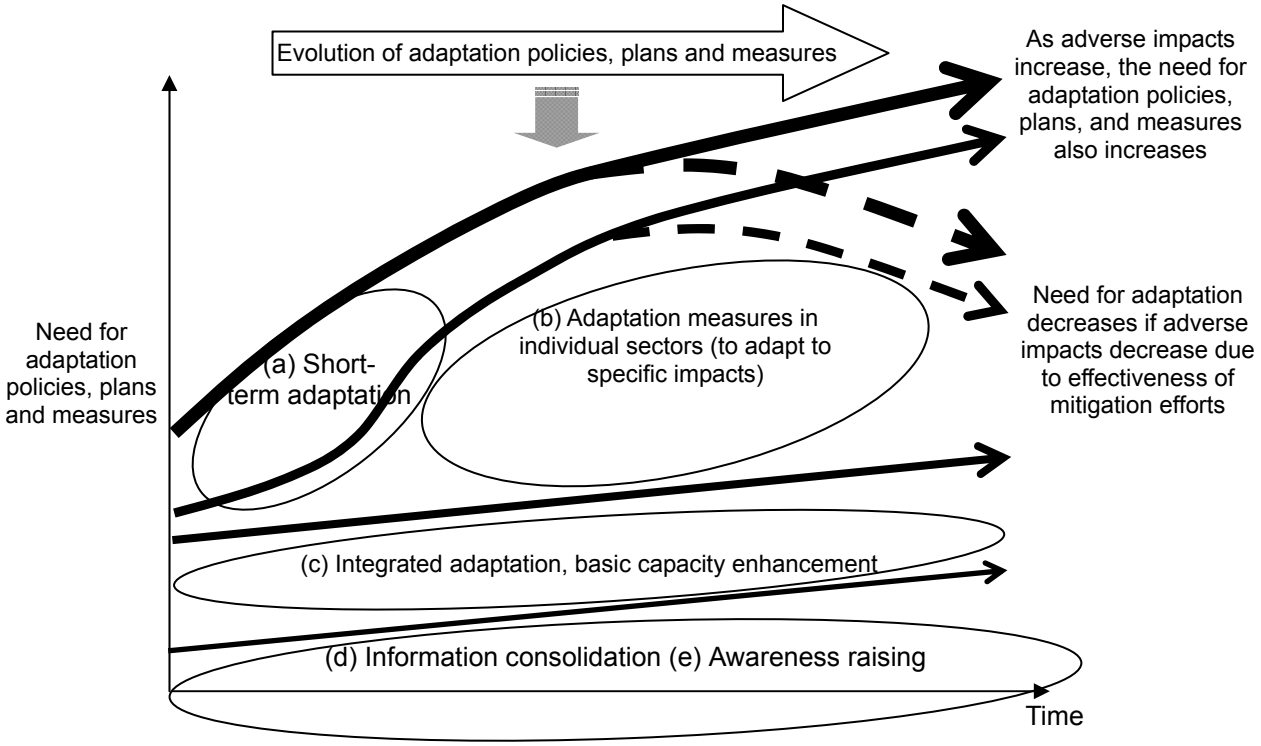


Figure 1. Types of adaptation measures needed over time (conceptual)

(1) Types of adaptation

1) Short-term adaptation (see (a) in Figure 1)

- During at least the next few decades, it will be essential to initiate and encourage—to the greatest extent possible and as quickly as possible—urgent adaptation and recovery measures for impacts that have a high likelihood of arising from climate change already occurring despite mitigation efforts.

Examples:

- The introduction of heat-resistant crop varieties and promotion of appropriate cultivation methods, to address the declining crop quality and yields
- Measures to protect against the loss of alpine vegetation, bleaching of coral, etc.

- Crisis management arrangements and improvements in early warning systems, to deal with sea-level rise and with rising damage in confined areas and from intense rainfall events
- Installation and augmentation of independent electrical generation equipment for water purification plants to respond to power outages caused by the increase of natural disasters

- It is difficult to determine whether environmental changes and disasters occurring today are all caused by climate change. Each event occurs through the interaction of a variety of factors, with climate change being one of them. Because complex factors are behind recent changes in natural ecosystems, intense rainfall events, landslides, and impacts on agriculture, increasingly robust adaptation measures are needed and should be implemented in individual sectors. In the process, it is important to incorporate the perspective of adaptation to climate change.
- To consider the likelihood that an impact may be caused by climate change, it is useful to refer to relevant resources such as IPCC reports and the "Climate Change and Its Impacts in Japan" report,[2] and to seek the advice of experts when necessary. Research projects currently underway are expected to provide accurate climate projections and impact estimates at the local level for the near future. Also, because of the diversity and localized nature of climate change impacts it is worthwhile to make the best use of knowledge based on the experience of persons working in the respective regions and fields.

2) Medium- and long-term adaptation

- It is essential to respond to climate change (and its associated impacts) in the medium and long term (on the scale of 10 to 100 years), as projected based on sets of scenarios using climate change projection models, by improving adaptive capacity in society and in individual sectors, based on risk assessments.
- Based on the types introduced above, below are descriptions of several approaches to "adaptation measures in individual sectors," plus "integrated adaptation and basic capacity enhancement."

(i) Adaptation measures in individual sectors (to be implemented to adapt to specific projected impacts) (item (b) in Figure 1)

[2] "Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change: Climate Change and Its Impacts in Japan," October 2009, Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment.

- To incorporate elements of adaptation into measures that have a long lifespan (e.g., infrastructure improvements) or a long duration, it is necessary to use integrated approaches to evaluate the costs and benefits of risk reduction benefits, by selecting standards for measures based on the uncertainty of climate change projections a few decades hence and based on specific projections.
- It is important to consider the latest climate change projections and their levels of uncertainty. Where measures are selected based on projections of larger impacts, the risks may be minimized but the costs will be higher, and the result may be over-adaptation. Conversely, measures are selected is based on projections of smaller impacts, the costs may be minimized but the risks will be higher, and the result may be inadequate adaptation.
- Keeping in mind future projections and the cost and time necessary for implementation of adaptation measures, examples of other options worth considering might include the following: (1) implementing measures as quickly as possible to withstand the future projected impacts, whatever the size of budget; (2) implementing measures gradually, based on accumulating knowledge about future projections; and (3) accepting a certain amount of minor risk of damage while enhancing measures wherever possible.
- In the context of uncertainty about future projections, a number of approaches may improve flexibility: (a) by utilizing a variety of measures that combine both “soft” and “hard” approaches, allow some flexibility in the timing of decisions and scale for hard measures that involve costs; (b) by including possible changes in climate factors into the design standards for built structures, make it possible to respond to climate change when upgrading facilities in the future; (c) since rapid advances are occurring in global observation and climate projections, introduce ways to revise plans every few years, rather than adopting unchangeable adaptation policies, plans and measures.
- Also, for ultimate decisions and choices such as these, it is important that the principal local actors consider collaborating with nearby regions that share similar projections, to accurately understand and share this information to the greatest extent possible, and to adopt consensus-building processes.
- In addition, adaptation measures that offer co-benefits are important. Measures that provide other benefits besides adaptation—such as improved convenience and environmental improvements—can be expected to offer larger synergies than measures that aim only for adaptation.
- In order to facilitate making rational ultimate decisions and choices, it is important to incorporate aspects such as the implementation of additional climate projections focusing on the target regions; the consideration and presentation of a variety of options,

including phased implementation and other options; careful examination of risk-reduction effectiveness and costs; and flexible arrangements that permit reviews and changes during planning and implementation.

Examples:

- Improvements of river and sea embankments, functional improvements of existing facilities, etc.
- Land-use regulations and incentives in affected areas
- Construction (nesting) of ecosystem networks
- Strengthening of measures to prevent outbreaks of infectious diseases
- Development of global food supply-and-demand systems that consider climate change impacts (30- to 50-year time frame) based on existing projection methods
- Systematic water supply development to cope with recent frequent droughts

(ii) Integrated adaptation, basic capacity enhancement (see (c) in Figure 1)

- Integrated adaptation is intended to be more effective—through unified handling of measures that would otherwise be handled separately, sector-by-sector. This approach includes coordination between adaptation measures in different sectors, cross-sectoral initiatives, and the establishment of collaborative arrangements among the relevant government departments.
- Basic capacity enhancement contributes to the improvement of adaptive capacity of local societies, by enhancing the basic capacity—technologies, programs, financing, and human resources—that is typically present in regions and sectors.
- Both integrated adaptation and basic capacity enhancement have other benefits—even if the actual situation differs from projected climate change and its impacts—and should be promoted systematically and consistently, with a long-term perspective.

Examples:

- Taking action to clarify issues that require cooperation and cross-sectoral initiatives among multiple departments and sections within an organization, for the purpose of more efficient implementation of measures
- Reviewing the collection and organization of basic data and information relating to impact assessments and adaptation measures, and where found to be inadequate, identifying issues that require priority attention and implementing

systematic improvements

- Prioritizing climate change adaptation measures within the comprehensive plans of local governments
- Establishing organizations that cooperate with local research institutions, non-profit organizations, and various other types of organization

3) Information consolidation (see (d) in Figure 1)

- Usable platforms, tools, and information infrastructure are needed for the publication and sharing of basic information and information sources, such as research data and future projections, as well as risk assessment case studies. Local information provides the basis for adaptation measures, so it is important to move as quickly as possible to strengthen collaboration among research projects already underway and among practitioners regionally and individual sectors.

  Examples:

  - Improving and promoting the use of basic information about research data and future projections
  - Developing and providing information about examples of risk assessments and assessment tools
  - Setting up Internet portal sites for impacts and adaptation information that will be useful for governments
  - Promoting information exchanges and collaborative research with local research institutes

4) Awareness raising (see (e) in Figure 1)

- To the extent possible and as quickly as possible, it is important to initiate and encourage communication about risk and the provision of risk-related information to citizens and other concerned parties, while adequately considering and efficiently using existing structures and frameworks. This information is the basis for all adaptation measures, including decisions about implementing adaptation measures.

  Examples:

  - Risk-related information provision, communication about risk, and awareness-raising activities (combined with mitigation efforts) targeting citizens and businesses

- Sharing of information among relevant government departments; establishing supportive institutional arrangements; creating collaborative arrangements among governments, research institutes, and NGOs

(2) Fundamentals needed to implement adaptation measures

1) Clarification of responsibilities among national and local government bodies

- Efforts should be made to clarify the responsibilities of departments in order to gather information relating to climate change, and to promote the adaptation measures in individual sectors in an organized way.

2) Role and collaboration of each actor

- Adaptation measures are normally related to the activities of national and local government bodies, but they also relate to the daily lives of citizens, and the activities of businesses. It is therefore important that a broad range of actors act with an awareness of their relationship with and roles in the respective adaptation policies, plans, and measures. Below are examples of the roles of each type of actor.
  - National governments: Monitoring of measures and programs implemented at the national level, projections at the national level, implementation of risk assessments, sharing of information with citizens, formulation of adaptation measures (including incorporation into existing plans, programs, and policies) and implementation, promotion of research and development, awareness-raising to contribute to higher awareness among the public, development of fundamental information and risk assessment tools.
  - Local governments: Monitoring of measures and programs implemented at the local level, projections at the local level, implementation of risk assessments, sharing of information with local citizens, formulation of adaptation measures (including incorporation into existing plans, programs, and policies) and implementation, and assessing progress.
  - Citizens: Implementing adaptation measures that can be taken in daily life, and participating in and cooperating with adaptation initiatives of local governments.
  - Businesses: Being aware of and responding to global warming impacts on business activities (including changes in demand; impacts on systems and infrastructure associated with business activities, including supply chains, factories, and roads; increased frequency and severity of disasters); considering adaptation in business activities (e.g., considering how to maintain the safety and

comfort of employees and customers); participating and cooperating with adaptation initiatives of local governments; and developing new businesses that contribute to adaptation.

- Initiatives by each actor and close cooperation among actors are essential to effectively and efficiently promote adaptation. Considering the fact that the initiatives of governments have only just begun, for the foreseeable future it will be important to have collaboration among the concerned government ministries at the national level, and among the related departments within local governments. At the national level, the ministries concerned should establish liaison committees relating to adaptation, and should engage in information exchanges. Local governments should also consider establishing institutional arrangements to promote collaboration and coordination among the internal departments concerned (or alternatively, utilizing existing institutional arrangements responsible for dealing with the environment and climate change). It is also important to have collaboration between national and local government bodies, as well as between the state/provincial/prefectural level and municipal level.
- After some progress has been made with adaptation initiatives, efforts should be made to promote collaboration and coordination among various actors, including local government bodies, citizens, and businesses, and among local government bodies.

3) Sharing information with citizens

- For the flow of tasks related to adaptation, it is important to share information at an early stage with the public while work progresses. Examples of such tasks include monitoring and future projections, risk assessments of climate change, assessments of the need for adaptation measures and their priority levels, assessments of planning, implementation, progress, and the results of adaptation measures. The results of risk assessments should be used in awareness raising, and the public should have the opportunity to comment.

4) Training and utilization of human resources

- Human resources should be trained to be capable of conducting awareness raising. Personnel are needed who possess knowledge about climate change impacts and adaptation, as well as know-how and knowledge for planning and implementation of adaptation measures, and should be able to implement climate change projections and impact assessments that can be easily applied to adaptation measures.
- Effort should be made to utilize existing human resources, by using personnel in positions that implement measures and programs in related fields, including researchers at research institutes in various related fields, and local university researchers.

5) Promoting research and technological development

- Efforts should be made to improve and utilize scientific knowledge that can be used in the next several years (3 to 5 years).

  Examples:

  - Reduction of the uncertainty of climate change projections and impact assessments, and increase in spatial resolution (e.g., accurate, high-resolution projections of warming; near-future projections; extreme-event projections)
  - Monitoring methods and methods to develop adaptation measures at the local government level
- Efforts should be made to enhance local observation and monitoring of climate change and its impacts.
- Efforts should promote research and development, as well as basic capacity enhancement for integrated analysis of data obtained through observation, monitoring, and warming projections.

- Efforts should be made to promote the development of adaptation technologies necessary to enhance society's capacity to adapt to climate change.

  Examples:

  - Integrated conservation systems for the utilization of water resources and the aquatic environment, responding in an integrated way to a variety of impacts besides climate change, including changes in land use, population, and industrial structure
  - Technologies to ensure stable production in agriculture, forestry, and fisheries, in response to climate change
  - Renewable energy systems that take climate change impacts into account
  - In local community planning (e.g., medium- and long-term comprehensive plans, and city planning), planning technologies incorporated into infrastructure plans and "soft" measures to create a society that can adapt to climate change

Case study: Enhanced real-time observation of localized heavy rainfall events with new high-performance X-band multi-parameter radar

In recent years, noting the frequent occurrence of flood damage due to localized heavy rainfall and intense rainfall events, the Ministry of Land, Infrastructure, Transport and Tourism has installed X band multi-parameter radar systems in major metropolitan areas (Kanto, Hokuriku, Chubu, Kinki) and launched trial operations with the objective of carrying out appropriate flood prevention activities and river management. Even for precipitation that the conventional C-band radar could not detect, observations by X-band multi-parameter radar permit accurate, real-time observation, and have enhanced the precision of projections of the degree of risk from water level increases and flooding due to intense rainfall events.

3. Basic factors of adaptation common to all sectors

3.1 Factors in considering adaptation

(1) Latest knowledge on climate change

- When considering adaptation measures, as a first step, it is essential to have the latest knowledge on climate change. Below are summaries of the latest knowledge about the current situation and key points to note when using the information to consider adaptation measures.

1) Observed climate change

Summary

- The annual temperature in Japan has been rising at the rate of 1.1°C per century since 1898.
- Years with high temperatures have been particularly frequent since the 1990s.
- As temperatures rise, hot nights (minimum nighttime temperature 25°C or greater) and hot days (maximum daytime temperature 35°C or greater) are increasing in number, while freezing days (maximum temperature 0°C) are decreasing in number.
- The annual precipitation in Japan varies largely from year to year. No clear increasing or decreasing trend has been observed. On the other hand, the number of days with heavy precipitation (daily precipitation of 100 mm or greater and 200 mm or greater) has been on a long-term increasing trend that may be influenced by global warming.

Source: “Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change: Climate Change and Its Impacts in Japan,” October 2009, Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment.

Key points

- Calculations of Japan’s average temperatures use observational records from sites where urbanization is minimal and where observational data is of consistent quality, but in some areas temperatures have increased even more due to urbanization.

2) Future projected climate change

Summary

- The temperature in Japan is projected to increase as the CO_2 concentration increases, and the range of warming is projected to be greater than the global average. As the temperature increases, the number of cold days (maximum temperature 0°C) is expected to decrease, while the number of hot days (maximum temperature 35°C or greater) and hot nights (25°C or greater) is projected to increase.

- Annual precipitation in Japan is expected to increase by about 5% by the end of the twenty-first century, in comparison to the end of the twentieth century. It is important to note, however, uncertainties of the projections as well as large inter-annual variability. Mean precipitation and the number of days with heavy precipitation in summer are expected to increase with global warming.

Source: "Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change: Climate Change and Its Impacts in Japan," October 2009, Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment.

Key points

- Future projections involve uncertainty. Sources of uncertainty include uncertainty of greenhouse gas emissions scenarios, future projection models, and natural variation of the climate.
- Uncertainty from scenarios originates in the ways assumptions are made for projections, such as the future development of human societies and economies (e.g., population dynamics, economic scale, etc.) and the resulting greenhouse gas emissions, as well as trends in atmospheric concentrations of CO_2 and other greenhouse gases. Future projections are made by applying a set of assumptions such as these to mathematical models, so it is important to note that a change in assumptions will change the results.
- Uncertainty originating from projection models comes from the mathematical models used when projecting the impacts of future climate change, based on the above scenarios. Because complex processes—such as the global carbon cycle, cloud formation, and cloud dissipation—significantly affect climate change, model results inevitably include a range of projections.
- This projection information represents the latest work by researchers on each individual research topic. Therefore, the results obtained may change with further progress in research. This information is different in nature from weather reports provided by governments.

3) Impacts of projected future climate change

Summary

- Water environment, water resources: With a wider fluctuation of annual precipitation, heavy rain will be more frequent, and drought risk will increase. It is expected that in the future, such risks will increase and lake water quality will decline due to increasing water temperatures and the inflow of turbid water.
- Water-related disasters in coastal areas, etc.: Damage is increasing from flooding and

other effects of storm surges and record rainfall. In the future, larger areas are expected to flood and beaches to be eroded by rising sea levels, and an increase is expected in damage from more frequent heavy rains and from larger storm surges associated with stronger typhoons.

- Natural ecosystems: Impacts already occurring include the loss of alpine flora, coral bleaching, changes in phenology, such as earlier blossoming in spring and later timing of foliage turning color and falling in autumn. In the future, impacts already being observed are expected to become more pronounced, including the further loss of suitable habitat for beech forests, spread of pine wilt disease, and expansion of coral bleaching.
- Food: Impacts believed to be caused by global warming, such as damage from high temperatures, are already being felt nationwide on crops, including rice and fruit. In the absence of measures, rice yields and quality are expected to change, as well as suitable areas for fruit growing. Changes in the habitat of migratory fish are also expected.
- Health: The occurrence of heat stroke has increased, and the distribution of vectors carrying infectious diseases pathogens has changed. In the future, it is expected that the risk of mortality from heat stress will increase, the number of people suffering from heat stroke will increase, and the distribution area of vectors carrying pathogens will expand.
- Human well-being and urban life: Impacts of changes in the natural environment and meteorological conditions are already affecting traditional events, tourism, and the sports industry (e.g., skiing). In the future, increases are expected in discomfort caused by extremely hot days and sweltering nights, household costs due to longer operation of air conditioners, and impacts on local culture due to lack of snow and changes in the timing of the blossoming of cherry trees, etc.

Source: “Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change: Climate Change and Its Impacts in Japan,” October 2009, Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment.

Key points

- The increase of average temperatures is a general indicator of the extent of climate change, but individual phenomena of impacts are more dramatically affected, as shown by indicators such as summer maximum temperatures, and the number of cold days in winter. It is important to pay attention not only to the average temperatures, but also to other indicators that are important for each impact phenomenon.
- The foregoing examples are for the national level, but depending on local characteristics,

there could be large differences in the impacts in individual sectors, in vulnerability, and in the need for urgent responses. Thus, when considering the indicators for each phenomenon of impacts, it is important to be conscious of both the general and the local aspects.

4) Consideration of relationship with other factors

- The impacts of climate change appear not just separately but may also be revealed in complex ways, combined with the impacts of human activities and other environmental problems. Below are concrete examples.
    - Disasters: Large disasters caused by a combination of multiple phenomena associated with climate change, and large disasters caused by earthquakes or other disasters coinciding with climate change phenomena.
    - Natural ecosystems: Ecosystems already degraded by human activities could face further deterioration from the impacts of climate change.
- When attempting to understand the complex impacts of factors—some associated and others not associated with climate change—and then designing and implementing adaptation measures, it is important to be conscious of the relationships with those other factors, and to avoid negatively affecting actions to address other factors assumed to be climate change impacts.

  Steps such as the following should be considered and addressed.

  (i) Consider what kinds of other factors besides climate change are involved.

  (ii) Identify (or hypothesize) what kind of compound impacts, damage, etc., are actually occurring (or could potentially occur).

  (iii) Estimate the extent of impacts or the damage that could occur if both climate change and other factors were to become more severe.

  (iv) From the perspective of prevention, consider adaptation measures to prevent and mitigate foreseeable impacts and damage, and implement those measures. A comprehensive view is needed in order to consider the degree of uncertainty, and the costs of countermeasures.

(2) Short-, medium- and long-term risk management in the face of uncertainty

- Adaptation measures include those to be undertaken in the short-term (from 0 to 10 years hence), those to be undertaken in the medium- and long-term (from 10 to 100 years hence). It is therefore important to manage activities with an awareness of the uncertainty of risk that arises with the different time scales.

- Short term (0 to 10 years):

  For impacts that have a high likelihood of arising from climate change already under way, urgent response measures and restoration measures should be implemented as quickly as possible. Concrete examples include responses to impacts arising from temperature increases and from increases in heavy rain.

- Medium term (about 10 to 30 years):

  Responses to impacts that could arise in the medium term should be based on risk assessments and enhance the adaptive capacity of societies and/or individual sectors. Because there are no scientific evaluation criteria to advise how to interpret the uncertainty of projections (i.e., which projected values to adopt), decisions are made based on policy considerations. If facing financial and human resource constraints, it is necessary to make decisions based on priority levels. For example, one approach is to adopt a high projected value in the range of impacts likely to have a particularly high risk in the target area, and for impacts that do not pose such a high risk, to adopt the most optimistic estimates.

- Long term (about 30 to 100 years):

  For impacts with the likelihood of occurring in the long term, just as with the medium term, responses should be based on risk assessments and enhance the adaptive capacity of societies and/or individual sectors. Current scientific knowledge about the long term is more limited than for the medium term, however, and the range of uncertainty in projections is large because of factors such as large changes in society itself. Meanwhile, climate change will continue over the next several decades regardless of the extent of mitigation measures, but in the longer term, will depend on the extent of global mitigation measures. Thus, it is important to be flexible and revise adaptation measures while considering the progress of mitigation measures. Accordingly, it is important to avoid rigidity in approaches to adaptation at this point in time, and to ensure flexibility. Adaptation measures should be actively promoted where synergies can be achieved in mitigation measures and in other sectors, with the aim of creating low-carbon societies and communities that are also capable of adapting to climate change.

(3) Consideration of regional characteristics

- The actual impacts, scale, and vulnerability to impacts arising from climate change differ considerably, depending on regional characteristics such as geographical features where the impacts are felt; there are also differences in which sectors require urgent responses. Thus, it is important that the adaptation measures taken to address those impacts be based on those regional characteristics, and that initiatives be taken after actively considering the regional situation.
- In particular, when conducting risk assessments, it is desirable to delineate sub-areas appropriately within the jurisdictions of the local governments as well, considering meteorology, topography, land use, and watersheds, and to implement risk assessments for each sub-area. Note that when classifying sub-areas, it is not necessary to use the same approach for every sector, as it may be more practical to delineate sub-areas in a way most suitable for each sector. (For example, for natural ecosystems, delineation based on land use might be the most appropriate, whereas for water-related disasters, delineation based on watersheds might be preferred.)

For further consideration: Strengthening international collaboration

- In principle, adaptation should be based on each local area, although international networks and perspectives are important to provide the basic functions (e.g., future projections), and for specific adaptation measures such as in food production. Japanese scientific knowledge and technologies relating to adaptation may be able to serve an important role in cooperation with developing countries, particularly in East Asia. In the area of international contributions, Japan is also being called upon as a developed country to strengthen international cooperation for the promotion of adaptation efforts.

3.2 Specific procedures for adaptation planning and implementation

- This report presents two “tracks” for the planning and implementation of climate change adaptation measures.
  - A track (detailed planning and implementation steps): These are standard steps that should always be conducted at some point. They can be implemented if a certain amount of information has already been collected on climate change and its regional impacts.
  - B track (simplified first five steps for adaptation planning and implementation): These are steps to begin with in situations where adaptation measures are being taken for the first time. They are simplified and more basic steps than in the A track, to facilitate initial efforts for adaptation measures utilizing currently-available information.
- It is envisioned that local governments intending to launch adaptation initiatives for the first time will begin by implementing the B track steps and then shift to the A track. Because steps (2) monitoring and (3) future projections in the A-track require time from start to full-scale operation, the later steps might be delayed if efforts start from there. The possible result may be delays in undertaking initiatives that should be started quickly to address short-term impacts. Therefore, B track permits any achievements in steps (2) monitoring and (3) future projections to be utilized, but otherwise, action can begin with step (4) risk assessment (utilizing simplified methods with existing and readily available information).
- Figure 2 shows the A-track planning and implementation steps, the B-track initial five steps, and the relationship between the two.

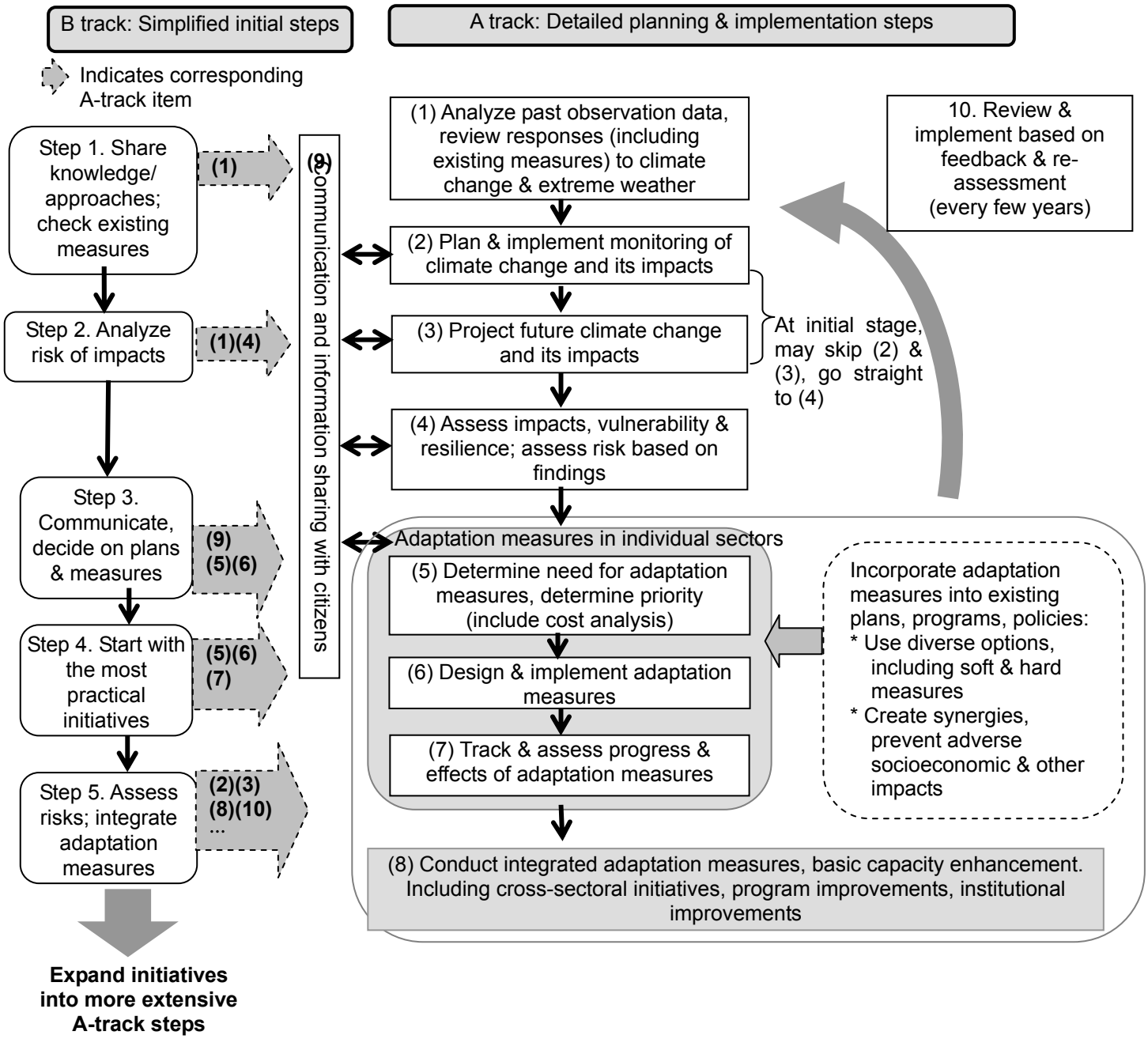


Figure 2. Overview of steps for planning and implementation of adaptation measures (relationship between A-track and B-track)

A Track. Detailed planning and implementation steps

- The following section explains detailed steps (1) to (10) for climate change planning and implementation.

Step (1). Analyze past observation data, review responses (including existing measures) to climate change and extreme weather events

- In areas to be studied, gather and confirm existing past meteorological and environmental observation data or records of weather-related disasters, etc.
- Similarly, conduct a review using a checklist or other means, to determine what kinds of climate change or extreme meteorological responses are included in measures already being implemented in the target region (i.e., what are their effects as adaptation measures), whether or not current measures can adequately respond to climate change, and whether or not measures and institutional arrangements are adequate.

Step (2). Plan and implement monitoring of climate change and its impacts

- Based on the results in (1), for areas and items where data is currently insufficient, an effort should be made to identify areas and items where monitoring of climate change and its impacts should be given a higher priority.
- Consider detailed methodologies and monitoring systems for areas and items that have been identified. Because it is important that monitoring be implemented continuously and with consistent methodologies, plans should be developed with consideration given to feasibility in terms of cost, labor, and time. Consider also the advice of local research institutes and local experts.
- Generally, there are three major targets for monitoring related to adaptation measures: meteorological conditions, impacts of climate change, and systems affected by impacts. Monitoring under item (2) generally includes two categories: meteorological conditions, and impacts. For affected systems, related information should be compiled on assessments of impacts, vulnerability, and resilience under item (3), and risk assessments based on them (described below).
- Furthermore, in order to properly assess meteorological conditions and impacts, it is essential to have human resources and software for interpreting the measurement results obtained from monitoring. This is why basic capacity building and human resources capacity building should be promoted, through cooperation and collaboration with research projects of national and local research institutes.
- Below are examples of monitoring envisioned for implementation in individual sectors.

Table 1. Examples of monitoring envisioned for each sector

Note: There may be some overlap between sectors indicated under “climate change monitoring items” in the table below. Also, some sectors such as “water-related disasters in coastal areas, etc.” and “health” include a portion of monitoring of affected systems.

Sector	Example of monitoring
Water environment, water resources	○ **Climate change monitoring items** ・Changes in annual average temperature, timing of snow melt ・Changes in annual precipitation (rainfall, snowfall), snow cover ○ **Monitoring items for changes in lake and reservoir environment, reservoir storage volume, etc.** ・Water temperature, water quality, dissolved oxygen, changes in turbidity, occurrence of thermal stratification ・Changes in water level and water volume, occurrence of drought ・Habitat conditions and distribution of fish, etc., changes in zooplankton and phytoplankton, establishment of alien species ○ **Monitoring items for changes in river environments and river flows** ・Changes in water temperature, water quality, turbidity ・River water levels, flow volumes, flow patterns, occurrence of drought ・Sediment discharge, changes in river channel shape ・Habitat conditions and distribution of fish, benthos, etc., changes in zooplankton and phytoplankton, establishment of alien species ○ **Monitoring items for changes in agricultural water use** ・Changes in snowmelt water, and availability of agricultural water ・Changes in potential water withdrawal volume ・Changes in soil humidity and water volume required for crops ・Changes in timing of planting and agricultural water-use patterns
Water-related disasters in coastal areas, etc.	○ **Climate change monitoring items** ・Annual precipitation, changes in frequency and intensity of heavy rain ・River levels, river flow volumes ・Changes in sea-surface levels and waves (wave height and period) ・Typhoon (tropic cyclone) intensity and changes in their landfall frequency and rate ○ **River-related monitoring items** ・Amount of sediment discharge from heavy rains, typhoons, etc.; changes in river channel shape, etc. ・Damage (human impacts, economic damage) from heavy rains, typhoons, etc. ○ **Coastal monitoring items** ・Damage from typhoons (human impacts, economic damage, etc.) ・Damage from changes in sea-surface levels, waves (wave height and period), tide levels (human impacts, economic damage, etc.) ・Damage from coastal erosion (human impacts, economic damage) ・Status of ground subsidence in coastal areas, and subsequent damage (human impacts, economic damage)
Food	○ **Climate change monitoring items** ・Annual average air temperature, soil temperature, seawater temperature ・Solar radiation ・Precipitation ・Changes in durations of rainy season, snowy season, East Asian rainy season ○ **Agricultural monitoring items** ・Changes in crop yield and quality due to high temperatures, etc. ・Changes in duration of crop growth and cultivation ・Occurrence of frost damage, pest outbreaks, etc.

Sector	Example of monitoring
	○ **Livestock industry monitoring items** ・Changes in milk production ○ **Fisheries monitoring items** ・Changes in fish species ・Distribution of salmonids and other cold-water fish ・Yields of clams and other major fisheries species in tidal wetlands and seaweed beds
Health	○ **Climate change monitoring items** ・Temperature (maximum daily temperature in summer, minimum daily temperature in winter, etc.), days with daily maximum 30ºC or greater, days with nighttime minimum 25ºC or greater ・Summer survival range of disease vectors ○ **Heat stroke-related monitoring items** ・Number of heatstroke patients, number of persons evacuated to hospital due to heat stroke (by age group) ○ **Infectious disease-related monitoring items** ・Number of persons affected by diseases connected with global warming ・Extent and distribution of vectors of diseases related to global warming
Natural ecosystems	○ **Monitoring items for climate change and the basic environment of ecosystems** ・Snow depth, snowy season, extent of snow cover ・Timing and scope of permafrost melting ・Water temperature of rivers and lakes, water quality, dissolved oxygen, river flow volume ・Seawater temperature, sea-surface level, plankton ・Season of pack ice in contact with coastline, pack ice extent, number of days observed ・Timing of lake freezing and melting ○ **Monitoring items for fragile ecosystems** ・Growing conditions, distribution of beech and other forests ・Condition of damage and distribution of pest/disease damage such as pine wilt disease ・Growing condition and distribution of alpine flora and meadows ・Distribution of alpine marshes, snow marshes; vegetation; soil moisture conditions ・Growth conditions, distribution of coral and mangrove forests ○ **Monitoring items for fragile populations and species** ・Habitat, growing conditions and distribution of southernmost and northernmost species ・Habitat, growing conditions of rare species; changes in number of species, distribution ・Status of establishment of alien species ・Changes in plant seasons (cherry blossom opening, maple leaf falling, etc.) ・Change in animal seasons (timing of insect emergence, etc.) ・Distribution of deer and other wildlife ・Dispersion volume and timing of cedar pollen, etc. ・Distribution, etc., of intertidal organisms in tidal flats and rocky shore areas (dynamics of northern-limit and southern-limit species, etc.) ・Routes of migratory species (fish, mammals, turtles, etc.)

Case studies in independent regional monitoring (Nagano Prefecture)

The Nagano Environmental Conservation Research Institute began research in 2003, with the purpose of determining as much as possible at the regional level how global warming phenomena were being manifested in Nagano Prefecture. Below are examples of the independent monitoring being attempted there.

- **Meteorological observation in mountainous areas**

By targeting mountainous areas that are less biased by anthropogenic and other influences, the Institute is implementing meteorological data collection and observation, with the objective of monitoring climate change and ascertaining the impacts of climate change on alpine regions. Specifically, this includes air temperature and snow depth measurements through collaboration with other organizations. No significant warming trend has been observed in data gathered to date, but alpine observation sites such as these are still small in number nationwide, so it is possible that future continuation of monitoring will provide valuable data.

- **Snow monitoring trial in mountain areas**

In order to better understand global warming's impacts causing changes in snow cover in mountainous areas, the Institute is considering a monitoring technique using images from live cameras. The area of remaining snow in mountainous areas is counted based on pixels that represent snow in processed images—an approach that offers relatively high temporal and spatial resolution. Information on snow cover in mountainous areas is seen as a potential tool for monitoring.

Case studies: Independent regional monitoring (Saitama Prefecture)

- **Precise monitoring of CO_2 concentrations**

Saitama Prefecture has been conducting precise monitoring of concentrations of GHGs such as CO_2 since 1990. It is rare for a local government to be conducting GHG monitoring so extensively, and in fact, there are few examples where monitoring is being conducted in areas neighboring highly urbanized emission sources.

Today, monitoring of CO_2 concentrations is being conducted here at two locations, but highly urbanized areas have higher concentrations, so it is possible that they are being affected by urban sources. This type of data can provide valuable information when considering mitigation measures and adaptation measures.

- **Citizens participating in study of photochemical oxidant damage to flowers (morning glory flower study)**

It has been projected that atmospheric concentrations of photochemical oxidants will increase as one of the impacts of global warming. In Saitama Prefecture, these concentrations have been increasing at the rate of 0.4 parts per billion (ppb) per year, with impacts on crops and so on. With cooperation from citizens, since 2005, the Center for Environmental Science in Saitama has been conducting studies on the health of morning glory flowers, which are highly sensitive to oxidants. The findings will lead to a better understanding of plant damage caused by photochemical oxidants in the prefecture, and will raise awareness about photochemical oxidants and global warming.

- **Precision monitoring of the thermal environment in Saitama Prefecture (heat island study)**

The Automated Meteorological Data Acquisition System (AMeDAS) conducts temperature measurements in Saitama Prefecture at 8 locations, but this is not enough to properly ascertain surface temperatures in Saitama Prefecture. Since 2006, surface temperature and environmental monitoring has been conducted using instrument shelters at elementary schools. In the future, this approach not only can help determine the warming conditions and heat island effect, but also has potential as a tool to appeal to the public about ways to avoid heat stroke.

Step (3). Project future climate change and its impacts

- There are two ways to make future projections of climate change and its impacts:

  (i) Utilize national- or regional-level projections by national governments and research institutions.

  (ii) Conduct and utilize independent projections by the local governments concerned.

- Some useful information about projections at the national level (in Japan) has been

published (item (i) above), but information that can be readily used for regional projections is generally still unavailable—even for such basic items as temperature increases and changes in precipitation. Meanwhile, independent initiatives for projections by local government bodies (item (ii) above) are still virtually nonexistent, although research programs now underway are expected to provide this kind of information in the future.

- Thus, for the foreseeable future, the best approach may be to utilize the latest knowledge (to reduce uncertainty, provide greater detail in spatial scale at the regional level, etc.) as research (item (i) above) progresses, while also utilizing the findings of future projections at the national level (item (ii) above).
- Meanwhile, independent projections (item (ii) above) should proceed actively, as progress is made in the understanding of information about future projections and in the accumulation of independent data at the regional level through the monitoring mentioned above in section 3.2(2). In particular, where a certain amount of progress has been made with the accumulation of data and information in all sectors, it would be desirable to also undertake "assessments through systematic methods" described below under section 3.2(4)3).
- Below are examples of scientific knowledge that can be expected to become available for use in the next several years, as well as future projections at the regional level.

Scientific knowledge expected to be available for use in next several years

- **Innovative Program of Climate Change Projection for the 21st Century (fiscal 2007–2011), Ministry of Education, Culture, Sports, Science and Technology**

Using one of the world's top-performing supercomputers, known as "Earth Simulator," this project aims to provide a scientific basis for the IPCC's Fifth Assessment Report, as well as policies and measures to respond to climate change. The program is working to make advances in warming projection models, working to quantify and reduce uncertainty, and working on impact assessments relating to natural disasters.

- **Research on Projection of Climate and Environmental Change to Contribute to Mitigation Plan Decision against Climate Change (fiscal 2010–2014),** Meteorological Research Institute (Japan Meteorological Agency)

This program is engaged in sophisticated projections of change in the climate and environment for the near future (two or more decades), aiming to provide information on climate change projections for consideration of cost-effectiveness and priorities. This is for the planning and implementation of responses to climate change, and to respond to the need for

information on projections of environmental change in the Asia-Pacific region associated with economic development and land-use changes.

- **Global Environment Research Fund: Comprehensive Study on Climate Change Scenario for Policy Support and Awareness Raising of Global Warming (S-5) (Phase I: 2007–2009, Phase II: 2010–2011), Ministry of the Environment, Japan**

This project is promoting research aiming to create integrated climate change scenarios that include specific impacts of climate change on society, and to establish methods to convey information to society in tangible ways. The project is establishing quantitative indicators of the reliability of projections through comprehensive analysis of the results of calculations on projections of future warming, using climate models from Japan and elsewhere; creating detailed information on spatial projections for the Japanese region using regional climate models; and providing greater spatial detail in socioeconomic scenarios as well as making projections of land-use changes.

- **Global Environment Research Fund: Comprehensive Study of Climate Change Impacts Assessment and Adaptation Policy (S-8) (fiscal 2010–2014), Japan Ministry of the Environment**

This project is developing an advanced impacts and adaptation assessment model using as inputs the results of the latest high-precision and high-resolution climate models; assessing the impacts of warming on Japan as a whole; and also assessing the effectiveness of adaptation measures after conducting quantitative analysis of changes in the magnitude of impacts depending on multiple trajectories for global emissions stabilization and adaptation scenarios. In addition, the project is developing assessment methodologies for vulnerability, impacts, and adaptation that can be easily used by local governments, and is developing adaptation planning methodologies considering the uncertainty of projections for local governments.

- **Initiative for Strategic Adaptation to Climate Change(starting fiscal 2010), Ministry of Education, Culture, Sports, Science and Technology**

This initiative develops downscaling techniques for specific regions to apply the latest climate change projection data to regional impact assessment studies. As a platform, it uses a detailed integration and analysis system that provides integrated analysis of a large and diverse amount of data on global observation and climate change projections, as well as socioeconomic information.

- **Development of Mitigation and Adaptation Technologies to address Global Warming in the Agriculture, Forestry and Fisheries (fiscal 2010–2014), Ministry of Agriculture, Forestry and Fisheries**

This project is studying the GHG generation and sequestration mechanisms in the agriculture,

forestry, and fisheries sectors; developing technologies to reduce GHGs emissions ; developing technologies to improve the sequestration functions of forests and agricultural soils. Besides monitoring of GHGs in the agriculture, forestry, and fisheries sectors, the project is also developing accurate models to predict crop yield and quality using the latest climate change models, as well as fisheries and other resource production models, and is conducting impact assessments. Based on impact assessments, it is also developing production stabilization techniques adapted to continued warming.

Step (4). Assess impacts, vulnerability, resilience, and risk

- Under this step, risks associated with climate change are assessed for the target region based on future projections.
- Risk assessments through integrated assessments of impacts, vulnerability, and resilience make it possible to obtain valuable basic information for the implementation of appropriate adaptation measures. The relationships between these assessments are shown in Figure 3. Definitions for terms mentioned above—including impacts, vulnerability, and resilience—are explained further below in the context of specific risk assessment methods.
- Risks associated with climate change could come in many forms, including risks to human life, to economies, and to society. While some risks may be difficult to ascertain quantitatively, it is still important to implement risk assessments—as much as circumstances permit—based on the actual circumstances in the target region, and from various perspectives.

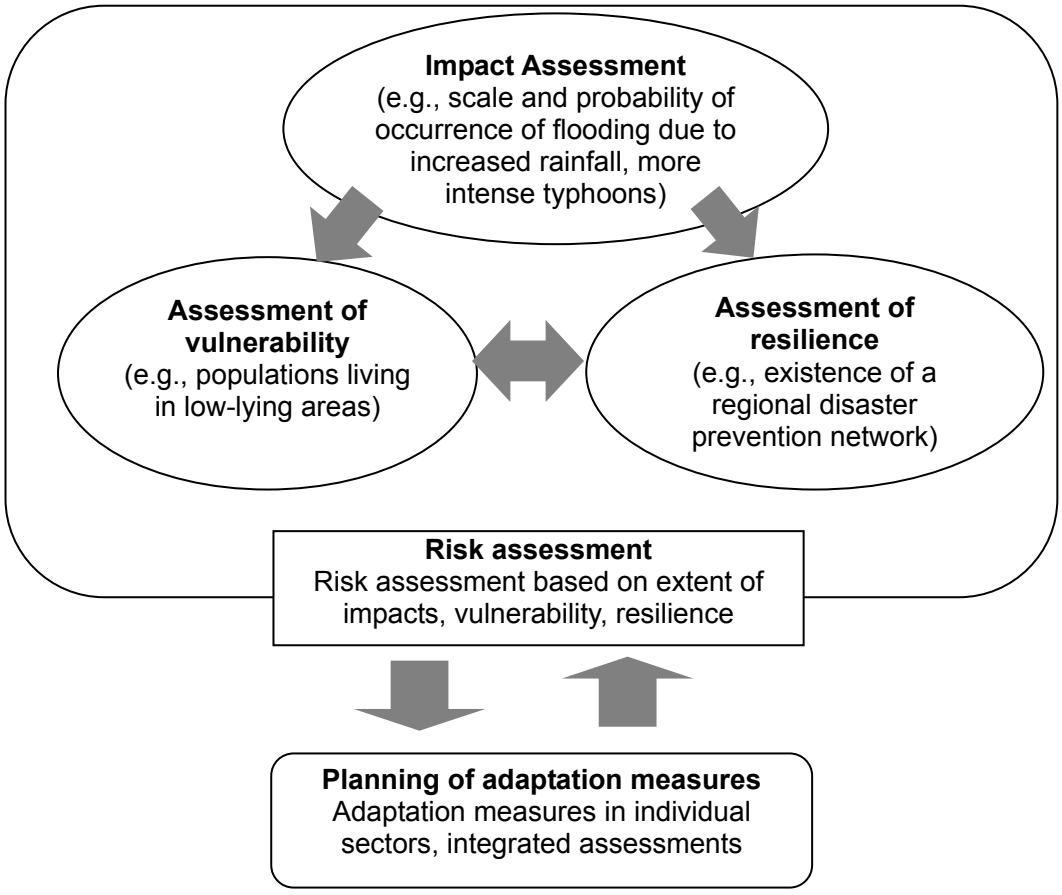


Figure 3. Relationships between adaptation measures and assessments of impacts, vulnerability, and resilience

Terminology of risk assessments

Impacts: The effects of changes in the climate on the natural environment and on human society, such as changes in temperatures and rainfall patterns, and increases in sea levels. Depending on whether or not adaptation is being considered, impacts can be divided into “potential impacts” and “residual impacts.” Potential impacts are all the impacts that could occur due to projected climate change if no adaptation is considered, while residual impacts are impacts that could occur even if adaptation is undertaken.

Vulnerability: The susceptibility of human society and natural systems to the impacts of climate change. There are two aspects to vulnerability: the state of regional society and individual sectors (i.e., distribution of population and property, particularly populations susceptible to impacts, the existence of weaknesses, etc.) and the resilience to respond to that state. In other words, the extent of damage that actually occurs is affected by the natural and societal factors, and by their resilience. Thus, for the same extent of climate change, a region that has low vulnerability will be able to get by with less damage.

Resilience: The capacity of society and natural systems to prevent or minimize the impacts of climate change. The resilience of society consists of “soft” factors such as legislation and regulations, evacuation plans, damage compensation and restoration frameworks, and public awareness, and “hard” factors such as construction standards for dikes and embankments. The resilience of natural systems is the ability to absorb impacts and recover to their original condition; the role of humans here is with measures to support the ability of nature to recover.

Risk: The extent of damage that could happen to society and to natural systems as a result of climate change. The amount of risk is assessed as a combination of the damage and its likelihood of occurring. The amount of damage is assessed by considering climate change impacts, resilience, and vulnerability. For impacts or risks, it is necessary to assess a multitude of factors, including human health and life, economic, societal, cultural, natural, and other factors.

Adaptation: The introduction of programs, policies, measures, or actions of governments, corporations, individuals, or other entities, in order to prevent or minimize, or to beneficially utilize the impacts of climate change. Successful adaptation strategies and measures result in societies that are more resilient and less vulnerable.

- Below are three examples of specific approaches to risk assessments:
  - Initial assessments (e.g., an assessment that utilizes readily-available information)
  - Assessments focusing on a specific sector (e.g., an assessment that utilizes existing approaches)
  - Assessments where considerable knowledge has already been accumulated (e.g., an assessment that utilizes a systems approach)

1) Initial assessments: An assessment that utilizes readily-available information)

- Using existing information, impacts and regions that have particularly high risks are identified through qualitative consideration using simple ranking. This approach is suitable in cases where it is possible to ascertain, in general and simple terms, the overall state of risk in a region, and where risk assessments and consideration of adaptation are just beginning.
- There are two stages, the first being an overall review of the risks across all sectors in a region, and the second being the identification of impacts and regions that involve high risk in terms of impacts and adaptive capacity in individual sectors. The relevant steps are shown in items (a) through (j) in Figure 4.

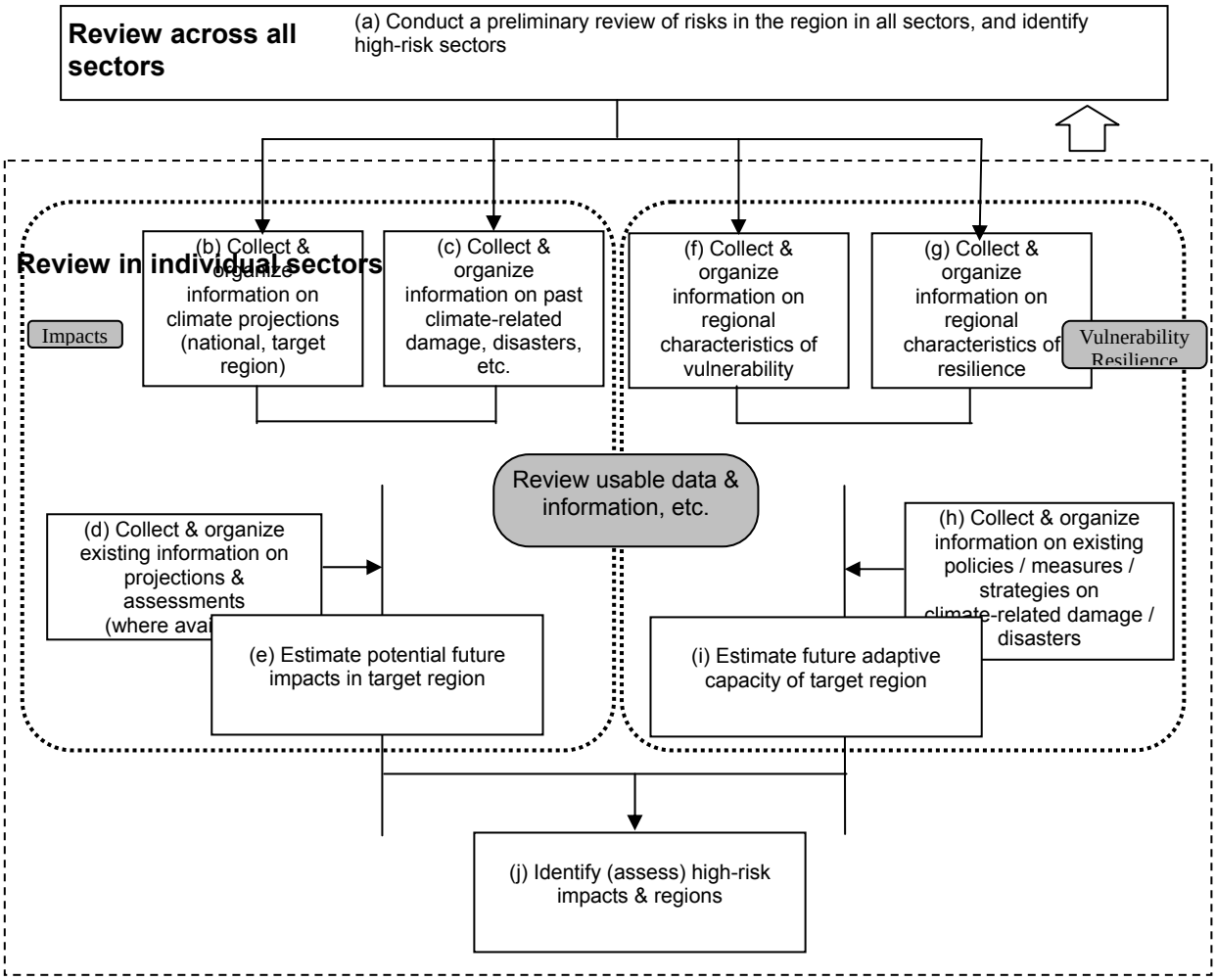


Figure 4. Flowchart of steps in risk assessment based on climate change impacts, vulnerability, and resilience

Note: Steps (a) through (j) are explained below.

(a) Review across all sectors

Conduct a preliminary review of risks across all sectors in the region, identify the types of risks in the region, and identify which sectors are particularly vulnerable.

(b) Collect and organize information on climate projections

Collect and organize information relating to projections of climate change, for the target country, and for the target region (target prefecture/state/province and surroundings). Refer to the latest reports and research findings (for example, in the case of Japan, the “Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change: Climate Change and Its Impacts in Japan,” October 2009, Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment). If doing so, take note of the extent (magnitude) of the projected impacts, as well as the nature and degree of the uncertainty (likelihood of occurring) of those projections.

(c) Collect and organize information on past climate-related damage, disasters, etc.

For each sector, collect and organize information on past climate-related damage, disasters, etc., in the target region.

(d) Collect and organize existing information on projections and assessments

For each sector, where examples already exist of projection and assessment of climate-related damage, disasters, etc., in the target region, collect and organize information relating to the methods used to make projections in those examples, as well as the results of projections and assessments. Examples might include projections and assessments typically being utilized for objectives other than projecting or assessing climate change impacts—for example, in the area of disaster prevention, projections of inundation caused by floods.

(e) Estimate potential future impacts in target region

Estimate potential future impacts in the target region by comparing information of past damage and disasters (step (c)) with projection information for the entire country or target region (step (b)). Expert advice and input should be sought for this estimate. Where examples of projections or assessments already exist under step (d), consider whether or not it is possible to project or estimate future climate change by using those projections or estimates, and where it is possible, do so.

(f) Collect and organize information on regional characteristics of vulnerability

For each sector, collect and organize information relating to regional characteristics of vulnerability in the target region. Collect critical information that will be especially important in estimating vulnerability, from the perspective of both natural and societal characteristics.

(g) Collect and organize information on regional characteristics of resilience

For each sector, collect and organize information relating to regional characteristics of resilience in the target region. From the perspective of both natural and societal characteristics, collect critical information that will be especially important in estimating resilience.

(h) Collect and organize information on existing policies/measures/strategies on climate-related damage and disasters

For each sector, collect and organize major existing policies, measures, and strategies (including those still at the planning stage) to address climate-related damage and disasters, from documentation in individual sectors—such as governmental basic plans and their annual reports, etc. Seek materials that are related to climate and weather disasters, even in documents that do not refer specifically to global warming or climate change.

(i) Estimate future adaptive capacity of target region

For each sector, estimate the potential future adaptive capacity of the target region, considering information about vulnerability considered in step (f), resilience considered in step (g), and also the effects of existing policies, measures, and strategies.

(j) Identify (assess) high-risk impacts and regions

For each sector, identify impacts and regions where projected impacts are great, risk is high and adaptive capacity is inadequate, by comparing future impacts estimated in step (e) and adaptive capacity estimated in step (i).

- At present, no reliable methodologies have yet been developed to organize the data and information in the steps described above, particularly for estimations in steps (e), (i) and (j). Discussions and information-sharing should continue in individual sectors, in order to develop more precise and appropriate methodologies. Available literature provides examples of references that can be used at present, regarding data and information collected in accordance with the above steps, and methodologies to organize what has been collected.

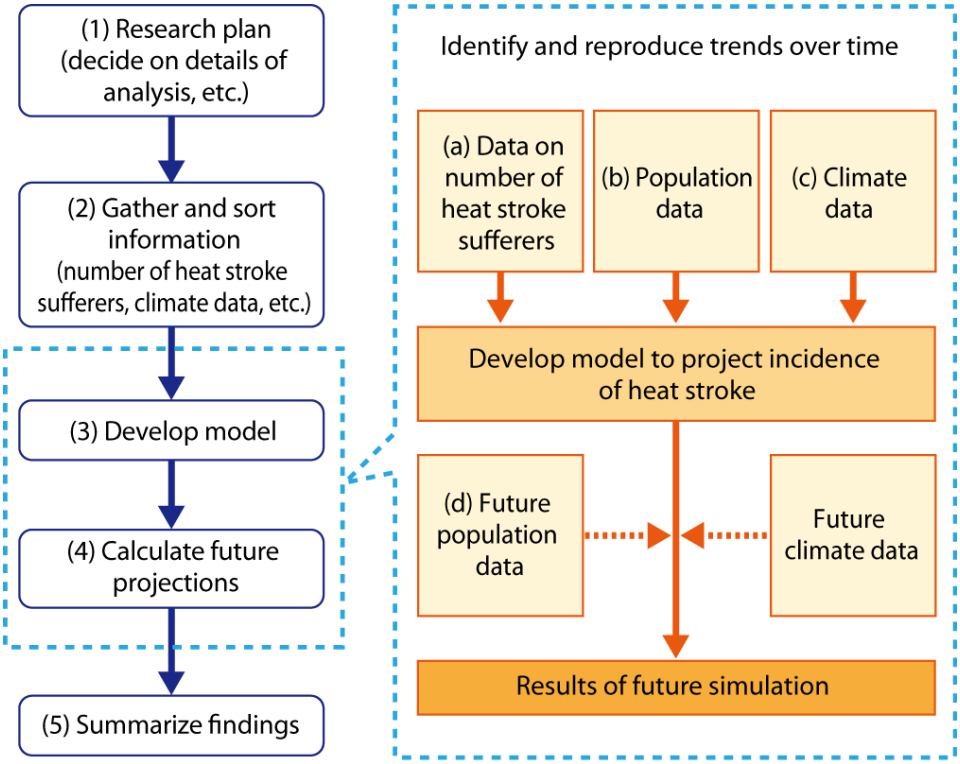
2) Assessments focusing on a specific sector: An assessment that utilizes existing approaches

- For this approach, attention is focused on sectors in which data and information have been collected in the target region, and where existing projection methods can be utilized. This approach is not comprehensive or systematic, but is suitable in cases where there is a desire to conduct risk assessments and consider adaptation focusing on high-priority impacts in the target region, or impacts where a considerable amount of knowledge is already available.
- Examples might include cases where various types of projection methods already exist that are being utilized for objectives other than projecting climate change impacts—for example, in the area of water-related disaster prevention and projections of inundation caused by floods. One possible approach here is to project impacts with future climate change in mind, and then conduct a risk assessment by comparing the projection with data and information on adaptive capacity.

Case Study: Tokyo Metropolitan Government

The Tokyo Metropolitan Government has launched efforts to project and assess the impacts of climate change within its jurisdiction. In terms of heat stroke, for example, the local government is building a model to estimate the incidence of heat stroke from data on population, climate and heat stroke sufferers, and using this to project the number of future cases of heat stroke (see figure). The model's basic approach makes use of research findings at the national level.

Projections such as these require data collection, model development, and calculations, and provide useful material for consideration of specific adaptation measures. In sectors thought to have a particularly high level of risk in a certain region, it is desirable to attempt future projections such as in this example.



Source: Tokyo Metropolitan Government

3) Assessments where considerable knowledge has already been accumulated: An assessment that utilizes a systems approach

- This approach involves organizing information relating to impacts, vulnerability, and resilience in individual sectors, in an integrated and systematic way, then combining the results in an assessment, and summarizing the findings in a risk map or other easy-to-understand format. This approach is suitable in cases where a certain amount of progress has been made with the accumulation of data and information in all sectors, and where elaborate assessments are sought. The relevant steps are indicated in Figure 5.

  (a) Organize each of the following in a map-based data format (mesh or grid units, etc.): external forcing and natural conditions (temperature, hourly rainfall, elevation, species distribution, water resource volume, etc.), vulnerability (population by age group, etc.), and indicators of resilience (protected bank ratio, permeable ground surface ratio, etc.).

  (b) Assess the potential or already-evident impacts, vulnerabilities, and resilience, by selecting and combining those items (from the above list) that are associated with map data

  (c) Assess future climate change risks, by giving consideration to the extent of future changes of external forcing (using the results of climate projections and so on).

  (d) Summarize the findings into risk maps for individual sectors.

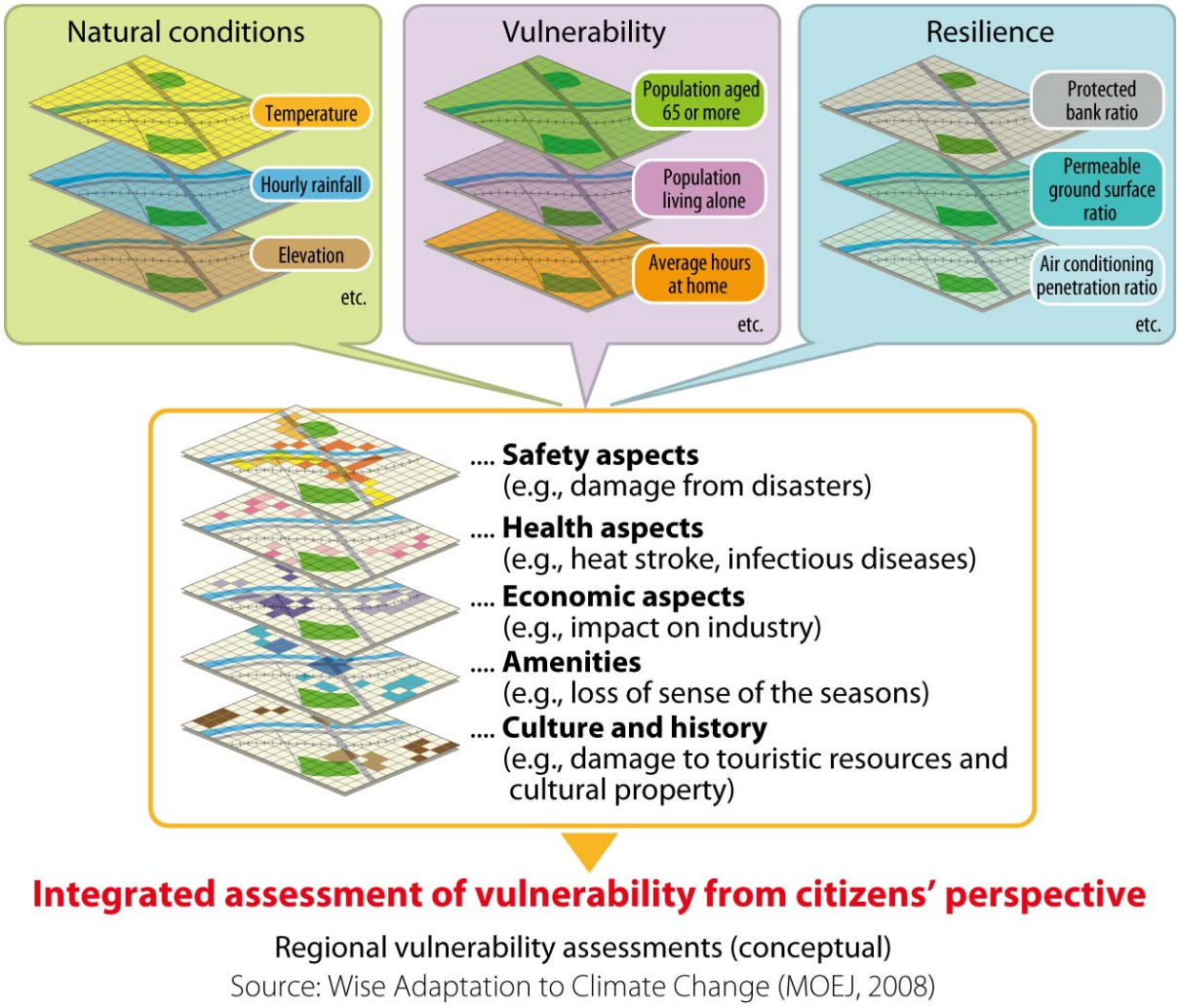


Figure 5. Example of an assessment using a systems approach

Source: Adapted from "Wise Adaptation to Climate Change: Report by the Committee on Climate Change Impacts and Adaptation Research," 2008, Committee on Climate Change Impacts and Adaptation Research, Ministry of the Environment, Japan.

Step (5). Determine need for adaptation measures, determine priority

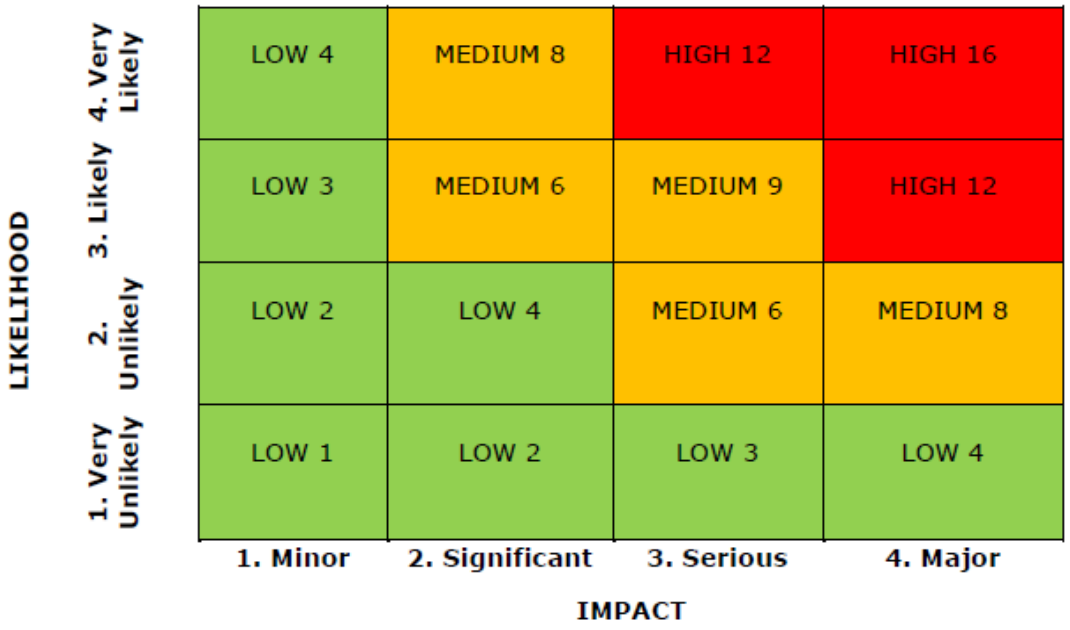
- Based on the results of climate change risk assessments and consensus-building with citizens, consider decisions on the need for adaptation measures based on scientific knowledge and priority. For example, the City Council in Liverpool, England, used common tools for risk assessment to assess the “impact” and “likelihood” of climate change impacts, and based on this assessment considered the major threats of climate change as well as new business opportunities.
- Precise cost-benefit analysis is difficult, however, because at present not enough scientific knowledge has been accumulated and future projections come with uncertainty. Thus, awareness raising and the development of a knowledge base are both important, especially at the initial stage.
- Also, besides urgent measures to address short-term impacts, high priority is also given to other measures, such as “no regrets” adaptation measures (which provide economic benefits regardless of the extent of future climate change), and “win-win” adaptation measures (which can help to address not only climate change but also other issues).
- For example, the European Union’s white paper “Adapting to Climate Change”[3] presents “no-regrets” and “win-win” adaptation measures as two options to minimize the risks associated with adaptation measures conducted under uncertainty. An example of a no-regrets adaptation measure is improving emergency responses rather than moving or improving infrastructure in areas at high risk of inundation or other threats. Examples of win-win adaptation measures that could minimize climate risk, while at the same time reducing GHG emissions and contributing to solutions in other social and environmental dimensions, include flood and coastal management through city planning, air pollution countermeasures, tree-planting, and restoration of floodplains and salt marshes.

[3] *WHITE PAPER, Adapting to climate change: Towards a European framework for action*, 2009, Commission of he European Communities

Case study: Liverpool risk assessment

The city of Liverpool in England conducted a vulnerability assessment.[4] The City Council classified risks as shown here, using a "Risk Management—Business Unit Toolkit," which it developed as a risk assessment tool for common use.

Figure: Liverpool City Council's matrix for risk assessment



[4] *Adapting to Climate Change: Liverpool City Council Adaptation Action Plan*, by CAG Consultants, March 2010.

Scoring system for “impact”

Factor	Score	Examples of types of impact
Major	4	Service disruption 5+ days Adverse national media coverage 1 or more deaths Cost over £500,000 3 months delay in project
Serious	3	Service disruption 3–5 days Persistent adverse local media coverage Major injury (1 or more) Cost £50,000–500,000 Project delay 2–3 months
Significant	2	Service disruption 2–3 days Adverse local publicity Severe injury (1 or more) Cost £5,000–50,000 Project slippage 3–8 weeks
Minor	1	Service disruption 1 day Complaints Minor injury (1 or more) Costs up to £5,000 Project delay up to 2 weeks

Scoring system for “likelihood”

Factor	Score	Risk description	Examples of typical likelihood/ frequency
Very likely	4	More than 75% chance of occurrence	Regular occurrence Circumstances frequently encountered (daily/weekly/ monthly)
Likely	3	40%–75% chance of occurrence	Likely to happen at some point within the next 1–2 years Circumstances occasionally encountered (few times a year)
Unlikely	2	10%–40% chance of occurrence	Only likely to happen after 3 or more years
Very unlikely	1	Less than 10% chance of occurrence	Has happened rarely/never before

Case study: The Netherlands' "hotspots" assessment

The Netherlands' national adaptation strategy released in 2007 points out the importance of the role of spatial planning in adaptation.[5] As a part of that initiative, the country implemented an adaptation "hotspot program" as a pilot project, with "hotspot" defined as "a sector, place or region in which spatial planning and climate change play an important role in the physical shape and land use of the area, and where conflicts of interest are found between these and other factors." Research began in 2010 to identify hotspots. Below is an excerpt.

Preliminary selection: Selection based on criteria of the candidate site

・Based on workshops and surveys completed by a large number of participants, 15 sites were selected from a total of 50 candidate sites, using the following indicators:

・Climate change has an important influence on the development pattern of the area or sector.
・Besides climate change, development in the area or sector is influenced by the physical development pattern, land-use planning and/or urban and regional planning; there is an ongoing planning process, including spatial investment, for climate-proofing to tie into.
・There is support among the parties for placing spatial investments and plans in a long-term context (2050–2100).
・The stakeholders or initiating parties must be able to demonstrate local support for preparing a hotspot project for this program.

[5] *National Programme on Climate Adaptation and Spatial Planning: National adaptation strategy – policy memorandum*, Ministry of Housing, Spatial Planning and the Environment (VROM), the Netherlands (2008).

Secondary selection: Selection based on indicators

・Research project members scored the sites by mutual reviews, reducing the number of candidate sites to five.

Description of indicator	Score
Most important indicators ・There are overlaps with several policy themes which may cause friction or opportunities where policies cross. ・There is stakeholder support. ・The hotspot has communicative appeal to a broad public; the project must have a demonstration function.	1 (Bad) 2 3 4 5 (Excellent)
Other indicators ・The hotspot is appealing to the general public. ・The project assumes several consequences of climate change. ・There is friction between short- and long-term policy. ・The hotspot ties in with currently running climate change spatial planning projects. ・The hotspot raises research questions which could be incorporated into the climate change spatial planning programme.	1 (Bad) 2 3 4 5 (Excellent)
Total for most important indicators	
Total for all indicators	
Is the following theme included in the target region? ・Water ・Agriculture ・Urban area ・Public health ・Recreation	Theme included 1 (Not at all) 2 3 4 5 (Very much)

Step (6). Design and implement adaptation measures

- Detailed individual adaptation measures can be designed after the overall necessity and priority of adaptation has been clarified. Rather than planning new adaptation measures from zero, however, greater priority should be given to incorporating the concept of adaptation into existing governmental plans and projects. This approach is taken in order to utilize resources effectively and to promote effective and efficient adaptation initiatives, by utilizing existing structures and frameworks to the greatest extent possible.

(a) Summarize the adaptation measures in individual sectors or those measures and policies that have adaptation effects, as well as the related plans of local governments that may include such aspects. These could include many aspects, such as land-use plans and city planning; policies and measures related to disasters, flood control, sewerage systems, water resources, ports, oceans, agriculture, forestry, fisheries, and natural ecosystem protection, as well as environmental policies and measures of local governments.

Example of related plans:

- A municipality's future vision for its water supply system has the aim of creating a common awareness among related entities about the ideal future state of the system. Such a vision could incorporate the objective of providing a stable supply of water in vulnerable areas, in the face of climate change-related changes in the state of water supplies—such as droughts and the need to quickly address issues for populations that cannot obtain an adequate amount of water even during normal times.

(b) Coordinate the opportunities and timing of inter-ministry or inter-departmental meetings and discussions where there is potential to incorporate the concept of adaptation into various related plans and adaptation measures, or into measures and policies that have the effect of increasing adaptation. More specifically, coordinate the opportunities to exchange information and perspectives among the related government departments regarding (i) the timing of annual progress checks and reviews of the relevant plans and projects, and (ii) other relevant plans and projects.

(c) Within prefectural/state/provincial governments, discuss how to incorporate the concept of adaptation, based on items (i) and (ii) in (b) above.

(d) For matters that are not adequately addressed in existing plans and projects, develop new proposals for the necessary adaptation measures.

(e) For adaptation measures already incorporated into existing plans as well as policies and measures in individual sectors, coordinate the details and collaboration among sectors. In particular, in order to prepare and implement appropriate adaptation

measures, it is important to promote sharing across sectors of the data and monitoring results relating to the impacts of climate change.

(f) As climate change continues, it is possible that in some cases policies and measures currently necessary may become less necessary and lower in priority. With progress in climate change mitigation measures in the medium and long term, the necessity for certain adaptation measures might also decrease. In such cases, it is essential to implement proper reviews and modifications.

- Below are concrete examples of how adaptation measures can be made more effective by adding certain components to existing plans and projects. Table 2 provides examples of adaptation-related plans in individual sectors as well as related policies and measures.

Examples of incorporating the concept of adaptation into existing plans and projects

Water-related disasters: When considering construction and upgrades of protection facilities (levees, breakwaters, seawalls, and sewerage facilities, etc.), planners should anticipate the potential impacts of climate change-induced changes, such as future changes in rainfall patterns and sea levels (from the perspective of medium- and long-term projections of impacts), and consider the higher among the range of projected values. (In such cases, however, because of the need to secure a certain amount of budgetary resources, it is important to seek adequate consensus among the authorities concerned with decisions relating to policy implementation.)

Natural ecosystems: When establishing or reviewing various protection and preservation areas, planners should anticipate the potential impacts of future temperature increases (from the perspective of medium- and long-term projections of impacts) on species that are particularly vulnerable to climate change (alpine plants, northernmost and southernmost species, etc.), and use a precautionary approach when establishing the areas.

Health: Regarding policies and measures to prevent labor-related accidents involving outdoor workers, particularly in urban areas where there are concerns about the combined effects of climate change and the heat-island effect, planners should anticipate the possibility of an increase in the number of cases of heat stroke due to higher temperatures (with a primary focus on the impact in the short term), and incorporate into plans awareness-raising about heat stroke and preventive measures to deal with heat.

Setting of objectives and standards (common to all sectors): When establishing or reviewing the desirable objectives or standards associated with various adaptation measures, instead of applying only the typical objective-oriented or standard-setting approaches in a given field, planners may also wish to consider multiple scenarios and establish objectives and standards by using a combination of new and conventional approaches, keeping in mind the assessments of climate risks as described in this paper. Consideration should also be given to ways of establishing such targets and standards.

Table 2. Adaptation-related plans[6]

Notes for table

1. This table gives examples that apply to Japan, but can be adapted for consideration in other countries.
2. Symbols in “Related plans and other” column:
   - The symbol ○ indicates that the item is a “statutory plan” required by legislation. Some include mandatory effort by the relevant bodies.
   - The symbol ▪ indicates that the item is not a statutory plan but is encouraged by guidelines issued by the national government or in some cases by a local government.
3. Words in parentheses indicate the authority required to formulate the plan: Ministry of Land, Transport, Infrastructure and Tourism (MLIT), Ministry of Agriculture, Forestry and Fisheries (MAFF), and “prefectural governments” could be interpreted overseas as states, provinces or other sub-national governments.

Sector	Related plans and other	Examples of policies and measures with adaptation effects
Water environment, water resources	○ Basic Plan for Water Resources Development (MLIT) ○ Regional water resources development plans (prefectures prepare, MLIT approves) ○ River improvement basic guidelines, river improvement plans (MLIT, prefectures, etc.) ▪ Waterworks development visions (waterworks contractors, etc.) ○Watershed-based water supply development master plans (prefectural governments) ○ Regional disaster response plans (prefectural governments, municipalities) ○ National spatial plans (national government) ○ Regional master plans (MLIT) ○ City planning (prefectural governments, municipalities) ○ Nation-wide forest plan (MAFF) ○Regional forest plans (prefectural governments, etc.) ○ Local forest improvement plans(municipalities)	▪ Technical measures for increasing water supplies (reservoirs, canals, water purification) and water conservation technologies (water quality, biological) ▪ Water resource options that do not rely on rainfall conditions, and revision of planning target years ▪ Forest management/conservation in headwaters areas ▪ Improve water-use efficiency (re-use of irrigation water, use of multipurpose water, etc.) ▪ Expand the collection of rainwater, use of gray water, re-use of treated wastewater, etc. ▪ Desalinization of seawater ▪ Water demand projection, water trading, emergency water-use restrictions ▪ Projection, monitoring, information provision on drought conditions ▪ Educate and build public awareness about water conservation, create conservation-oriented society oriented through water demand management ▪ Economic instruments (water-price setting, insurance systems) ▪ National land strategy to improve water “budgets” (supply and demand) ▪ Create green networks of forests in watersheds, parks, and greenways, etc.; secure wind paths; measures to address the heat island effect
Water-related disasters in coastal	**Rivers** ○ River improvement basic guidelines, river improvement	**Rivers** ▪ New facilities construction, upgrading of existing facilities

[6] This table includes plans formulated specifically for climate change adaptation, as well as plans, policies and measures not formulated specifically for climate change but still having climate change adaptation effects.

Sector	Related plans and other	Examples of policies and measures with adaptation effects
areas, etc.	plans (MLIT, prefectures, etc.) ○ Sewerage system development plans (municipalities) ○ Land-use basic plans (prefectural governments, municipalities) ○ Regional disaster response plans (prefectural governments, municipalities)	▪ Construction of landslide prevention structures suitable for the level of hazard ▪ Promote integrated designation of disaster hazard zones and flood control measures, etc. ▪ Promote low-carbon and water-disaster-resistant styles of integrated town planning, for example with lake towns designed to have low-CO_2-emission housing (e.g., through the use of solar energy) and large regulating ponds, etc. ▪ Flood disaster/flood prevention measures by planting/management of riparian forests ▪ Construct/improve facilities for rainwater storage, permeation, and runoff control ▪ Improve wastewater handling capacity of cities by construction/improvement of wastewater treatment facilities ▪ Create wide-area networks with dikes, emergency-access roads along rivers, and elevated roads, well as wide-area disaster prevention centers ▪ Use land-use regulations and incentives in affected areas ▪ Improve disaster management systems ▪ Designate evacuation areas ▪ Develop disaster evacuation systems
	Coastal areas ○ Plans, designs, and construction of port development projects and coastline improvement projects (specified port facilities development projects, etc.) (MLIT) ○ Port plan and individual project plans (port management authorities of major ports) ○Master plans for coastal conservation (prefectural governments) ○ Regional disaster response plans (prefectural governments, municipalities)	**Coastal areas** ▪ Consider planning of the locations for protective facilities (dikes, breakwaters, reinforced embankments, etc.) to anticipate sea-level rise; and capacity building ▪ Promote work on tsunami and storm-surge hazard maps ▪ Implement measures to minimize damage from water-logging due to storm surges (e.g., higher foundations for warehouses, sheds) ▪ Restructure land use in coastal areas to anticipate climate change ▪ Create information-sharing and cooperative structures with related organizations ▪ Strengthen emergency recovery arrangements to deal with disasters ▪ Formulate business continuity plans (BCPs) to maintain port functions in times of disaster ▪ Adopt designs that allow quick recovery even after being struck by disaster ▪ Improve disaster evacuation facilities/equipment ▪ Designate evacuation areas ▪ Develop disaster evacuation systems

Sector	Related plans and other	Examples of policies and measures with adaptation effects
	Forests ○ Nation-wide forest plan(MAFF) ○Regional forest plans (prefectural governments, etc.) ○Local forest improvement plans (municipalities)	**Forests** ▪ Mitigate flooding through forest management/conservation ▪ Improve erosion control structures on slopes
Food	○ Basic Plan on Food, Agriculture and Rural Areas (MAFF) ○ Basic Policy on Promotion of Fruit Tree Cultivation (MAFF) ○ Livestock Breeding Targets (MAFF) ○ Basic Policy for Achieving the Modernization of Dairy and Beef Cattle Production (MAFF) ▪ Policies for the promotion of fisheries (local governments)	▪ Introduce cultivation methods and facilities to avoid heat damage, develop and convert to heat-tolerant varieties, etc. ▪ Optimize planting programs and mix of plant varieties, introduce superior varieties, and popularize new technologies, etc. ▪ Appropriate pest control, appropriate use of pesticides ▪ Promotion of livestock improvements, improve and popularize new technologies, etc. ▪ Develop and disseminate fisheries technologies, etc.
Natural ecosystems	○ Ordinances and plans relating to conservation of the natural environment (prefectural governments) ○ Master plans for parks and open spaces (municipalities) ▪ Ecological network plans (prefectural governments, municipalities, etc.) ▪ Biotope plans (prefectural governments, municipalities, etc.) ○ Implementation plans of nature restoration projects (local governments, councils) ○Regional biodiversity strategies (prefectural governments, municipalities)	▪ Establish various types of protection and conservation areas (prefectural parks for nature conservation, scenic areas, nature conservation areas, special landscape conservation areas, etc.) or review those areas (establish protected areas for vulnerable communities, or consider other means) ▪ Secure green areas on urban land ▪ Create ecological networks (secure space for migration of flora and fauna due to warming) ▪ Create, protect, and restore biotopes (to secure refuges and the environment for flora and fauna in the face of extreme weather events, etc.)
	○ Nation-wide forest plan(MAFF) ○Regional forest plans (prefectural governments, etc.) ○ Local forest improvement plans (municipalities) ▪ Plans to promote programs to counter pine wilt disease damage from pine weevils	▪ Forest management/conservation of various forest types, including conifer-broadleaf mixed, etc. ・ Forest Ecosystem Reserve ▪ Prepare forest damage maps and damage control guidelines to deal with pine wilt disease (e.g., to address the spread and northern expansion of pine wilt disease due to warming) ▪ Measures to control pine wilt disease (e.g., to address the spread and northern expansion of pine wilt disease due to warming)
	○Specified Wildlife Management Plan (sika deer, etc.) (prefectural	▪ Conduct monitoring studies of species populations, determine status of their

Sector	Related plans and other	Examples of policies and measures with adaptation effects
	governments)	distribution ▪ Population management by capture, extension of hunting season, etc. ▪ Damage prevention measures such as installation of fences, etc. (as a conservation measure for alpine ecosystems, in response to expanded range of deer due to warming)
	○Lake water quality management plans (prefectural governments) ▪ Plans relating to water cycles and circulation (local governments)	▪ Measures to reduce inflow of polluting substances (e.g., improvement of sewerage systems, installation of septic tanks, improvement of rural community's wastewater treatment plants) ▪ Water purification measures (purification by vegetation, dredging of sediment, etc.) (e.g., to prevent lake-bottom hypoxia caused by warming)
	○River improvement basic guidelines, river improvement plans (MLIT, prefectures, etc.)	▪ Maintain normal functions of flowing water ▪ Improve and conserve river environments ▪ Construct or improve reinforced embankments while cognizant of aquatic life (to secure refuges and the environment for flora and fauna in the face of extreme weather events, etc.) ▪ Create waterside green spaces and link them together as networks (to secure space for migration of flora and fauna due to warming)
	○Master plans for coastal conservation (prefectural governments) ○Watershed-based water supply development master plans (prefectural governments) ▪ Recovery plans for fisheries resources (prefectural governments)	▪ Conserve and restore sandy beaches ▪ Reduce pollution load (deterioration of water quality in public water source areas due to combined effects of warming, etc.) ▪ Resource management (declining marine populations due to overfishing and the combined effects of warming)
Health	**Heat stroke** ▪ Guidelines and programs to prevent heat stroke (local governments) ▪ Regional housing plans, plans for provision of assisted living and seniors' housing (local governments) ○ City planning(prefectural governments, municipalities)	**Heat stroke** ▪ Compile information on heat stroke (conditions for susceptible environments, individuals, places, plus the extent and symptoms of heat stroke) ▪ Raise awareness of preventive measures, prevent heat stroke injury to workers (especially outdoor workers) ▪ Make use of information websites to prevent heat stroke (heat index, etc.) ▪ Make installation of air conditioning mandatory in rental housing, assisted living , seniors' housing, etc. ▪ Secure wind paths in urban areas, measures to address the heat island effect, etc.

Sector	Related plans and other	Examples of policies and measures with adaptation effects
	Infectious diseases ○Infectious disease prevention plans (prefectural governments) (Quarantine measures) (Strengthen regulations on importation of animals)	**Infectious diseases** ▪ Clarify the roles of national and local governments, physicians, etc. ▪ Secure and improve first-response systems for emergencies ▪ Strengthen quarantines to reflect disease incubation period; for example, ensure ability to confirm health condition after an individual enters a country even if no symptoms were evident when passing quarantine. ▪ Mandatory notification of importation of animals
Integrated monitoring	(Reference: Japan's fiscal 2010 implementation plan for global observation)	▪ Promotion of development of a unified observation system to respond to climate change

Step (7). Track and assess progress and effects of adaptation policies and measures, and revise regularly

- After implementing adaptation measures, the relevant departments in local governments should collaborate to track and assess progress and effectiveness. If adaptation measures are only seen as separate and unconnected, it is difficult to determine in a comprehensive way whether they are being conducted effectively and efficiently, and difficult to track progress. Thus, an effort should be made to use a cross-sectoral approach to track and assess the implementation of adaptation measures, and to implement them with an integrated approach.
  - The tracking and assessment can be divided into three steps: (i) assess the *overall progress* of initiatives toward adaptation, (ii) assess the *progress of individual* adaptation policies and measures, and (iii) assess the *effectiveness of individual* adaptation measures. It is desirable to begin with step (i), and then, when individual adaptation measures have been identified and there has been some progress toward their implementation, to move to step (ii). For step (iii)—the effectiveness of adaptation measures—it is best to conduct quantitative assessments promptly based on current knowledge, but going forward, the relevant departments should collaborate to consider what kinds of indicators could be used as they proceed further with adaptation measures.
  - For all three steps, it is necessary to consider and develop detailed assessment methods and indicators. Below are examples of indicators used in other countries to assess progress with adaptation.
- In addition to tracking and assessing policies and measures in individual sectors, it is also important to track and assess comprehensively at the prefectural (or state or provincial) level and municipal level, as well as in even more refined local units. It will be necessary in the future to consider the different methods for tracking and assessing at these various levels.

Case Study: Indicators for adaptation measures in the United Kingdom

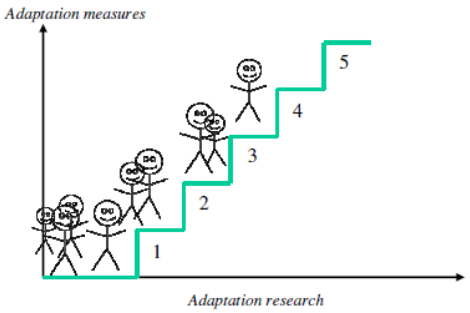
In the U.K., indicators to assess progress in climate change adaptation are seen as a part of indicators to assess the progress of various types of initiatives of local governments.[7] Given that there is still insufficient knowledge about adaptation, indicators are used to show *progress* rather than *outcomes* relating to adaptation. Further, the local governments using these indicators assess both the risks and opportunities of climate change, and they also aim to incorporate the indicators into their decision-making and implementation of government services, planning.

Level 0	Getting started	The government authority has begun the process of assessing the potential threats and opportunities, and has identified and agreed on the next steps to build on that assessment in a systematic way.
Level 1	Public commitment and impact assessment (assembling an evidence base)	The government authority has made a public commitment to identify and manage climate-related risk. It has undertaken a local risk-based assessment of significant vulnerabilities and opportunities to weather and climate, both now and in the future.
Level 2	Comprehensive risk assessment (with prioritised action in some areas)	The government authority has undertaken a comprehensive risk-based assessment of vulnerabilities to weather and climate, both now and in the future, has identified priority risks for its services, has identified the most effective adaptive responses, and has started incorporating these into strategies, plans, and operations.
Level 3	Comprehensive action plan (and prioritised action in priority areas)	The government authority has embedded climate impacts and risks across municipal council decision-making, has developed a comprehensive adaptation action plan. Also, in all priority areas, it is implementing appropriate adaptive responses.
Level 4	Implementation, monitoring, and continuous review	The government authority and local strategic partnerships are implementing the comprehensive adaptation action plan, and there is a robust process for regular and continual monitoring and review to ensure progress with implementation of each measure and updating of objectives.

[7] *Climate Impacts and Vulnerabilities Framework for Liverpool City: Final report prepared for Liverpool City Council*, by CAG Consultants, June 2009.

Case Study: Indicators for adaptation measures in Finland

Finland considered tentative indicators to assess progress in 15 sectors, for individual adaptation measures proposed in Finland's National Strategy for Adaptation to Climate Change, which was adopted in 2005. Together with the state of implementation of adaptation measures that had been launched in those sectors, Finland also considered the state of research about adaptation, cooperation among sectors, and the state of awareness about the needs for adaptation.[8]

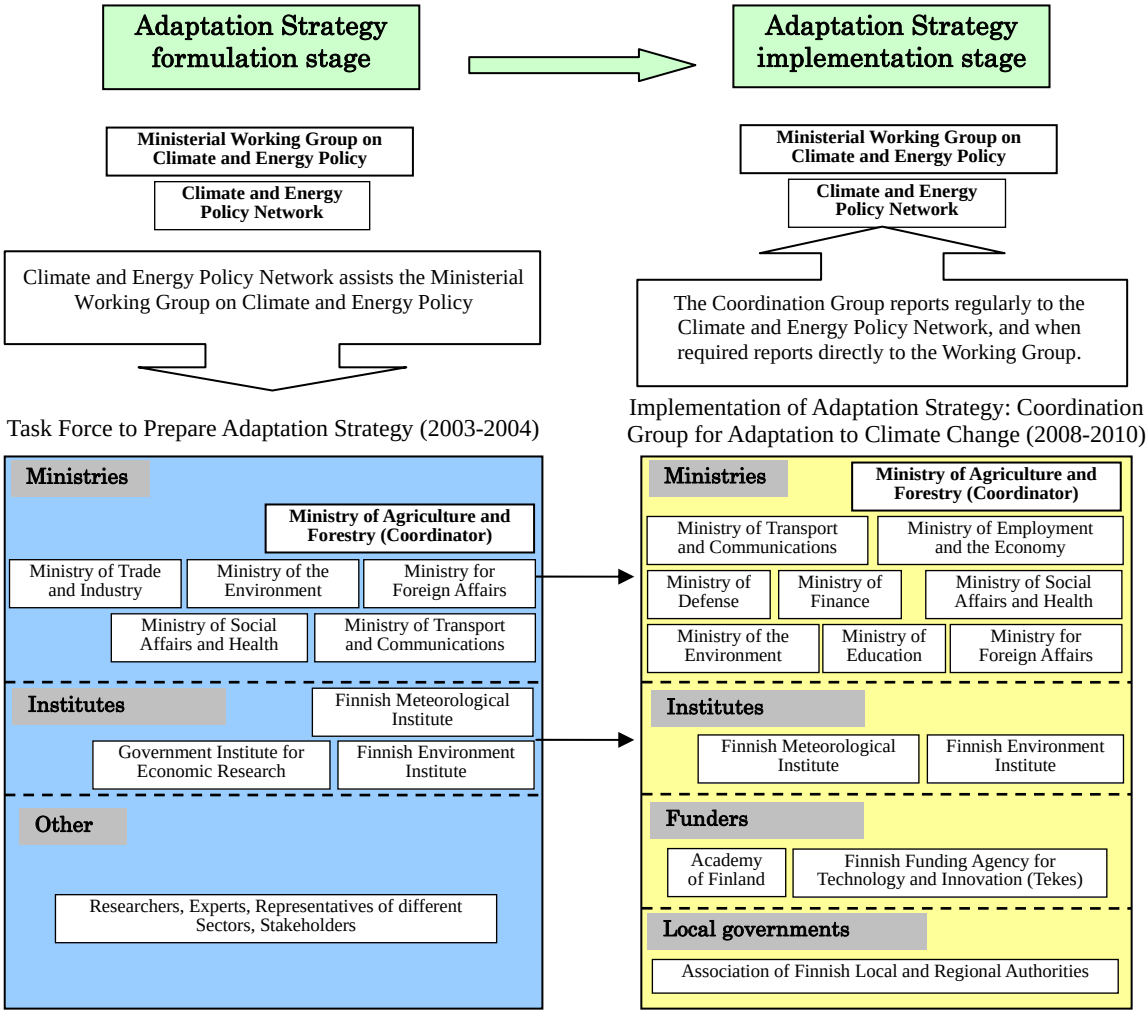


Step 1	・Need for adaptation recognised among a group of pioneers in the sector ・Little research done on the impacts of or adaptation to climate change ・Some adaptation measures identified but not yet implemented
Step 2	・Need for adaptation measures recognised to some extent in the sector (by some decision-makers) • Impacts of climate change known indicatively (qualitative information), taking account of the uncertainty involved in climate change scenarios ・Adaptation measures identified and plans made for their implementation, some of them launched
Step 3	・Need for adaptation measures quite well recognised (by majority of decision-makers) in the sector • Impacts of climate change quite well known (quantitative information), taking account of the uncertainty involved in climate change scenarios ・Adaptation measures identified and their implementation launched ・ Cross-sectoral cooperation on adaptation measures started
Step 4	・Need for adaptation measures widely recognised and accepted in the sector ・Adaptation incorporated into regular decision-making processes ・Impacts of climate change well known, within the limits of the uncertainty involved in climate change scenarios ・ Cross-sectoral cooperation on adaptation measures an established practice
Step 5	・ Adaptation measures under an official adaptation strategy, or recognized otherwise, are being implemented in the sector

[8] *Evaluation of the Implementation of Finland's National Strategy for Adaptation to Climate Change 2009*, Ministry of Agriculture and Forestry, Finland, 2009.

The term “cross-sectoral cooperation” arises in Steps 3 and 4. In the development and implementation of the Adaptation Strategy, Finland incorporated many related bodies, and created an interlinked structure, as shown in the figure below.

The “Evaluation of Implementation of Finland’s National Strategy for Adaptation to Climate Change” in 2009, however, states that the current emphasis is on individual sectors and individual research, and that more research is required in order to establish a comprehensive perspective.



Source: Prepared from “Finland’s National Strategy for Adaptation to Climate Change (2005),” and “Evaluation of the Implementation of Finland’s National Strategy for Adaptation to Climate Change” (2009).

Institutional structure for preparing and implementing Finland’s Adaptation Strategy

Step (8). Conduct integrated adaptation, basic capacity enhancement

- Relevant local governments departments should cooperate with each other. By using a unified approach to address measures that would otherwise be handled separately or sector-by-sector, together they should coordinate the adaptation measures being conducted in individual sectors, engage in cross-sectoral initiatives, and establish collaborative arrangements among the relevant government departments. All this will increase the effectiveness of their efforts. Examples include prioritizing climate change adaptation in master and in measures in individual sectors, and actions to clarify issues that require cooperation and cross-sectoral initiatives among multiple departments and sections within an organization, for the purpose of more efficient implementation of measures.
- Policies and measures should be actively promoted to improve the adaptive capacity of local societies, by enhancing the basic capacity (technologies, programs, financing, and human resources, etc.) typically present in regions and sectors. Specific examples include the research and development of technologies, the introduction or improvement of systems or programs, and the training and utilization of personnel.
- These adaptation measures have other benefits—even if the actual situation differs from projected climate change and its impacts—and should be promoted systematically and consistently, with a long-term perspective.
- It is also important to review the status of collection and compilation of basic data and information relating to impact assessments and adaptation measures, to identify areas where the compilation of the data and information is still inadequate, and to make systematic improvements.

Step (9). Communicate and share information with the public

- The results of risk assessments should be released to citizens in order to promote a shared awareness of the risks of climate change. This approach can facilitate subsequent communication and decision-making relating to adaptation measures, by raising awareness about impacts and adaptation, and by creating a common understanding of these kinds of risks at an early stage.
- Below are some examples of specific approaches for information sharing:
  - Publish reports and pamphlets about climate change risk assessments.
  - Seek public comments before official publication of reports and other materials.
  - Conduct awareness-raising efforts about risk assessments, through seminars, meetings, lectures, etc.
  - Release information through mass media, Internet, etc..

Step (10). Review and implement based on feedback and re-assessment

- Reviews should be conducted based on the latest knowledge about the appropriateness of risk assessments and adaptation measures, as the body of scientific knowledge about climate change impacts and adaptation measures steadily grows.
- To establish and implement more effective adaptation plans, policies and measures, the adaptation measures in individual sectors—as well as integrated adaptation and basic capacity enhancement—should be implemented following the flow in A-track steps (1) through (9), the approach to monitoring should be reviewed, and future projections and risk assessments should be reviewed.

B Track. Simplified first five steps for adaptation planning and implementation

- Figure 6 and the following pages explain the details of the simplified first five steps to initiate when approaching planning and implementation of climate change adaptation. The brackets < > on the following pages indicate the corresponding step in the more detailed A track. Not all B-track steps match those in the A track, but this is due to the fact that the primary aim of the B-track steps is to avoid delays in starting adaptation initiatives. As mentioned above, the B track proposes procedures that can be implemented quickly and with the minimal amount of effort.

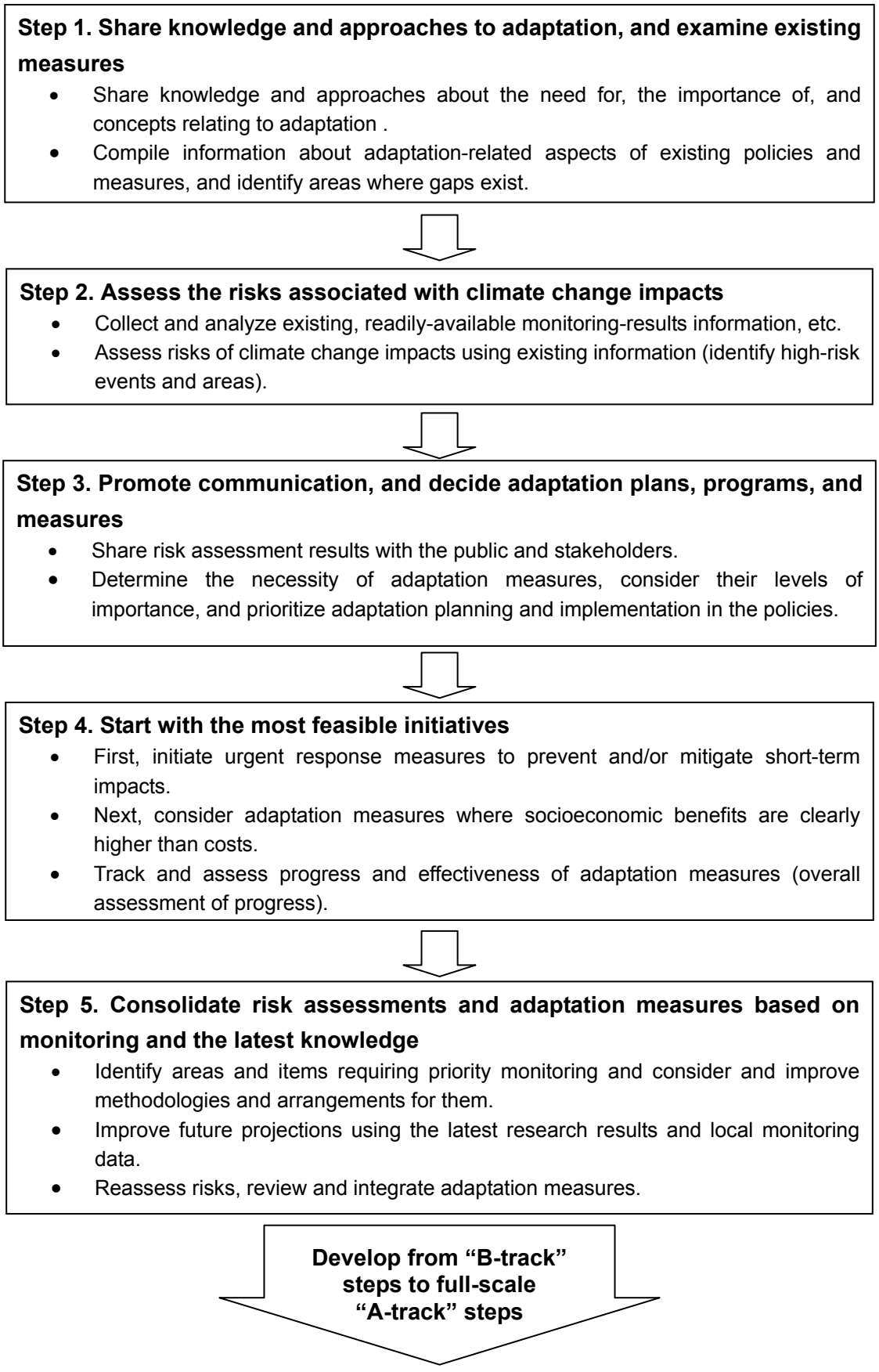


Figure 6. The simplified first five steps for adaptation planning and implementation

Step 1. Share knowledge and approaches to adaptation measures, and examine existing measures

- Efforts should be made to create a common understanding within an organization on integrated measures to address climate change, consisting of both mitigation and adaptation. This understanding includes awareness about the importance of adaptation measures. Related to this, there should be a certain level of shared knowledge relating to concepts such as climate change impacts, vulnerability, resilience, risks, and adaptation. There should also be a common awareness among the relevant government departments of the importance of adaptation measures. **<Only for B track. Not included in A track>**
- Each department should list the relevant aspects of adaptation to climate change and extreme weather events that are already part of existing measures and programs, and identify generally and in simple terms the sectors where adaptation measures are adequate or inadequate. **<Corresponds to step (1) in A track>**

Step 2. Assess risks associated with climate change impacts

- Readily-available information on climate change and its impacts should be collected and organized. This effort should include past meteorological observation data and meteorological observation conducted independently by local governments, as well as case studies of impacts in individual sectors, and interviews with citizens. An effort should also be made to utilize information from the public and local research institutes, rather than depending solely on information from within the government. **<Corresponds to step (1) in A track>**
- The risks from impacts of climate change should be assessed using the information collected. Impacts and regions where risks are particularly high should be identified, based on whatever qualitative consideration of simple ranking is possible using current knowledge and data, and the overall state of risk in a region should be ascertained in general and simple terms. It may be worth allocating a higher priority to the assessment of sectors in Step 1 that do not yet have sufficient adaptation measures. **<Corresponds to step (4) in A track>**
- Where enough knowledge and data have been accumulated to permit detailed and systematic assessments based on the results of independent regional monitoring and projections, more elaborate assessments should be done using that knowledge and data. **<Corresponds to steps (2) and (3) in A track>**

Step 3. Promote communication and decide adaptation plans, programs, and measures

- The results of risk assessments should be released to citizens and concerned parties, and an effort made at an early stage to broadly promote the sharing of risk-rated information and awareness. This approach can have the effect of facilitating subsequent communication and decision-making relating to the implementation of adaptation measures. **<Corresponds to step (9) in A track>**
- While seeking to enhance mutual cooperation relating to adaptation, the relevant government departments should judge the importance of adaptation measures, and give adaptation initiatives an adequate level of priority within plans and measures. In the interest of promoting effective and efficient adaptation efforts, priority should be given to incorporating the concept of adaptation into existing plans and measures in individual sectors, rather than trying to formulate completely new plans and establish completely new measures. When deciding on plans and measures, an effort should be made to provide information to citizens and concerned parties, and also to gather feedback and information. **<Corresponds to steps (5), (6) and (9) in A track>**

Step 4. Start with the most feasible initiatives

- After the importance and priority of adaptation measures are determined, efforts should start with the most feasible initiatives. First, urgent response measures should be initiated to prevent or mitigate short-term impacts. Next, adaptation measures should be considered where socioeconomic benefits are clearly higher than costs. Some options may be “no regrets” adaptation measures (which provide economic benefits regardless of the extent of future climate change), and “win-win” adaptation measures (which can help to address not only climate change but also other issues). **<Corresponds to steps (5) and (6) in A track>**
- After implementing adaptation measures, the relevant departments within local governments should collaborate to track and assess their progress and effectiveness. This effort should begin with an assessment of the overall progress of adaptation initiatives, and when individual adaptation measures have been decided and there has been some progress with implementation, the progress and outcomes of individual adaptation measures can be assessed. **<Corresponds to step (7) in A track>**

Step 5. Consolidate risk assessments and adaptation measures based on monitoring and the latest knowledge

- Identify areas and items where risk assessment data is insufficient, and among them, where monitoring of climate change and its impacts in the relevant regions should be

prioritized. Methodologies and arrangements to implement continuous monitoring of those areas and items should be considered and improved. **<Corresponds to step (2) in A track>**

- Knowledge about future projections should be improved, by using the latest research findings on projections and assessments, or by making projections using independent data collected through local monitoring. Where necessary, climate scenarios and impact assessments should be developed in cooperation with the appropriate organizations. **<Corresponds to step (3) in A track>**
- Risks should be reassessed by improving monitoring as suggested above and by using new knowledge about future projections. Adaptation measures should be refined based on those reassessments, and efforts should be made to integrate adaptation measures. **<Corresponds to steps (8) and (10) in A track>**

3.3 Approaches to incorporate adaptation into plans, programs, and policies

(1) Use diverse options, including both “hard” and “soft” measures

- Various approaches to adaptation are possible, including both “hard” measures (structural aspects such as physical infrastructure, equipment, facilities, etc.) and soft measures (non-structural, non-physical, institutional, operational aspects, etc.). Approaches may also involve regulatory systems, technological development, economic measures, and information systems. When incorporating the perspective of adaptation into existing plans and measures, it is important to have an understanding of the diverse approaches available. As indicated in section 3.1, some adaptation measures contribute to the prevention or mitigation of impacts in the short term, and others in the medium and long term. Because the timeframes differ, it is important to be aware of such differences. Table 3 indicates adaptation measures in individual sectors, separated into short-term and medium/long-term measures.

Table 3. Examples of options for adaptation measures

● Indicates “hard” measures
○ Indicates “soft” measures

Food

	Measures that help prevent or mitigate short-term impacts	**Measures that help prevent or mitigate medium- and long-term impacts**
Technology	○ Introduce heat-tolerant varieties, etc. ○ Change cultivation methods, cropping season ○ Proper water management ● Install equipment and facilities to avoid heat damage, etc. ○ Assess impacts of extreme heat on reproductive functions ● Environmental control of livestock barns	○ Develop heat-tolerant varieties, etc. ○ Develop water saving cultivation methods in regions projected to have water shortages ○ Develop technologies to reduce stress on reproductive functions, etc. ○ Develop technologies to avoid infertility of breeding stock during extreme heat ○ Develop flood/inundation-tolerant varieties
Economic measures	○ Use mutual aid systems	
Information systems	○ Collect and organize information from farm extension workers ○ Use information systems related to adaptation to global warming (e.g., “Ondanka Net,” a Japanese website)	○ Develop systems to issue weather alerts in the context of global warming
Awareness-raising	○ Provide guidance for extension workers	
Other	○ Create systems to support and guide farmers with adaptation measures ○ Provide information and capacity building for farm extension workers and instructors	○ Set fishing seasons to be optimal for fish migratory routes and fishing grounds

Water environment and water resources

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Technology	● Desalinization of seawater, delivery of freshwater ● Eutrophication control measures (blue-green algae control fences, aeration equipment, etc.) ● Promote the use of water-saving devices ● Install and augment electrical generation equipment for water purification plants	● Introduce water supply and wastewater management systems as measures for times of drought ● Use reclaimed sewage water, grey water, and rainwater, etc. ● Take steps to prevent salinization of groundwater ● Create attractive waterfronts and green space along urban rivers, taking measures against the heat island effect ● Manage and conserve forests ● Restructure networks of dams to manage flood control volume and service water volume
Regulatory systems	○ Improve water-related operations	○ Regulate deep groundwater pumping in order to control land subsidence ○ Regulate wastewater quality
Economic measures	○ Introduce systems or mechanisms to accommodate mutual needs flexibly in a region during times of drought	○ Reallocate water usage rights ○ Indirectly control land subsidence through economic measures such as levy systems to restrict the use of deep groundwater
Information systems	○ Provide drought information	○ Use integrated analysis of water quality characteristics of water supplies, and select suitable water purification processes based on that analysis
Awareness-raising	○ Improve awareness about water conservation	○ Create a water-conserving society through demand-side management

Water-related disasters in coastal areas, etc.

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Technology	● Improve canals, dikes, breakwaters, storm surge barriers, flood-control facilities, and sewerage facilities ● Improve erosion control facilities on slopes ● Reinforce dikes in hazard zones (potential flooding areas), implement measures to prevent their aging ● Reinforce buildings and raise their foundations ○ Improve refuge areas ○ Determine current safe water levels, etc. ○ Assess disaster risks ○ Prepare hazard maps for tsunamis, storm-surges, and inland waters ○ Enhance maintenance and inspection abilities of facilities management personnel ○ Upgrade control systems for	● Improve facilities and conduct capacity building based on hazard risk assessments ○ Implement measures (e.g., resettle local residents) based on land-use regulation changes that consider climate change ● Improve refuge areas ○ Conduct ongoing research and development of technologies for countermeasures

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
	floodgates, land locks, etc. ○ Research and develop technologies for countermeasures	
Regulatory systems	○ Regulate land use by designating disaster hazard zones	○ Change land-use regulations on land set back from rivers and coastlines ○ Adjust legislation to prevent construction in hazard zones, and to require removal of structures (potential flood areas)
Economic measures	○ Realize rapid restoration of infrastructure through collaboration among regional development bureaus, the National Institute for Land and Infrastructure Management and the Public Works Research Institute, local governments, and the private sector ○ Improve flood insurance programs, etc. ○ Establish funds, subsidies, etc., for post-disaster recovery	○ Improve flood insurance programs
Information systems	○ Provide information about hazard maps, past flooding evidence, etc. ○ Provide information about disaster risks	○ Provide information about disaster risks
Awareness-raising	○ Strengthen organizations' abilities for disaster prevention ○ Provide observational information, damage projections, and other information ○ Educate for disaster prevention	○ Provide observational information, damage projections, and other information ○ Educate people about disaster prevention

Natural ecosystems

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Technology	● Create, conserve, and restore biotopes ● Implement measures to control pine wilt disease ● Use damage prevention measures such as installation of fences to exclude deer ● Use measures to reduce flow into rivers, lakes, and seas, of polluting substances (e.g., improve sewerage systems, install septic tanks, improve rural community's wastewater treatment plants) ● Use measures to purify river and lake water (purification by vegetation, dredging of sediment, etc.) ● Ensure that fish ladder installations provide continuous passage ● When reinforcing embankments, also consider aquatic organisms	● Create ecological networks ● Manage and conserve various forest types, including conifer-broadleaf mixed, etc. ● Secure migration routes for flora and fauna by managing and conserving riparian forests ● Secure refuge areas for flora and fauna by ensuring rivers have natural diversity ● Conserve and restore habitat, growing, breeding and propagation environments of flora and fauna ● Create green spaces along coastal waterfronts, and connect them as networks ● Conserve and restore sandy beaches

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Regulatory systems	○ Control deer and other populations through extension of hunting season, capture, etc., based on Specified Wildlife Management Plan ○ Restrict tourist activities in highly vulnerable areas (alpine zones, etc.)	○Establish various types of protection and conservation areas (prefectural parks for nature conservation, scenic areas, nature conservation areas, forest ecosystem conservation areas, special landscape conservation areas, etc.) or review those areas
Economic measures	○ Use fee-based systems to control number of visitors to alpine and other tourism sites	○ Maintain deer capture numbers by utilizing deer resources and creating a market for them
Information systems	○ Building risk maps of pine wilt disease	○ Monitor dynamics of forest ecosystems ○ Formulate pine wilt disease control guidelines ○ Conduct monitoring studies of deer species populations, determine status of their distribution ○ Phenological monitoring
Awareness-raising	○ Raise awareness to reduce trampling and compaction of alpine vegetation, wetlands, etc.	○ Publicize findings of phenological monitoring ○ Conduct phenological monitoring through collaboration among local governments (to determine northward migration of species distributions, etc.) ○ Give volunteers the knowledge and skills to cooperate in monitoring ○ Raise awareness about coral protection

Health

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Technology	Heat stroke ● Improve heat stroke warning systems <Infectious diseases> ○ Vaccinate ○ Control disease vectors (mosquitoes, etc.)	Heat stroke ● Conduct city planning to include prevention of heat island effect, heat countermeasures that involve low CO_2 emissions ● Improve water supply and sewerage systems ● Improve heat stroke prevention shelters <Infectious diseases> ● Ongoing research and development into vaccines and treatments targeting infectious disease pathogens ● Establish methodologies to detect and assess pathogens ○ Clarify impacts of global warming on propagation of pathogens
Regulatory systems	Heat stroke ○ Enact/adopt regulations/ ordinances/programs to prevent heat stroke	
Economic measures	Heat stroke ○ In regions with high risk of heat stroke, provide financial assistance to	

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
	install air conditioners in homes without air conditioners	
Information systems	Infectious diseases ○ Study occurrence of disease vectors	Infectious diseases ○ Conduct surveillance of infectious diseases ○ Study the state of occurrence of pesticide-resistance ○ Conduct ongoing studies of disease vectors, bacterial counts in seawater, etc., in each region
Awareness-raising	Heat stroke ○ Distribute health guidance manuals ○ Provide guidance to households with seniors, etc. (distribute posters, use care provider systems) ○ Support initiatives at workplaces and schools	Infectious diseases ○ Provide information on preventing disease vectors

Common to all sectors

	Measures that help prevent or mitigate short-term impacts	Measures that help prevent or mitigate medium- and long-term impacts
Technology	● Install, enhance, and upgrade monitoring equipment and monitoring systems ● Improve precision of climate change and impact projections	● Install, enhance, and upgrade monitoring equipment and monitoring systems ● Improve precision of climate change and impact projections

(2) Create synergies and prevent adverse socioeconomic and other impacts

・ When incorporating the concept of adaptation, an active effort should be made to promote adaptation measures that have synergies within individual sectors, as well as synergies with other sectors. It is also important to consider ways to avoid negative socioeconomic impacts and other types of negative impacts. Below are examples of positive synergies and possible negative impacts.

Examples of synergies

・Management and conservation of forests and green spaces (providing migration paths and refuge areas for flora and fauna, land conservation, water retention in water source areas, conservation of biodiversity, mitigation of the heat island effect, and improvement of amenities.): These may offer benefits as adaptation measures as well as benefits from the sequestration of CO_2, etc.

・Effective use of rainwater and reclaimed water: These may offer benefits as

adaptation measures that help reduce drought damage, as well as benefits such as reducing CO_2 emissions associated with the supply of water.

・Building insulation: These may offer benefits as adaptation measures that help prevent heat stroke and reduce discomfort from summer heat, as well as benefits of reducing CO_2 emissions by reducing the use of heating and cooling.

Examples of negative impacts

・Depending on their details, adaptation technologies adopted may use more energy (in the form of fossil fuels) than conventional technologies, and could lead to an increase in CO_2 emissions. In such cases, it is important to make an effort to reduce the CO_2 emissions as much as possible, such as by adopting similar technologies that have lower CO_2 emissions.

・The construction of landslide prevention structures to deal with hazards can in some cases have negative impacts on surrounding ecosystems. In such cases, it is important to carefully consider facilities and structures that have a lower impact on ecosystems.

(3) Integrate adaptation measures

- Adaptation measures can only be effective if introduced with an adequate awareness of societal issues (e.g., declining birthrates and the aging of society in Japan). For the near future, the prevention and mitigation of short-term impacts are priority issues. It is also important to have the concept in national planning that adaptation to climate change is an opportunity for the creation of a new society that permits people to live safe, secure, and more prosperous lives. This approach uses an integrated and long-term perspective that includes regional and social development.
- The report of a task force under Japan's Council for Science and Technology Policy (top scientific advisory body for the Japanese government) defines[9] the strengthening of social infrastructure based on this type of thinking as "green social infrastructure." It gives special attention to making cities more compact, to guaranteeing safety and security, and to ensuring health and longevity, and emphasizes the importance of adapting flexibly to climate change, while shifting to urban designs that foster dynamic productive activity and offer opportunities for living prosperous lives.

[9] Task Force Report on Science and Technology Diplomatic Strategy, 2010, by Council for Science and Technology Policy (in Japanese)